ClairCity: Citizen-led air pollution reduction in cities

D7.5 Final City Policy Package – Last City

June 2020

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 689289

This deliverable

This report is deliverable D7.5 Final City Policy Package – Last City.

It is a compilation of the final ClairCity policy package reports for 5 cities.

- D7.5 Final City Policy Package – Amsterdam
- D7.5 Final City Policy Package – Ljubljana
- D7.5 Final City Policy Package – Sosnowiec
- D7.5 Final City Policy Package – Aveiro Region
- D7.5 Final City Policy Package – Liguria Region / Genoa

The final 'Bristol' (pilot city) policy package report was submitted earlier as D7.4 Final City Policy Package – First City.

These policy package reports gather the most relevant results, findings and evidence gathered as part of ClairCity activities and research unders WP4 – Citizen Engagement; WP5 – Quantification and WP6 – Policy and Governance. As such each report includes a synthesis of citizens behaviours and prefered future policies, policymakers' views, modelling impacts (economic, air quality, health, cost-related) of a set of selected policy measures. The reports also provide recommendations to city / region authorities.

ClairCity: Citizen-led air pollution reduction in cities

D7.5 Final City Policy Package – Amsterdam

January 2020

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Document Details

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V1	Irati Artola	September – October 2019	First draft
V2	Stephan Slingerland, Irati Artola	December 2019	First full draft
V3	Stephan Slingerland, Irati Artola	January 2020	Final draft

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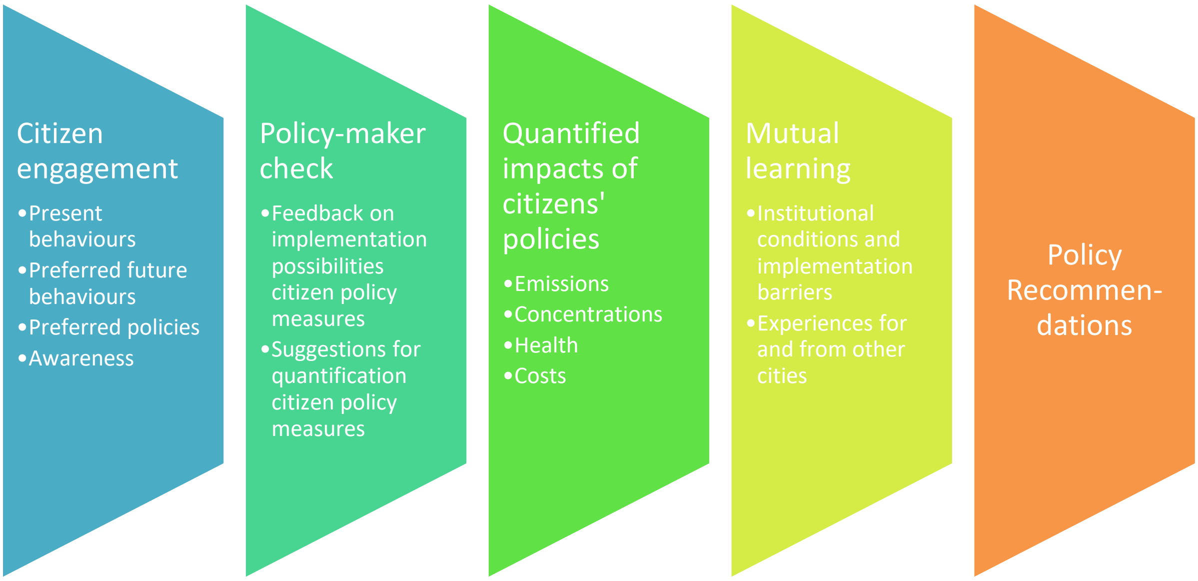
Contents

Executive Summary

ClairCity project and method

The ClairCity Horizon2020 project aims to contribute to citizen-inclusive air quality and carbon policy making in middle-sized European cities. It does so by investigating citizens' current behaviours as well as their preferred future behaviours and policy measures in six European cities[1] through an extensive citizen and stakeholder engagement process. The project also models the possible future impacts of citizens' policy preferences and examines implementation possibilities for these measures in the light of the existing institutional contexts in each city (Figure 0-1). **This report summarises the main policy results for Amsterdam (the Netherlands)**.

Figure 0-1: The ClairCity method in brief



The methodological understanding as developed in the ClairCity project of what is citizen-inclusive policy-making, and what it should and should not comprise, is given in Textbox 0-1.

Textbox 0-1 Citizen-inclusive policy-making according to ClairCity

- Tailor local policies based on detailed knowledge of behavioural practices of citizens;
- Engage with citizens via a diversity of methods, paying particular attention to hearing the voice of 'hard-to-reach' groups;
- Ask citizens for their preferred future behaviours and barriers to behavioural changes. Address the perceived barriers of citizens by concrete measures or initiate dialogue with citizens about misconceptions concerning air quality and climate change;

[1] Bristol, Amsterdam, Sosnowiec, Ljubljana,Aveiro/CIRA region, Genoa/Liguria region

- Ask citizens for their preferred future policies for the city, examine potential impacts of these policies and discuss with stakeholders and policy makers their implementation possibilities;
- Examine and address potential implementation barriers for preferred citizen policy measures beyond citizen perceptions;
- Experiment, and exchange experiences with other cities that are also aiming to implement citizen-inclusive policies;
- Do not confuse citizen-inclusive policies with populist policies. Take full responsibility for democratically implementing popular or unpopular measures considered appropriate, after having been extensively informed about citizens' views and behaviours.

In total, during the period 2017-2019 over 1,100 Amsterdam citizens were reached by the various ClairCity citizen engagement methods (Table 0-1). While this sample is not fully representative of the Amsterdam population as a whole[2], it gives an indication of support for policy measures and intentions for behavioural change that can be used by policy makers to inform future policies.

Table 0-1: Number of participants in ClairCity citizen engagement methods in Amsterdam

Citizen engagement activity	# of participants engaged
Delphi Process	638
Skylines Game	371
Mutual Learning Workshop	20
Stakeholder Dialogue Workshop (in Delphi process)	19
Policy Workshop*)	6

*) the number of participants of the policy workshop is also included here, despite not being formally part of the citizen and stakeholder engagement process

Amsterdam city conclusions and recommendations

The main conclusions and recommendations from the ClairCity project for citizen-inclusive policy making in Amsterdam are:

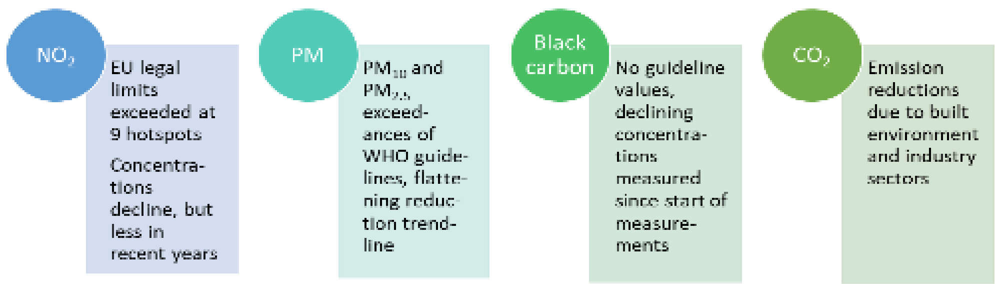
[2] 638 people responded to the ClairCity survey in Amsterdam, out of a city population of 834,713 . The Amsterdam respondents were 55% male, which is slightly higher than the city gender ratio. The respondents were disproportionately older compared to the city population, with 89% of respondents aged 37 or older in the Round 1 sample, compared to only 52% of the city population. The sample was more educated (i.e. had higher level of qualifications) than average, with limited representation of those who had a low level of education compared to the categories used to collect city-wide data. In the sample, 67% of the respondents had a "high" level of education with only 5% having "no/low" level of eduation, compared to the city population where 47% have a "high" level, and 22% have a low level of education. In The Netherlands, categories regarding the national identity are more relevant than ethnicity of respondents. The "non-Dutch" population of Amsterdam is around 14% according to city statistics. In Round 1, 13% of the sample were non-Dutch nationals with 5% of the total from Western countries (Europe, North America, Japan etc) and 8% from non-Western countries.

Current air quality and carbon situation in Amsterdam

Ambitious air quality and carbon policies in Amsterdam aim to go beyond EU legal limits, but still have a far way to go to reach their objectives.

- The main Amsterdam **city policies** include a 'natural-gasfree' Amsterdam by 2040; a 'transport emissions free' city within the city ring road by 2030; meeting WHO guideline concentrations by 2030; and, reducing overall CO2 emissions in the city by 55% in 2030 and by 95% by 2050. There has been significant progress towards these targets, but there is still a long way to go.
- **NO_2 yearly average guideline values** given by WHO (40 µg m^{-3}) were exceeded at 22 street lociations in 2018[3]. Concentrations are declining over recent years, but similar to PM and black carbon the trendline is flattening.
- **PM_{10} concentrations** are decreasing over the period 2008-2018, but concentrations measures at street stations still exceed WHO yearly average (20 µg m^{-3}) and daily average guideline values (50 µg m^{-3} for no more than three days per year). In recent years reductions are less than in previous years, suggesting a flattening reduction trend for PM_{10}.
- **$PM_{2.5}$ concentrations** in 2018 exceeded WHO guideline values for yearly and daily averages (10 / 25 µg m^{-3}) at all measuring stations. Over the period 2010-2018, $PM_{2.5}$ concentrations are decreasing, but the reduction trendline is – as for PM_{10} – flattening out.
- **Black carbon concentrations** are measured in Amsterdam as well. Although no WHO guideline values exist for black carbon, the WHO notes that due to its negative health effects, black carbon concentrations in general should be minimised. Measurement data are more limited than for PM (only for recent years), but suggest a slightly decreasing trend.
- **CO_2 emissions** in Amsterdam have declined from almost 4.8 Mt in 2013 to 4.4 Mt in 2017. While emissions of the sectors built environment and industry dropped, those of the transport sector remained almost constant[4]. The goal is to become climate neutral by 2050.

Figure 0-2: Main features of the current Amsterdam air quality and carbon situation (sources: Municipality of Amsterdam, GGD)



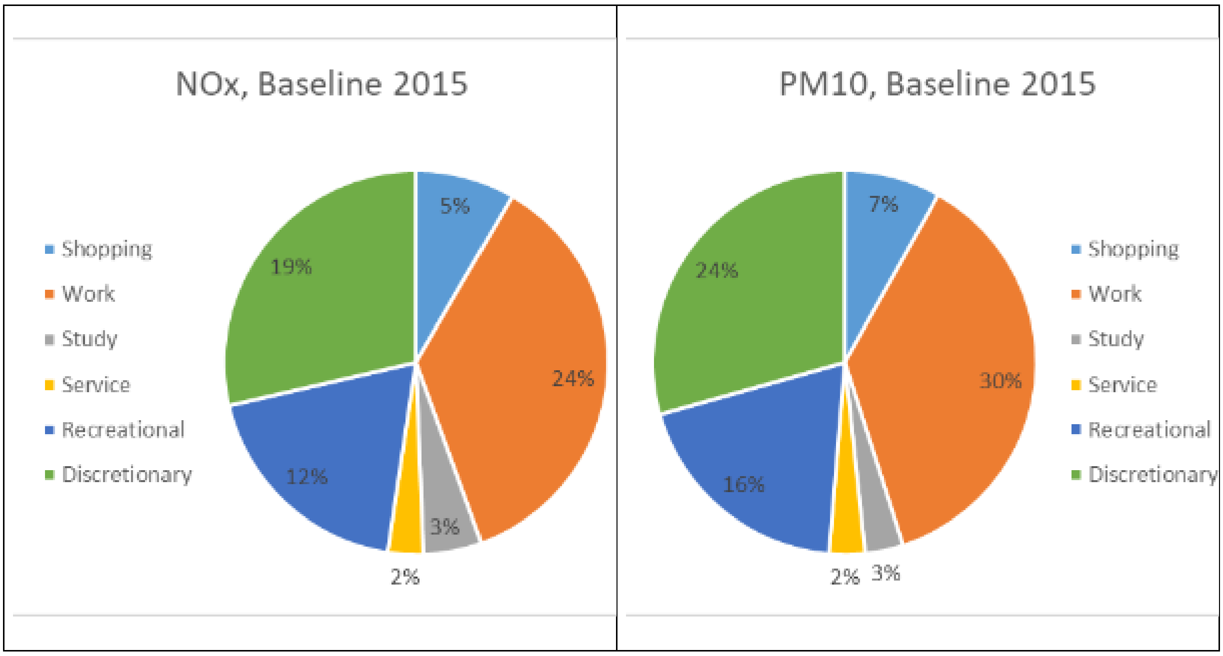
[3] Measured concentrations, Palmes Tubes.
[4] See https://klimaatmonitor.databank.nl

Current behaviours of Amsterdam citizens

Currently, most transport-related emissions of air pollutants by citizens in Amsterdam are caused by work-related transport. This holds for NO_x as well as for PM_{10}.

- 24% of transport-related NO_x and 30% of PM_{10} emissions in Amsterdam are related to work-related trips, compared to 12 and 16% of NOx/PM emissions for recreational trips and 5 and 7% for shopping trips, respectively.

Figure 0-3 Amsterdam NO_x and PM emissions from transport by trip motive of citizens in 2015[5]



Analysing NOx emissions further, main emitters in Amsterdam are men, middle-income citizens and younger adults.

- Detailed demographic analysis of the group of citizens causing NO_x emissions from transport shows that men in Amsterdam cause more NOx emissions than women due to their greater use of car transportation (32% versus 23% of total transport emissions respectively). Work related NOx emissions are more prominent for men than for women (15% versus 6%). Recreational transport for both genders is the second largest emission category (6 and 5% of emissions).
- Assigning NOx emissions of Amsterdam citizens into three income groups, low (0 – 21,000 euro/year), middle (21 – 36,000 euro/year) and high (> 36,000 euro/year), the data shows that the middle income group causes most emissions, followed by the high income group and then the low income group. The analysis also shows that public transport use decreases with higher incomes, while emissions caused by private car use are highest in the middle income group, followed by the low income group.

[5] Based on Centraal Bureau voor de Statistiek (CBS); Rijkswaterstaat (RWS) (2016): Onderzoek Verplaatsingen in Nederland 2015 - OViN 2015. DANS. https://doi.org/10.17026/dans-z38-prz4

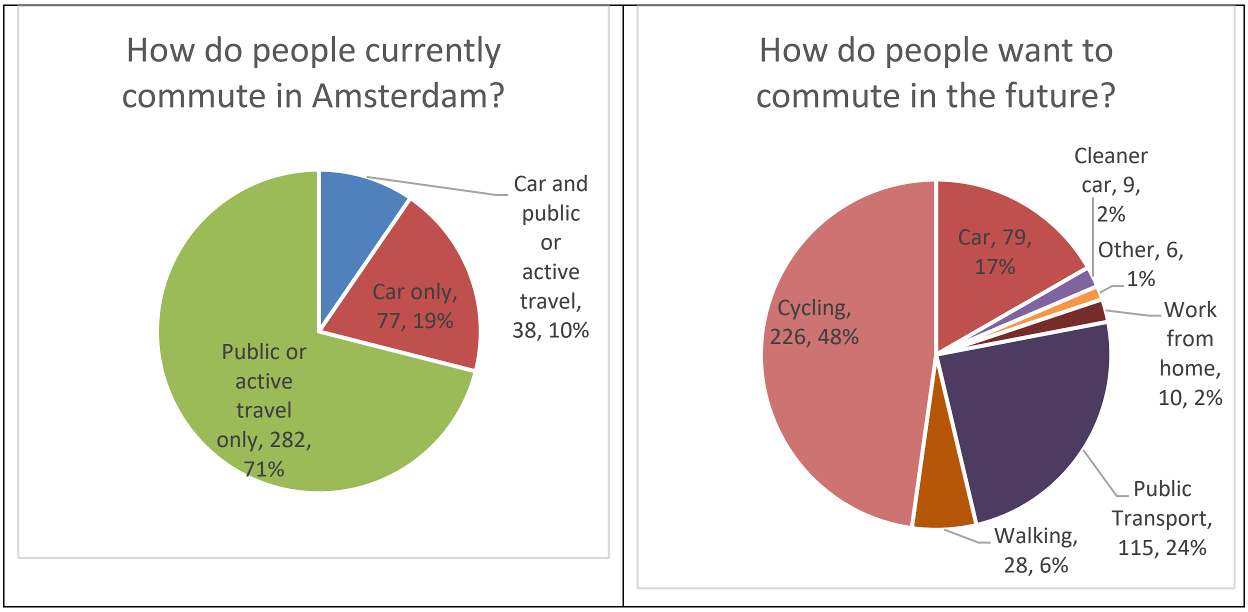
- In regards to different age categories, teenagers and younger adults (15-44 years) by far cause the most transport emissions in Amsterdam (27%), followed by older adults (45-64 years; 18%) (Figure 3-11). The 65+ and the below 15 age groups (as car passengers) cause significantly less emissions (5% and 4% respectively).

Preferred future behaviours of Amsterdam citizens

There is substantial scope with Amsterdam citizens to change their commuting behaviour in the future, but these are not yet aligned to city policy objectives.

At present 29% of the respondents in Amsterdam only use their car for work, or use it next to other forms of transport (Figure 0-4). In the future, the share of car users (car-only or part-time) will decline to 17%. 2% of the respondents are considering to buy a greener car and 2% are anticipating to work from home in the future. The share of respondents using 'public or active travel (walking/cycling) only' will rise from 71 to 78%. The figures show that there is still a significant gap between the policy ambition to end the access of non-electric cars to the city by 2030 and the anticipated future transport behaviours of citizens.

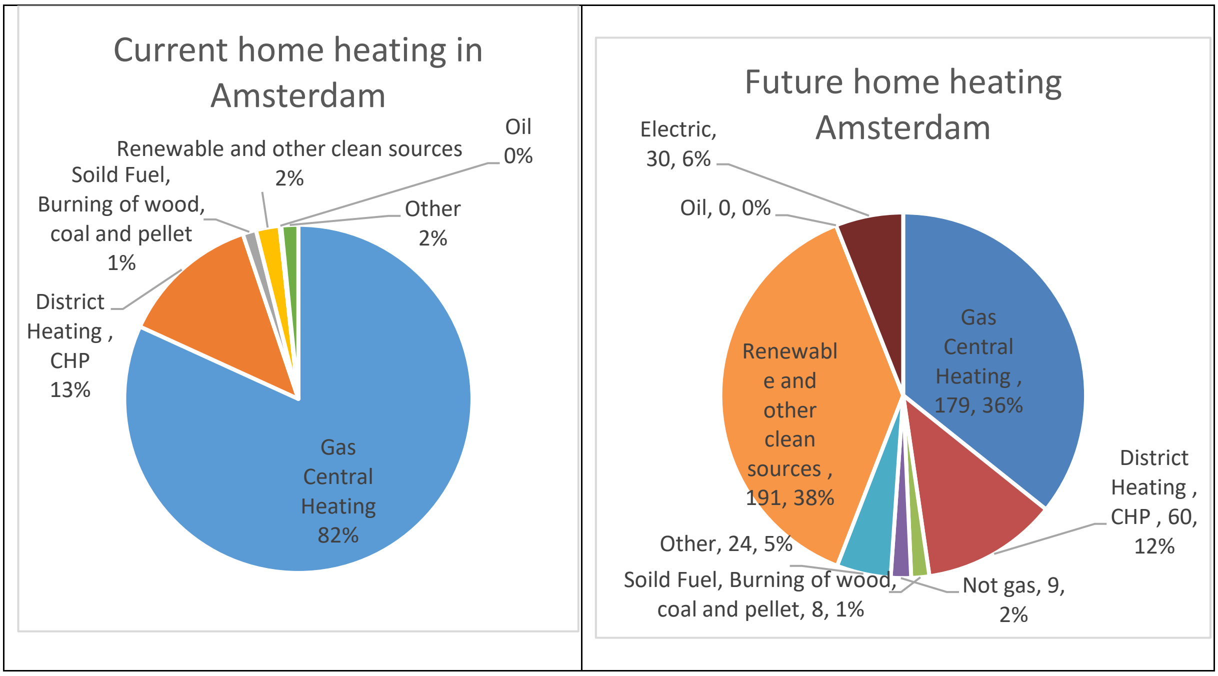
Figure 0-4: Proportions of present and future car use of commuters Amsterdam



Many Amsterdam citizens are also willing to change their home heating behaviour away from natural gas, but the willingness of respondents to change is behind city ambitions.

The vast majority of Amsterdam respondents indicated that they currently have gas heating at home (82%). Some 13% of the respondents are conneced to the district heating grid and 5% use renewables or solid fuels at present (5%) (Figure 0-5). Given the current policy ambitions for a gas-free built environment in Amsterdam by 2040, everybody should switch towards other sources than the current natural gas. Yet, 36% of respondents still expect to use natural gas in the future. The number of respondents that anticipate using district-heating in the future does not increase (12%, compared to 13% now), which is also not in line with current policy ambitions to expand the district-heating grid.

Figure 0-5: Current and future choices for home heating in Amsterdam



Preferred future policies of Amsterdam citizens and reflections by policy makers

Citizens support ambitious policy measures in the city. A ban on wood stoves and improving public transport are the two most preferred measures by citizens and policy makers alike.

- The eleven most popular measures that were indicated by the Amsterdam respondents are shown in Table 0-2. A ban on wood stoves and improving public transport are the most preferred measures of citizens and policy makers alike. Only for these two measures, both groups selected the highest ambitious levels for implementation they could choose from.

Table 0-2 Amsterdam citizen policy measures

#	Measures	Detailed policy measure for modelling
1	**Cleaner buses**	Half of the buses emission-free (100% electric or hydrio-powered) by 2025
2	**Better public transport**	Increase network density from the net and increase frequency by 2030
3	**More bike paths and bike parking spots**	60 000 new bike parking spots by 2025. Improving current bike pats and fast bike routes (bike highways) by 2022
4	**Cheaper public transport**	Price of public transport remains the same until 2030
5	**Environmental zone for polluting cars**	Adding an environmental zone for private cars and making current environmental zones more stringent
6	**Limiting parking for cars**	Remove 7.000-10.000 parking spots (approx. 10% of the current parking spaces in the city centre) and charge € 7.50 per hour everywhere in the city by 2020
7	**Limiting car-traffic in the city centre**	Cars in the city centre are only allowed for people living there
8	**Accelerating energy-efficient house renovations**	All houses belonging to housing associations reach an energy label B or C by 2050
9	**Ban wood stoves and fireplaces in houses and bars & restaurants**	Ban wood stoves and fireplaces in both new buildings and existing buildings from 2025

10	**Accelerate the uptake of solar panels in the built environment**	Mandatory solar panels in all suitable roofs and provide subsidies for it
11	**Amsterdam gas-free**	€ 10.000 subsidy per household in order to facilitate renovation to become gas-free. Mandatory gas-free building sector by 2030.

Policy makers overall express support for these citizen measures, but also sometimes add reflections regarding their implementation possibilities.

- Reflections of policy makers to the ambitions of citizens include, for instance, foreseen limitations to the speed of increasing the number of charging stations for buses, incompatibility of reducing public transport tariffs with expanding and greening public transport, and doubts on increasing the speed of energy efficiency improvements by housing corporations even more.

Table 0-3 Main reflections of policy makers to citizen measures

Policy area	Main reflections of policy makers
Public transport	- Capacity of batteries and fast recharging possibilities are a key implementation issue for electrification of public transport. Hydrogen fueled public transport is currently underdeveloped; - An integrated vision on higher capacities in public transport is still lacking. Public transport density within the ring is already very high and further intensification can lead to new problems (e.g. noise); - Making private car travel more expensive is a more feasible implementation option than reducing public transport prices;
Active transport	- Focus in active travel is to better facilitate current cycling densities within the city ring and to increase cycling density outside the ring;
Private car	- An environmental zone for private cars would affect in particular commuters, as car ownership of Amsterdam citizens is very low; - There should be ample room for exemptions, such as for medical transport or for elderly; - High parking tariffs are implementable (and already implemented), but outside the city ring are currently not considered feasible
Energy	- Banning woodstoves from the city centre is high on the policy agenda, but enforcement options are probably low; - Current policy targets to have al dwellings of housing corporations at energy level A is considered as very difficult to implement. Energy level B/C would already be very positive; - Solar panels are very popular and therefore a higher policy ambition might be feasible, but making them mandatory would probably go too far; - Current policies to make the built environment natural gas-free by 2040 is already very ambitious. Monitoring and acting on public resistance to change would be key, next to gradual implementation.

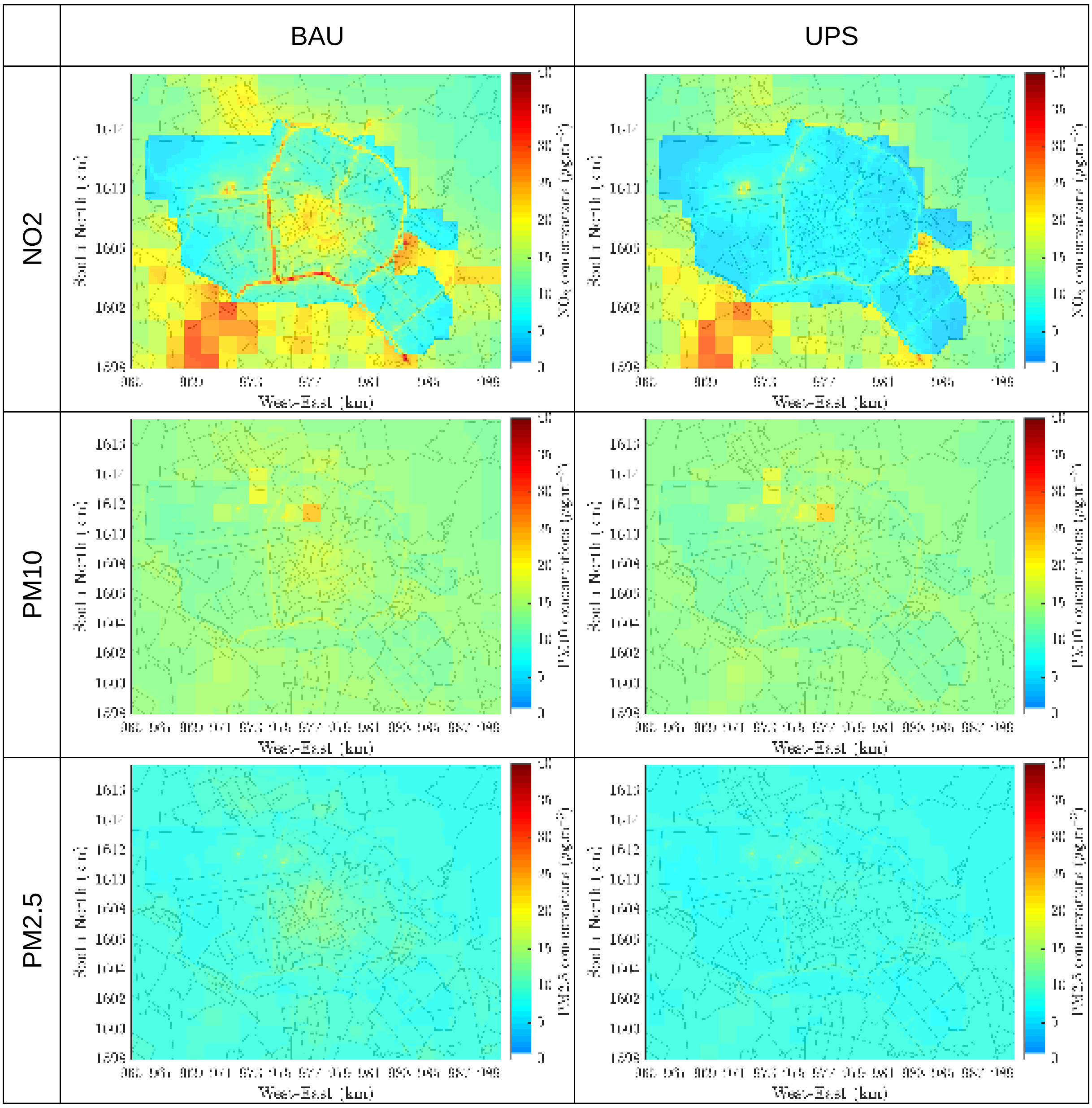
Modelled impacts of the the combined citizen and policy maker measures

The citizen scenario consisting of the 11 citizen measures would result in far larger reductions in air pollutant concentrations than a business-as-usual scenario (base year 2015). However, meeting WHO guideline concentrations in particular for PM would remain problematic even for the citizen scenario.

- The Business as Usual (BAU) scenario still shows NO_2 concentrations within the city borders around the legal limit values at some spots in 2050 (these are equal to the WHO guideline values), whereas the Unified Policy (UPS) scenario reduces concentrations to values well below those limits everywhere;
- For PM_{10}, the BAU and UPS scenario comply with the legal limit values, but neither BAU nor UPS result in compliance with WHO guidelines- even in 2050;

- For $PM_{2.5}$, BAU and UPS scenarios comply with legal limit values, but even in the UPS scenario there will be still significant exceedances of WHO guideline values in 2025, and meeting the guidelines will only occur in 2050.

Figure 0-6 NO_2, PM_{10} and $PM_{2.5}$ concentrations in the BAU and UPS scenario in 2050[6]



[6] ClairCity modelling results cannot be directly compared to the national models in the Netherlands due to different modelling approaches. Also, within the ClairCity approach gradients between concentrations within and outside the city borders result from the overlay of different models. Only concentrations within the city borders should be regarded. See also the statement on ClairCity modelling in chapter 5.

Institutional conditions and mutual learning for implementing citizen-inclusive policies in Amsterdam

Current institutional conditions for change in Amsterdam seem relatively positive compared to other ClairCity cities, but significant issues can be foreseen when further scaling up the energy transition in the city.

- Funding for air quality and carbon policies seems less problematic in Amsterdam than in other ClairCity cities, and the dependence of EU funding is small. Despite this, the expansion of public transport and electrical recharing infrastructure in the city might require substantial additional funding in the future. Also, past spatial planning issues with the province regarding wind turbine siting now seem to be solved. Nevertheless, the renewable energy infrastructure required for fully switching from natural gas to other sources will require so much space in an already densily populated city and region that spatial planning for the future is very likely to become a main issue.

While experiences with ambitious policy making in Amsterdam could inspire other cities, Amsterdam can also learn from the other ClairCity cities.

- Lessons that Amsterdam could learn from other ClairCity cities include the pedestrianisation of the city centre (Ljubljana), integrating air pollution into the transport information system (Sosnowiec), work with rather than against citizen culture (Genoa), integrating local and regional transport (Bristol) and including active transport promotion into primary and secondary school education (Aveiro).
- Potential lessons from Amsterdam for other middle-sized European cities could include the gradual implementation of the clean air zones; the integration of large-scale cycling infrastructure in the city and its combination with public transport; the gradual reduction of road space and increase in parking tariffs for private cars; and the convertion of an almost fully natural gas-based housing stock into a gas-free built environment.

The ClairCity Amsterdam Action Plan

For citizen-inclusive city air quality and carbon policies

- **Engage even more actively with citizens to align the willingness of citizens to change their current transport and heating behaviours with policy ambitions for the future.**

While the behavioural practices of many Amsterdam citizens in terms of active transport (cycling) are already very positive and there is considerable willingness to change in terms of getting out of the car and switching to non-gas heating, a substantial part of the ClairCity respondents still envisage to continue driving by car into the city centre and to heat their homes with gas. Further engagement with citizens is therefore required to increase willingness for change.

- **Engage in particular with commuters as a main group contributing to air pollution in the city.**

In Amsterdam, the main polluters in terms of transport behaviour seem to be younger, middle income male adults that commute into the city via cars. Hence, communications and interactions should be directed in particular to this group. This group could be addressed in dialogue with main businesses situated in Amsterdam.

- **Increase the awareness and attractiveness of district heating in the city as the main means to reduce dependency on natural gas in the built environment.**

As for gas heating, few respondents indicate a willingness to change the existing district heating system in the city, which will be expanded substantially in the future. Hence, citizen engagement should address in particular citizen views on this system.

- **Focus on measures addressing Particulate Matter (PM).**

Whereas NO_x emissions are substantially reduced by the envisaged policy and citizen measures, PM emissions are decreasing substantially less. Hence, additional policy actions should be directed at this source. For example, through specific attention to wood and biomass burning. Actions regarding wood stoves are being considered in the city, but communications on the negative environmental aspects of wood burning could still be expanded.

- **Stimulate the visibility of live air quality data in the city.**

General awareness of air quality of Amsterdam citizens could also be increased by publishing live air quality data, in particular also at hotspots in the city. Combining this with public transport information panels, as has been done in Sosnowiec, could be an interesting option to do so.

- **Increase the exchange with other cities, focusing on mutual learning and training.**

Amsterdam is already involved in several international and national city networks. However, the experiences in Amsterdam with transport and heating measures affecting citizens can be useful to many other cities, while Amsterdam in turn could also learn from other cities. A review and expansion of training and network possibilities would therefore be very useful in the process towards a further transition in the city.

1 Introduction to this report

This chapter provides the context for the ClairCity project (section 1.1) and introduces its objectives (section 1.2). It also gives a reading guide for this report (section 1.3).

1.1 Introduction

In 2015, the Paris climate agreement set the goal to reduce global greenhouse gas emissions to keep global temperature rise this century to well below 2 degrees Celsius above pre-industrial levels[7]. A similar binding agreement for global air quality is lacking, but in 2005 the World Health Organisation formulated guidelines for ambient air quality aiming to improve health and reduce premature death caused by air pollution throughout the world. In 2016, 91% of the world population was living in places where the WHO air quality guidelines levels were not met.[8] Numerous countries and the European Union have set air quality targets that are often not as ambitious as the WHO guideline values, yet provide a legally binding framework for emission and concentration reductions of air pollutants.

Cities are the main contributors to the emissions of greenhouse gases and air pollutants, and many have set stricter local goals for emission reductions of greenhouse gases and air pollutants than the national or EU targets. Improving air quality and reducing carbon emissions as a contribution to the global, national and local targets and ambitions therefore will be a huge challenge for cities all over the world in the years to come.

Citizens living in these cities do not only cause an important part of these emissions through their daily behaviours, they can also play a key role in solving these issues. This can be via a change in behaviour and through providing democratic support for policy measures to be implemented that will affect their daily lives. ‘Citizen-inclusive policy making’ is therefore a crucial prerequisite for future air quality and carbon policies in cities to be successful in reducing emissions and reaching targets set on the local, national and global scales.

[7] https://unfccc.int/process-and-meetings/the-paris-agreement/the-paris-agreement
[8] https://www.who.int/en/news-room/fact-sheets/detail/ambient-(outdoor)-air-quality-and-health

This project has received funding from the European Union’s Horizon 2020 research and innovation programme under grant agreement No 689289

1.2 Project objectives

The main objective of the **ClairCity Project**[9] is to contribute to successful, citizen-inclusive[10] air quality and carbon policy making in cities worldwide.

'Citizen-inclusive policy making' in the ClairCity project is defined as

1. Tailoring city air quality and carbon policy measures based on a detailed knowledge of current behavioural practices of citizens;
2. Asking citizens for their preferences regarding own future behavioural changes and taking these preferences into account in policy making;
3. Asking citizens for their preferences regarding future air quality and carbon policy measures in their city and also taking these into account in policy making.

'Citizen-inclusive policy making' within the ClairCity project is seen as competely distinct from 'populistic' policy making. While the latter is seen as an uncritical adoption of the majority voice of citizens on singular policy topics, 'citizen-inclusive policies' to ClairCity means establishing city policies that are as much as possible informed by a detailed and constantly refreshed knowledge of citizens' opinions and behaviours. Ultimately, the final responsibility for taking – popular and unpopular – policy measures remains at all times with the democratically elected bodies.

ClairCity aims to contribute to citizen-inclusive policy making through a detailed examination and cross-case comparison of six middle-sized cities throughout Europe. In each of these cities, a comprehensive citizen engagement process has been established, consisting of a mix of proven and innovative methods. This carefully designed suite of activities aims to examine current behavioural practices of citizens as well as preferred future behaviours and policy preferences. By carrying out these activities, ClairCity also contributes to awareness of citizens of air quality and carbon policy issues.

The six pilot cities and regions examined in the ClairCity project are:
- Bristol (United Kingdom),
- Amsterdam (Netherlands),
- Ljubljana (Slovenia),
- Sosnowiec (Poland),
- Aveiro / CIRA Region (Portugal) and
- Genua/ Liguria Region (Italy).

[9] The ClairCity project ('Citizen Led Air pollution Reduction in the City') is funded under the EU Horizon2020 programme, grant agreement nr 689289. It started in May 2016 and runs until May 2020. ClairCity website: www.claircity.eu.
[10] The initial subtitle of ClairCity to promote 'citizen-led' policies throughout the project evolved into 'citizen-inclusive' policies, in order to take into account the important role of citizens and stakeholders for informing and co-creating policies, as well as the final responsibility of democratically elected policy makers for deciding on the implementation of these policies.

1.3 This report

This report is the ClairCity "**City Policy Package Report**" for Amsterdam, the second city for which the ClairCity engagement process has been completed[11]. It provides a summary of the lessons learned for local air quality and carbon policy making in Amsterdam. The primary target group of this report are therefore Amsterdam policy makers and politicians. The report can be of further interest to: politicians and policy makers in other cities; (supra) national and regional policy makers; and not least, to stakeholders and citizens engaged or interested in improving air quality and reducing carbon emissions in their city.

Chapter 2 of this report discusses the ClairCity citizen engagement methods that were applied and tested in the city. Chapter 3 analyses the current air quality and carbon situation in Amsterdam and looks into current behaviours of citizens that contribute to air pollution and carbon emissions. Chapter 4 examines what behavioural changes Amsterdam citizens envisage for themselves in the future and what preferences they have for policy measures. It also shows what reflections Amsterdam policy makers have on the views of citizens. Chapter 5 quantifies potential consequences of the citizens' preferences in terms of emissions and concentrations of air pollutants and of carbon dioxide, in terms of health and in terms of costs of measures. Chapter 6 discusses specific institutional conditions and barriers for citizen-inclusive policies found in Amsterdam as well as mutual learning possibilities in order to remove these barriers. Chapter 7 finally gives the main conclusions and policy recommendations that follow from the ClairCity citizen engagement and analysis in Amsterdam.

[11] In the ClairCity project, this report is part of deliverable D7.5 Final Policy Package – Last City.

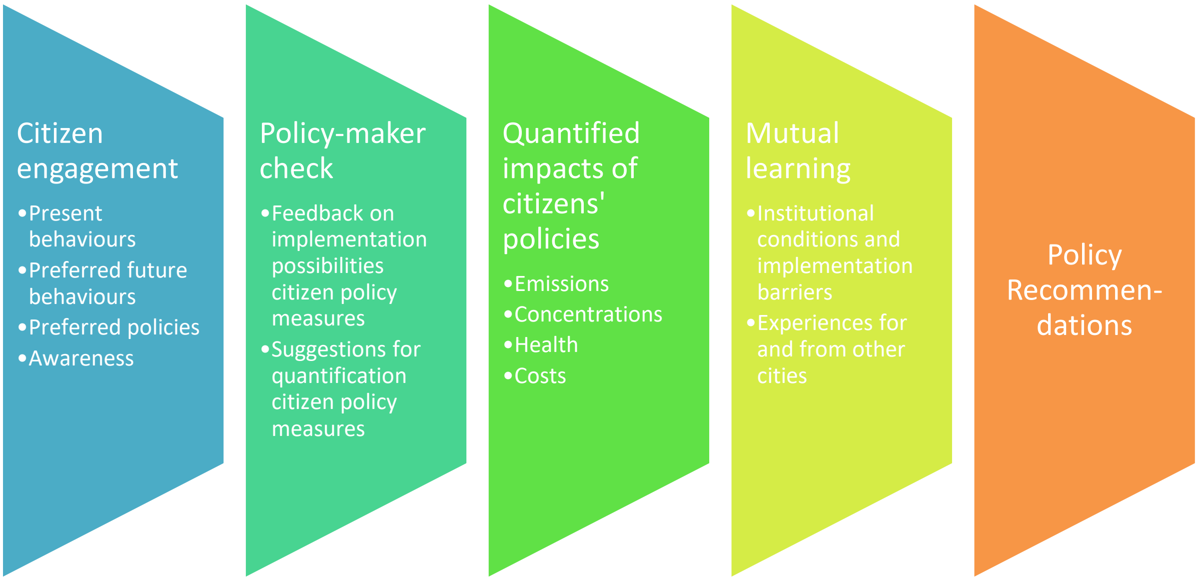
2 ClairCity engagement in Amsterdam

This chapter gives an outline of the ClairCity method of preparing the policy recommendations (section 2.1) and of the citizen engagement activities in Amsterdam (section 2.2). A more detailed overview of the ClairCity project and the positioning of this 'Amsterdam Policy Package' can be found in Annex A. Details of the different ClairCity engagement methods applied in Amsterdam are given in Annex B.

2.1 The ClairCity method and positioning of the Policy Package

Figure 2-1 shows the five-step process in which the policy recommendations for city policy makers in Bristol were prepared.

Figure 2-1: ClairCity process including key phases and activities (Policy Package highlighted in red box) and chain of evidence leading to ClairCity policy recommendations



First, in the ClairCity engagement process citizens were consulted in order to examine their present behavioural practices, their preferences for future behaviours and their preferences for future policies. The process by itself contributed to citizen awareness of air quality and carbon issues and policies in the city and also included some activities specifically directed at awareness building.

Second, feedback was obtained on implementation possibilities of the citizen policy preferences through a workshop with local and regional policy makers involved in air quality and carbon related policies. In the workshop, the policy measures that evolved from the engagement process were further developed and partly quantified.

Third, from the more detailed citizen policy measures a 'Unified Policy Scenario' was constructed. In this scenario the impacts were modelled regarding emissions and concentrations of air pollutants and greenhouse gases, health impacts and costs to citizens and city. These impacts were compared to a business-as-usual scenario with city policy measures implemented and specified in the base year 2015.

Fourth, the specific institutional conditions and barriers for implementation of the citizen measures in Amsterdam were examined. These consisted of political framing, financial conditions, multilevel policies and other conditions. These were compared with the experiences in the other ClairCity cities to examine what lessons could be learned from and for Amsterdam regarding promising ways for implementation of the citizen measures.

Finally, detailed policy recommendations for Amsterdam were prepared taking all the steps in the ClairCity process into account.

2.2 Citizen engagement in Amsterdam

Central in the ClairCity project stands the engagement process that was specifically designed for the project and rolled out in all six cities. It consists of a suite of existing and proven methods as well as of experimental and innovative methods (Table 2-1).

Table 2-1: ClairCity's citizen engagement activities

		Citizens, general	Citizens, specific target groups[1)]	Other stake-holders[2)]
Policy related	Mutual Learning Workshop	X		X
	Delphi Process	X	X	X
	Skylines Game	X		
Aware-ness related	Secondary schools activities		X	
	Elderly film competition		X	
	ClairCity City Day	X		X
	GreenAnts App	X		

1) Elderly, pupils secondary school
2) NGOs, business, knowledge institutes

Three engagement activities served as key sources to inform the policy workshop and policy recommendations: the Mutual Learning Workshop, the Skylines game for mobile phones and the Delphi-process. In the Mutual Learning Workshop, citizens and other stakeholders (business, NGOs, knowledge institutions) could discuss in the beginning of the engagement process potential policies for the city[12]. In the Skylines game, citizens could decide on policies for their city as if they were the mayor of the city[13]. The Delphi process consisted of a three step funneling process, starting with general questionnaires about citizens behaviours and preferences, and ending with 'Stakeholder Dialogue Workshops' to discuss outcomes of the process with stakeholders and to build various citizen scenarios as an input for the policy workshops[14].

In addition, several awareness building activities were carried out in the city to reach specific target groups and to further inform the policy recommendations. These were a film competition for the elderly, classroom discussions with secondary school pupils and a City Day to present ClairCity. An app for the mobile phone that tracks citizens' personal transport

[12] See ClairCity Report D4.16 Mutual Learning Workshop
[13] See ClairCity Report D4.10 Game User Manual and Data Report
[14] See ClairCity Report D4.4 Delphi Evaluation Report

behaviour and shows its consequences in terms of concentrations of air pollutants (GreenAnt) still needs to be implemented in the city[15].

In total, during the period 2017 – 2019 over 1,100 Amsterdam citizens were reached by the various ClairCity citizen engagement methods (Table 2-2). While this sample is not fully representative of the Amsterdam population as a whole[16], it gives an indication of support for policy measures and intentions for behavioural change that can be used by policy makers to inform future policies.

Table 2-2: Number of participants in ClairCity citizen engagement methods in Amsterdam

Citizen engagement activity	# of participants engaged
Delphi Process	638
Skylines Game	371
Mutual Learning Workshop	20
Stakeholder Dialogue Workshop (in Delphi process)	19
Policy Workshop*)	6

*) the number of participants of the policy workshop is also included here, despite not being formally part of the citizen and stakeholder engagement process

[15] As of December 2019

[16] 638 people responded to the ClairCity survey in Amsterdam, out of a city population of 834,713 . The Amsterdam respondents were 55% male, which is slightly higher than the city gender ratio. The respondents were disproportionately older compared to the city population, with 89% of respondents aged 37 or older in the Round 1 sample, compared to only 52% of the city population. The sample was more educated (i.e. had higher level of qualifications) than average, with limited representation of those who had a low level of education compared to the categories used to collect city-wide data. In the sample, 67% of the respondents had a "high" level of education with only 5% having "no/low" level of eduation, compared to the city population where 47% have a "high" level, and 22% have a low level of education. In The Netherlands, categories regarding the national identity are more relevant than ethnicity of respondents. The "non-Dutch" population of Amsterdam is around 14% according to city statistics. In Round 1, 13% of the sample were non-Dutch nationals with 5% of the total from Western countries (Europe, North America, Japan etc) and 8% from non-Western countries.

3 Current air quality and carbon situation in Amsterdam

In order to establish a baseline against which the impacts of citizen desires for the future of their city can be compared, this chapter identifies the existing air quality and carbon concentrations and emissions in Amsterdam (section 3.1), current city air quality and carbon policies (section 3.2) and current stated behaviours of citizens that took part in the engagement process (section 3.3).

3.1 Current concentrations and emissions

In the ClairCity Policy Baseline report as of 2017[17], it was noted that:

> "Decreasing emissions and concentration levels point to some successes of Amsterdam air quality and climate change policies in recent years. For particulate matter (PM), the European standards are clearly met in the city, although values measured still exceed the WHO guidelines. NO_2 concentrations at some hotspots still exceed the EU limit values. Total CO_2 emissions have remained almost constant over the period 2011 – 2015, whereas CO_2 emissions per capita have somewhat decreased as the city population has grown faster than emissions."

The latest figures as of 2018 indicate that legal limit values of air pollutants in Amsterdam are generally met, but at nine 'hotspot' streets in Amsterdam the European legal limit values are still exceeded[18].

Figure 3-1 Modelled exceedances of legal NO_2 EU limit values in Amsterdam in 2018, divided over nine streets[19]

However, recent municipal policy goals to comply with the stricter WHO air quality guideline values by 2030 make a comparison with the WHO values more relevant than comparison

[17] ClairCity (2017) D6.1 Amsterdam Policy Baseline report, see www.claircity.eu
[18] Modeled concentrations. Municipality of Amsterdam (2019) website "Follow the Policy: Clean Air" (in Dutch), https://www.amsterdam.nl/bestuur-organisatie/volg-beleid/duurzaamheid-energie/schone-lucht/
[19] Monitoring NSL, NOx > 40,5 microgrammes, https://www.nsl-monitoring.nl/viewer/

with legal limits[20]. Local measurements show that these guideline values are not met for several pollutants:

NO_2 concentration yearly average guideline values given by WHO (40 µg m^{-3}) were exceeded at 22 street lociations in 2018[21]. Concentrations are declining over recent years, but similar to PM and black carbon, the trendline is flattening.

PM_{10} concentrations are decreasing over the period 2008-2018, but concentrations measures at street stations still exceed WHO yearly average (20 µg m^{-3} and daily average guideline values (50 µg m^{-3} for no more than three days per year). In recent years reductions are less than in previous years, suggesting a flattening reduction trend for PM_{10}.

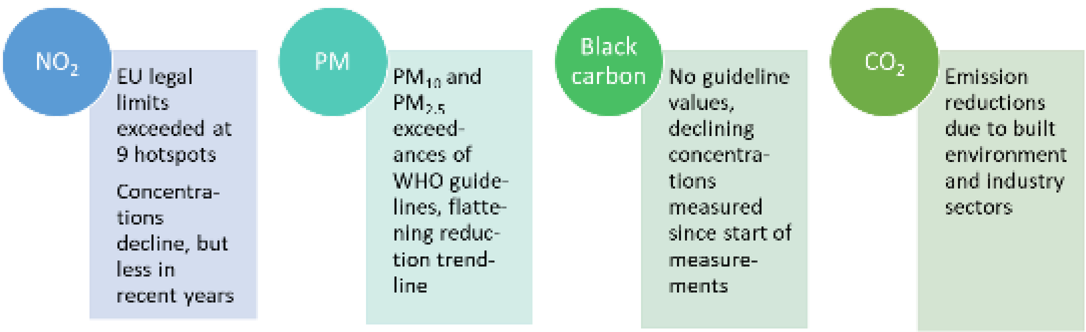
$PM_{2.5}$ concentrations in 2018 exceeded WHO guideline values for yearly and daily averages (10 / 25 µg m^{-3}) at all measuring stations. Over the period 2010-2018, $PM_{2.5}$ concentrations are decreasing, but the reduction trendline is – as for PM_{10} – flattening out.

Black carbon concentrations are measured in Amsterdam as well. Although no WHO guideline values exist for black carbon, the WHO notes that due to its negative health effects, black carbon concentrations in general should be minimised. Measurement data are more limited than for PM (only for recent years), but suggest a slightly decreasing trend.

CO_2 emissions in Amsterdam have declined from almost 4.8 Mt in 2013 to 4.4 Mt in 2017. While emissions of the sectors built environment and industry dropped, those of the transport sector remained almost constant[22]. Amsterdam aims to become climate neutral by 2050.

Figure 3-2 summarises main features of the current Amsterdam air quality and carbon situation.

Figure 3-2: Main features of the current Amsterdam air quality and carbon situation (sources: Municipality of Amsterdam, GGD)



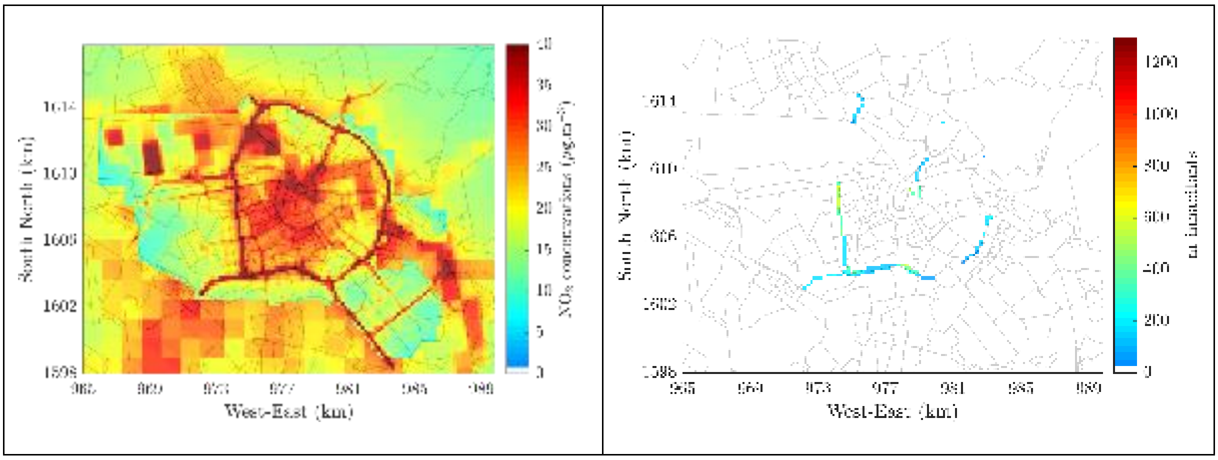
[20] GGD Amsterdam (2019) Meetresultaten luchtkwaliteit Amsterdam 2018
[21] Measured concentrations, Palmes Tubes.
[22] See https://klimaatmonitor.databank.nl

In the ClairCity project, concentrations of air pollutants were modelled for the base year 2015 in order to compare them to business-as-usual policies as known in 2015 as well as to the measures jointly suggested by citizens and policy makers. Annex C gives more information of the ClairCity modelling assumptions[23].

Figure 3-3 a) shows the exceedances of NO_2 limit values in 2015 as modelled by ClairCity[24]. The map indicates main sources of air pollution, as it shows a clearly visible correlation to the street pattern, the shipping/docks patterns, as well as to Amsterdam airport. The simulation results suggest a maximum concentration of 82.7 µg.m^{-3} at the ring road/highway A10 and at the harbour.

ClairCity modelling further suggests that in 2015 the current EU annual legal limit value for NO_2 annual concentrations (40 µg.m^{-3}) was exceeded in 155 grid cells of 200 x 200 metres in Amsterdam[25] (Figure 3-3 b) This corresponds to 3% of the total population within the urban area that might have been exposed to those concentrations[26]. The figure suggests in particular inhabitants living next to the ringroad A10 and IJ-tunnel connecting roads were affected. However, negative health effects also occur below EU legal limit values and in other city areas.

Figure 3-3 NO_2 contour maps for Amsterdam in current situation (reference year 2015): a) annual average of NO_2 concentrations and b) number of inhabitants within the cells exceeding the EU annual limit value of 40 µg.m^{-3}.



For PM, the ClairCity modelling indicates that, while Amsterdam complied with the legal limit values for PM concentrations in 2015, it did not comply with the stricter guidelines of the World Health Organisation (WHO)[27]. Figure 3-4 a) shows 102 cells exceeding the WHO guideline value for PM_{10}, which represents less than 1% of the population. For $PM_{2.5}$, no less

[23] The results of ClairCity modelling do not fully correspond to those of local modelling as a result of different modelling assumptions. A full comparison of ClairCity modelling assumptions with those of all cities was considered to be outside the scope of this project. ClairCity modelling results should therefore be seen as indicative only.
[24] ClairCity modelling results cannot be directly compared with modelling in the Netherlands due to different modelling assumptions. See Textbox 5-1 for more information.
[25] A 'cell' refers to the 200 m x 200m modelling domain that was utilsed by ClairCity
[26] See for the calculations the annexes to this report and the ClairCity final modelling report.
[27] Based on the latest scientific evidence available, WHO has established limit values for PM10 and PM2.5 that are substantially below current EU and British legal limit values. These values are 20 µg.m-3 for PM10 (compared to a legal limit value of 40 µg.m-3) and 10 µg.m-3 for PM2.5 (legal limit value 25 µg.m-3 annual mean). See https://www.who.int/news-room/fact-sheets/detail/ambient-(outdoor)-air-quality-and-health

than 3455 cells are exceeding the standard, denoting that some 62% of the population were potentially exposed to those elevated concentrations in 2015 (Figure 3-4 b).

Figure 3-4: Number of inhabitants within the cells exceeding the WHO air quality guideline values: a) of 20 µg.m^{-3} for PM_{10} concentrations, and b) of 10 µg.m^{-3} for $PM_{2.5}$ concentrations.

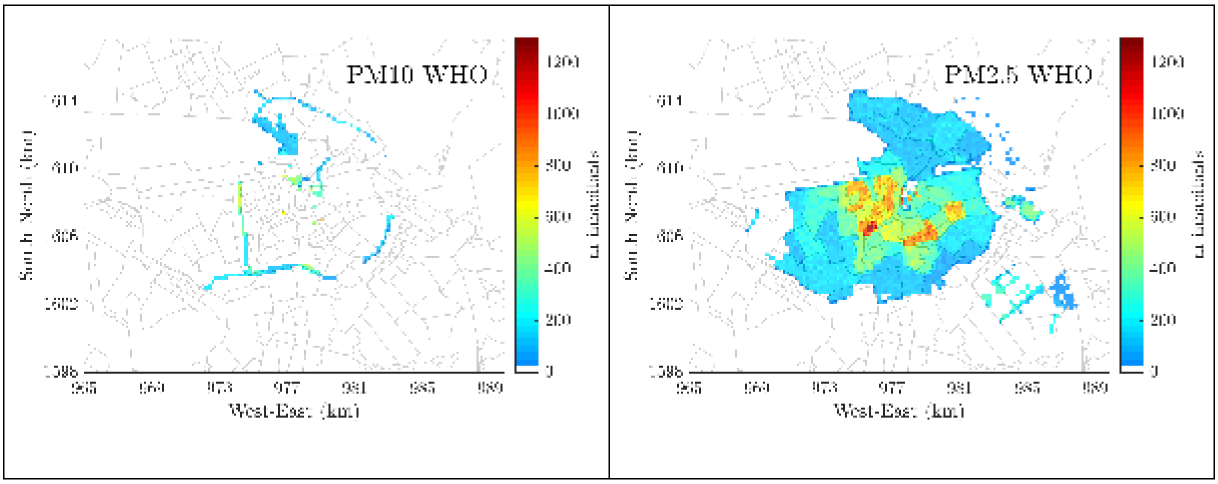


Figure 3-5 shows the Amsterdam Carbon Footprint in 2015 as modelled by ClairCity. The indicator takes into consideration the overall life cycle of the energy carrier, hence not only the emissions of the final combustion, but also emissions that take place outside the location where the fuel is used. As can be seen in the figure, the services and residential sectors cause by far the largest part of the (lifecycle adjusted) greenhouse gas emissions in Amsterdam.

Figure 3-5 Amsterdam Carbon Footprint expressed as tonnes CO_2-eq on Life Cycle by fuel and sector in 2015 (Source: ClairCity modelling)

3.2 Existing air quality and carbon policies

The ClairCity Amsterdam policy baseline report, as published in 2017, gave the following main targets of Amsterdam policies[28]:

- **Renewable energy** – 20% more renewable energy and 20% less energy use per citizen in 2020 compared to 2013;
- **Clean and healthy air** – 30% lower soot concentrations and 35% lower NO_2 concentrations in 2025 compared to 2015 as a result of smart and clean traffic;
- **Circular economy** – Waste is a source of new products and materials, 65% of waste will be recycled in 2020;
- **Climate-proof city** – Spatial and infrastructural planning in Amsterdam that takes into account the effects of climate change;
- **Sustainable municipality** – Public procurement of the municipality which takes into account all sustainability targets of the Agenda.

However, since the elections in March 2018, the four-party, centre-left coalition holds even more ambitious sustainability goals than that of the previous city council (See Textbox 3-1).

Textbox 3-1 Main local air quality and climate related policy targets Amsterdam in 2019 [29]

- A 'natural-gasfree' Amsterdam by 2040;
- A 'transport emissions free' city within the city ring by 2030;
- Meeting WHO guideline concentrations by 2030;
- Reducing overall CO_2 emissions in the city by 55% in 2030 and by 95% by 2050.

For transport, there are currently 'clean air'- or 'environmental zones' (milieuzones) in place for polluting trucks, taxis, buses, delivery vans, scooters and mopeds. These do not apply to private cars, but in 2030 no diesel/petrol cars will be allowed anymore within the city ring. Private car use at present is discouraged through a strict parking policy with high hourly tariffs and a reduction of the number of general parking spots by 7,000 to 10,000 until 2025. At the same time, recharging facilities for electric cars are strongly stimulated throughout the city.

For public transport the ambition is that all buses in Amsterdam are emission free by 2025. There are also investments planned to increase the amount of metro and tram/bus frequency. The council further expects to invest substantially in infrastructure for high-speed cycling as well as to create up to 40,000 new bike parking spots by 2030 with the aim to stimulate active travel.

Energy policies at present focus on expansion of the heat grid, stimulating solar PV at private and public rooftops and improving energy efficiency of the stock of housing corporations. Within the city in recent years also several citizen-initiated energy renewable energy

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[28] ClairCity (2017) D6.1 Amsterdam Policy Baseline report, see www.claircity.eu

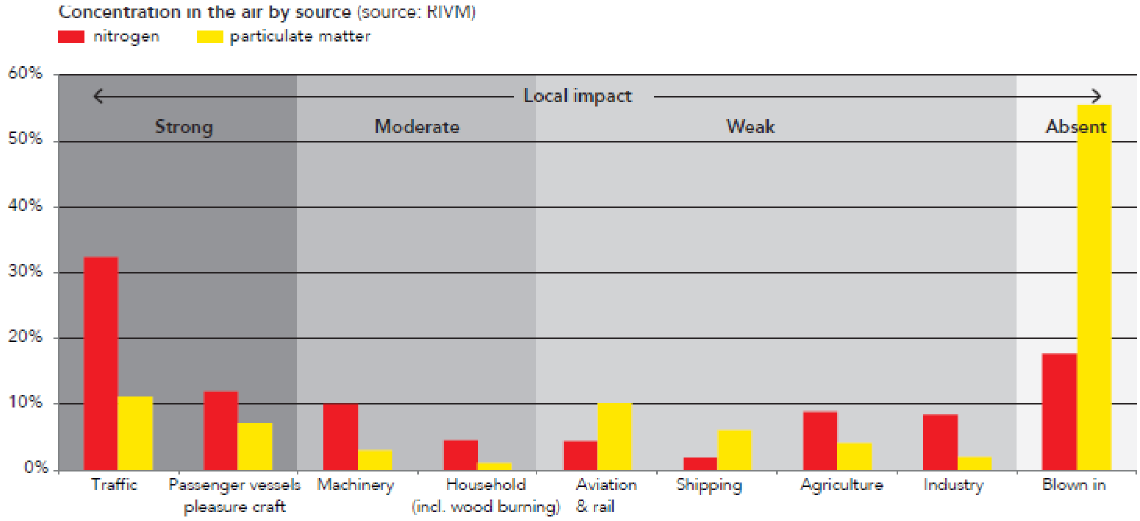
[29] Municipality of Amsterdam (2019) website "Follow the Policy" Clean Air / Sustainability and Energy / Natural-Gasfree (in Dutch), https://www.amsterdam.nl/bestuur-organisatie/volg-beleid/duurzaamheid-energie/schone-lucht/; https://www.amsterdam.nl/bestuur-organisatie/volg-beleid/duurzaamheid-energie/duurzame-energie/ https://www.amsterdam.nl/bestuur-organisatie/volg-beleid/duurzaamheid-energie/aardgasvrij/

cooperations have become active, which stimulate the use and production of renewable energy by private households and companies.

3.3 Concentrations and emissions relating to citizen behaviour

Figure 3-6 shows the local contribution to main sources of air pollution in Amsterdam. As can be seen, road transport ('traffic') is the local pollution source of primary concern in Amsterdam. To better understand the impact that citizens are having on emissions of NO_2 and km travelled from road transport, road transport emissions attributable to citizens were apportioned by a number of categories, including trip purpose[30], gender and income.

Figure 3-6 Main local sources of air pollution in Amsterdam (local impact = contribution of local sources to concentrations of pollutants, % of total concentration)[31]



3.3.1 Road transport emissions by trip purpose / daily activity

The total annual road transport NOx and PM emissions for Amsterdam by trip mode in 2015 are presented in figure 3-7. The figure shows that private cars cause by far the most transport emissions in Amsterdam compared to other modes of road transport. This holds even more for PM (77% of total emissions) than for NOx (55%).

[30] The trip purpose / citzen activity definitions are taken from the Uk National Travel Survey. These include: Commuting: trips to a usual place of work from home, or from work to home; Business: personal trips in course of work, including a trip in course of work back to work. This includes all work trips by people with no usual place of work (e.g. site workers) and those who work at or from home; Other: trips to work from a place other than home or in course of work, e.g. coming back to work from going to the shops during a lunch break. In most tables this is included with 'personal business'; Education: trips to school or college, etc. by full time students, students on day-release and part time students following vocational courses; Shopping: all trips to shops or from shops to home, even if there was no intention to buy; Personal business: visits to services, e.g. hairdressers, launderettes, dry-cleaners, betting shops, solicitors, banks, estate agents, libraries, churches; or for medical consultations or treatment; or for eating and drinking, unless the main purpose was entertainment or social; Leisure: visits to meet friends, relatives, or acquaintances, both at someone's home or at a pub, restaurant, etc.; all types of entertainment or sport, clubs, and voluntary work, non-vocational evening classes, political meetings, etc.; Escort: used when the traveller has no purpose of his or her own, other than to escort or accompany another person; for example, taking a child to school. 'Escort commuting' is escorting or accompanying someone from home to work or from work to home. Similarly, other escort purposes are related to the purpose of the person being escorted.

[31] Municipality of Amsterdam (2018) Clean Air Action Plan

Figure 3-7 Amsterdam NOx and PM emissions from transport by trip mode in 2015

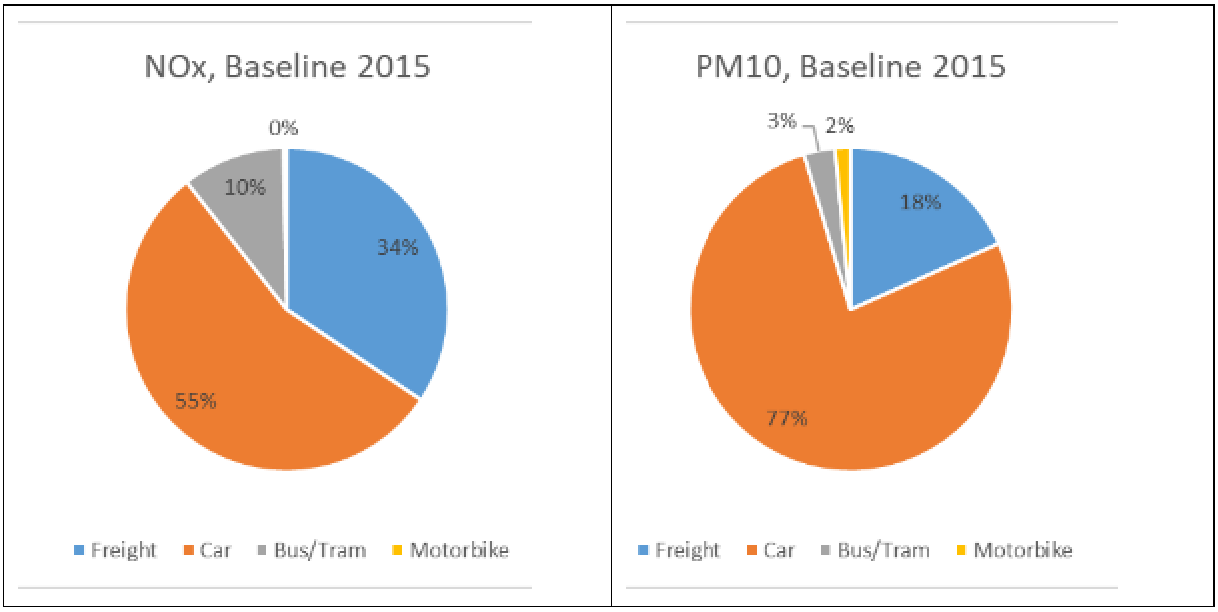
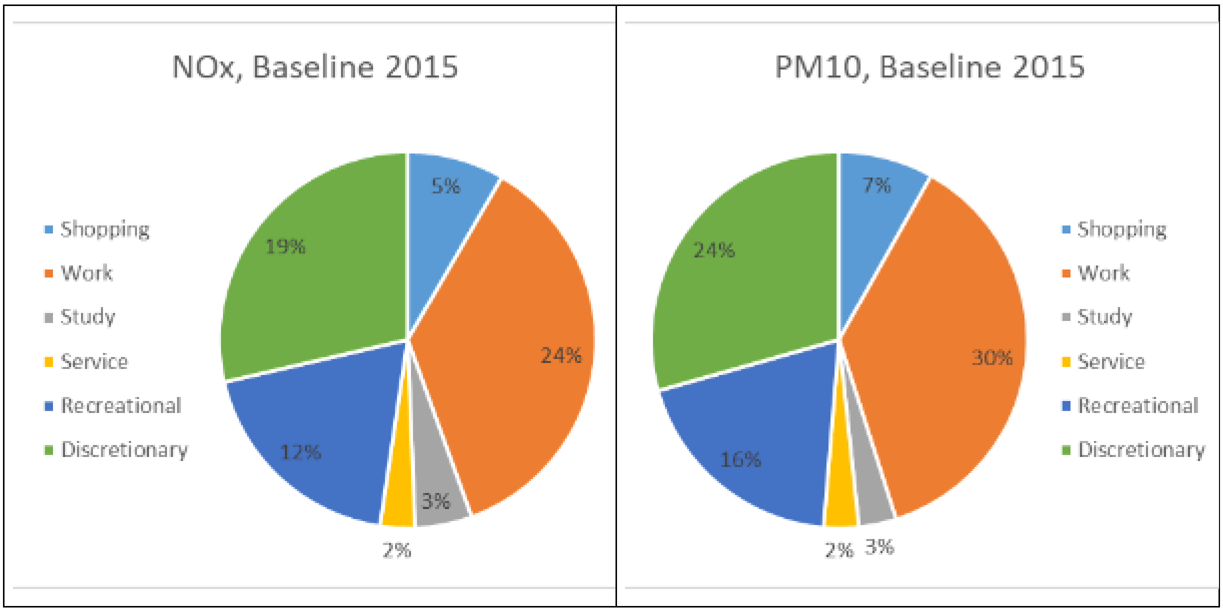


Figure 3-8 shows the same transport emissions data as Figure 3-7, focusing on private trip motives and hence excluding freight transport. The figure shows that in Amsterdam most emissions are caused by work related transport. This holds for NO_x as well as for PM_{10}. This in contrast to for instance Bristol, one of the other ClairCity cities, where shopping and leisure transport cause most emissions. Nevertheless, the figure also shows that shopping and leisure together form an important part of total emissions (17 and 23% of NO_x and PM_{10} emissions respectively). A large part of transport emissions in Amsterdam is also caused by trips for 'discretionary' (unidentified) trip motives.

Figure 3-8 Amsterdam NOx and PM emissions from transport by trip motive of citizens in 2015[32]

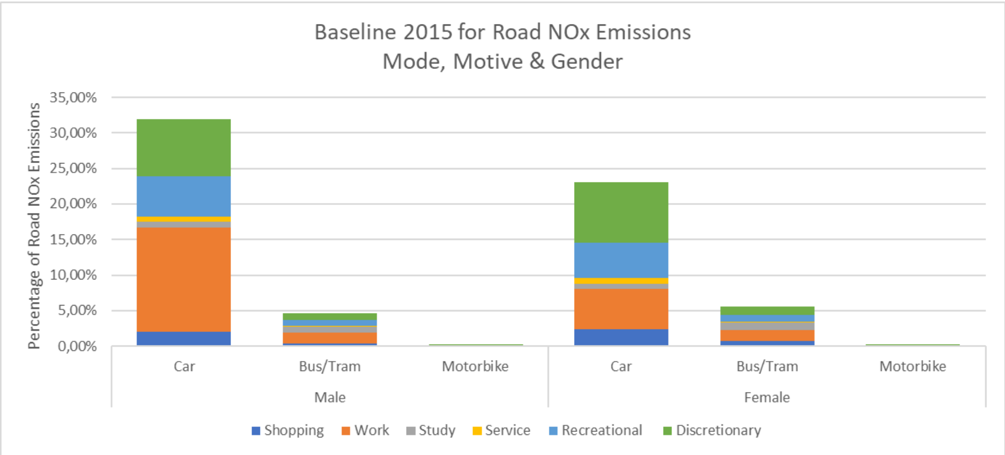


[32] Centraal Bureau voor de Statistiek (CBS); Rijkswaterstaat (RWS) (2016): Onderzoek Verplaatsingen in Nederland 2015 - OViN 2015. DANS. https://doi.org/10.17026/dans-z38-prz4

3.3.2 Road transport emissions by gender

The annual road transport NOx emissions and km travelled data for Amsterdam is presented in Figure 3-9 as percentages and apportioned by gender. The figure shows that men in Amsterdam cause more NOx emissions than women due to their displacements by car (32 versus 23% of total transport emissions respectively). Work related emissions are more prominent for men than for women (15% versus 6%). Recreational transport for both genders is the second largest emission category (6% and 5% of emissions).

Figure 3-9 NOx emissions in Amsterdam per gender, trip mode and trip motive (% of total transport emissions in 2015)[33]

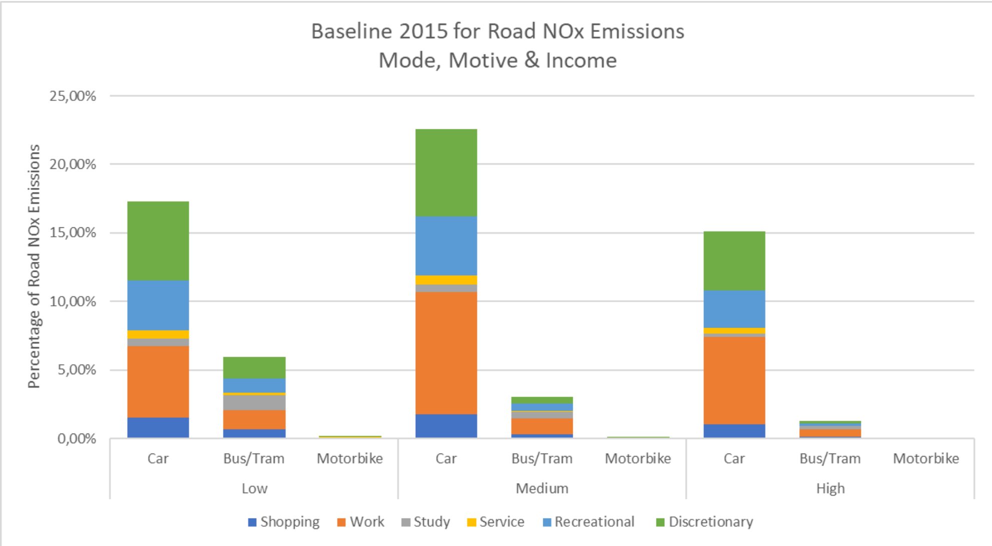


3.3.3 Road transport emissions by income

Figure 3-10 shows NOx emissions of Amsterdam citizens split out into three income groups, low (0 – 21,000 euro/year), middle (21 – 36,000 euro/year) and high (> 36,000 euro/year). The data shows that the middle income group causes most emissions, followed by the high income group and then the low income group. The figure also shows that public transport use decreases with higher incomes, while emissions caused by private car use are highest in the middle income group, followed by the low income group.

[33] Centraal Bureau voor de Statistiek (CBS); Rijkswaterstaat (RWS) (2016): Onderzoek Verplaatsingen in Nederland 2015 - OViN 2015. DANS. https://doi.org/10.17026/dans-z38-prz4

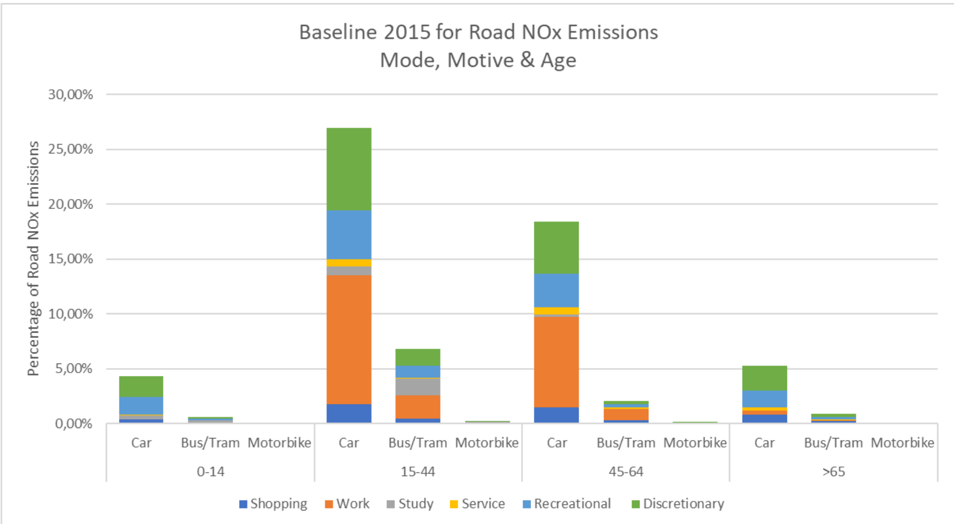
Figure 3-10 NOx emissions of Amsterdam citizens' transport behaviour split out by income (%)[34]



3.3.1 Road transport emissions by age

Teenagers and younger adults (15-44 years) by far cause the most transport emissions in Amsterdam (27%), followed by older adults (45-64 years; 18%) (Figure 3-11). The 65+ and the below-15 group (as car passengers) cause far fewer emissions (5 and 4% respectively).

Figure 3-11 NOx emissions of Amsterdam citizens' transport behaviour split out by age (%)[35]



[34] Centraal Bureau voor de Statistiek (CBS); Rijkswaterstaat (RWS) (2016): Onderzoek Verplaatsingen in Nederland 2015 - OViN 2015. DANS. https://doi.org/10.17026/dans-z38-prz4
[35] Centraal Bureau voor de Statistiek (CBS); Rijkswaterstaat (RWS) (2016): Onderzoek Verplaatsingen in Nederland 2015 - OViN 2015. DANS. https://doi.org/10.17026/dans-z38-prz4

4 Citizens’ views on cleaner air and carbon policies in Amsterdam

In addition to data on current behaviours of Amsterdam citizens, the ClairCity citizen engagement process gave also insights into the degree that citizens want to change their behaviour. This included insights into ways that would contribute to cleaner air and lower carbon emissions in Amsterdam, and views that citizens had about future policies. These are outlined here[36].

4.1 Views of citizens on their own transport and heating behaviours in the future

In Amsterdam, 638 respondents answered to the round 1 Delphi questionnaire. In this sample, there were more male, older and higher educated respondents than in the overall Amsterdam population, while the percentage of non-Western respondents was almost the same as that of the population as a whole[37]. The sample therefore should not be seen as representative of the population, but nevertheless giving insights into behaviours and visions of the Amsterdam population. The respondents were interviewed for their commuting, shopping, leisure and heating behaviours as well as for their preferences regarding these practices for the future.

4.1.1 Commuting behaviour

Figure 4-1 shows that at present 29% of the respondents in Amsterdam only use their car for work, or use it part of the time. In the future, the share of car users (car-only or part-time) will decline to 17%. 2% of the respondents is considering to buy a cleaner car and 2% is anticipating to work from home in the future. The share of respondents using ‘public or active travel only’ will rise from 71 to 78%. The figures show that there is still a significant gap between the policy ambition to end the access of non-electric cars to the city by 2030 and the anticipated future transport behaviours of citizens.

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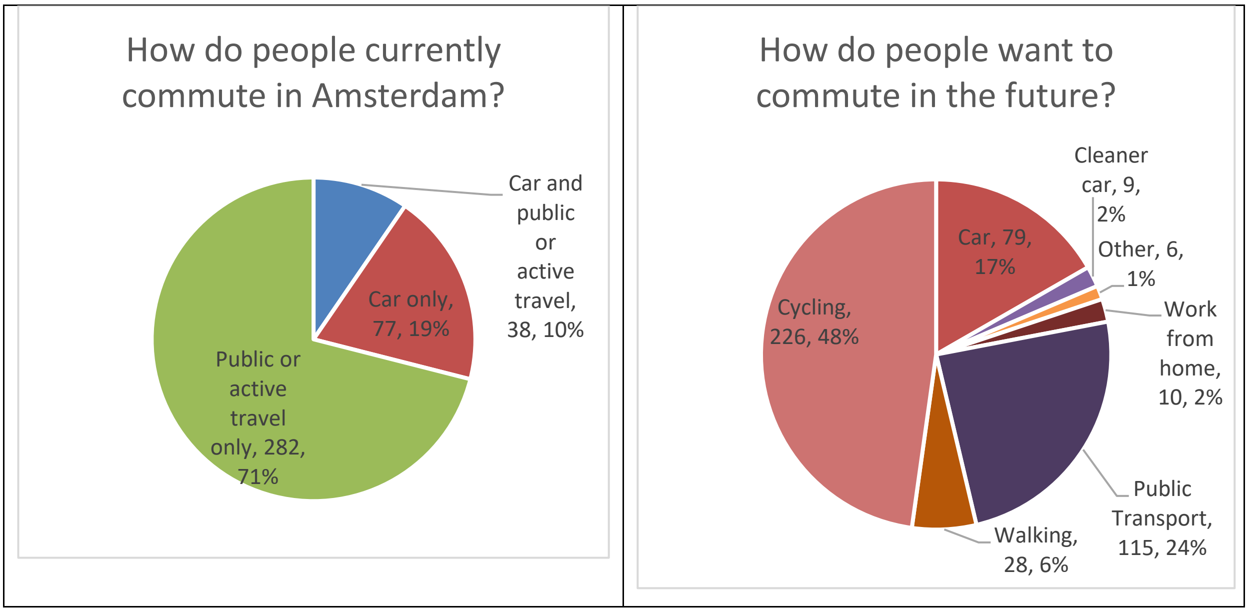
[36] Data primarily derived from the Amsterdam ‘Delphi process’, see Annex B

[37] The Amsterdam respondents were 55% male, which is slightly higher than the city gender ratio. Our respondents were disproportionately older compared to the city population, with 89% of respondents aged 37 or older in our Round 1 sample, compared to only 52% of the city population. Our sample was more educated (i.e. had higher level of qualifications) than average, with limited representation of those who had a low level of education compared to the categories used to collect city-wide data. In our sample, 67% of the respondents had a “high” level of education with only 5% having “no/low” level of eduation, compared to the city population where 47% have a “high” level, and 22% have a low level of education. In The Netherlands, categories are more relevant regarding the national identity rather than ethnicity of respondents. The “non-Dutch” population of Amsterdam is around 14% according to city statistics. In Round 1, 13% of our sample were non-Dutch nationals with 5% of the total coming from Western countries (Europe, North America, Japan etc) and 8% coming from other non-Western countries.

Figure 4-1: Proportions of present and future car use of commuters Amsterdam



There are 18 respondents (5% of the 331 'commuter' respondents) who only travel by car in the present that would like to switch to using alternative means (Table 4-1). The most frequent responses why they haven't switched yet related to negative comments about public transport (6 responses), with two respondents saying that public transport took longer, and two mentioning that they had children and this was one of the reasons that made public transport less convenient.

Table 4-1 Matrix of modal change desires for commuting trips in Amsterdam

Row Labels	FUTURE COMMUTING CATEGORISED
Entrenched	38
Getting worse	8
Looking for positive change	18
Staying positive	267
Grand Total	**331**

4.1.2 Shopping and leisure behaviour

Figures 4-2 and 4-3 show current and desired future shopping and leisure behaviours of Amsterdam respondents. The percentage of respondents that uses only the car for shopping at present is 11% and an additional 12% uses it sometimes (Figure 4-2). In the future, the percentage of car users (car-only and part-time) will decline to 14%. The number of public or active travel users will rise from 76% to 83%. An increase of delivery options in the future does not seem to affect transport modes much (1% at present and in the future).

Anticipated changes for leisure seem larger than in shopping. Here a total of 45% of car-only or occasional car users in the future will decline to 23% in the future (Figure 4-3).

Figure 4-2: Current and future transport choices for shopping in Amsterdam

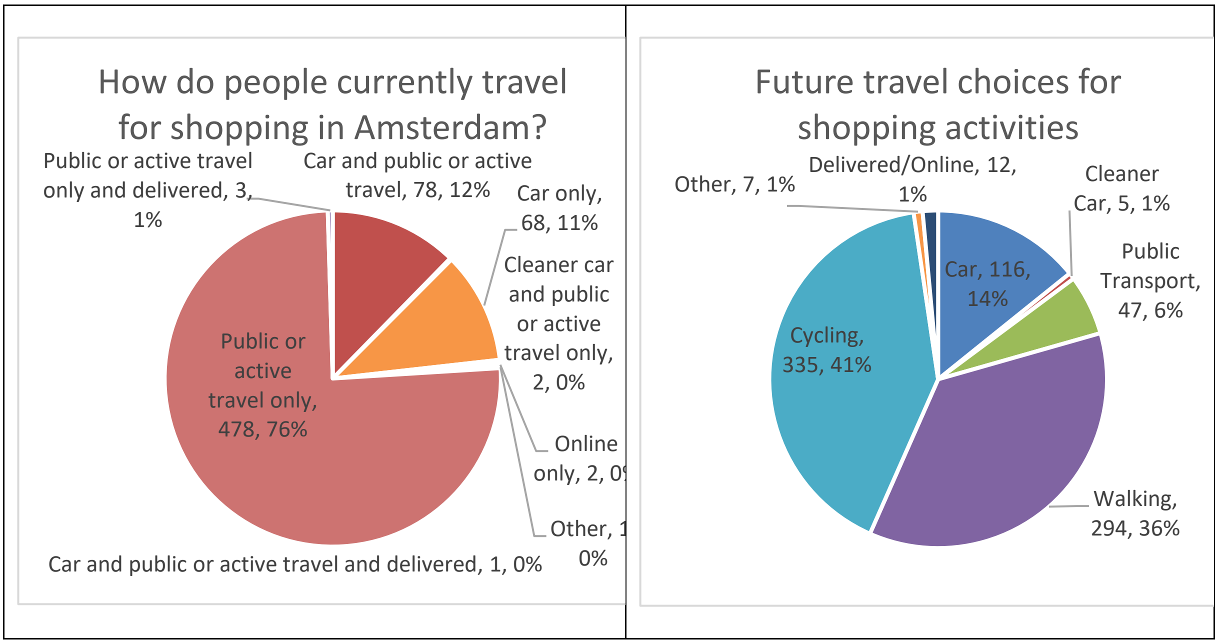
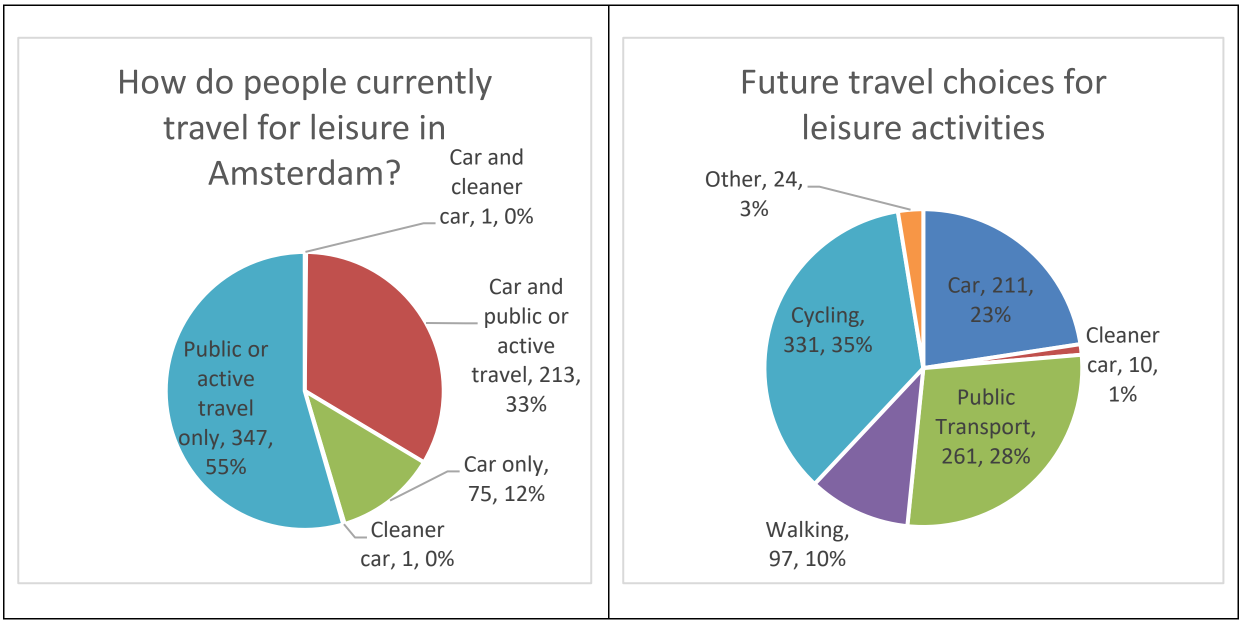


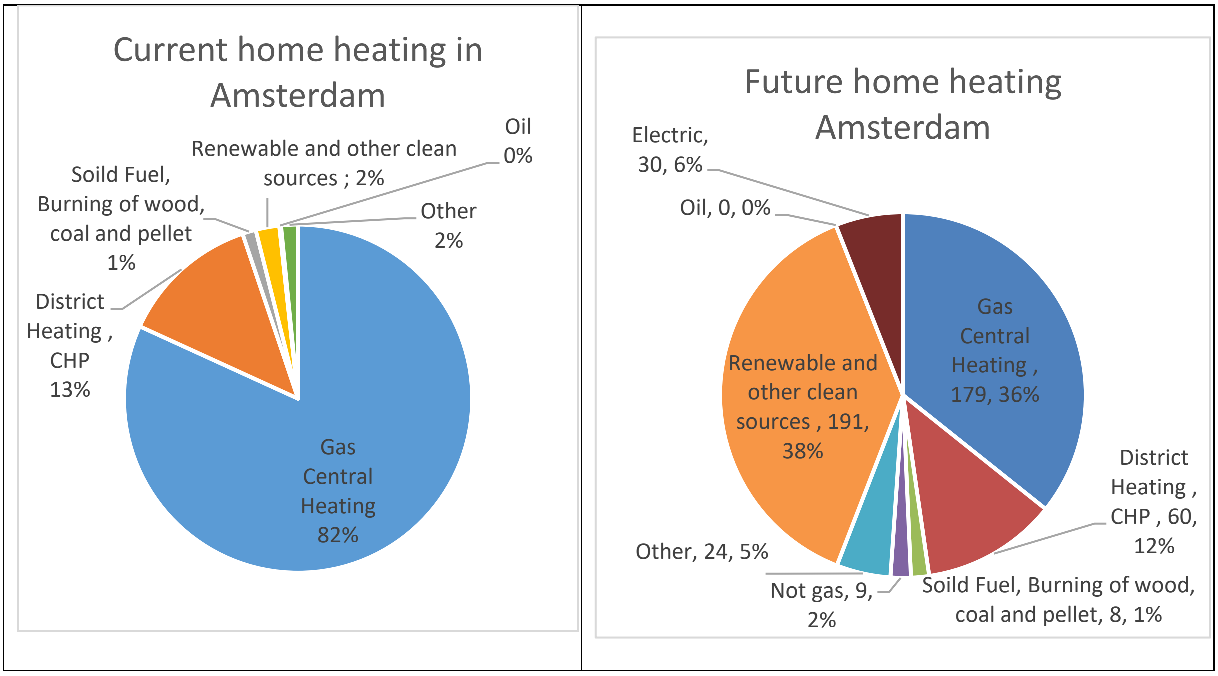
Figure 4-3: Current and future transport choices for leisure in Amsterdam



4.1.3 Home heating behaviour

Not surprisingly, the vast majority of Amsterdam respondents indicate they have gas heating at home (82%). Some 13% of the respondents are conneced to the district heating grid and 5% uses renewables or solid fuels at present (5%) (Figure 4-4). Given the current policy ambitions for a gas-free built environment in Amsterdam by 2040, everybody should be switching towards other sources than the presently dominant fuel source gas. Yet, 36% of respondents still expects to use gas in the future. The number of respondents that anticipate using district-heating in the future does not increase (12%, compared to 13% now), which is also not in line with current policy ambitions to expand the district-heating grid.

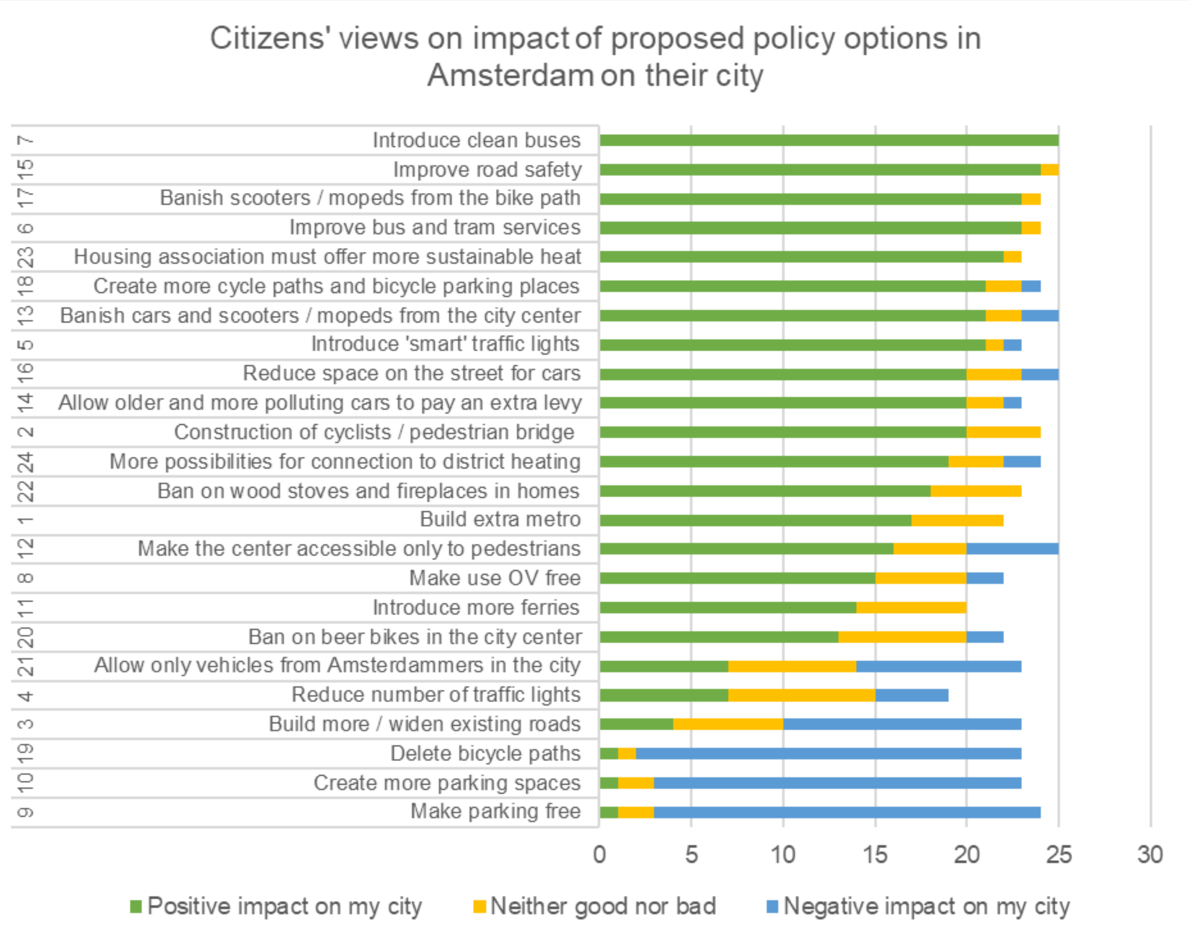
Figure 4-4: Current and future choices for home heating in Amsterdam



4.2 Views of citizens on future policies in Amsterdam

The ClairCity team also asked Amsterdam citizens for the preferred future air quality and carbon policies in the city (Figure 4-5). Improving public transport was the most popular measure with respondents, next to creating more cycle lanes and cycle parking was also very popular. Road safety was also a key concern to individuals. Further, there was some support for levies for older/more polluting cars and banning cars and mopeds from the city centre. Regarding heating, action from housing corporations to provide more sustainable heating sources was strongly supported. Respondents were far less positive about completely pedestrianizing the city centre and about car-centered policies like more roads, free parking and reducing the number of cycle lanes.

Figure 4-5: Citizens' views on the impact that proposed policy options in Amsterdam would have on their city (Source: ClairCity Delphi process)



The eleven most popular measures that were indicated by the Amsterdam respondents were used as an input for a 'Stakeholder Dialogue Workshop' in which Amsterdam citizens and other stakeholders could participate[38]. Participants in the workshop had to choose between three different ambition levels for each measure: one level lower than current policy ambitions; one level similar to these ambitions; and, one level higher than the policy ambitions. From their choices, two different coherent scenarios were produced by the ClairCity team, one merging all selected lowest ambition levels by participants (Scenario 'LOW'), and one merging all selected highest ambitions (Scenario 'HIGH') (Table 4-2).

In the scenario HIGH, based on the choices of workshop participants ten out of eleven selected ambition levels are higher than the current policy ambition level. Only for the measure of reaching energy level A for all housing owned by housing corporations the participants considered it not possible to go beyond the current policy ambition levels (measure to be achieved by 2050). In the scenario LOW, six ambition levels are below current policy ambitions and three are at three measures are at the current policy level. Still two out of the eleven selected ambition levels by participants go beyond the present policy ambition levels, indicating that more ambitious policies to 'improve public transport' and for 'banning woodstoves and fireplaces' are high on the priority list of participants.

[38] 19 people participated in the workshop held on 23 January 2019

Table 4-2 Overall preferred policy measures of Amsterdam citizens

#	Measure	Proposed scenario LOW *)	Proposed scenario HIGH **)
1	Cleaner buses	Half of the buses emission-free (100% electric or hydro-powered) by 2025	All buses emission-free (100% electric or hydro-powered) by 2022
2	Better public transport	Increase network density from the net and increase frequency by 2030	Increase network density from the net and increase frequency by 2030
3	More bike paths and bike parking spots	40.000 new bike parking spots by 2030. Improving current bike paths and fast bike routes (bike highways) by 2025	60.000 new bike parking spots by 2025. Improving current bike pats and fast bike routes (bike highways) by 2022
4	Cheaper public transport	Price of public transport remains the same until 2030	Price of public transport becomes 50% cheaper for everyone
5	Environmental zone for polluting cars	Maintain current environmental zones	Adding an environmental zone for private cars and making current environmental zones more stringent
6	More parking for cars	Maintain the current number of parking spots	Remove 7.000-10.000 parking spots (approx. 10% of the current parking spaces in the city centre) and charge € 7.50 per hour by 2020
7	Limiting car-traffic in the city centre	Maintain current legislation for cars (i.e. reducing car traffic by one-way roads and splitting up traffic routes)	Cars in the city centre are only allowed for people living there
8	Accelerating energy-efficient house renovations	All houses belonging to housing associations reach an energy label B or C by 2050	All houses belonging to housing associations reach an energy label A by 2050
9	Banning wood stoves and fireplaces in houses and bars & restaurants	Ban wood stoves and fireplaces in both new buildings and existing buildings from 2025	Ban wood stoves and fireplaces in both new buildings and existing buildings from 2025
10	Accelerating the uptake of solar panels in the built environment	Maintain current regulation. No incentives from the Municipality of Amsterdam to promote solar energy (except for housing associations)	Mandatory and subsidised solar panels in all suitable roofs
11	Amsterdam gas-free	€ 2.500 subsidy per household in order to facilitate renovation to become gas-free. No obligations for the building sector.	€ 10.000 subsidy per household in order to facilitate renovation to become gas-free. Mandatory gas-free building sector by 2030.

4.3 Reflections from Amsterdam policy makers

The overall preferred policy measures of Amsterdam citizens were discussed in a workshop with Amsterdam policymakers[39]. These policymakers consisted of policy advisors on air quality (from environment and health department), transport advisors and emission-free public transport experts (from transport and public space department.

For each of the eleven measures that were given as an input from the ClairCity stakeholder engagement process, policymakers could provide their remarks regarding inplementation possibilities. They could also choose between the low and the high ambition level as being the most realistic to be implemented in practice. The resulting policy ambitions from citizen engagement and policy reflections together form the ClairCity “Unified Policy Scenario” (UPS), which is a main output of the overall ClairCity engagement process. The impacts of this UPS were subsequently used to model what would be the impacts of implementing these commented citizen views (see Chapter 5).

In the workshop, the policymakers in general backed the high ambition options. Only for the introduction of ‘cleaner buses’, ‘cheaper public transport’ and ‘accelerating energy-efficient house renovations’, the low ambition option was favoured. The main reasons to justify these lower ambition choices were that the current policy ambitions are already very ambitious and that the ‘high’ ambition options (going beyond current policy) were considered unrealistic to implement in practice due to practical considerations (too short implementation deadline or other).

Table 4-3 provides more detailed insights on the main implementation barriers identified by policy makers and ways to overcome these barriers. Key messages of policy makers for implementation are:

Public transport

- Capacity of batteries and fast recharging possibilities are a key implementation issue for electrification of public transport. Hydrogen fueled public transport is currently underdeveloped;
- An integrated vision on higher capacities in public transport is still lacking. Public transport density within the ring is already very high and further intensification can lead to new problems (e.g. noise);
- Making private car travel more expensive is a more feasible implementation option than reducing public transport prices;

Active transport

- Focus in active travel is to better facilitate current cycling densities within the city ring and to increase cycling density outside the ring;

Private car

- An environmental zone for private cars would affect in particular commuters, as car ownership of Amsterdam citizens is very low;

[39] Workshop held on 27 March 2019, 6 participants

- There should be ample room for exemptions, such as for medical transport or for elderly;
- High parking tariffs are implementable (and already implemented), but outside the city ring are currently not considered feasible

Energy

- Banning woodstoves from the city centre is high on the policy agenda, but enforcement options are probably low;
- Current policy targets to have al dwellings of housing corporations at energy level A is considered as very difficult to implement. Energy level B/C would already be very positive;
- Solar panels are very popular and therefore a higher policy ambition might be feasible, but making them mandatory would probably go too far;
- Current policies to make the built environment natural gas-free by 2040 is already very ambitious. Monitoring and acting on public resistance to change would be key, next to gradual implementation.

Overall, the policy makers participating in the workshop believed that current air quality and climate policy measures formulated in Amsterdam until now would be not enough to achieve the very ambitious local policy goals set. The Amsterdam Roadmap currently drafted would be key to change this. The cost of action in general did not seem a major problem to the policy makers. However, of the available city budgets a larger share would have to be dedicated to air quality and climate policies. Overall citizen support for air quality and carbon policy measures in Amsterdam was considered high by the policy makers. However, it was also remarked that citizens could become more negative when they would envisage that measures also were very likely to require their own investments and/or behavioural changes.

Table 4-3 Amsterdam policy makers' choice on preferred citizen measures: Final ClairCity Policy Unified Scenario for Amsterdam (March 2019 workshop)

#	Measures	Chosen option	Concrete policy measure	Implementation comments
1	**Cleaner buses**	Low ambition	Half of the buses emission-free (100% electric or hydrio-powered) by 2025	• The high scenario is too ambitious, not achievable • Current electric buses have a range of 80 km on one battery load, which is not enough for a full day service. More buses and more charging points are therefore needed. Finding charging points and permits takes too long. • There are currently no fast-charging stations for buses. In 2020, seven fast-charging stations will be opened. • Current batteries cannot service larger buses. Night buses have a charging problem (same buses as during the day, need time to recharge). • Policy issue at the moment is to decide who has to pay for what exactly (the local public transport company GVB, the municipality and/or the regional transport cooperation Vervoersregio Amsterdam) • The implementation of hydrogen busses is lagging behind. They are expensive and there are no fuelling possibilities yet.
2	**Better public transport**	High ambition	Increase network density from the net and increase frequency by 2030	• This is an obvious policy option, but it also entails high costs. • Higher density can lead to problems e.g. more stops in a bus-line lead to more commuting time and noise in streets where (tram) transport increases. • Inside the city ring A10 the network density is already high; outside the ring travelling times are an issue. • There is currently no integrated vision on how the public transport network will look like in 2030, not even at the Municipality.
3	**More bike paths and bike parking spots**	High ambition	60 000 new bike parking spots by 2025. Improving current bike pats and fast bike routes (bike highways) by 2022	• It can be unpleasant to ride a bike on a street in Amsterdam – roads are very busy and not safe. • Current ambition: 40 000 – 60 000 places on top of the previously planned ('Meerjarenprogramma Fiets'). There are in particular ambitions to increase current cycling rate (25-30%) outside the ring (to approx 56%).
4	**Cheaper public transport**	Low ambition	Price of public transport remains the same until 2030	• High ambition ('cheaper public transport') is reckless and not in line with other policy ambitions. • Make driving a car more expensive is a financially more viable way to reduce the relative costs of public transport.
5	**Environmental zone for polluting cars**	High ambition	Adding an environmental zone for private cars and making current environmental zones more stringent	• The high ambition is achievable and ways of implementation of a environmental zone for cars are currently investigated, since this is the ambition of the new city council coalition. • How much support there is from citizens for an environmental zone for cars is not clear yet. • Only 24% of the Amsterdam citizens own a car, which is very low. The zone would therefore affect in particular commuters.

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 689289

6	**Limiting parking for cars**	High ambition	Remove 7.000-10.000 parking spots (approx. 10% of the current parking spaces in the city centre) and charge € 7.50 per hour everywhere in the city by 2020	• A high ambition is considered feasible and participants agree with the removing parking spaces part, but a high parking tariff outside the ring (centre) is probably not feasible.
7	**Limiting car-traffic in the city centre**	High ambition	Cars in the city centre are only allowed for people living there	• What it's meant by 'city centre' should be more exactly specified and there should be exemptions for people who need access for e.g. medical reasons, for deliveries to shops and for clean cars.
8	**Accelerating energy-efficient house renovations**	Low ambition	All houses belonging to housing associations reach an energy label B or C by 2050	• The current level of policy ambitions is already very high • It is very expensive to isolate all houses to an A level, housing associations and the municipality together need to pay for this. • There is a distinction needed between the kind of houses. 17th century monumental buildings in the city centre and other older buildings will be very hard to isolate to the desired levels.
9	**Banning wood stoves and fireplaces in houses and bars & restaurants**	High ambition	Ban wood stoves and fireplaces in both new buildings and existing buildings from 2025	• Policies in this area very difficult to enforce. • The current alderman is slightly more open for this. • Public opinion on this issue is changing rapidly, leading to increasing support for measures.
10	**Accelerating the uptake of solar panels in the built environment**	High ambition	Mandatory solar panels in all suitable roofs and provide subsidies for it	• There is scope for a higher ambition as solar panels are very popular in Amsterdam. • Making something "mandatory" should be used only as a last resort. Making non-solar more expensive by way of taxation would therefore probably be more feasible than an obligation. • Outside Amsterdam the network might not be able to sustain all capacity but in Amsterdam city this is not an issue. • Large solar PV projects are presently already being implemented (with SDE Subdidy)
11	**Amsterdam gas-free**	High ambition	€ 10.000 subsidy per household in order to facilitate renovation to become gas-free. Mandatory gas-free building sector by 2030.	• The 'High ambition' is unachievable, as this would mean an implementation 10 years faster than aimed for by current policy and "mandatory" but the 'Low ambition' is not ambitious enough so the high ambition is closer. • Most realistic is to maintain the current implementation target (gas-free by 2040), make switching as attractive as possible to frontrunners and gradually switch to a policy that increasingly taxes the laggards. • Monitor and mitigate public resistance and barriers against implementation ((e.g. noise, difficult appliances – heat pumps).

5 Impacts of implementing citizens' views

This chapter discusses the potential impacts of implementing the citizens' views on future policies on air quality (section 5.1), health (section 5.2), carbon emissions (section 5.3), costs (section 5.4) and on citizen behaviour (section 5.5). It is based on ClairCity modelling to which the disclaimer formulated in Textbox 5-1 applies.

Textbox 5-1 Disclaimer ClairCity modelling versus national modelling

"ClairCity modelling differs from local and national models in the Netherlands due to different modelling assumptions and inputs. Although the utmost care has been taken to calibrate the ClairCity models to local conditions, a detailed comparison of ClairCity modelling assumptions to those of local and national models in each country was considered to be outside the scope of this project. Therefore ClairCity modelling outcomes cannot be one-to-one compared with the outcomes of national and local models; they should be regarded as indicative and can deviate from measured and modeled concentrations in the Netherlands."

The modelled potential impacts are based on a 'Unified Policy Scenario' (UPS) that was prepared by combining citizen preferences for future policy measures with policy maker reflections and quantifying them where possible. Main assumptions made for preparing the UPS are given in Annex C. The impacts of the UPS are compared with those of a 'Business-As-Usual' scenario (BAU) that is based on all city policy measures implemented in Amsterdam in the base year 2015[40].

5.1 Impacts on air quality

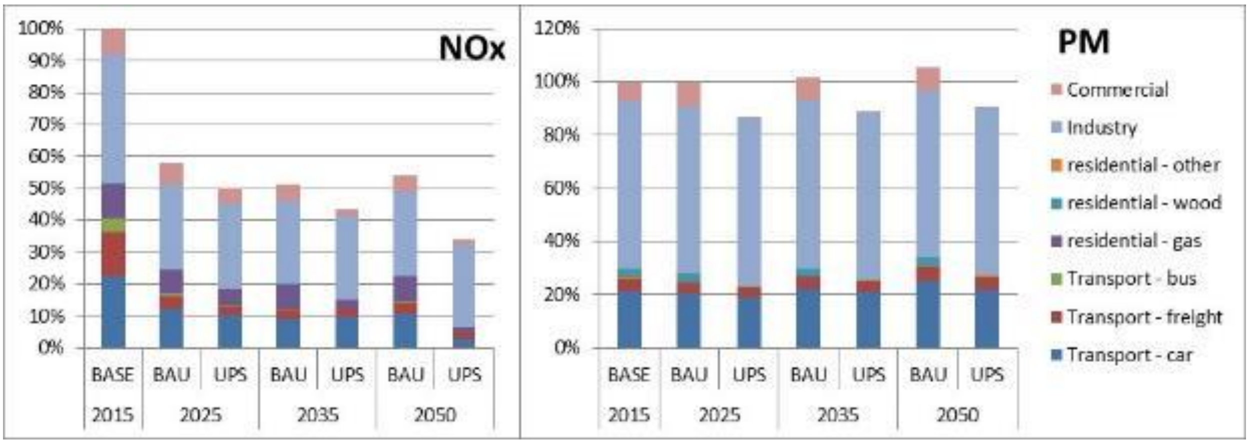
ClairCity models NO_2, PM_{10} and $PM_{2.5}$ air pollutants. Measures implemented in the business-as-usual (BAU) scenario starting in 2015 would already substantially reduce NOx emissions from 2025 onwards (Figure 5-1). The UPS scenario adds a further decrease in emissions beyond the reductions already in the BAU. This is mainly due to decreasing transport emissions due to tighter emission regulation and the stricter environmental zone. The decrease of using natural gas in residential and commercial heating further adds to this reduction.

Figure 5-1 also shows that for PM-emissions the emission reductions achieved by BAU and UPS are limited, mostly due to the large share of industrial emissions on the outskirts of the modelling domain (port area in the North-West).

[40] Policy changes and much stricter targets formulated in Amsterdam since 2015 could not be incorporated in the baseline. This obviously affects the differences between BAU and UPS scenario.

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 689289

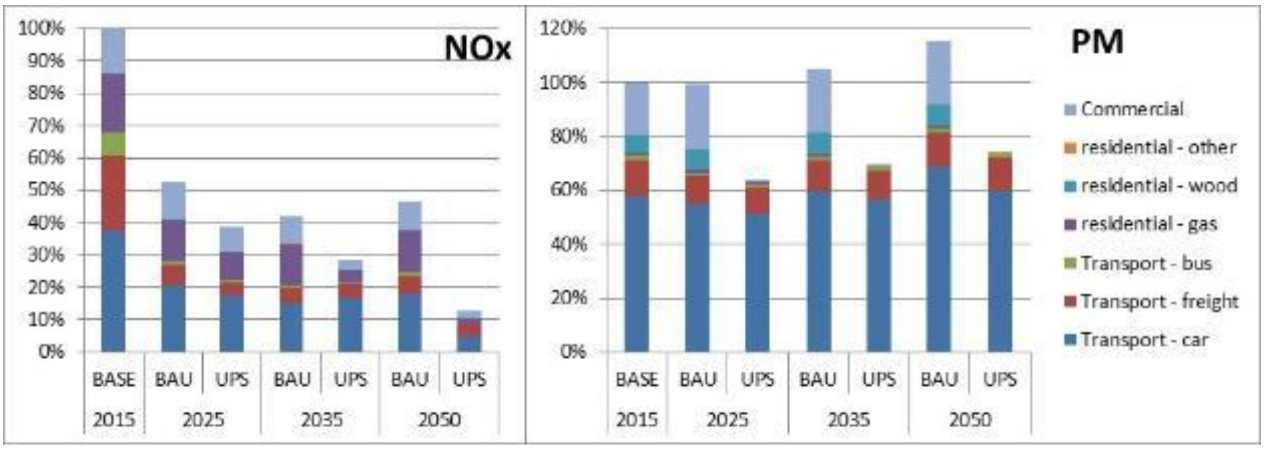
Figure 5-1: Trend of PM and NOx emissions in the UPS scenario (citizens measures), compared to the BAU scenario (Amsterdam policies as of 2015) (source: ClairCity modelling)



If the emissions from these sources are removed, and the focus is placed on sources within the city-center, Figure 5-2 shows that a different trend emerges. In this case NO_x emission reductions would be higher in the BAU and UPS scenarios than in the scenario with industrial emissions. Furthermore, emission reductions would be achieved that would result in only 10% of 2015 values remaining in the UPS scenario in 2050. The PM emissions in the city centre would increase in the BAU scenario as a result of higher car, wood burning and commercial emissions, but would strongly decrease as a result of the ban of wood burning from residential and commercial sources included as a measure in the UPS.

It can also be observed in Figure 5-2 that PM emissions from car transport will rise even in the UPS scenario. This is due to the non-exhaust emissions of transport, i.e. the brake and tyre wear and tear. These emissions are not mitigated, as the current emission standards only target exhaust emissions, which already have declined significantly.

Figure 5-2: Trend of PM and NOx emissions in the UPS scenario, compared to the BAU scenario, city-centre emissions only (source: ClairCity modelling)



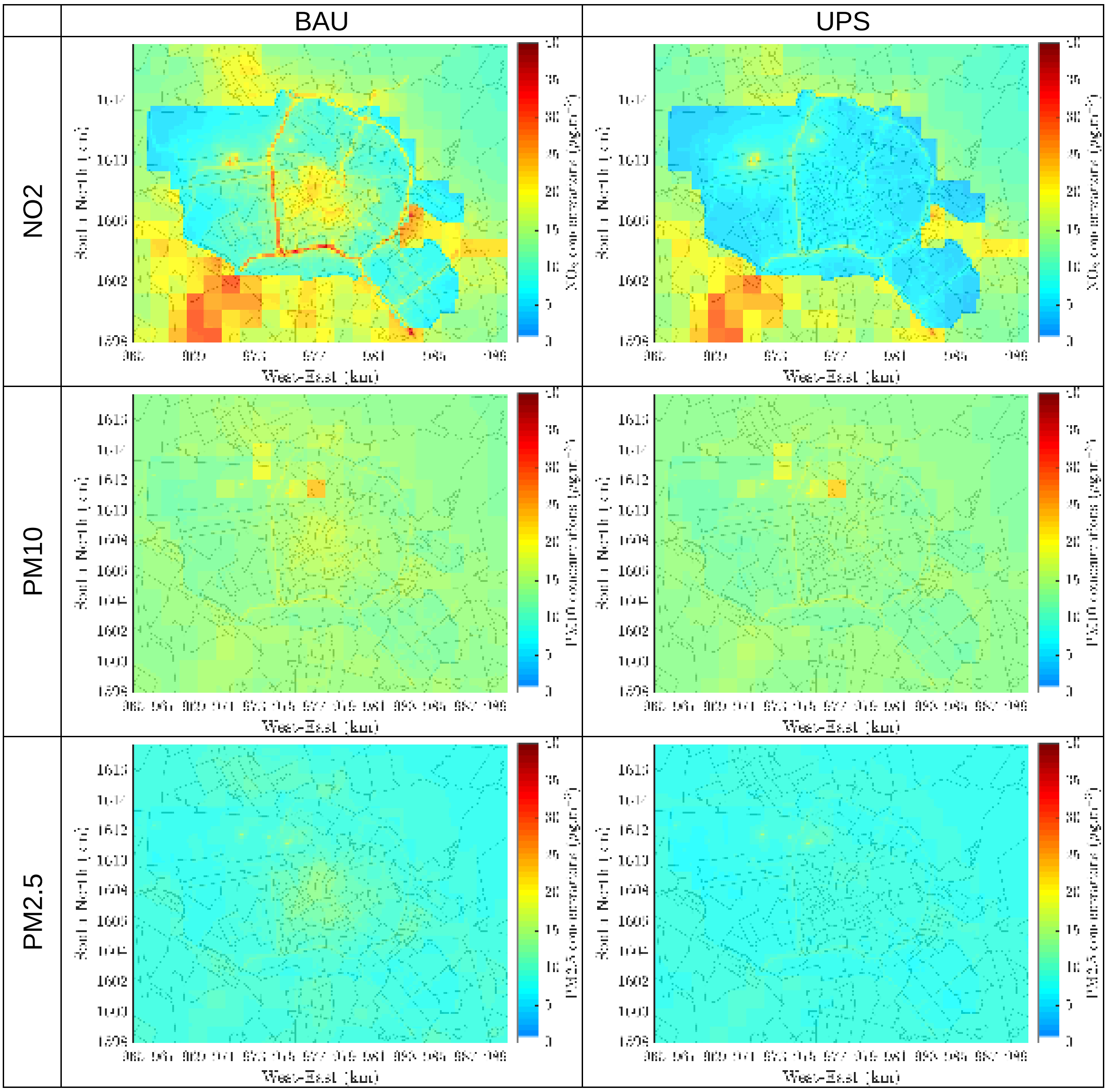
Based on these modelled emission changes in BAU and UPS, Figure 5-3 gives an overview of the resulting modelled NO_2, PM_{10} and $PM_{2.5}$ concentrations in the BAU and UPS scenario in 2050. More detailed modelling results can be found in Annex C. The overall analysis of the modelling results, comparing UPS and BAU modelling results with legal limit values and WHO guideline values, shows that:

- **The BAU scenario still shows NO_2 concentrations around the legal limit values at some spots in 2050, whereas the UPS scenario reduces concentrations to values well below those limits everywhere.** In the BAU scenario, concentrations will not be below 40 µg/m3 everywhere in the city in 2025 (modelled maximum NO_2 concentrations will be equal to 52.1 $\mu g.m^{-3}$). Exceedences of the EU and WHO guideline value (40 $\mu g.m^{-3}$) will occur in 14 cells of the domain. In the UPS scenario in 2025 the maximum NO_2 concentration will be equal to 48.1 $\mu g.m^{-3}$, showing five grid cells with exceedances of the limit value in 2025. The UPS scenario will reduce the maximum NO_2 concentrations by 6 and 15% respectively compared to the BAU in 2025 and 2050. The result would be in the BAU scenario that at the ring road still values would be measures around current NO_2 limit values in 2050 in the BAU scenario, whereas these concentrations would be well below legal limits everywhere in Amsterdam in the UPS scenario.

- **For PM_{10}, the BAU and UPS scenario comply with the legal limit values, but neither BAU nor UPS result in compliance with WHO guidelines even in 2050.** The UPS scenario will reduce PM_{10} concentrations by 2 and 3% in 2025 and 2050 respectively as compared to the BAU scenario. In 2025, the maximum value in the UPS scenario corresponds to 24.3 $\mu g.m^{-3}$ and in 2050 to 22.8 $\mu g.m^{-3}$, well below legal limit values (40 $\mu g.m^{-3}$). However, even in the UPS scenario, 41 cells are exceeding the WHO guideline value (20 $\mu g.m^{-3}$) in 2025. In 2050, 38 cells are still exceeding this guideline.

- **For $PM_{2.5}$, BAU and UPS scenarios comply with legal limit values, but even in the UPS scenario there will be still significant exceedances of WHO guideline values in 2050.** When comparing the UPS scenario with the BAU scenario, the maximum concentrations will be reduced by 3 and 3.4% respectively in 2025 and 2050. In 2025, the maximum modelled $PM_{2.5}$ value in the UPS scenario corresponds to 16.2 $\mu g.m^{-3}$ and in 2050 to 15.5 $\mu g.m^{-3}$. Based on the WHO guideline values (10 $\mu g.m^{-3}$), 158 grid cells will still show exceedances in the UPS scenario in 2025. By 2050 this number is reduced to 46 cells.

Figure 5-3 NO_2, PM_{10} and $PM_{2.5}$ concentrations in the BAU and UPS scenario in 2050



5.2 Impacts on health

The UPS scenario significantly improves human health compared to the current situation and to the BAU scenario (see Annex C for the methodology on the health impact assessment and results)**.** Table 5-1 shows the comparison between the UPS scenario against the BAU scenario, assessing the relative health impact benefits of the emission levels proposed by the scenarios.

The health benefit from implementing the citizen measures in the UPS is considerable. In 2015, the number of premature deaths as a result of $PM_{2.5}$, PM_{10} and NO_2 is 568, 557, and

697respectively[41]. In 2050, the BAU scenario reduces these numbers by 8%, 10% and 46% respectively, but the UPS scenario results in larger reductions for all pollutants: 23% for $PM_{2.5}$, 17% for PM_{10}, and 84% for NO_2. The UPS scenario is therefore effective in reducing long-term health effects of NO_2 as well as PM concentrations.

The health benefit from the emissions reduction is in line with the concentration levels reduction predicted for Amsterdam. However, the reduction on the number premature deaths and the numbers of years of life lost is much higher than average concentration levels reduction. This is explained by the emission reduction measures targeting the more densily populated areas, thus benefiting the population health.

Table 5-1 Benchmarking the UPS, low and high emission scenarios in 2025, 2035, and 2050 against the baseline scenario in terms of health indicators (%) related to $PM_{2.5}$, PM_{10} and NO_2 exposure.

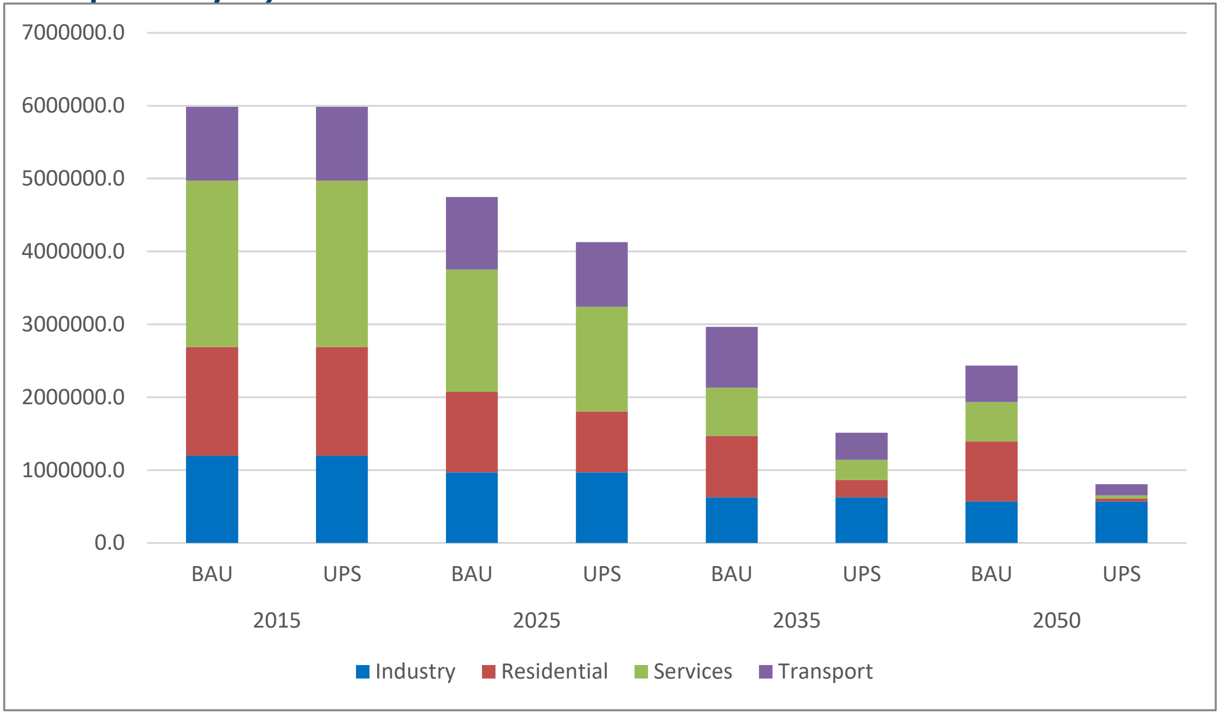
	$PM_{2.5}$			PM_{10}			NO_2		
scenario	**2025**	**2035**	**2050**	**2025**	**2035**	**2050**	**2025**	**2035**	**2050**
BAU	-4	-7	-8	-6	-8	-10	-42	-51	-46
UPS	-18	-22	-23	-12	-15	-17	-63	-79	-84

5.3 Impacts on carbon emissions

Figure 5-4 shows the impacts of UPS measures compared to the BAU scenario in terms of Carbon Footprint. The figure clearly shows that the UPS measures have an important impact in particular from 2035 onwards and make the city of Amsterdam – contrary to the BAU - achieve near carbon neutrality by 2050.

[41] The quantification of health impacts is done individually, although all the pollutants considered in this study co-exist in ambient air. The rationale is that individual implications on human health of a single pollutant in ambient air are not easily quantifiable. Therefore, there is a stronger possibility of overestimating the impact on human health when considering all the pollutants together than underestimating the effect related to a single pollutant. The WHO expects that the overestimating can be up to 30% when assessing these pollutants combined, recommending only concentration-response function for individual air contaminants.

Figure 5-4 Carbon emissions of UPS scenario in Amsterdam compared to BAU (tonnes of CO_2-eq on life cycle)



The largest differences between UPS and BAU are found in the residential (built environment) sector, where the UPS measures, contrary to BAU, lead to almost zero emissions in 2050 as a result of e.g. the energy efficiency renovation of houses, the increased solar energy use and the substitution of natural gas. It is clear that in order to achieve these emission reductions, a large citizen involvement for renovations of houses and installation of solar panels is required.

5.4 Impacts on costs

Table 5-2 gives a qualitative estimate of the cost of the measures in the UPS scenario versus the BAU. More detail on the method applied can also be found in Annex C. We distinguish between estimated monetary costs to citizens, costs for government/city council (no distinction is made between different levels of government) and a net total cost to society, summing up both. On top of that, for an exact calculation of benefits also the indirect benefits of health improvement of citizens (saved public health costs) have to be taken into account. This was beyond the scope of the ClairCity modelling.

In total, net monetary cost effects of the 11 UPS measures vary substantially and will sometimes result in additional costs and other times in net benefits for citizens and for government. Exact costs will also depend on how measures are designed in detail. Further detail of the assumptions made is given in annex C. The annex also gives an order-of-magnitude cost estimate of car user costs, car charging revenues and bus subsidies in the UPS compared to the BAU scenario.

However, the overall balance of direct costs of all measures in the citizens' UPS scenario together suggests that a cost effective execution of the UPS for citizens and city council /

government is very well possible, as measures with a net direct cost to society can be balanced by measures with net revenues. This balance would be even more positive if also the indirect health benefits of improved health of citizens would be added.

Table 5-2 Estimated cost impacts of citizen measures that are part of the UPS scenario in Amsterdam

#	Policy measure	Citizens	Government	Society
1	Cleaner buses	0	-	-
2	Better public transport	+	-	-
3	More bike paths and bike parkings	n/a	n/a	n/a
4	Cheaper public transport	n/a	n/a	n/a
5	Environmental zone for polluting cars	-	0	-
6	Less parking for cars	-	+	0
7	Reducing car traffic in the centre	0	0	0
8	Accelerate energy efficient renovations	+	+	+
9	Ban wood stoves and fireplaces in houses and bars & restaurants (terraces)	0	0	0
10	Accelerate the uptake of solar panels in the built environment	++	-	+
11	Amsterdam (natural) gas-free	+	-	?

(+) assumed net positive direct effect/ benefits for target group; (-) assumed net negative direct effect / costs for target group; n/a effect of measure cannot be assessed

The assumed cost effects per measure are explained in more detail in textbox 5-2.

Textbox 5-2 Main assumptions for qualitative cost estimates of UPS scenario measures

1. Cleaner buses require extra investment at a cost to the government (-) without a cost effect on citizens (0), leading to an overal net negative cost effect on society (-).
2. Better public transport is operationalised in the UPS scenario as an increased coverage and frequency, thus requiring a higher subsidy for buses to be provided by government (-). This measure leads to a cost decrease for citizens as public transport becomes an attractive alternative at times and locations currently not the case (+). Yet, this is at a greater expense for the government as an incremental shift to public transport will also require a larger public support by government. Further, it conincides with a drop of government income from other alternatives (i.e. cars). The overall societal cost effect is therefore considered to be negative (-).
3. The cost impact of adding bicyle parking, bike lanes and fast bike routes is difficult to assess. When assuming a reallocation of the (fixed) investment fund in infrastructure (i.e. from road for cars to infrastructure for walking and cycling), there is no extra cost. When assuming an aggressive investment strategy in new walking/cycling infrastructure, this measure would come at an (extra) cost to the government. As a consequence, we did not consider this measure to have a direct measurable cost effect.
4. The UPS measure is the same as the BAU measure, since citizens together with policy makers finally considered reducing costs of public transport not feasible.
5. Banning polluting cars leads to early scrappage of the existing car fleet, and hence to a loss of capital for private owners (-). The measure is assumed to be cost neutral for government (0), leading to an overal net negative cost effect on society (-).
6. Reducing the amount of parking space and increasing the rate of parking fees will create and extra cost for the citizen and revenue for the government, net cost neutral to society.

7. Reducing the traffic in the city is considered a mandatory regulation, not directly influencing the cost to citizens or government.

8. Accelerating energy efficiency renovation is expected have a positive impact for all parties involved (citizens and government), as investment cost is offset by energy expenditure savings.

9. Banning wood combustion is considered to have no cost effect whatsoever. Alternative heating fuels have comparable costs.

10. Though requiring an upfront investment, on the long term solar panel energy generation is leading to cost benefits for citizens (+), as the initial investment cost will be offset by lower fuel cost, leading to a net benefit for citizens. The policy as implemented here includes a subsidy from the government to the citizen, adding to the benefit of the citizens. It thus generates a strong benefit for citizens (++), a cost for the government (-) and a net benefit for society (+)

11. Financial incentives from government to citizens to convert to gas-free households lead to a negative cost for the government associated with the subsidy (-) and a benefit for the household (+), assuming the switch with the subsidy leads to lower net fuel costs for the household. It is not clear if this leads to a societal benefit or cost, as this will depend on the cost of the alternative vs. using gas. It is expected at at last in the short term substantial subsidies are needed to stimulate household to switch, thus implying a societal net cost, yet this may change over time as alternative technologies are becoming cheaper.

5.5 Impacts on citizen behaviours

Figures 5-5 shows the changes in NOx and PM emissions in the BAU and UPS scenarios due to changes in trip mode (including commercial freight). The figures show that freight NOx and PM emissions are are already reduced substantially by the BAU in 2025, and even more by UPS and in further years. The same holds for car emissions. Bus/tram emissions do only contribute only for a small part to total emissions in the base year. In later years, their emissions become even lower due to in particular the electrification of buses.

Figure 5-6 shows that the reductions are in particular related to a sharp decrease in the number of work related trips and also, but less to a decrease in recreational and shopping trips.

Figure 5-5 Changes in NOx emissions due to trip mode changes of Amsterdam citizens in BAU and UPS (% of total transport emissions from citizens)

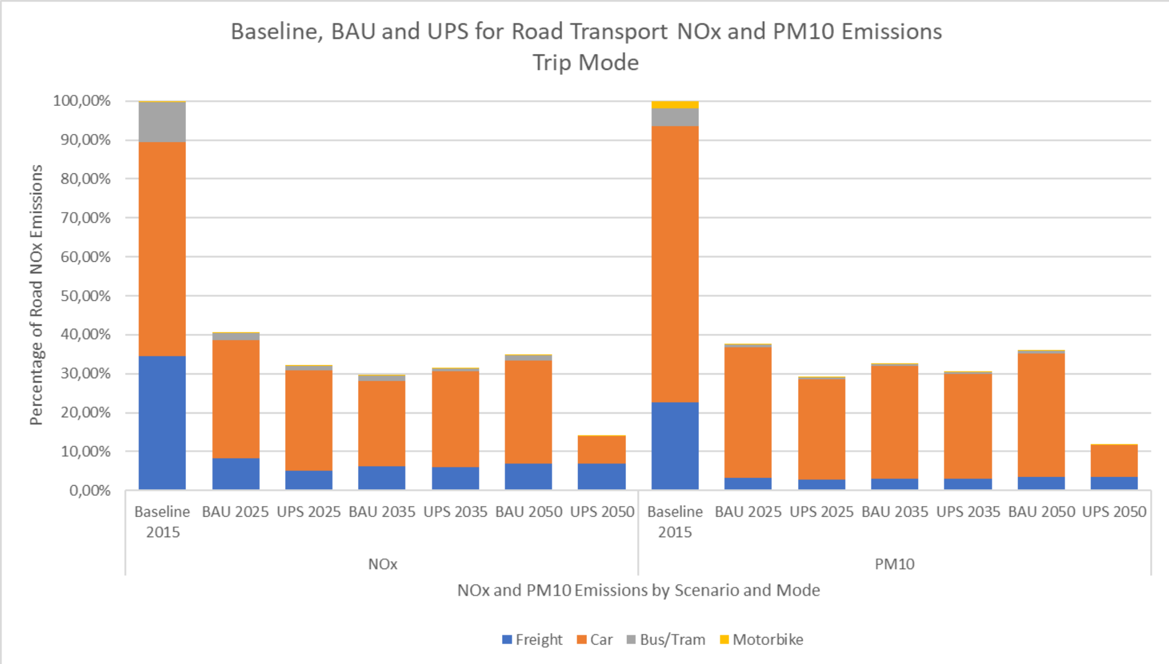
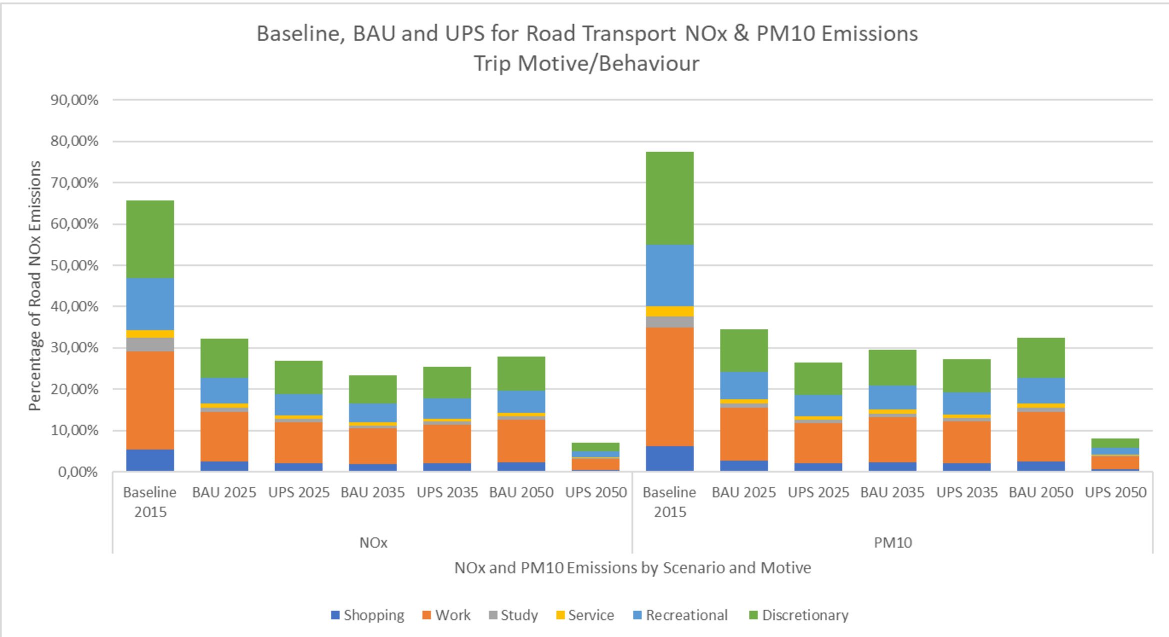


Figure 5-6 Changes in NOx emissions due to trip motive changes of Amsterdam citizens in BAU and UPS (% of total transport emissions from citizens)



The emission changes can also be differentiated based on gender, income and age (Figures 5-7, 5-8 and 5-9 respectively). These figures show that men reduce their number of work related trips by car far more than women, but they also start from a higher number of work related trips by car (see section 4.1.1). The reduction in trips by bus/tram is similar between men and women. It is also the middle income group (21 – 36,000 euro/year) that reduces their emissions most, with reductions in work related trips being most prominent but also with a significant reduction of recreational and other trips. It is also the group of younger adults

(15-44 years)[42] that will mostly reduce their emissions, followed by the older working population (45-64 years).

Figure 5-7 Changes in NOx emissions due to changes in trip motives by gender between 2015 and 2025 (UPS)

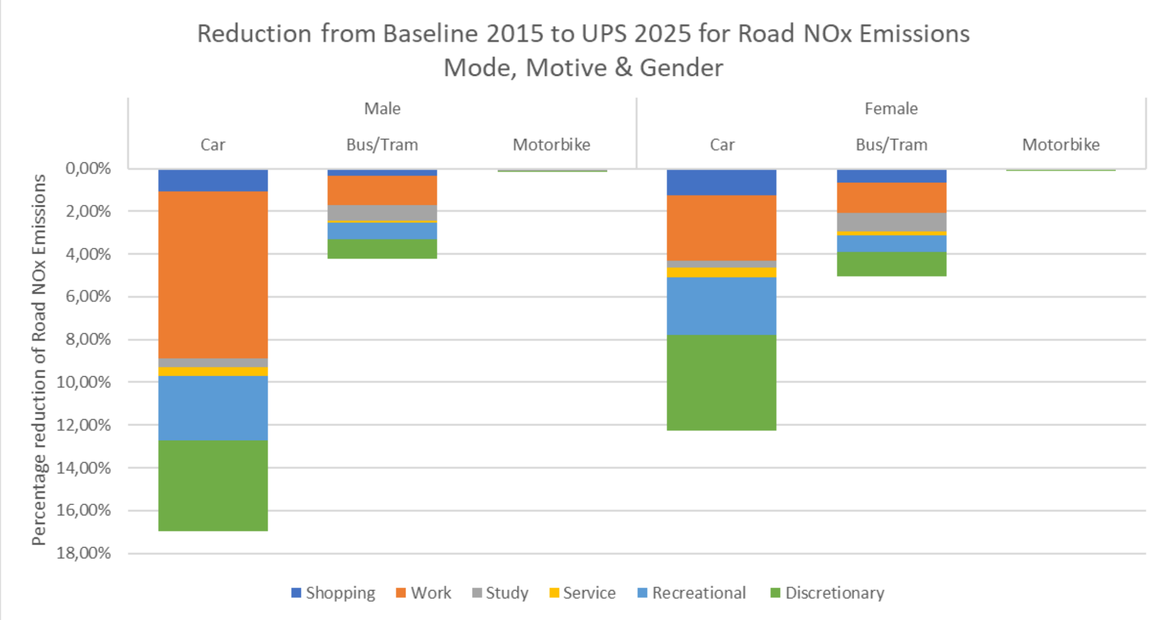
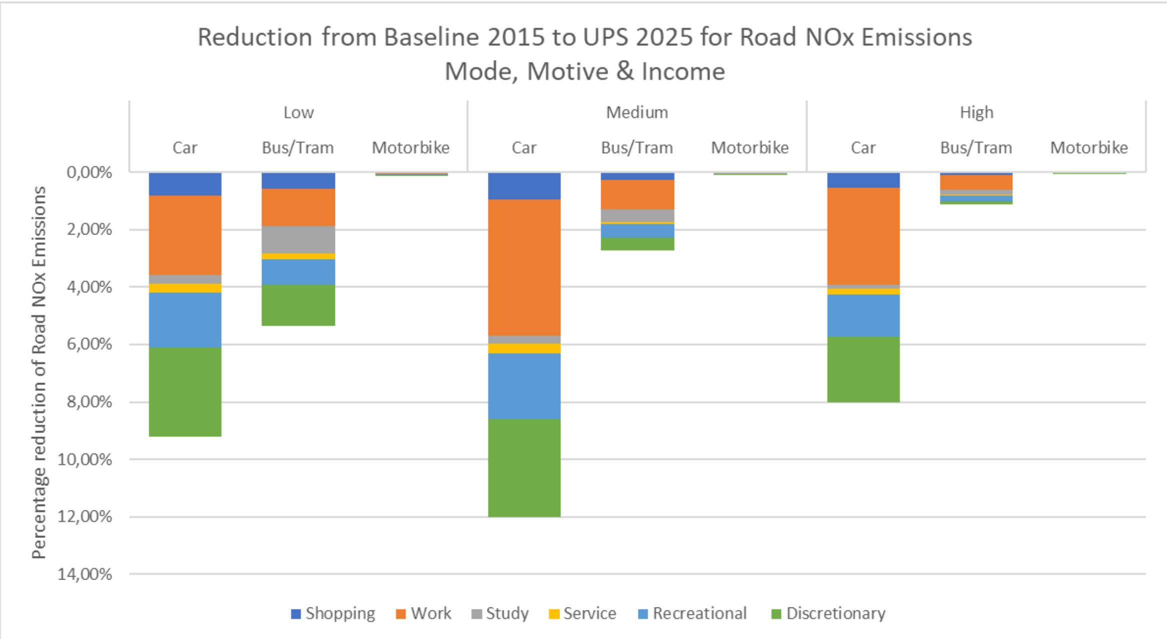
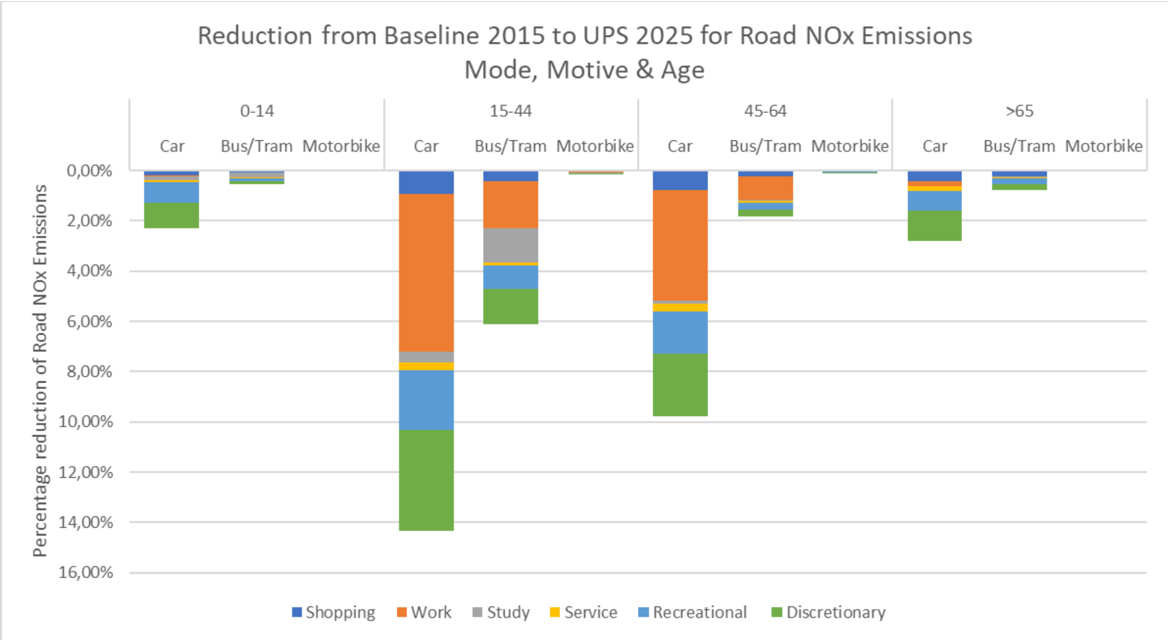


Figure 5-8 Changes in NOx emissions due to changes in trip motives by income between 2015 and 2025 (UPS)



[42] Including also teens from 15-18 that will be car passengers

Figure 5-9 Changes in NOx emissions due to changes in trip motives by age between 2015 and 2025 (UPS)



6 Amsterdam and other ClairCity cities – mutual learning

In this chapter, main institutional conditions and barriers for implementing citizen policy preferences are discussed (section 6.1). Possible lessons from other ClairCity cities for Amsterdam are outlined in section 6.2 and lessons from Amsterdam for other ClairCity cities in section 6.3

6.1 Institutional conditions and barriers for citizen-inclusive policies in Amsterdam

Political framing

The current city council in Amsterdam pursues a very pro-active environmental policy making that goes way beyond the national and EU legislative obligations. While the previous council was more focused on citizens' and businesses' own independent action within a liberal policy framework, the current council also has an eye on a just transition that includes socially less priviledged groups. In line with its high policy ambitions, also measures are implemented that are not popular amongst all Amsterdam citizens, such as higher parking tariffs and an environmental zone also for private (more polluting diesel) cars.

Finance

Amsterdam policy ambitions seem to be less limited by a shortage in financial means than other ClairCity cities, although a detailed financial budget comparison between the cities has not been made. The need for European support to implement measures is not mentioned in the main Amsterdam policy documents.

Citizen-engagement culture

By taking the city to court, NGOs directed at air pollution in recent times have taken a confrontational attitude towards local city policies. The aim was to make the city meet its legal obligations regarding limit values also in the 'hotspot' streets. However, the court case was lost by the NGOs. Amsterdam suports citizen initiatives for instance in the field of energy, but does not seek to actively expand citizen engagement beyond the many initiatives in this field that have already appeared.

Links with other stakeholders and governance levels

In the past, provincial spatial planning hindered the construction of new wind turbines in the Amsterdam city area. With a new provincial government, this ban now has been lifted. Amsterdam cooperates closely with its surrounding communities to prepare a regional energy strategy that will make the region as energy-autonomous as possible.

6.2 Lessons from other ClairCity cities for Amsterdam

Compared to other ClairCity cities, Amsterdam has relatively elaborated and ambitious air quality and carbon policies. However, while there is a regular interaction with citizens, more action in this field could help to successfully implement the ambitious policy measures still ahead. In that respect, there are several lessons that Amsterdam could learn from the other ClairCity cities, as noted below.

In Ljubljana, Amsterdam could learn lessons from what a full pedestrianisation of the city centre means. One of the lessons is that the fear of decreasing economic activity for businesses in the city did not become true. Rather, tourism in Ljubljana increased to levels that might be comparable to those of Amsterdam. Electric taxis in the pedestrian zone together with a free bike system assured access to the city centre and its surroundings also for residents with disabilities and for those having to travel larger distances. Further, Amsterdam could learn lessons from Ljubljana through its very active citizen engagement in various EU and otherwise funded projects, which contributed to gaining support for sustainable change in Ljubljana.

In Sosnowiec, the air pollution indication system that was integrated in the electronic information panels of public transport could also be an asset for Amsterdam when trying to increase citizen awareness of air pollution in the city.

In Genoa, the scooter ban protests might give Amsterdam valuable insights into what could happen to city policies when not sufficiently taking citizen opinions and culture into account.

In Bristol, the development of the integrated Metrobus system that connects regional and city transport might provide new ideas for promoting public transport based commuting into Amsterdam.

In Aveiro, finally, the small-scale bike workshops integrated in secondary school education might inspire Amsterdam to further promote the integration of sustainability into primary and secondary school education.

6.3 Lessons from Amsterdam for other ClairCity cities

The experiences in Amsterdam with the implementation of air quality and carbon policies might be useful for other cities as well. Lessons from Amsterdam could include:

Clean Air Zones

The implementation of clean air zones in city centres is a process that has already taken place in many European cities. Within the ClairCity context, Amsterdam and Bristol have taken steps towards such a zone. Ljubljana has gone one step further, by pedestrianising the city centre. Genoa tried to implement a clean air zone for mopeds, but initially had to take back its announced plans due to public resistance.

A lesson from the Amsterdam way of implementing the clean air zone is that it has been introduced in a stepwise process for different categories of vehicles. Until end 2019, only environmental obligations for mopeds, buses, taxis and freight transport existed. In November 2019, a clean air zone for older diesel vehicles was introduced. The limit values for all zones now will be gradually made stricter. In this way, citizens can slowly get used to the zone, which is hoped to contribute to public acceptance.

Active transport

Amsterdam and the Netherlands are internationally known for their cycling culture, facilitated by a completely flat country and city. As the number of cyclists in Amsterdam is much higher than in the other ClairCity cities, its way of implementing cycling infrastructure, including cycle lanes, paths and parkings could be an example to the other ClairCity cities. Also, the way of integrating public transport and bike rent at train stations in one ticket could be of use to other cities. Furthermore, cities that are more advanced in implementing bike infrastructures could learn from the new problems that have to be tackled when cycling becomes a major activity in the city, like congestion on bike paths, massive uncontrolled bike parking littering streets and a large number of cyclists that do not respect traffic lights nor general traffic rules.

Cleaner and better public transport

Amsterdam has a very extensive public transport system which facilitates door-to-door transport. Its buses will be electrified in the near future and existing metro lines are to be expanded. Lessons for other cities could for instance be learned in the way that the expansion of public and active transport infrastructure was combined with gradually reducing road space for private cars and increasing car parking tariffs in the city centre.

Energy

Amsterdam and the Netherlands have embarked on a worldwide unique process of making the built environment of a country and city that were up to now almost completely dependent on natural gas gas-free. Energy policies therefore are an area where other cities in particular could learn from Amsterdam. For instance, by the way in which citizen renewable energy cooperations are developing and supported, the rapid expansion of solar PV and the engagement of housing corporations in increasing the energy efficiency of their housing stock.

7 Citizen-inclusive air quality and carbon policies in Amsterdam: Conclusions and recommendations

The ClairCity project has set up an innovative citizen engagement process and verified implementation possibilities of policy desires of citizens with that of stakeholders and policy makers. The project has also modelled the likely consequences of the consolidated citizen scenario for air quality and carbon emissions.

In this chapter we draw the main conclusions and propose recommendations to Amsterdam policy makers. These have to be understood within two main limitations of the ClairCity project:

- Although ClairCity managed to engage a large (1.100) and varied number of citizens in Amsterdam (in terms of age, income, origin, gender, neighbourhood), the sample is not fully representative of the Amterdam population as a whole.
- ClairCity modelling assumptions do not fully correspond with those of local modelling. The quantitative outcomes of modelling the citizen policy measures in terms of emissions, concentrations and health cannot be directly compared with those of local models.

Despite these limitations, however, the ClairCity project gives an overall indication of how Amsterdam citizen behavioural practices and anticipated future behaviours might affect policy making. The project also gives a view on what citizens in Amsterdam think of future policies and what might be the consequences of implementing these views, callibrated by policy maker comments, into actual policies.

7.1 Conclusions

Three main conclusions stand out from the ClairCity analysis in Amsterdam:

1. Meeting the very high policy and citizen ambitions in Amsterdam is facing technical barriers.

Overall, in the ClairCity project Amsterdam compared to the other pilot cities has very ambitious local policies that go way beyond the legal obligations on a national and EU level. Citizens partly demand even more ambitious measures, but policy maker comments also point to the technical limitations of even faster implementation rates.

2. Under Amsterdam citizens there exists considerable scope for changing own behaviours.

Current behavioural practices of Amsterdam citizens already appear relatively sustainable compared to other ClairCity cities. Based on the statements of preferred future behaviours, there seems to exist considerable scope under Amsterdam citizens for behavioural change towards even more sustainable behaviours.

3. However, willingness to change own behaviours does not yet seem to meet the requirements of intended policy change.

Comparing stated intentions for behavioural change with policy ambitions, the pace of own behavioural change in transport and energy does not seem to keep up with the ambitions of local policies. More attention to communicating the consequences of local policies for citizens' own behaviours and discussing possibilities and limitations for such changes therefore is be required.

In the following sections, more detailed conclusions from the ClairCity analysis are drawn.

7.1.1 Current city policies in Amsterdam

- **Amsterdam has very ambitious local policy goals for air quality and carbon policies that go much further than legislative requirements. Further implementation of these measures is a main challenge.**

Apart from hotspots in several streets that still have to be dealt with effectively, Amsterdam complies with EU air quality regulations. However, Amsterdam is still far from reaching the much stricter voluntary WHO guideline targets that it wants to achieve. Concentrations of main pollutants NO_x, PM_{10}, $PM_{2.5}$ and black carbon are declining in recent years, indicating success of policy measures so far, but the trend lines are flattening – suggesting that a successful implementation of further measures is needed to reach the goals set.

7.1.2 Current behaviour of citizens in Amsterdam

- **Current transport and heating behaviour of Amsterdam citizens is still far from in line with local policy goals, as private car use and gas heating are still the most important transport and heating practices.**

Private car use was responsible for more than half of the citizen-related road transport NO_x emissions in 2015, and for more than three-qua rter of the PM_{10} emissions. 82% of the ClairCity respondents indicated that they still have central gas heating as a main heating source for their home. With limiting private car access to the inner city and making the built environment natural-gas free as important local policy goals, changing current citizen behaviour is still a main challenge.

- **Breakdown of citizen transport behaviour shows that work related trips, men, middle-income groups and younger adults cause proportionally more pollution than other groups.**

In the ClairCity sample of respondents, work related trips caused 24% of the NOx emissions and 30% of the PM10 emissions, much more than the second most important singular trip purpose, recreation (causing 12 and 16% of emissions respectively).

- **Men cause more transport related emissions than women.**

In the ClairCity sample, men cause 37% of the NOx emissions, against 29% for women (47 / 35% of PM emissions). The remainder are freight emissions that were left out of the demographic analysis.

- **Middle-income groups cause more pollution than low and high income groups.**

A middle-income group of citizens (21 – 36,000 euro/year) in Amsterdam causes 26% of the road transport NOx emissions and 33% of the PM emissions in Amsterdam, compared to 23/27% for the low-income group and 16/22% for the high-income group.

- **Younger adults cause more pollution than older adults, retired persons and children.**

The group of 15-44 year old teenagers and younger adults is responsible for 34% of NOx emissions and 41% of PM emissions. Older adults (45-64) are the second most important group responsible for emissions (20/27%), while children (<15) and retired persons (>65) only contribute to a limited extent to road transport emissions (5/6% and 6/8% respectively).

7.1.3 Behavioural preferences of Amsterdam citizens for the future

- **Citizens indicate to want to change their behaviour towards less private car use for transport and less natural gas use for home heating. However, the willingness to change is less high than would be necessary for meeting the ambitious policy targets set.**

In the ClairCity citizen sample, 17% of the respondents indicated still to prefer using their car as only means of transport for commuting in the future, compared to 29% currently. The percentage of shopping and leisure trips by car only would decline to 14 and 23% in the future, compared to 23 and 45% currently. 36% of the respondents still anticipate to use gas heating in the future (82% currently), and only 12% foresees to be connected to the district heating network (13% currently). Considering policy aims of a fully emission free city centre and a complete ban of natural gas, further behavioural change of citizens would be required.

7.1.4 Policy preferences of Amsterdam citizens for the future

- **Citizens support ambitious policy measures, but policy makers sometimes point to technical limitations of even faster change.**

When not asked explicitly for own behavioural change, citizens often support even more ambitious policies than current plans. Policy makers overall express support for these citizen measures, but also sometimes add reflections regarding their implementation possibilities. These reflections include for instance foreseen limitations to the speed of increasing the number of charging stations for buses, incompatibility of reducing public transport tariffs with expanding and greening public transport, and doubts on increasing the speed of energy efficiency improvements by housing corporations even more.

- **A ban on wood stoves and improved public transport are the two most preferred measures by Amsterdam citizens and policy makers involved in ClairCity.**

A ban on wood stoves and improving public transport are the most preferred measures of citizens and policy makers alike. Further preferred transport policy measures of Amsterdam citizens include measures directed at reducing private car use, improving public transport and increasing active transport (biking, walking). Regarding energy, citizens want housing corporations to substantially improve energy efficiency of their housing, subsidised solar PV, a ban on wood stoves and more possibilities for district heating.

7.1.5 Impacts of the citizen policy preferences

- **The UPS scenario leads to lower emissions and concentrations of air pollutants and greenhouse gases than the BAU scenario. The corresponding improvement of public health is proportionally even larger.**

NOx emissions in the city centre will decrease to 48 and 12% of 2015 values in the BAU and UPS scenario respectively. PM10 emissions in 2050 in the BAU scenario might increase to 115% of the 2015 values due to increased transport, and will decrease to 75% of 2015 values in the UPS scenario. The corresponding health improvements are -52% of premature deaths in 2050 due to NOx, and -3% due to PM in the BAU scenario, and -93/-60% in the UPS scenario. The health improvement is relatively higher than the emission reduction because the emission reductions occur particularly in densily populated areas.

- **PM emissions for the longer term are likely to be more problematic than NOx emissions, as neither BAU nor UPS will result in compliance with WHO guideline**

values even in 2050. Non-exhaust PM emissions will increasingly be an issue for the future.

The figures show that the measures in BAU as well as in UPS scenario are likely to be more effective in reducing NOx emissions than in reducing PM emissions. Since no measures are directed at reducing non-exhaust PM emissions of car tyres and brakes, the relative importance of these emissions to pollutant concentrations and health effects in the future is likely to increase.

- **Many measures in the UPS scenario come with a net direct cost to society, but indirect cost benefits by public health improvements would reduce overall societal costs. Some measures after initial investments are likely to have net benefits to society on the long term.**

Many measures considered by Amsterdam citizens are likely to have a net cost to citizens or to authorities, with a resulting net direct cost to society. However, if indirect health benefits of the measures would also be included in the cost pictures, the net societal costs would be smaller and measures might even result in net benefits. The measures concerning solar PV panels and increased energy efficiency by housing corporation investments in the long term already might have net benefits to society even without taking indirect costs into account.

- **The UPS scenario reduces in particular the number of work related trips. Men, the middle income group and younger adults reduce their number of trips most, in line with the higher emissions than other groups which they have right now.**

The behavioural changes caused by the UPS scenario are in line with what would be expected with current emissions. Work related trips and the demographic groups that right now already have the highest emissions will reduce their emissions most.

7.1.6 Institutional conditions and barriers for implementation of citizen policies

- **Current institutional conditions for change in Amsterdam seem relatively positive, but main issues can be foreseen when further scaling up energy transition in the city.**

Funding for air quality and carbon policies seems less problematic in Amsterdam than in other ClairCity cities, and the dependence of EU funding is small. Still, in particular the expansion of public transport and electrical recharing infrastructure in the city might require substantial additional funding in the future. Also, past spatial planning issues with the province regarding wind turbine siting now seem to be solved.
Nevertheless, the renewable energy infrastructure required for fully switching from natural gas to other sources will require so much space in an already densily populated city and region that spatial planning for the future is very likely to become a main issue.

7.2 Policy recommendations

Based on the conclusions of the Amsterdam ClairCity analysis several recommendations for more citizen-inclusive policy making can be given:

7.2.1 Tailoring policies to current behaviours and to preferred future behaviours of citizens

- **Engage even more actively with citizens to bring willingness of citizens to change their current transport and heating behaviours in line with policy requirements.**

Many Amsterdam citizens partake in active transport (cycling) and there is considerable willingness to change in terms of getting out of the car and switching to non-gas heating, yet a substantial part of the ClairCity respondents envisage continuing with driving by car into the city centre and heating their homes with gas. Further engagement with citizens is therefore required to increase willingness for change.

- **Engage in particular with commuters as a main group contributing to air pollution in the city.**

In Amsterdam, the main polluters in terms of transport behaviour seem to be younger male adults with middle incomes that drive into the city for commuting to work. Hence, communications and interactions should be directed in particular to this group. This group could be addressed in dialogue with main Amsterdam employers.

- **Increase the awareness and attractiveness of district heating in the city as a main means to reduce dependency on natural gas in the built environment.**

As for gas heating, few respondents indicate a willingness to change to the existing district heating system in the city, which will be expanded substantially in the future. Hence, citizen engagement should address in particular citizen views on this system.

- **Focus on measures addressing Particulate Matter (PM).**

Whereas NO_x emissions are substantially reduced by the envisaged policy and citizen measures, PM emissions are decreasing substantially less. Hence, additional policy actions should be directed at this source. For example, through specific attention to wood and biomass burning. Actions regarding wood stoves are being considered in the city, but communications on the negative environmental aspects of wood burning could still be expanded.

- **Stimulate the visibility of live air quality data in the city.**

General awareness of air quality of Amsterdam citizens could also be increased by publishing live air quality data, in particular also at hotspots in the city. Combining this with public transport information panels, as has been done in Sosnowiec, could be an interesting option to do so.

7.2.2 Addressing institutional barriers and mutual learning

- **Increase the exchange with other cities focusing on mutual learning and training.**

Amsterdam is already involved in several international and national city networks. However, the experiences in Amsterdam with transport and heating measures affecting citizens can be useful to many other cities, while Amsterdam in turn could also learn from other cities. A review and expansion of training and network possibilities would therefore be very useful in the process towards a further transition in the city.

Annex A. The ClairCity process in detail

This annex explains in more detail the ClairCity process and the positioning of this 'Amsterdam policy package report'.

The ClairCity project consists of three phases and seven work packages (Figure A-1):

Phase 1: Establish the Baseline Evidence

The primary aim of Phase 1 is to understand and quantify the baseline status of air quality, carbon emissions and related public health in our cities. Phase 1 is achieved with the following main activities:

1. **Benchmarking behaviour**: Understanding the local demographic data and establishing the citizen practice-activity data to feed into the air quality models.
2. **Quantify the baseline**: Quantification of the baseline air quality emissions and concentrations, carbon emissions and public health impacts in a city.
3. **Assessment of Policy**: Collation and analysis of current policies (local, regional, national and EU) that influence the city.

Phase 2: Citizen and Stakeholder Engagement & Co-creation of Scenarios

Phase 2 has three key aims: (1) understand citizens' current behaviours, practices and activities, (2) enable citizens and stakeholder to co-create and visualise their low carbon, clean air, future city and (3) raise awareness of the environmental challenges and their solutions. Phase 2 utilised evidence from Phase 1 to help frame and inform the engagement activities. Phase 2 is achieved with the following main activities:

Citizen and stakeholder engagement & co-creation

1. The ClairCity Delphi method uses citizens as local experts to generated qualitative evidence of their entrenched behaviours and what enabling interventions would allow them to act and behave differently in future (WP4).
2. The Mutual Learning Workshop brings citizens and stakeholders together to debate the challenges facing the city and co-create policy interventions for cleaner, healthier futures (WP4).
3. The ClairCity Skylines Game 'crowd-sources' the public perceptions and public acceptability of difference policy interventions (WP4)
4. Citizens and stakeholders come together in a Stakeholder Dialogue Workshop to review and debate the Delphi, Mutual Learning Workshop and ClairCity Skylines evidence and co-create scenarios for a low carbon, clean air, health futures (WP4 and WP7).
5. The scenarios generated in the Stakeholder Dialogue Workshop go through a rapid quantification step (WP5) and are then returned to the local citizens/stakeholders to discuss in a Policy Workshop (WP6) and to agree a single Unified Policy Scenario (WP7).

Public Engagement & Awareness: Additional awareness raising activities are also implemented across the project in each city (WP4). These include:

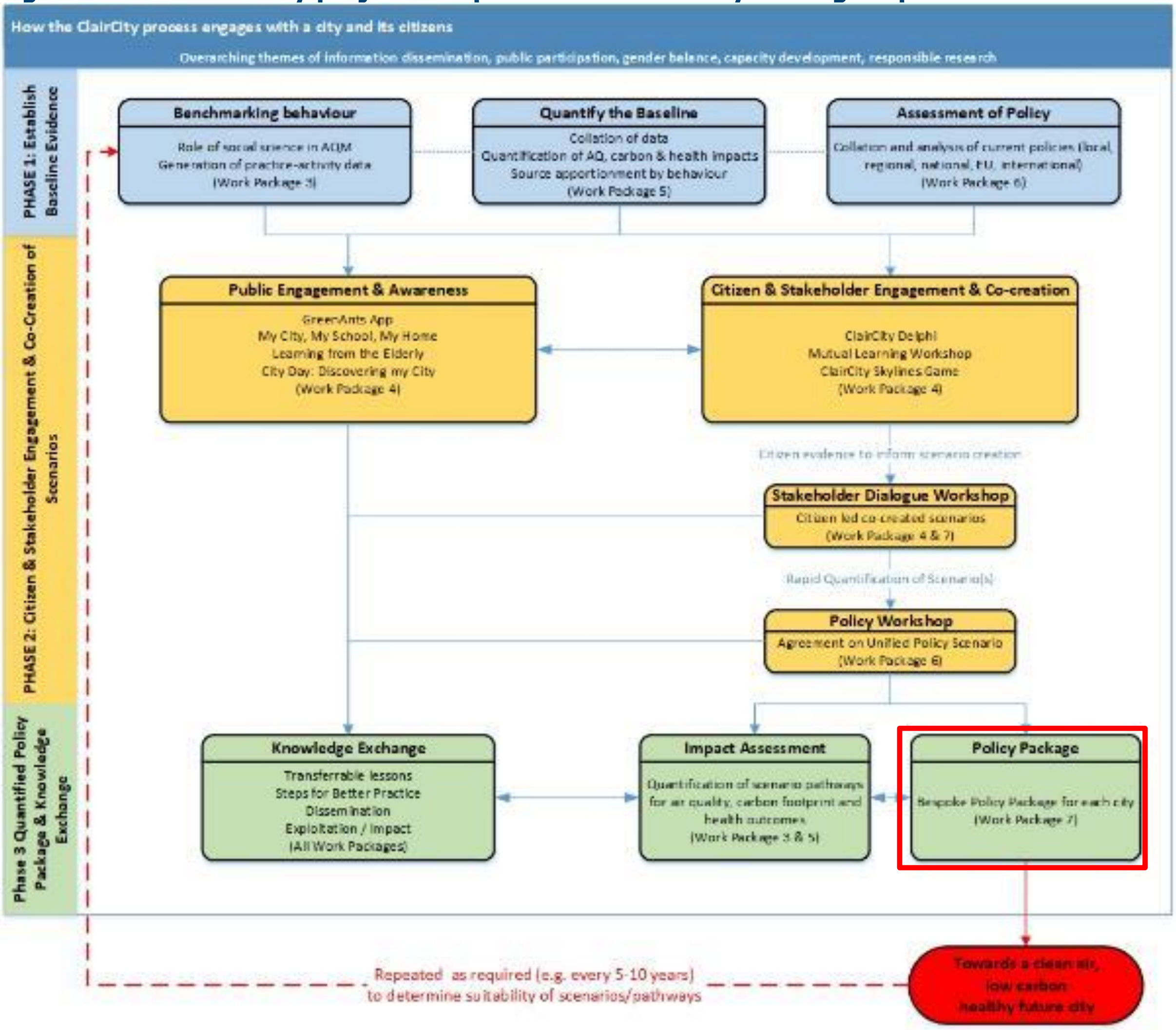
6. The GreenAnt App which allows citizens to become a citizen scientist and monitoring their transport activities, emission generation and exposure using mobile GPS data.
7. The School Competition: My City, My School, My Home engages young people in the air quality, carbon and public health debate utilising an online platform for the students to select the interventions that influence their housing, transport and use of resources in order to be able to design tools for change towards smart consumption, reduced emissions and healthy lifestyles.
8. Learning from the elderly filming activity engages the older, potentially vulnerable, community to talk about the changes in their city, their personal mobility and the steps they take to minimise their exposure to air pollution.
9. The City Day: Discovering my City helps disseminate the final project results and provide healthy and smart tips to promote non-motorised mobility of citizens by highlighting availability and benefits of walking and cycling routes in the city.

Phase 3: Quantified Policy Package & Knowledge Exchange

The primary aim of the final Phase 3 is to collate the evidence and lessons learned from Phase1 and Phase 2 to generate a quantified, bespoke, citizen-led and citizen-inclusive policy package for each city. Phase 3 is achieved with the following main activities:

1. **Knowledge Exchange**: Collation of transferrable lessons and steps for better practice based on the experiences of the ClairCity project to inform other environmental and public health practitioners (WP3, WP4, WP5, WP7).
2. **Impact Assessment**: Rapid quantification of the scenarios generated in the Stakeholder Dialogue Workshop (WP4) and detailed impact assessment of the final Unified Policy Scenario generated in the Policy Workshop (WP6). This quantification includes an assessment of the source apportionment by behaviour or purpose; air quality emissions and concentrations, carbon emissions, air pollution related health impact and interventions cost analysis (WP5).
3. **Policy Package**: Development of a bespoke Policy Package for each city drawing together the findings from across the whole project (WP7).

Figure A-1 The ClairCity project and position of the Policy Package report in detail



Annex B. The ClairCity citizen engagement and awareness process

The citizen engagement process developed by ClairCity consisted of policy focused activities and of awareness raising directed activities. In annex B-1 the former are discussed in some more detail, in annex B-2 the latter. For an even more comprehensive overview and analysis in addition the more detailed ClairCity reports on each activity can be consulted.

B.1 Policy related engagement activities

Three main engagement activities directly informed the policy workshop and the policy recommendations: the Mutual Learning Workshop, the Delphi process and the Skylines game.

Mutual Learning Workshop (MLW)

The MLW in Amsterdam was attended by 13 participants. The participants represented various departments of the Municipality of Amsterdam (health, energy, transport), the Netherlands National Institute for Public Health and the Environment (several citizen science experiments are being run by them), a biking association, an institute for art, science and technology working on smart citizen science experiments among others in Amsterdam, an organisation in support of the automobile manufacturing sector and an energy cooperation in Amsterdam.

Overall views of the participants were:

- They share the vision that improvements are needed regarding more public transport, more room for biking and stimulation of electrical private transport;
- Some believe that the city can become completely car-free within the city-ring;
- Many believe that individual transport will remain important, even with improved public transport;
- The city council in the discussion rather promoted central systems (district heating), whereas others believed in the possibilities of all-individual zero-energy houses;
- Also, the city council preferred in the discussion concrete measures over awareness raising;
- Participants do not believe that current government action will be sufficient to achieve targets;
- Overall the vision for the city is that of a very green, clean, pleasant city with very good network of public transport and only electric private transport.

As main barriers to future air quality and carbon policies, the participants identified the following:

- Large infrastructure (district heating) versus individual choice (individual zero energy housing): no solution provided
- Expertise from professionals in the built environment needed: skills of the construction sector

- No level playing field between sustainable and fossil technologies: taxing, financial incentives
- Mismatch between those who invest and those who profit: no solution provided
- Mismatch between interests on different governance levels (city want turbines, province doesn't allow): no solution provided

Delphi process

The Delphi process in Amsterdam consisted of two survey rounds followed by a Stakeholder Dialogue Workshop.

In total, 638 people responded to our survey in Amsterdam, out of a city population of 834,713[43]. The Amsterdam respondents were 55% male, which is slightly higher than the city gender ratio. Our respondents were disproportionately older compared to the city population, with 89% of respondents aged 37 or older in our Round 1 sample, compared to only 52% of the city population. Our sample was more educated (i.e. had higher level of qualifications) than average, with limited representation of those who had a low level of education compared to the categories used to collect city-wide data. In our sample, 67% of the respondents had a "high" level of education with only 5% having "no/low" level of eduation, compared to the city population where 47% have a "high" level, and 22% have a low level of education. In The Netherlands, categories are more relevant regarding the national identity rather than ethnicity of respondents. The "non-Dutch" population of Amsterdam is around 14% according to city statistics. In Round 1, 13% of our sample were non-Dutch nationals with 5% of the total coming from Western countries (Europe, North America, Japan etc) and 8% coming from other non-Western countries.

In Round 2, we had a predominantly male sample in Amsterdam with 57% of respondents identifying as male. As with Round 1, the respondents were disproportionately older with 76% of them over the age of 54, compared to only 23% of the city in this category. 73% of respondents had a high level of education, compared with 47% of the city as a whole. 91% of the respondents were Dutch nationals, compared to 86% of the Amsterdam population.

19 people living in Amsterdam joined the Stakeholder Dialogue Workshop – 11 women and 8 men. The age group was probably above the Amsterdam average although there were a few young people (a woman in the age range 16-24, three women in the age range 25-36 and a man in the age range 25-36). The group was rather homogeneous: all white and Dutch and concerned about air quality / environmental issues.

Skylines Game

ClairCity Skylines is a 'serious game', designed to capture citizen decision making about issues in their city, where players travel between areas representing a city's environment, economy and its citizen's health & satisfaction, collecting ideas for policies to enact to achieve a low carbon, clean air, healthy future before 2050 (Figures B-2 and B-3).

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[43] UrbiStat. Municipality of Amsterdam Statistics 2016, Avalable from https://ugeo.urbistat.com/AdminStat/en/nl/demografia/eta/amsterdam/23055764/4 Accessed on 3 October 2018.

Figure B-2: Google Play Store listing

Figure B-3: Six playable cities completed

Bristol was the first of the six partner cities to to be included in the game, and launched in April 2018. An updated, localised version of ClairCity Skylines was launched in Amsterdam following a significant database upgrade in November 2018 based on the findings of the Bristol pilot. The upgrade allowed the final 4 cities/regions to launch simultaneously in Ljubljana, Sosnowiec, Aveiro and Liguria in January 2019, with primary data capture closing at the end of March 2019. The game includes English, Dutch, Slovenian, Polish, Italian and Portuguese localisations for game text, UI and the policy database.

B.2 Awareness related engagement activities

Four activities in the ClairCity engagement process were mainly awareness related: the secondary school activities, the film competition for the elderly, the city day and the GreenAnts app. The GreenAnts app still has to be launched, but the other activities also indirectly informed the process towards the policy recommendations.

Film and schools competition

Reason for the focus on young people and the elderly is that ClairCity builds on the WHO Policy Framework and the European Commission's Clean Air Policy Package that promote public health by paying special attention to more vulnerable groups, such as children and senior citizens. The aim is to empower these citizens to better understand the specific challenges and opportunities that their city currently offers and to engage them into moving towards reduced air pollutant emissions and carbon footprints. The project has therefore collected their perceptions and ideas on sustainable lifestyles and a *'better quality of life'* within their city in the future.

Young people

ClairCity has run an activity targeting schoolchildren. The goal of the activity was to engage pupils in learning about air quality and carbon related issues. In Amsterdam, the school competition involved young people in secondary schools, aged 13-16.

For the Claircity school activity in the Netherlands, ClairCity visited two secondary schools in Leiden, a small city near Amsterdam. Like Amsterdam, Leiden is part of the Randstad Urban area. We did our school activity at two schools in Leiden, namely the Visser 't Hooft Lyceum and the Stedelijk Gymnasium. The school activity was done in four 4th grade pre-university[44] classes with a total of 92 students. Additionally, the school activity will still be held in four classes (5th grade) in a school in Almere on 13 December 2019, which is also in the Amsterdam Metropolitan area.

In order to make it attractive to the schools to participate in the school activity, we tailored the setup of the activity to the interests of the participating teachers and tried to connect it to topical themes in the curriculum. We found we could only get school's participating by using our personal networks. The curricula of the schools are already fully planned (including often themes like climate and pollution) and only based on personal contacts we could get the ClairCity activity accepted.

The main conclusion of the schools activity is that interest in climate and air quality in the classes that were visited seemed limited. In the classes, there was a shared general concern about in particular climate, but the underlying knowledge level was limited (although perhaps corresponding to this age of pupils). The willingness to change personal behaviour was found to be low – students do not see many possibilities for changing their own behaviours. Neither do they have very specific ideas about what should be done for change or what a 'better' future for them in practice would look like.

City Day

The ClairCity City Day took place on 19th June 2019 in Amsterdam. For this the ClairCity Amsterdam partnered up with a well-known event namely WeMakeThe.City (https://wemakethe.city/nl/) on liveable, sustainable, inclusive cities. WeMakeThe.City lasts three days and ClairCity participated in one of the days.

ClairCity was featured twice in the programme – the team gave two presentations as part of the blocks 'bike & city' and 'car-free city'. The presentations introduced the ClairCity project, explained the ClairCity process and stage thereof in Amsterdam, showcased outputs of the project – e.g. Skylines Game, videos with the elderly etc. This was complemented by an interactive session (using Kahoot) aiming to share knowledge and raise awareness on air quality related issues and facts.

[44] In the Dutch secondary school system, there are three tiers, where one tier 'VWO' prepares students for an academic education. All of the classes where we did the school activity were in this tier of pre-university education.

Figure B-3 Amsterdam City Day event (19 June 2019)

Elderly

ClairCity activities with the elderly focused on promoting non-motorised mobility of citizens in Amsterdam. The activity invited older citizens from the cities to tell about their experiences in short films and opinions with regards to walking and cycling in their city in order to demonstrate the health, environmental and social benefits of walking and cycling in the city.

The most important lesson drawn from organising the movie competition in Amsterdam is that the format that had been foreseen for the movie competition (elderly making their own videos and sending then to us) did not work in Amsterdam. Another potential mismatch concerned the main stakeholder engagement channels used (website, social media), which are the channels ClairCity typically uses to promote its work and events but do not reach out to the elderly.

Local residents participating in the ClairCity Amsterdam video project shared a range of thoughts and ideas:

- Many elderly in Amsterdam use public transport, bike or move around on foot;
- People are generally satisfied with public transport (bus, metro, tram) in Amsterdam, although there some concerns about bus stops that are being discontinued (with as result elderly people having to walk further to find a stop);
- The people who have a car mostly use it for specific occasions, e.g. transporting children to school or off-school activities, visits outside of Amsterdam or convenience rides (e.g. transporting large materials to a painting class), but less for commuting within the city.
- People feel that public transport has become busier compared to previously;
- Street works that hinder public transport are sometimes noted as a nuisance;
- Some elderly are less confident in cycling than before due to busy points in the city where different kinds of traffic come together; and the increasing frequency of mopeds, electric bikes and cargo bikes on cycling lanes;

- Mopeds in general are seen as an important problem, because of the noise and pollution but also because of the unsafety related to the large speed differences in bicycle lanes;
- A larger pedestrian zone is seen by some as contributing to cleaner air, but is not mentioned spontaneously as an important solution;
- Some people mentioned that E-bikes should be stimulated instead of mopeds, and suggest that due to the high speed they can reach, these should go on regular roads and not bicycle lanes.

GreenAnts App

GreenAnts is a system identifying how travelling impacts efficiency and wellbeing developed in ClairCity. It consists of:

1. GreenAnt – a smartphone application collecting information about travel patterns using GPS and motion sensors on the phone

2. ANTS - a web tool for analysing and presenting data, from investigated zones.

To use the system, it is necessary to register zones on the web tool named ANTS, where you want to collect data about how people travel. Users can assign themselves to the zone by downloading the GreenAnt smartphone app. When the user is within the zone, route and transportation data will be collected and later stored on the server.

At the moment of writing this report, the GreenAnts system in Amsterdam was not yet rolled out.

Annex C. Amsterdam citizen engagement impacts: scenarios and modelling

C.1 Overview of modelling activities

To understand the impact of the policies the citizens put forward, we assessed the impact of policies on emissions, air quality, health and costs in three steps:

1. Step 1: Reproduce the air quality situation as it is currently, in a modelling environment (“baseline”):
    a. First, estimate total emissions from different sources, in line with statistics (by sector, by time of day, link with behaviour);
    b. Second, model the air quality and validate the modeling ouput with with observations;
    c. Third, assess exposure and health impact with common indicators.
2. Step 2: Estimate future emissions in a scenario with existing policy measures and model the resulting air quality. This business-as-usual scenario (BAU Scenario) aims to capture the changes in air quality if no further measures are taken, only accounting for changes in the emissions due to policy measures made in the past and expected technological and/or behavioural changes.
3. Step 3: Estimate future emissions in a scenario with additional policy measures as aimed for by Amsterdam citizens and commented by Amsterdam policy makers (Unified Policy Scenario, or short UPS Scenario). We follow the same route, from estimating the impact of the measures on emissions, to air quality and health impact.

The three steps are explained in more detail in section C.2. Section C.3 gives further results from the behavioural modelling / source apportionment approach carried out with the data in order to relate air quality emissions and concentrations to citizens’ behavioural activities.

C.2 Results

The results of the modelling exercise consist of three parts:

- Results for the situation as it is in base year 2015 (baseline)
- Expected future without future action (BAU)
- Future with additional policy action (UPS)

C.2.1 Baseline

Assessment of air quality for the baseline (2015)

The second-generation Gaussian model URBAIR was setup and run at an urban scale for the computational domain over the urban area of Amsterdam. The baseline simulations were performed for the full-year using the meteorological vertical profiles from the WRF-CAMx system and the emissions available on the ClairCity emissions database.

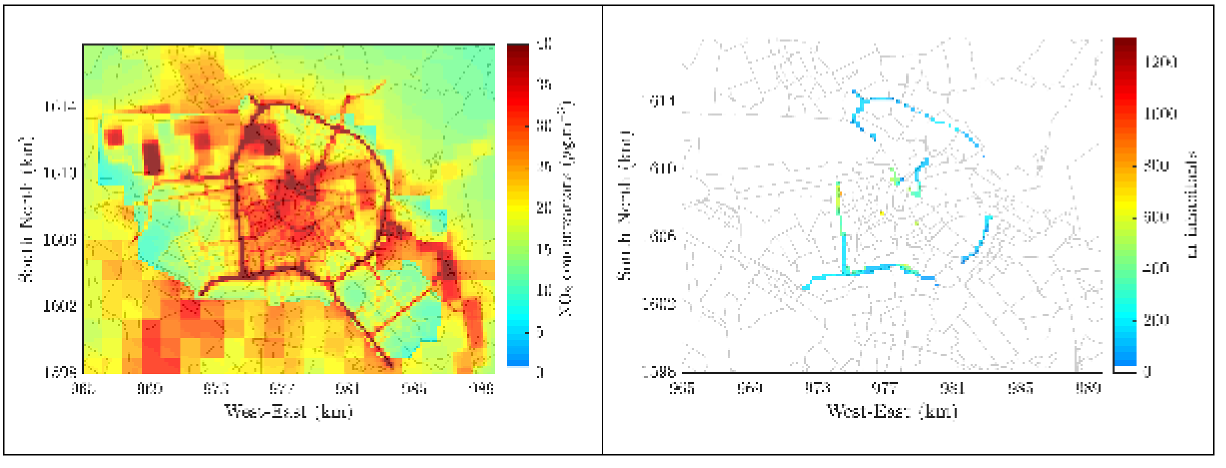
A preliminary comparison of the URBAIR outputs with the observations in Amsterdam pointed out a clear underestimation of the simulated concentrations. The underestimation of the simulation results is mainly associated with the lack of the other emission sources contributing to the concentrations within the area, as well as the background concentrations.

Therefore, a procedure was defined to account for the background concentrations and other remaining sources, following the background concentration maps for 2015 published by the National Institute for Public Health and the Environment of the Netherlands (RIVM; these maps are available on http://geodata.rivm.nl/gcn/). The background air pollution maps made available by RIVM are the total annual average concentrations based on modelled data on 1 km x 1 km grid squares. The background concentrations added for the NO2, PM10 and PM2.5 concentrations simulated with URBAIR model included the contributions from the following categories based on source apportionment data made available by GGD Amsterdam: foreign sources, aviation, rail traffic, agriculture, and waste processing.

The simulation results together with the added background concentrations were calibrated against the measurements[45] with this adjustment procedure. For NO_2 concentrations, a slope of 1.4 obtained from the linear regression is applied as a correction factor over all the domain, together with a unique correction factor applied to each cell with measurements available. In case of particulate matter, PM10 and PM2.5 concentrations, the slope obtained from the linear regression is equal to 3.2 for PM10 and 4.3 for PM2.5 concentrations.

Figure C-1 a) shows the resulting NO_2 annual average concentrations. Figure C-1 b) points out the population potentially exposed to NO_2 concentrations above the EU legal limit value of 40 µg.m^{-3}.

Figure C-1 NO_2 contour maps: a) annual average of NO_2 concentrations and b) number of inhabitants within the cells exceeding the EU annual limit value of 40 µg.m^{-3} in 2015



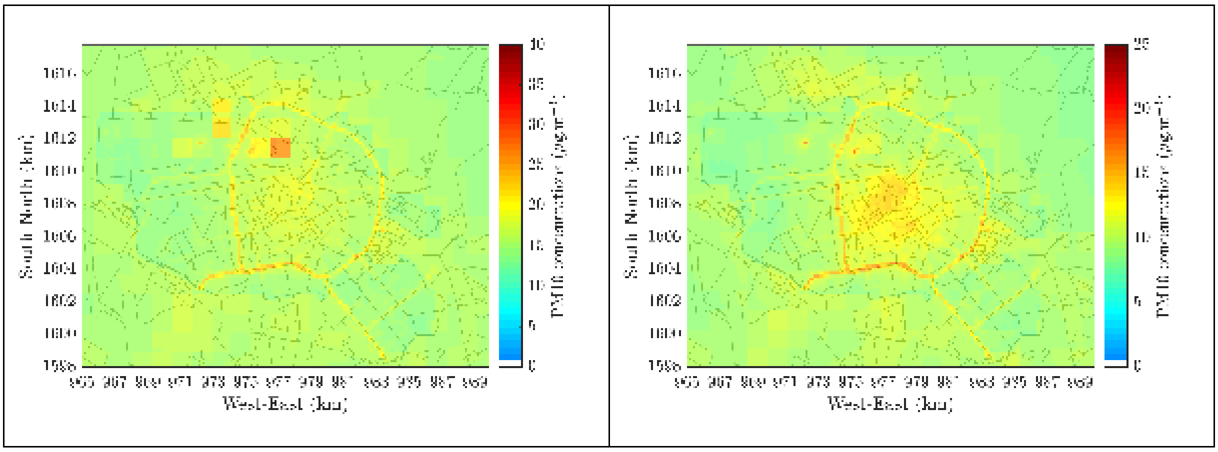
The simulation results indicate a maximum concentration of of 82.7 µg.m^{-3} within the urban area over the ring road/ highway A10, together with an hot-spot of concentrations from shipping sector. The EU annual legal limit value for NO_2 annual concentrations is exceeded

[45] The NO_2 observations available for 2015 include measurements from 100 diffusion tubes with valid measurements available: 44 classified as background sites; 51 classified as street sites; 3 classified as waterway sites; and 2 classified as highway sites. Besides the diffusion tubes, there was also data available from 16 continuous measurements for 2015: 5 road traffic sites, 7 urban background sites, 3 rural sites, and 1 industrial site. The PM10 observations available include measurements from 12 continuous sites: 4 road traffic sites, 4 background sites, 3 rural sites and 1 industrial site. PM2.5 observations available include measurements from 4 continuous sites, 3 urban background and 1 rural sites.

in 105 cells corresponding to 3% of the total population within the urban area potentially exposed to those concentrations.

Figure C-2 presents the PM_{10} annual average concentrations (Figure C-2 (a)) and the $PM_{2.5}$ annual average concentrations (Figure C-2 (b)).

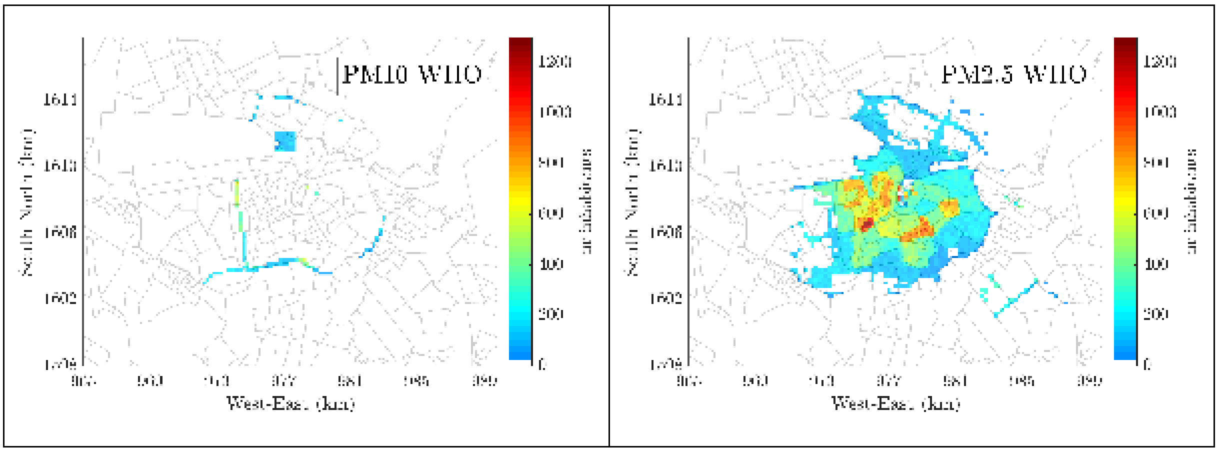
Figure C-2 (a) PM_{10} annual average concentrations and (b) $PM_{2.5}$ annual average concentrations in 2015



The maximum value of PM_{10} concentrations is equal to 26.4 µg.m $^{-3}$, which is simulated over the urban area: the hot-spots are recorded over the A10 ring road, the shipping docks, while the simulated maximum concentration of $PM_{2.5}$ is equal to 17.4 µg.m $^{-3}$. The PM concentration contour maps point out no exceedances to the EU legal limit values for PM_{10} and $PM_{2.5}$, equal to 40 µg.m $^{-3}$ and 25 µg.m $^{-3}$.

However, despite the compliance of the EU legal limit values for particulate matter concentrations, the annual concentrations indicate exceedances of the WHO guideline values. Figure C-3 a) shows 102 cells exceeding the WHO guideline value, which represents less than 1% of the population within the simulation area potentially affected by PM_{10} concentrations above the recommended value. For $PM_{2.5}$, 3455 cells of the simulation area are exceeding the WHO guideline values representing a risk to the inhabitants potentially exposed to those concentrations (Figure C-3 b).

Figure C-3 Number of inhabitants within the cells exceeding the WHO air quality guideline values: a) of 20 µg.m-3 for PM10 concentrations, and b) of 10 µg.m-3 for PM2.5 concentrations in 2015



B.2.2 BAU

BAU impacts on air quality

The substantial reductions of the NOx emissions in the BAU scenario will lead to significant reductions of the NO_2 concentrations. Figure C-5 presents as example the NO_2 annual average concentrations considering the impacts of BAU scenarios for 2025 and 2050. The maximum NO_2 concentration will be equal to 52.1 µg.m $^{-3}$ in 2025 and to 49.8 µg.m $^{-3}$ in 2050, corresponding to an overall reduction of the maximum concentration of 17% in 2050 when compared with the baseline year. In the BAU scenario, the NO_2 concentrations will still exceed the EU limits and WHO guidelines in 2050, showing exceedences in 10 cells of the domain.

Figure C-4 NO_2 annual average concentrations for the BAU scenarios: a) 2025 and b) 2050.

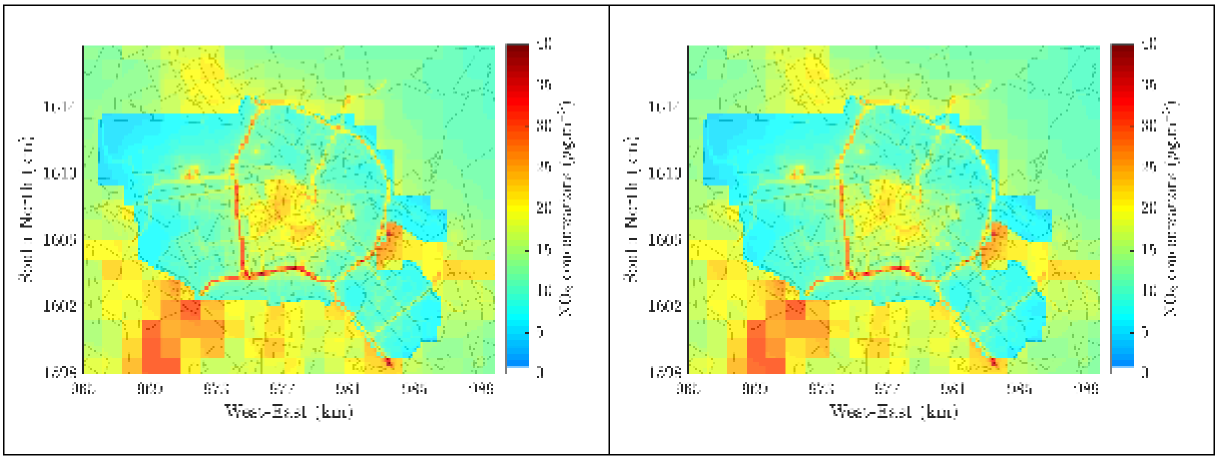
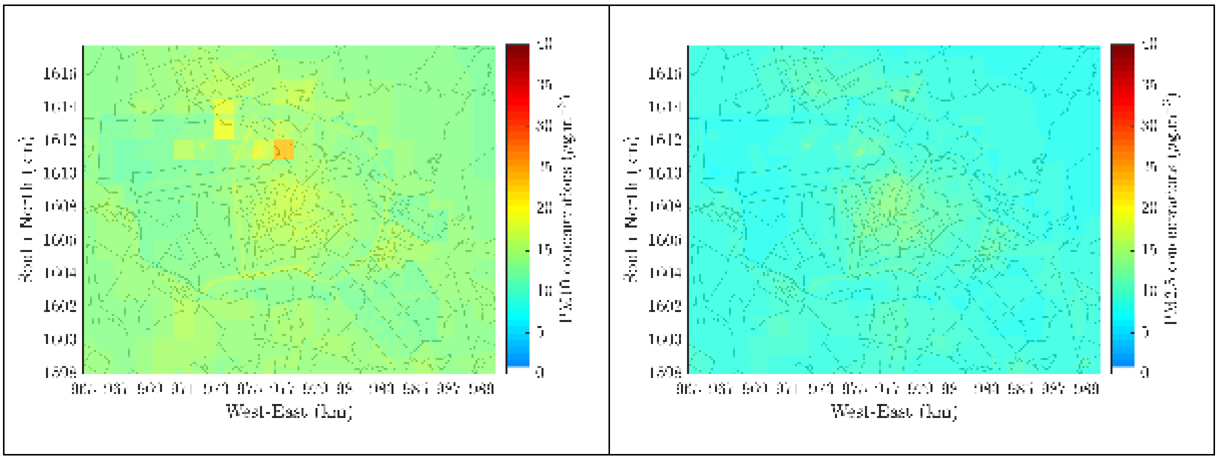


Figure C-4 (a) presents the PM_{10} annual average concentrations for 2050 and (b) the $PM_{2.5}$ annual average concentrations for the same year. The simulated maximum values of PM_{10} concentrations range from 24.7 to 23.4 µg.m $^{-3}$ between 2025 and 2050, while the simulated maximum concentration of $PM_{2.5}$ vary from 16.7 to 16.0 µg.m $^{-3}$. Therefore, the BAU scenarios will lead to the reduction of both PM_{10} and $PM_{2.5}$ concentrations showing compliance with EU limit values in 2025. However, for the WHO guideline values for PM_{10} there are still 66 cells exceeding this limit in 2025 and for $PM_{2.5}$ 2553 cells.

Figure C-5 Particulate matter annual average concentrations for the BAU scenario in 2050. a) PM_{10} and b) $PM_{2.5}$ concentrations



B.2.3 UPS

UPS impacts on air quality

The significant reductions of the NOx emissions in the UPS scenario comparing with the BAU scenarios will lead to even more significant reductions of the NO_2 concentrations. Figure C-6 shows for example the NO_2 annual average concentrations considering the impacts of UPS scenarios for 2025 and 2050. In 2025 the maximum NO_2 concentration will be equal to 48.4 µg.m^{-3} and in 2050 equal to 38.8 µg.m^{-3}, showing no grid cell exceeding the legal limit value in 2050. Comparing UPS and BAU scenario, the maximum concentrations will be at 29% and 17% compared to 2015.

Figure C-6 NO_2 annual average concentrations for the UPS scenarios: a) 2025 and b) 2050.

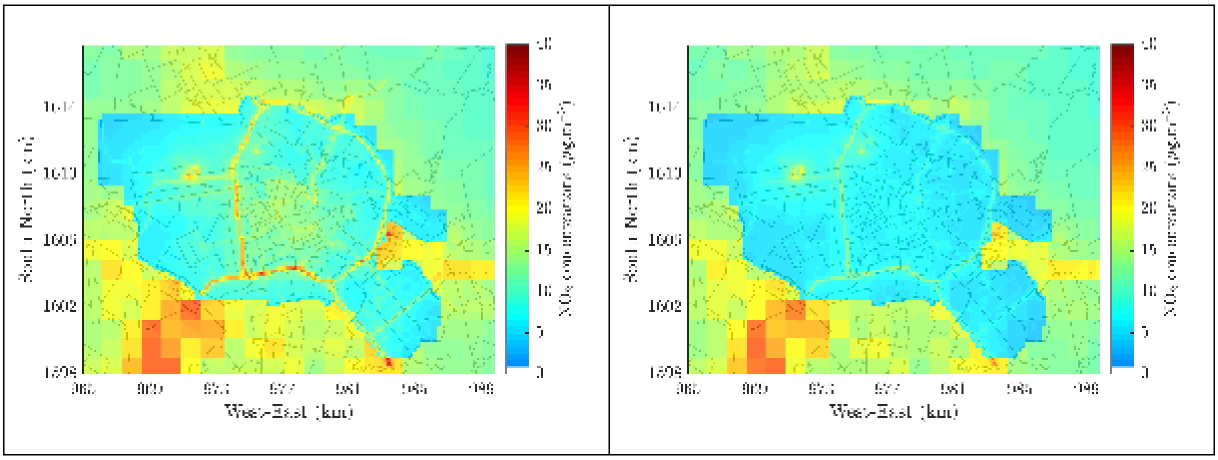


Figure C-7 presents the UPS PM_{10} annual average concentrations (a) in 2025 and (b) in 2050. For PM_{10}, in 2025 the maximum value corresponds to 24.3 µg.m^{-3} and 22.8 µg.m^{-3} in 2050. This means that there are no exceedances of the EU limit values, but the WHO guideline values were exceeded in 41 grid cells in 2025 and in 38 cells in 2050. Compared to the BAU scenario, the UPS scenario will reduce the maximum concentrations by a further 2 and 3% in 2025 and 2050.

Figure C-7 PM10 annual average concentrations for the UPS scenario: a) in 2025 and b) in 2050.

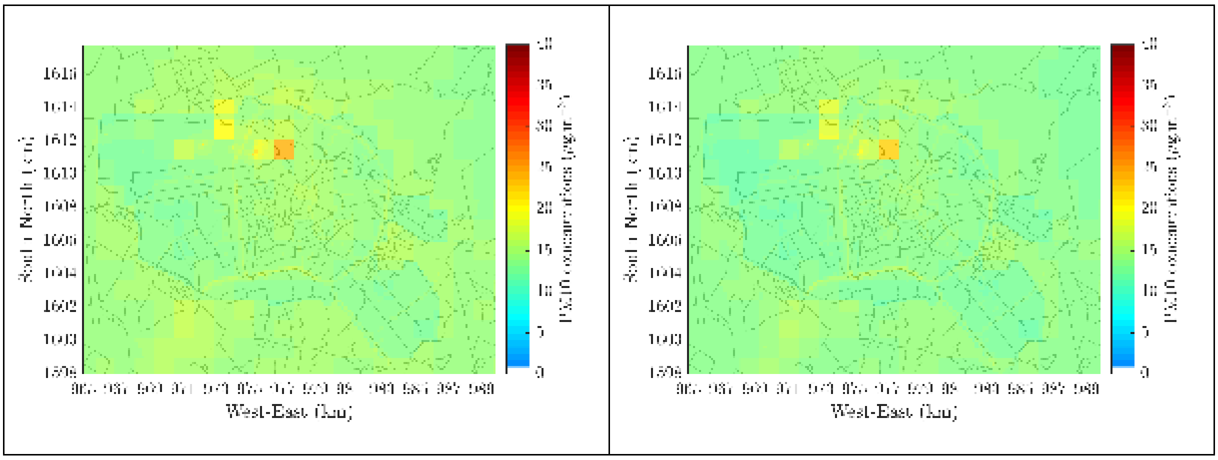
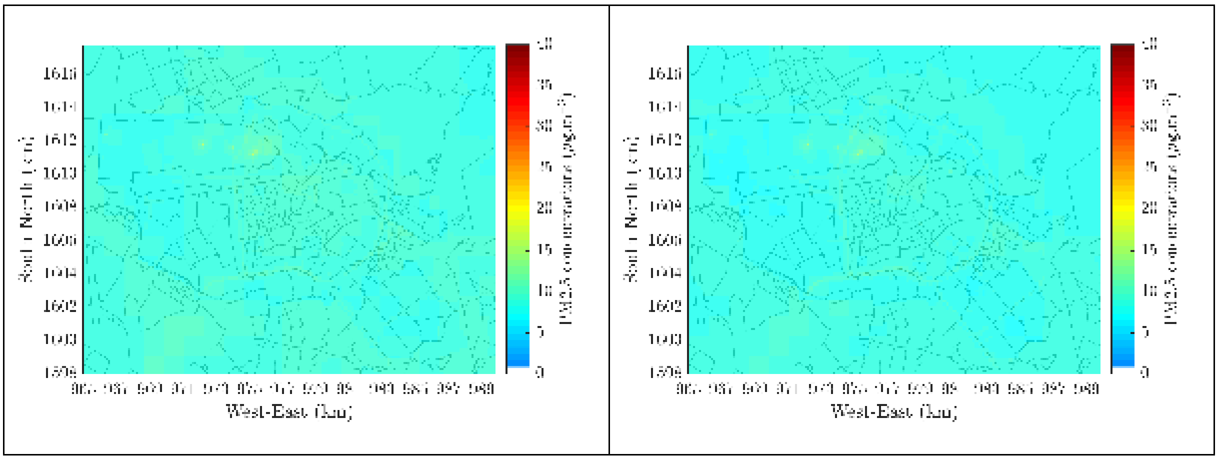


Figure C-8 presents the $PM_{2.5}$ annual average concentrations in the UPS scenario (a) in 2025 and (b) in 2050. For $PM_{2.5}$, in 2025 the maximum value corresponds to 16.2 µg.m $^{-3}$ and 15.5 µg.m $^{-3}$ in 2050, translating into a further 3.4% reduction of the maximum concentration compared to BAU. Based on the WHO guidelines in 2025, 158 cells show exceedences, and by 2050 this number is reduced to 46 cells. The UPS will reduce the maximum concentrations by a further 3 and 3.4% in 2025 and 2050 as compared to BAU.

Figure C-8 PM2.5 annual average concentrations for the UPS scenario: a) in 2025 and b) in 2050.



UPS impacts on health

To illustrate the health benefits related to the air pollution reduction scenario, the following health impact indicators were calculated for different air pollutants: i) number of premature deaths and ii) years of life lost (YLL). Premature mortality is a standard measure of the burden of the population’s health as it is expected that most deaths are preventable before a person reaches an expected age. YLL is defined as the years of potential life lost due to premature deaths. Since YLL take into account the age at which deaths occur, relative to life expectancy, a greater weight is given to deaths at a younger age than at an older age. Life expectancy can also be differentiated by country and sex (de Leeuw and Horálek, 2016)[46].

The burden of disease associated with ambient air pollution is estimated by relating air concentrations to health outcomes. Gridded annual averages were used as input to quantify the relative risk in a population, based on concentration-response functions (CRF). CRFs reflect the effect of a pollutant on a health outcome, e.g., NO_2 on mortality from cardiopulmonary diseases. Relative risk is based on epidemiological studies and is expressed as the increase in incidence or prevalence per unit increase in concentration. The risk ratios used in this work are described in Table C-1. This table also oulines the mortality causes, age interval, and concentration threshold consider when calculating the health outcomes for each air pollutant. The threshold concentration is the concentration level below which no health effects are expected.

Table C-1 Risk ratios (RR) for mortality

Pollutant	Value [per 10 µg/m^3]	Type	Reference
$PM_{2.5}$	RR 1.062 (95 % CI 1.040-1.083) No threshold	All-cause (natural) mortality in ages above 30 (ICD-10 codes A00-R99).	WHO 2013a[47]
PM_{10}	RR 1.04 (95% CI, 1-1.09) No threshold	All-cause (natural) mortality in ages above 30 (ICD-10 codes A00-R99).	Beelen et al., 2014[48]
NO_2	RR 1.055 (95 % CI 1.031-1.08%) Threshold: 10 µg/m^3	All-cause (natural) mortality in ages above 30 (ICD-10 codes A00-R99).	WHO 2013a

Premature deaths can be estimated at grid-cell level by multiplying the population attributable fraction (PAF), crude death rate (CDR) broken down by age and sex, and total population within the grid cell and summing over all ages and sex pairs. PAF is defined as the reduction in population mortality if exposure to a risk factor were reduced to an ideal exposure scenario (e.g. concentrations equal to zero). PAF can be calculated from the relative risk, assuming a linear behavior linear approach. CDRs by age, for 5-year age groups (all ages above 30), and by sex, were calculated from natural all-cause mortality in 2015 (ICD codes A00-R99) and total population, both at country level[49]. It is assumed that CDRs is constant throughout the country population. YLL are calculated at grid cell level by multiplying premature deaths with life expectancy by age and sex. Life expectancy data is based on data published by the UN.[50] The expected burden of disease attributable to air pollution in one specific area can finally be estimated by summing over all grid cells in the area of interest for the indicator of interest. Reductions are subsequently calculated for each of the scenarios by benchmarking against the baseline scenario (2015) results.

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[46] de Leeuw, F. & Horalek, J. 2016. Quantifying the health impacts of ambient air pollution: methodology and input data. European Topic Centre on Air Pollution and Climate Change Mitigation.
[47] WHO 2013a. Health risks of air pollution in Europe - HRAPIE project. Recommendations for concentration-response functions for cost-benefit analysis of particulate matter, ozone and nitrogen dioxide. Copenhagen, Denmark.
[48] Beelen et al. 2014. Effects of long-term exposure to air pollution on natural-cause mortality: an analysis of 22 European cohorts within the multicentre ESCAPE project. The Lancet 383 pp 785-795
[49] Population data available here: https://population.un.org/wpp/Download/Standard/Population/ Tables F15-2 and F15-3; mortality data available here: http://apps.who.int/healthinfo/statistics/mortality/causeofdeath_query/start.php
[50] Life expectancy at exact age and average age at death is available here: https://population.un.org/wpp/Download/Standard/Mortality/ Tables F16-2, F16-3, F17-2 and F17-3

UPS impacts on costs

For the assessment of costs, we used 3 indicators:

1. The car user cost: to what extend does the cost to drive a car changes relatively over time in the BAU as well as under influence of the scenarios;

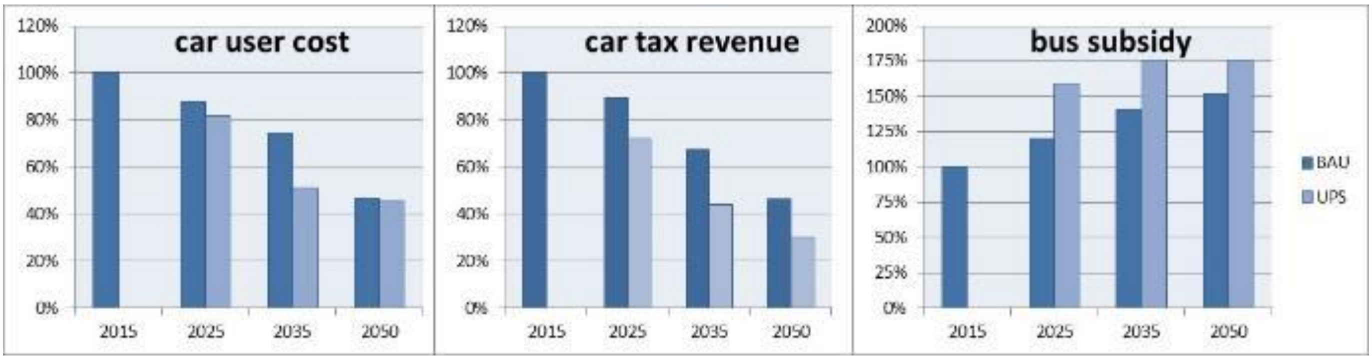
2. The government tax revenue from car transport, combing fuel excises, registration taxes as well as any levy's (e.g. cordon charge);

3. The government expenditure on public transport, i.e. bus subsidies.

The indicators on tax revenue or subsidy expenditure do not distinguish between different types of government (local, regional, national).

With these indicators, we assessed qualitatively the likely costs of measures for citizens, government and society at large. Costs for society were assumed to be the net sum of citizen and government costs. The cost estimations have to be seen as order-of-magnitude estimations only, as the real costs until 2050 will depend on many variables that were not included in the ClairCity modelling. Figure C-9 gives an overview of these order of magnitude costs of the UPS scenario compared to the BAU scenario. The figures only take into account direct costs and benefits, not indirect benefits as a result of e.g. health improvement of citizens.

Figure C-9 trends of user cost (left), government tax revenue (middle) and bus subsidy (right) in the Amsterdam BAU and UPS scenario



Car user cost

The car private user cost is expected to decrease over time in the BAU. The cost decrease over time, in the BAU, is due to the combination of the cost benefit of more fuel efficient cars (fuel savings offset the higher purchase cost) as well as the uptake of electric vehicles (EVs) that are becoming ever cheaper in the future, reflected in the strong decrease of user cost in 2050 due to massive uptake of EVs. The cost decrease particularly manifests from 2035 onwards.

The car private user cost in the UPS only drops significantly to the BAU in 2035. We have assumed a stronger EV-uptake scenario in the UPS compared to the BAU, as a consequence of the (strengthened) environmental zone, which will push consumers earlier towards EVs, at a time when EVs are already expected to be cheaper in resource cost and taxation compared to conventional cars. The effect diminishes by 2050 as already in the BAU EV adoption rates will be high by 2050. The other cost effect of the increased parking tickets is expected to be low (+/- 10% increase compared to the BAU).

Car tax revenues

The tax revenue decreases in the BAU. This decrease follows the lower tax revenue from electric vehicles as the fleet gradually electrifies. Under current assumptions, the taxation of EVs is limited and as EVs enter the fleet, government revenue from taxing cars on average will shrink. Clearly, this has to change over time as the decreasing tax revenue of excise duties on diesel and petrol will become an issue public authorities. However, in the ClairCity simulation, we have kept the taxation levels constant as the loss of tax revenue is more of a concern to central governments, as the bulk of the revenue is collected at national level (fuel excise, registration/circulation taxes,…).

The tax revenues from increased parking revenues add to the overall government revenue but are insufficient to offset the lack of taxation of EVs.

Bus subsidies

Bus subsidy are left unchanged, both in the BAU and the UPS, yet additional supply in the UPS (higher density and higher frequency) leads to a higher use of public transport and thus increases the required subsidies. Assuming no changes to the level of cost coverage, required subsidy follows the total demand of public transport, resulting in a gradual increase of 52% in the BAU and 79% in the UPS by 2050.

Costs of other measures

Regarding the cost impacts of investments (e.g. in cycling infrastructure), we assume these come at the expense of other investments and are phased in gradually. They will thus lead to a shift in existing (investment) expenditure rather than to new investments. To estimate costs, the measures would have to be described in more detail, with a full investment plan including suspended investments to compensate for the costs made. This was considered outside of the scope of the exploratory ClairCity modelling.

C.3 Behavioural modelling / source apportionment

A fine granular dataset of road transport emissions was generated that allowed source apportionment not only at the typical level of mode choice (e.g. car, bus, taxi, cycling, walking etc) but also the underlying behaviour or motive (e.g. shopping, commuting, leisure etc) and socio-economic properties of the people travelling (e.g. gender, age, income etc). The scientifically robust yet flexible methodology is designed to allow it to use different types of public datasets, which can be applied to different cities in similar fashion. The methodology had two primary steps:

1. A simple traffic demand generation and assignment algorithm to establish traffic flows at link level to calcuate total emissions; and
2. Merging the emission dataset from step 1 with travel survey data holding information on the underlying motives and socio-economic properties of travellers of individual trips.

C.2.1 Step 1: Traffic Demand Generation

The first step is to develop emissions at link level. This is done with the following sequential steps:

1. **Establishing a noded network of the city**. We use OpenStreetMaps (OSM) to establish the network. OSM holds all details necessary for traffic assignment including: road type (residential, regional, highway) number of lanes, directions, speed limits, etc. We developed a Matlab script to convert the OSM map to a simple network
2. **Generation of transport demand from land use information to an origin-destination table**. We use a generalised approach focusing on peak travel demand that allows different data-sources for land-use. OSM in itself is a potential source we have tested, but for the case of Bristol we've used land-use information of UrbanAtlas
3. **Assigning demand on the network to generate traffic at link level**. We use a static assignment and generic assumptions on trips distance and flexible assumptions on preferences for different types of road insofar as they are available from [Step 1]
4. **Calibrate the traffic demand with a limited amount of counting points**. The traffic generation form [Step 2] is highly uncertain and is to be scaled in such a way that the resulting traffic demand at link level corresponds to measurements. The amount of counting data available, determines the quality of the traffic demand estimation
5. **We multiply the traffic demand with common emission factors**. The emission factors are derived from the publicly available COPERT V methodology, taking into account the fleet composition (age, fuel type, EURO-standard etc.) at country level.[51]

C.2.2 Step 2: Linking to Travel Survey Data

In the second step, we link the traffic demand data with travel survey data to further break down the emissions by motive. Travel survey data typically hold detailed information about travel behavior, combining information of the individual as well as information of the trip. In this particular case, we have travel data at:

1. The individual scale
    a. Income group (3 groups)
    b. Age group (5 groups)
    c. Gender
    d. Car ownership (0, 1, more)
2. The trip-scale
    a. Transport mode (bicycle, bus, car, motor, taxi, train, walk)
    b. Trip motive (Business, commute, education, leisure, other escort, personal business, shopping, other)
    c. Time of day (morning, midday, evening, night) as well as day type (weekday, weekend)

The data fusion focusses on the matching trip distances observed from the travel survey data, which only holds a sample of all trips with the estimated traffic demand from estimated transport volumes (and emissions) at link level. This fusion results in a dataset that allows us to understand the underlying source of the emission by properties of the citizen (age, income, sex) as well as the behavioral element (trip motive).

The trip motive / citizen behaviour activity definitions are taken from the UK National Travel Survey (HM Government, 2018). These are defined as:

[51] Initial estimates used fleet at local level but revealed a similar fleet composition at country level, so we opt for country level fleet composition as typically more data is available at country level compared to city level.

- **Commuting**: trips to a usual place of work from home, or from work to home;
- **Business**: personal trips in course of work, including a trip in course of work back to work. This includes all work trips by people with no usual place of work (e.g. site workers) and those who work at or from home;
- **Other**: trips to work from a place other than home or in course of work, e.g. coming back to work from going to the shops during a lunch break. In most tables this is included with 'personal business';
- **Education**: trips to school or college, etc. by full time students, students on day-release and part time students following vocational courses;
- **Shopping**: all trips to shops or from shops to home, even if there was no intention to buy;
- **Personal business:** visits to services, e.g. hairdressers, launderettes, dry-cleaners, betting shops, solicitors, banks, estate agents, libraries, churches; or for medical consultations or treatment; or for eating and drinking, unless the main purpose was entertainment or social;
- **Leisure**: visits to meet friends, relatives, or acquaintances, both at someone’s home or at a pub, restaurant, etc.; all types of entertainment or sport, clubs, and voluntary work, non-vocational evening classes, political meetings, etc.;
- **Escort**: used when the traveller has no purpose of his or her own, other than to escort or accompany another person; for example, taking a child to school. 'Escort commuting' is escorting or accompanying someone from home to work or from work to home. Similarly, other escort purposes are related to the purpose of the person being escorted.

ClairCity: Citizen-led air pollution reduction in cities

D7.5 Final City Policy Package – Ljubljana

April 2020

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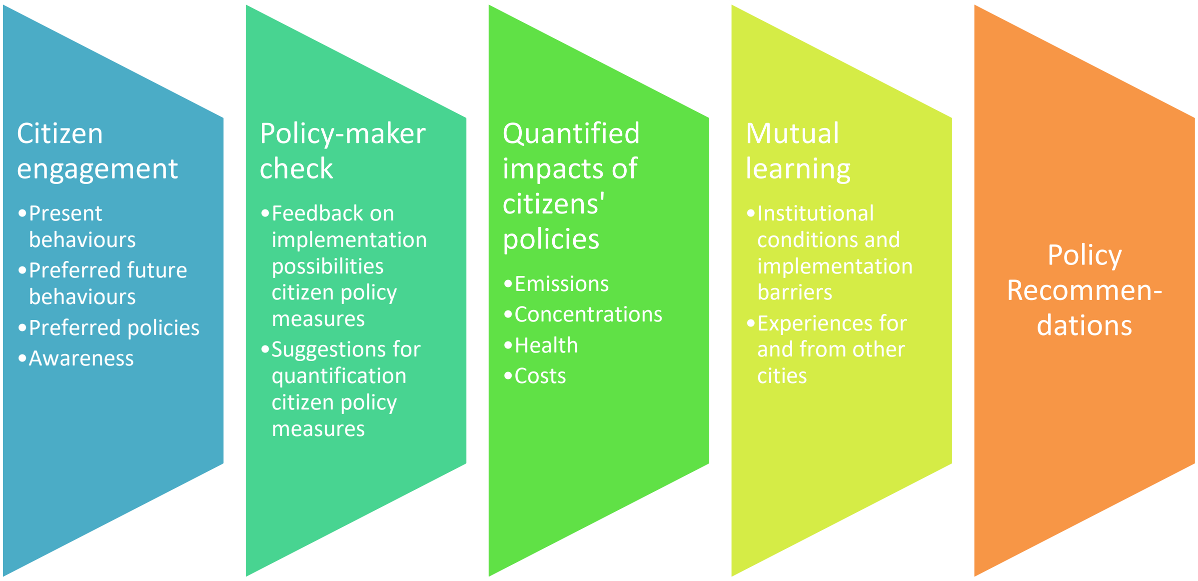
Contents

Executive Summary

ClairCity project and method

The ClairCity Horizon2020 project aims to contribute to citizen-inclusive air quality and carbon policy making in middle-sized European cities. It does so by investigating citizens' current behaviours as well as their preferred future behaviours and policy measures in six European cities[1] through an extensive citizen and stakeholder engagement process. The project also models the possible future impacts of citizens' policy preferences and examines implementation possibilities for these measures in the light of the existing institutional contexts in each city (Figure 0-1). **This report summarises the main policy results for Ljubljana.**

Figure 0-1: The ClairCity policy method in brief



The methodological understanding as developed in the ClairCity project of what citizen-inclusive policy-making is, and what it should and should not comprise, is given in Textbox 0-1.

Textbox 0-1 Citizen-inclusive policy-making according to ClairCity

- Tailor local policies based on detailed knowledge of behavioural practices of citizens;
- Engage with citizens via a diversity of methods, paying particular attention to hearing the voice of 'hard-to-reach' groups;

[1] Bristol, Amsterdam, Sosnowiec, Ljubljana,Aveiro/CIRA region, Genoa/Liguria region

- Ask citizens for their preferred future behaviours and barriers to behavioural changes. Address the perceived barriers of citizens by concrete measures or initiate dialogue with citizens about misconceptions concerning air quality and climate change;
- Ask citizens for their preferred future policies for the city, examine potential impacts of these policies and discuss with stakeholders and policy makers their implementation possibilities;
- Examine and address potential implementation barriers for preferred citizen policy measures beyond citizen perceptions;
- Experiment, and exchange experiences with other cities that are also aiming to implement citizen-inclusive policies;
- Do not confuse citizen-inclusive policies with populist policies. Take full responsibility for democratically implementing popular or unpopular measures considered appropriate, after having been extensively informed about citizens' views and behaviours.

In total, during the period 2017 – 2019 some 250 Ljubljana citizens were reached by the various ClairCity citizen engagement methods (Table 0-1). This is a limited sample, also compared to the other ClairCity cities and it is not fully representative of the Ljubljana population as a whole[2]. Nevertheless, it gives an indication of support for policy measures and intentions for behavioural change of Ljubljana citizens that can be used by policy makers to inform future policies.

Table 0-1: Number of participants in ClairCity citizen engagement methods in Ljubljana

Citizen engagement activity	# of participants engaged
Delphi Process	199
Skylines Game	24
Mutual Learning Workshop	16
Stakeholder Dialogue Workshop (in Delphi process)	26
Policy Workshop*)	12

*) the number of participants of the policy workshop is also included here, despite not being formally part of the citizen and stakeholder engagement process

[2] In Ljubljana, we received 199 responses out of a city population of 280,210. 58% of our respondents were female. In Ljubljana, we have an under-representation of the oldest and youngest categories, with more than two thirds of respondents aged 25-50 compared to 38% in this category in the city as a whole. Our respondents are highly educated, with 65% holding a university education compared to only 24% of the city population. A third of Ljubljana residents have vocational education qualifications, but only 1% of our survey respondents have this. In Slovenia the national or cultural identities of citizens is a politically charged topic due to the histories of Former Yugoslavian populations. As a consequence for ethical reasons we have not used nationality or ethnicity as a demographic identifier for population sampling in Ljubljana.
The majority of respondents were female, making up 68% of the Round 2 respondents. The 37-50 age category were a disproportionate set in our data, at 51% compared to only 24% of the total population. This was at the cost of older people, with only 3% of our Round 2 sample over 65, compared to 15% of the city. The data also represents the highly educated more than the average citizens, with 85% holding some form of higher education certificate, compared to only 31% of the general population.

Conclusions and recommendations for Ljubljana

The main conclusions and recommendations from the ClairCity project for citizen-inclusive policy making in Ljubljana are:

Current air quality and carbon situation in Ljubljana

- **The main air quality issue related to citizens seems PM and biomass burning outside the city, although NO_2 might be also still an issue for the future.**

  Ljubljana has initiated a large number of environmental measures over the last decades, with as most prominent measure the introduction of a large pedestrian zone in the city centre. Particulate matter emissions and resulting concentrations, to a large extent caused by biomass burning outside the city, are noted as a main air quality problem. This holds in particular when comparing concentrations to the much stricter WHO guideline values and more for $PM_{2.5}$ than for PM_{10}. However, ClairCity modelling suggests that also NOx emissions and resulting NO2 concentrations at some hotspots could be an issue when comparing them to legal limit values.

Current behaviours of Ljubljana citizens

- **Current transport behaviour of Ljubljana citizens is already quite environmentally friendly, with shopping as the least environmentally friendly transport activity**

  Of the ClairCity respondents, 42% currently uses only their private car for shopping, compared to 23 and 16% for commuting and leisure. Also, a much smaller number (32%) presently only uses public transport and active travel for shopping, compared to 65% for commuting and 54% for leisure.

Behavioural preferences of Ljubljana citizens for the future

- **Comparing stated intentions of respondents for behavioural change with the policy ambition of the city council to achieve 2/3 active transport, suggests that this could be in line with citizens' intentions for commuting and leisure, but for shopping behaviour achieving the policy target might be more difficult.**

  When asking respondents for their behavioural preferences in the future, 77% indicated preferring to use only public and active transport for commuting in the future, 70% did so for leisure and 60% for shopping transport needs. Equally, of the respondents 4% indicated wanting to use only their private car for commuting, 9% did so for leisure and 20% for shopping.

- **While expansion of district-heating is an option that could contribute to reducing air pollution in the future, the expansion of district-heating does not seem popular with respondents.**

District heating can be an environmentally friendly option for the heating of private homes, provided that the heat is generated for instance from renewables or waste heat from industry. 32% of the ClairCity respondents indicated to be currently connected to the district-heating system, but only 16% wanted to use district-heating in the future.

Policy preferences of Ljubljana citizens for the future

- **Expansion of cycling lanes in streets at the cost of space for motorised traffic seems controversial.**

  Out of the selected most popular policy measures of citizens for their city in the future, the expansion and the scrapping of cycling lanes showed to be almost equally popular with respondents.

- **The impacts of citizen policy measures as compared to a business-as-usual policy scenario for Ljubljana are small due to the nature of the finally selected measures and ambition levels finally selected by policy makers.**

  Policy makers had a relatively large influence on the impacts of the citizen policy measures compared to other ClairCity cities. Firstly, input measures for the policy workshop were limited to transport measures only, giving an indication where current policy priorities in Ljubljana are. Secondly, policy makers in Ljubljana, contrary to many of the other ClairCity cities, selected low or medium ambition levels for many of the measures preferred by citizens.

- **Costs of policy measures are a key concern to Ljubljana policy makers.**

  The main reason for selecting low or medium ambition levels for preferred measures of citizens given by policy makers are the concerns about costs, as the infrastructural measures preferred by citizens would often incur high costs. Impacts of citizen policy preferences

Institutional conditions and barriers for implementation of citizen policies

- **The integration of local policy measures with the region needs attention**

  The urban area of Ljubljana is surrounded by mostly rural areas. Integration of policy measures with those in the region is therefore a key issue, for instance to integrate regional with urban public transport (bus and train) and to address mostly rural biomass burning – next to industrial background emissions - that impact air quality in the city.

- **Civil society and NGOs need to be fostered**

  In Ljubljana, the mayor is in office for many years and was re-elected several times. In this situation, civil society and NGOs indicate that it is sometimes difficult to make their voices heard. Hence, care has to be taken that also citizen inputs given through these channels remain to be considered in policy decisions taken.

The ClairCity Ljubljana Action Plan

For citizen-inclusive city air quality and carbon policies.

- **Address in particular shopping behaviour, next to other transport behaviours**
  Since shopping behaviour from the ClairCity research appears a main area where behavioural change towards public and active transport is difficult for citizens, a specific campaign could be directed at facilitating non-car shopping transport, e.g. by promoting (electrical) transport bikes, public transport rebates provided by shopping centres and increasing parking fees in shopping areas. Also, home delivery by electric vans could be stimulated.

- **Make citizens aware of the advantages of district heating to combine with renewables**
  Increasing awareness of the positive environmental aspects of district heating – if realised with renewables, waste heat from industry or geothermal heat sources – could make citizens easier accept a switch to this heat source.

- **Discuss the impacts of cycling lanes with citizens**
  Increasing the number of cycling lanes seems controversial with Ljubljana citizens, as it will decrease road space for cars. While this is an intended effect in order to stimulate modal shift from private cars to bikes, it could be investigated where specific hotspots are that are particularly controversial and it could be discussed with citizens what are the intended impacts of the cycling lanes and why.

- **Increase measuring and modelling facilities in Ljubljana, for instance by stimulating citizen science measurements**
  Stimulating citizen science measurements of air quality is a cheap way of increasing the number of measuring spots in the city, that simultaneously increases awareness of citizens of live air quality conditions. Several other cities in Europe, including ClairCity cities Amsterdam and Bristol, are already experimenting with such approaches.

- **Integrate policy measures with those in the regions bordering to Ljubljana and disseminate the successes of the Ljubljana approaches**
  Integration of regional and urban public transport could for instance be studied from the Bristol Metrobus system. A systematic study of integration approaches throughout Europe and their applicability to Ljubljana could be made.

- **Show live air quality conditions in the city in order to increase awareness of citizens of the health benefits of clean air**
  ClairCity city Sosnowiec has integrated live air quality information into the public transport timetable information system. Amsterdam is experimenting with an approach that expresses health benefits of clean air in the reduction of number of sigarettes smoked per year. Similar approaches could be applied in Ljubljana, on top of the approaches already applied in the city, such as the ‘Cyanometer’ art sculpture in the city, that gives an indication of air quality in the city in an artistic way.

- **Communicate successes of the ‘European approach’ in Ljubljana to other cities**
  Ljubljana has been very successful over the last years to attract European projects that contributed to greening the city. Ljubljana also has been ‘European Green Capital’ in 2016. The lessons and successes of this approach could be communicated more extensively to other cities in order to strengthen mutual relationships, which in turn could be used further to attract new European projects.

- **Investigate success stories of integration of train transport in the overall transport system in other countries and regions**
  Expansion of train transport is a particular area of interest in Ljubljana. Other ClairCity cities already have extensive experience with integration of train and active transport, for instance Amsterdam.

- **Make sure that voices of civil society and opposition remain to be heard and discussed**
  Existing exchanges between policy makers and civil society should be fostered and could from time to time be rechecked if they fulfill their purpose for both sides.

1 The ClairCity project

This chapter provides the context for the ClairCity project (section 1.1) and introduces its objectives (section 1.2). It also gives a reading guide for this report (section 1.3).

1.1 Introduction

In 2015, the Paris climate agreement set the goal to reduce global greenhouse gas emissions to a level keeping a global temperature rise this century well below 2 degrees Celsius above pre-industrial levels and to pursue efforts to limit the temperature increase even further to 1.5 degrees Celsius[3]. A similar binding agreement for global air quality is lacking, but in 2005 the World Health Organisation formulated guidelines for ambient air quality aiming to improve health and reduce premature death caused by air pollution throughout the world. In 2016, 91% of the world population was living in places where the WHO air quality guidelines levels were not met.[4] Many countries and the European Union have set national air quality targets that are often not as ambitious as the WHO guideline values, but still set a legally binding framework for emission and concentration reductions of air pollutants.

Cities are main contributors to the emissions of greenhouse gases and air pollutants. Recognizing their responsibilities, on top of their legal obligations many cities have set stricter voluntary local goals for emission reductions of greenhouse gases and air pollutants. Improving air quality and reducing carbon emissions as a contribution to the global, national and local targets and ambitions set therefore will be a huge challenge for cities all over the world in the years to come.

Citizens living in these cities do not only cause an important part of these emissions through their daily behaviours, they also can, and have to, contribute to solutions for reducing emissions not only by changing their own behaviour, but also by providing democratic support for policy measures to be implemented that will affect their daily lives. 'Citizen-inclusive policy making' is therefore a crucial prerequisite for future air quality and carbon policies in cities to be successful in reducing emissions and reaching targets set on the local, national and global scales.

[3] https://unfccc.int/process-and-meetings/the-paris-agreement/the-paris-agreement
[4] https://www.who.int/en/news-room/fact-sheets/detail/ambient-(outdoor)-air-quality-and-health

1.2 Project objectives

Main objective of the **ClairCity Project**[5] is to contribute to successful, citizen-inclusive[6] air quality and carbon policy making in cities worldwide.

'Citizen-inclusive policy making' in the ClairCity project is defined as

1. Tailoring city air quality and carbon policy measures based on a detailed knowledge of current behavioural practices of citizens;
2. Asking citizens for their preferences regarding own future behavioural changes and taking these preferences into account in policy making;
3. Asking citizens for their preferences regarding future air quality and carbon policy measures in their city and also taking these into account in policy making.

'Citizen-inclusive policy making' within the ClairCity project is seen as competely distinct from 'populistic' policy making. While the latter within the project is seen as an uncritical adoption of the majority voice of citizens on singular policy topics, 'citizen-inclusive policies' to ClairCity means establishing city policies that are as much as possible informed by a detailed and constantly refreshed knowledge of citizens' opinions and behaviours, with the final responsibility for taking – popular and unpopular – policy measures remaining at all times with the democratically elected bodies.

ClairCity aims to contribute to citizen-inclusive policy making by a detailed examination and cross-case comparison of six middle-sized cities throughout Europe. In each of these cities, a comprehensive citizen engagement process is set up consisting of a mix of proven and innovative methods. This carefully designed suite of activities aims to examine current behavioural practices of citizens as well as preferred future behaviours and policy preferences. By carrying out these activities, ClairCity also contributes to awareness of citizens of air quality and carbon policy issues.

The six pilot cities and regions examined in the ClairCity project are:
- Bristol (United Kingdom),
- Amsterdam (Netherlands),
- Ljubljana (Slovenia),
- Sosnowiec (Poland),
- Aveiro / CIRA Region (Portugal) and
- Genua/ Liguria Region (Italy).

[5] The ClairCity project ('Citizen Led Air pollution Reduction in the City') is funded under the EU Horizon2020 programme, grant agreement nr 689289. It started in May 2016 and runs until May 2020. ClairCity website: www.claircity.eu.
[6] The initial subtitle of ClairCity to promote 'citizen-led' policies throughout the project evolved into 'citizen-inclusive' policies, in order to take into account the important role of citizens and stakeholders for informing and co-creating policies, as well as the final responsibility of democratically elected policy makers for deciding on the implementation of these policies.

1.3 This report

This report is the ClairCity "**City Policy Package Report**" for Ljubljana[7]. It provides a summary of the lessons learned for local air quality and carbon policy making in the city. The primary target group of this report are therefore Ljubljana policy makers and politicians. The report can be further of interest to politicians and policy makers in other cities, to national and regional policy makers, to EU policy makers, and last but not least to stakeholders and citizens in Lubljana and elsewhere engaged or interested in improving air quality and reducing carbon emissions in their city.

Chapter 2 of this report discusses the ClairCity citizen engagement methods that were applied and tested in the city. Chapter 3 analyses the current air quality and carbon situation in Ljubljana and looks into current behaviours of citizens that contribute to air pollution and carbon emissions. Chapter 4 examines what behavioural changes Ljubljana citizens envisage for themselves in the future and what preferences they have for policy measures. It also shows what reflections Ljubljana policy makers have on the views of citizens. Chapter 5 quantifies potential consequences of the citizens' preferences in terms of emissions and concentrations of air pollutants and of carbon dioxide, in terms of health and in terms of costs of measures. Chapter 6 discusses specific institutional conditions and barriers for citizen-inclusive policies found in Ljubljana as well as mutual learning possibilities in order to remove these barriers. Finally, chapter 7 gives the main conclusions and policy recommendations that follow from the ClairCity citizen engagement and analysis in Ljubljana.

[7] In the ClairCity project, this report is part of deliverable D7.5 Final Policy Package – Last City.

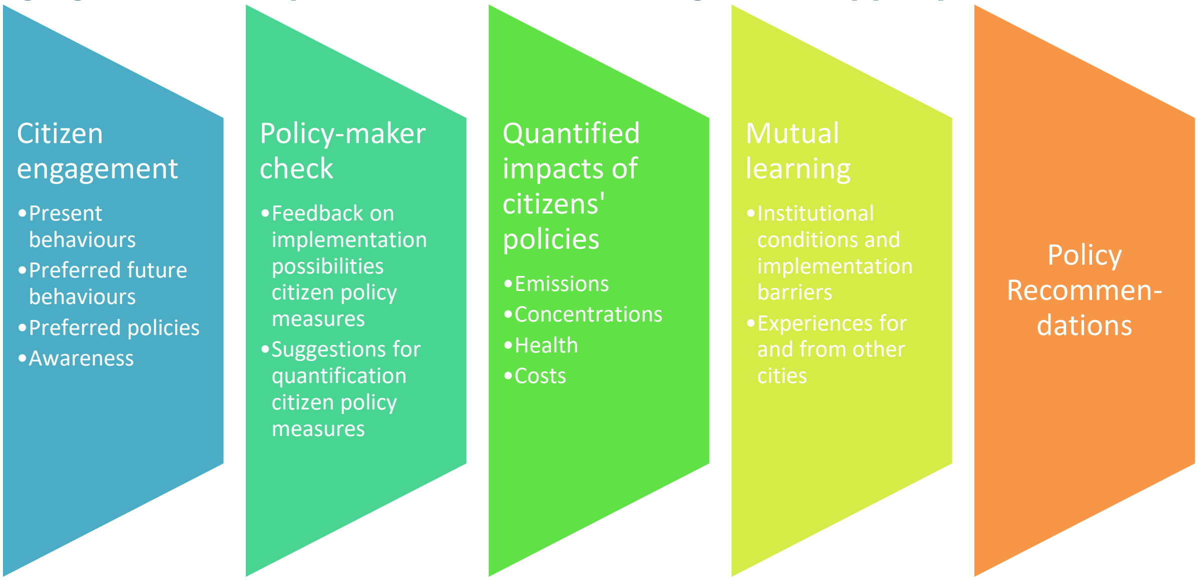
2 ClairCity citizen engagement in Ljubljana

This chapter gives an outline of the ClairCity method of preparing the policy recommendations (section 2.1) and of the citizen engagement activities in Ljubljana (section 2.2). A more detailed overview of the ClairCity project and the positioning of this 'Ljubljana Policy Package' can be found in Annex A. Details of the different ClairCity engagement methods applied in Ljubljana are given in Annex B.

2.1 The ClairCity method and positioning of the Policy Package

Figure 2-1 shows the five-step process in which the policy recommendations for city policy makers in Ljubljana were prepared.

Figure 2-1: ClairCity process including key phases and activities (Policy Package highlighted in red box) and chain of evidence leading to ClairCity policy recommendations



First, in the ClairCity engagement process citizens were consulted in order to examine their present behavioural practices, their preferences for future behaviours and their preferences for future policies. The process by itself contributed to citizen awareness of air quality and carbon issues and policies in the city and also included some activities specifically directed at awareness building.

Second, in a workshop with local and regional policy makers involved in air quality and carbon related policies feedback was obtained on implementation possibilities of the citizen policy preferences. In the workshop, the policy measures that evolved from the engagement process were also more worked out and partly quantified.

Third, from the more detailed citizen policy measures a 'Unified Policy Scenario' was constructed, of which the impacts were modelled regarding emissions and concentrations of air pollutants and greenhouse gases, health and costs to the citizens and city. These impacts were compared to a business-as-usual scenario with city policy measures implemented and specified in the base year 2015.

Fourth, the specific institutional conditions and barriers for implementation of the citizen measures in Ljubljana were examined, consisting in particular of political framing, financial conditions, multilevel policies and other conditions. These were compared with the experiences in the other ClairCity cities in order to examine what lessons could be learned from and for Ljubljana regarding promising ways for implementation of the citizen measures.

Fifth and finally, detailed policy recommendations for Ljubljana were prepared taking all the steps in the ClairCity process into account.

2.2 Citizen engagement in Ljubljana

Central in the ClairCity project is the engagement process that was specifically designed for the project and rolled out in all six cities. It consists of a suite of existing and proven methods as well as of experimental and innovative methods (Table 2-1).

Table 2-1: ClairCity's citizen engagement activities

		Citizens, general	Citizens, specific target groups1)	Other stake-holders2)
Policy related	Mutual Learning Workshop	X		X
	Delphi Process	X	X	X
	Skylines Game	X		
Aware-ness related	Secondary schools activities		X	
	Elderly film competition		X	
	ClairCity City Day	X		X
	GreenAnts App	X		

1) Elderly, pupils secondary school
2) NGOs, business, knowledge institutes

Three engagement activities served as key sources to inform the policy workshop and policy recommendations: the Mutual Learning Workshop, the Skylines game for mobile phones and the Delphi-process. In the Mutual Learning Workshop, citizens and other stakeholders (business, NGOs, knowledge institutions) could discuss in the beginning of the engagement process potential policies for the city[8]. In the Skylines game, citizens could decide on policies for their city as if they were holding the position of Mayor of the city[9]. The Delphi process consisted of a three step funneling process, starting with general questionnaires about citizens behaviours and preferences, and ending with 'Stakeholder Dialogue Workshops' to

[8] See ClairCity Report D4.16 Mutual Learning Workshop
[9] See ClairCity Report D4.10 Game User Manual and Data Report

discuss outcomes of the process with stakeholders and to build various citizen scenarios as an input for the policy workshops[10].

In addition, several awareness building activities were carried out in the city to reach specific target groups and to further inform the policy recommendations. These were a film competition for the elderly, classroom discussions with secondary school pupils and a City Day to present ClairCity. An app for the mobile phone that tracks citizens' personal transport behaviour and shows its consequences in terms of concentrations of air pollutants (GreenAnt) still needs to be implemented in the city[11].

In total, during the period 2017 – 2019 some 250 Ljubljana citizens were reached by the various ClairCity citizen engagement methods (Table 2-2). This is a limited sample, also compared to the other ClairCity cities and it is not fully representative of the Ljubljana population as a whole[12]. Nevertheless, it gives an indication of support for policy measures and intentions for behavioural change of Ljubljana citizens that can be used by policy makers to inform future policies.

Table 2-2: Number of participants in ClairCity citizen engagement methods in Ljubljana

Citizen engagement activity	# of participants engaged
Delphi Process	199
Skylines Game	24
Mutual Learning Workshop	16
Stakeholder Dialogue Workshop (in Delphi process)	26
Policy Workshop*)	12

*) the number of participants of the policy workshop is also included here, despite not being formally part of the citizen and stakeholder engagement process

[10] See ClairCity Report D4.4 Delphi Evaluation Report
[11] As of December 2019
[12] In Ljubljana, we received 199 responses out of a city population of 280,210. 58% of our respondents were female. In Ljubljana, we have an under-representation of the oldest and youngest categories, with more than two thirds of respondents aged 25-50 compared to 38% in this category in the city as a whole. Our respondents are highly educated, with 65% holding a university education compared to only 24% of the city population. A third of Ljubljana residents have vocational education qualifications, but only 1% of our survey respondents have this. In Slovenia the national or cultural identities of citizens is a politically charged topic due to the histories of Former Yugoslavian populations. As a consequence for ethical reasons we have not used nationality or ethnicity as a demographic identifier for population sampling in Ljubljana.
The majority of respondents were female, making up 68% of the Round 2 respondents. The 37-50 age category were a disproportionate set in our data, at 51% compared to only 24% of the total population. This was at the cost of older people, with only 3% of our Round 2 sample over 65, compared to 15% of the city. The data also represents the highly educated more than the average citizens, with 85% holding some form of higher education certificate, compared to only 31% of the general population.

3 Current air quality and carbon situation in Ljubljana

This chapter gives an overview of the current air quality and climate situation in Ljubljana based on city data and on ClairCity modelling (section 3.1) and will outline existing policies in these areas in Ljubljana and Slovenia (section 3.2).

3.1 Current concentrations and emissions

In the policy baseline report for Ljubljana[13], it was concluded that:

- One of the most pressing issues in Slovenia is PM_{10} pollution. Slovenia is one of the European countries with the highest levels of PM_{10} pollution and highest levels of PM_{10} emissions per capita and per land area[14]. The reason for it is that in Slovenia, there is a widespread use of wood for domestic heating in outdated boilers and stoves. The contribution of the wood/ biomass stoves to the PM_{10} daily exceedances is about 50%.[15]
- In Ljubljana this also holds, but to a lesser extent. In 2014, the average annual concentration of PM10 particles at the Ljubljana Centre monitoring station fell below the permitted level for the first time. The number of daily exceedances of PM10 emissions is gradually decreasing, even though this number is still above the permitted level.
- For NOx, from 2014 on exceedances of annual mean limit values were not recorded at any Slovenian monitoring station. No exceedances of the one-hour limit value for nitrogen dioxide have been recorded at the Ljubljana Centre monitoring station for several years. The city succeeded in bringing concentrations below the limit value of 40 µg/m3 on an annual level for the first time in 2014[16].
- Regarding greenhouse gases, important reforms in the Slovenian economy led to significant drops in emissions in the 1990s, but since the 2000s, performance in this field has been uneven. While successfully reducing the emissions from the manufacturing, commercial and residential sector, environmental policies were not sufficient to prevent an increase of emissions from the transport sector. As a result, there was an increase in total emissions during the 2000s. In 2009, due to the financial and economic crisis, CO2 emissions fell by over 10%. From 2011 to 2015, GHG emissions in Slovenia have continuously declined.

The city of Ljubljana has been monitoring air quality through continuous measurements since 1968. In 2006 PM10 particle measurements started.However, the findings for Ljubljana are based on only two measuring stations in the city. Modelling can therefore provide additional information next to these direct measurements. The modelling method developed in ClairCity

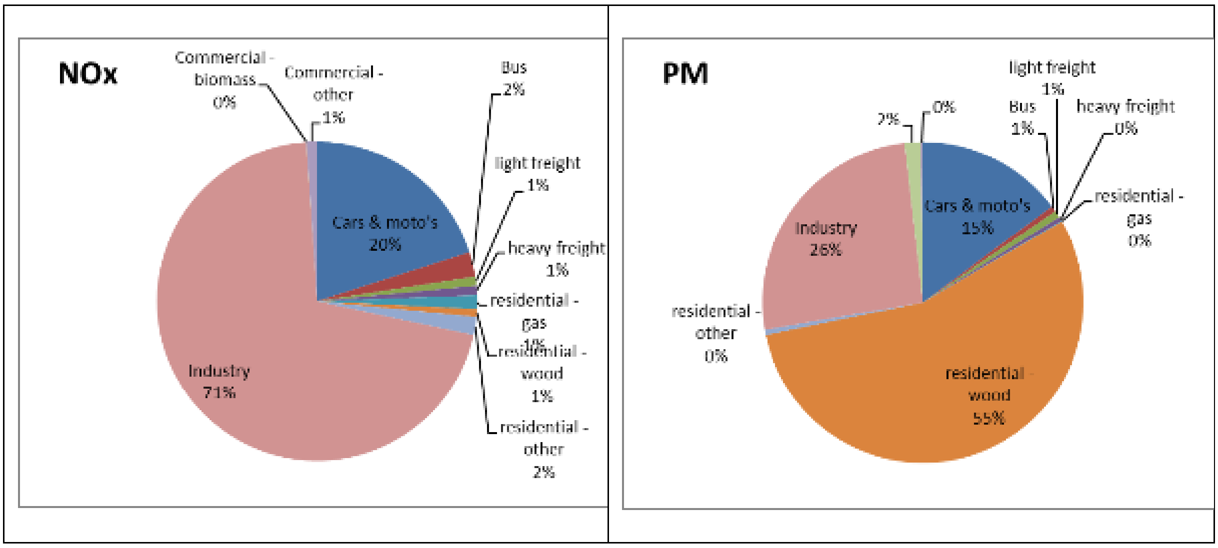
[13] ClairCity report D6.2 Ljubljana – Policy Baseline report, www.claircity.eu
[14] ARSO, Report on air quality in Slovenia, 2015
[15] Interviews with Bostjan Paradiz and Rahela Zabkar, Slovenian Environment Agency (ARSO)
[16] City of Ljubljana, Environment in the City of Ljubljana : European green capital 2016

gives such additional information for NO_x, PM_{10}, $PM_{2.5}$ and CO_2 emissions as well as for NOx and PM concentrations[17]. The outcomes of the ClairCity modelling suggest:

- For NOx emissions, an expansion of measurements to main hotspots of the city might well reveal more exceedances of EU legal limit values than are currently shown;
- Further extending policy ambitions from reaching EU legal limit values to reaching voluntary WHO guideline values would need additional measures in particular for reducing exposure of the Ljubljana population to potentially dangerous exceedances of those values for $PM_{2.5}$.
- Next to industry, resident and road emissions are important target groups for policies to reduce CO_2 emissions in the city, with both contributing almost 50% to total emissions in the city, next to industry and services.

Figure 3-1 shows the emissions of NOx and PM as modelled by ClairCity for the base year 2015. For NOx, industry is by far the dominant source of emissions. However the ClairCity modelling shows that citizens are an important direct source of emissions as well: NOx emissions are caused for 20% by cars and moto's. Citizens play a far larger role in PM emissions: only 26% of these emissions is caused by industry, while 15% of these emissions are caused by cars and moto's and 55% by residential biomass burning.

Figure 3-1 NOx and PM emissions in Ljubljana (Source: ClairCity modelling)



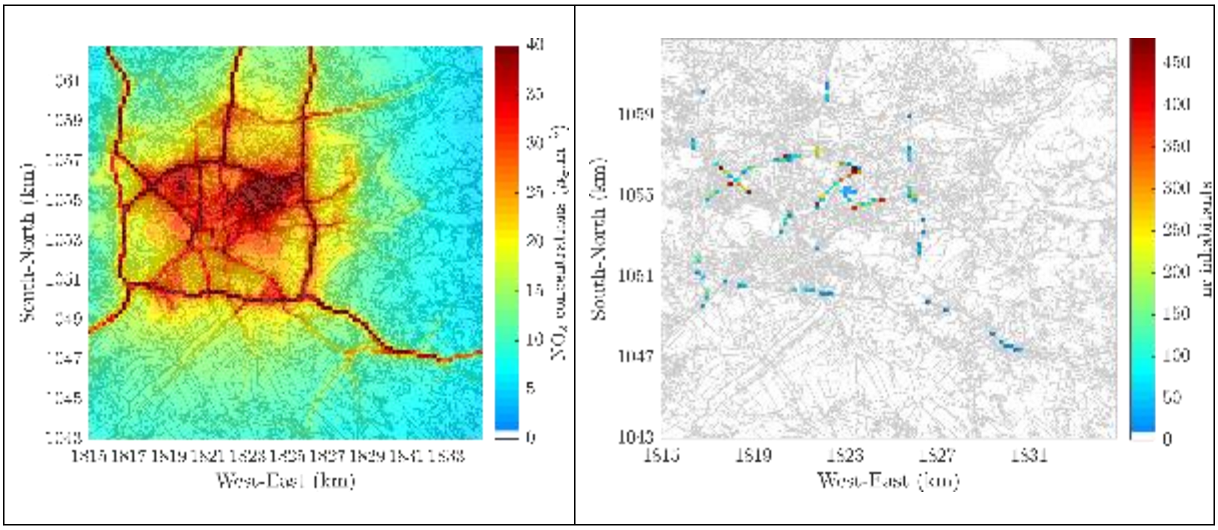
ClairCity also modelled the resulting concentrations of NO_2 and PM based on these emissions. Figure 3-2 a) shows the exceedances of NO_2 limit values in the current situation. The simulation results indicate a peak concentration of 77 $\mu g.m^{-3}$ in one cell of the urban area of Ljubljana, with a contribution for the cell where the maximum is simulated of 81% from the transport sector, 17% from the industrial sector, and 2.3% from the residential and

[17] In the annexes of this report and in the ClairCity modelling methodology report a more detailed background is given to all modelling assumptions. To the ClairCity modelling the disclaimer in Texbox 5-1 applies: it's results cannot be directly compared with national modelling results due to differences in underlying assumptions which are beyond the context of this project.

commercial sector. This concentration is much higher than the current EU annual legal limit value for NO_2 annual concentrations (40 µg.m^{-3}).

According to the modelling, the legal NO_2 limit value is exceeded in 304 grid cells of 200 x 200 metres in Ljubljana closely related to roads[18]. The number of cells with exceedances that have population linked to it that is living permanently there is 170 (Figure 3-2 b). This corresponds with 5% of the population within the area potentially exposed to those concentrations.

Figure 3-2 NO_2 contour maps for Ljubljana in current situation (reference year 2015): a) annual average of NO_2 concentrations and b) number of inhabitants within the cells exceeding the EU annual limit value of 40 µg.m^{-3}.



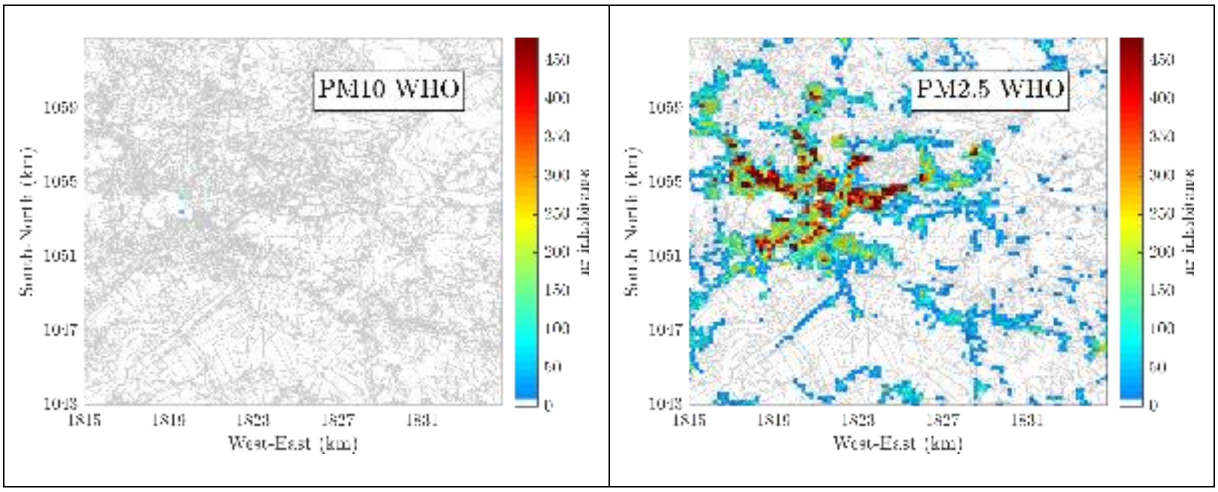
The ClairCity modelling indicates that there are no exceedances of PM_{10} and $PM_{2.5}$ EU legal limit concentrations in the Ljubljana area. However, while Ljubljana urban area complies with the EU legal limit values, it does not comply with the stricter (but voluntary) guidelines of the World Health Organization (WHO)[19]. Figure 3-3 indicates two grid cells with inhabitants allocated to those cells exceeding the WHO recommendations for PM_{10}. In total, 147 grid cells were found exceeding these recommendations, but most of these did not have permanently resident population allocated to them[20]. For $PM_{2.5}$, the situation looks less good when comparing exposed population to WHO recommendations for $PM_{2.5}$: the urban area of Ljubljana 100% of the total population are potentially exposed to $PM_{2.5}$ concentrations exceeding the WHO recommendations (Figure 3-3 b).

[18] A 'cell' refers to the 200 m x 200m modelling domain that was utilsed by ClairCity

[19] Based on the latest scientific evidence available, WHO has established limit values for PM_{10} and $PM_{2.5}$ that are substantially below current EU and British legal limit values. These values are 20 µg.m^{-3} for PM_{10} (compared to a legal limit value of 40 µg.m^{-3}) and 10 µg.m^{-3} for $PM_{2.5}$ (legal limit value 25 µg.m^{-3} annual mean). See https://www.who.int/news-room/fact-sheets/detail/ambient-(outdoor)-air-quality-and-health

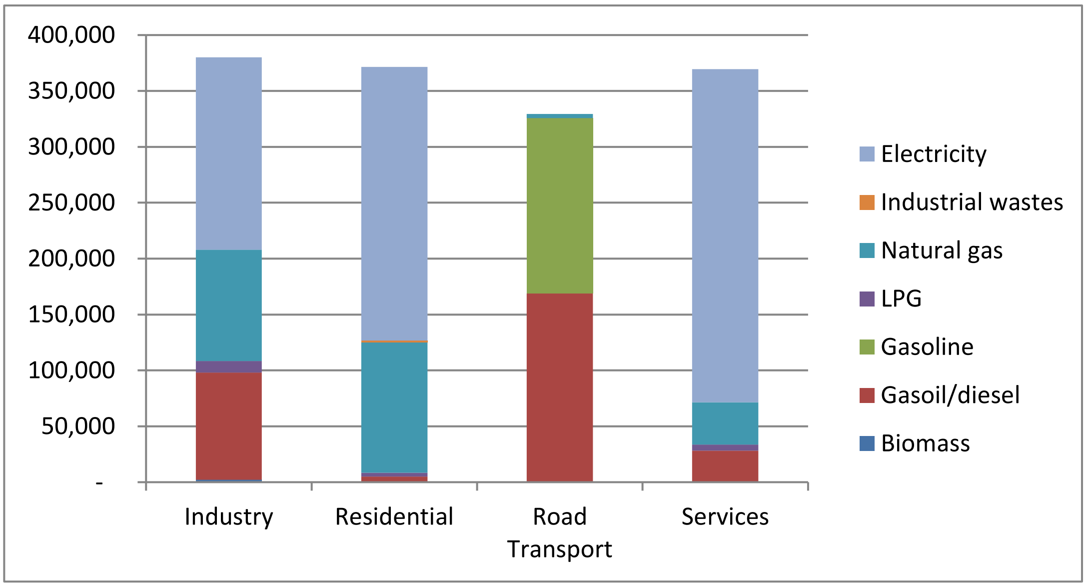
[20] Population data based on Copernicus Urban Atlas, https://land.copernicus.eu/local/urban-atlas

Figure 3-3: Number of inhabitants within the cells exceeding the WHO air quality guideline values: a) of 20 µg.m^{-3} for PM_{10} concentrations, and b) of 10 µg.m^{-3} for $PM_{2.5}$ concentrations.



Regarding greenhouse gas emissions, ClairCity modelling specifies the emissions for 2015. In Figure 3-4 the Carbon Footprint expressed as tonnes CO_2 equivalent on Life Cycle is reported by fuel and sector. The computed indicator takes into consideration the overall life cycle of the energy carrier; this approach includes not only the emissions of the final combustion, but also all emissions of the supply chain; it includes emissions from exploitation, transport and processing (e.g. refinery) steps in addition to the final combustion; this hence includes also emissions that take place outside the location where the fuel is used. The figure shows that the different sectors contribute almost equal to the total carbon footprintof the (lifecycle adjusted) greenhouse gas emissions in Ljubljana. Residential CO_2 emissions (fully citizen-based) and road transport (partly citizen-based) together are responsible for almost half of the CO_2 emissions in Ljubljana.

Figure 3-4: Carbon Footprint expressed as tonnes CO_2-eq on Life Cycle by fuel and sector



3.2 Existing air quality and carbon policies

The ClairCity policy baseline report for Ljubljana concluded regarding existing air quality and carbon policies that

- Main air quality actions are outlined in the Slovenian Action Plan on Clean Air (2014), which is complemented by seven city level air quality plans, including one for Ljubljana. In 2007, Ljubljana adopted the Air Quality Programme (2007-2013), which was later expanded with the Operational programme for the protection of Ambient Air against PM10 Pollution (2009) and an update aiming at the period 2014 - 2020.
- The aim of these plans it to reduce the air pollutant emissions exceeding the permitted levels. The focus is on residential heating and traffic. In particular, the PM10 daily exceedances are addressed in these plans. While in the past it was a long-time perception that industry and traffic were the main contributors to these daily exceedances, the focus of these plans is on addressing the small combustion installations in residential housing as main contributors to winter air pollution.
- Operational plans on a city level include the Sustainable Energy Action Plan (2011–2020) and the Sustainable Mobility Plan (2012- 2020) and 2017 update. The mobility target for 2020 is to divide mobility into thirds: 1/3 public transport, 1/3 non-motorised traffic, 1/3 private vehicle, with an updated version (2017) envisaging that until 2027 two thirds of journeys are going to be completed in a sustainable way – on foot, by bicycle or by public passenger transport and only one third by private cars.
- In 2014, the government adopted the Operational Programme of measures for reducing Greenhouse gas (GHG) emissions until 2020 (OP GHG 2020) .
- The plan includes sectoral and development programmes that target GHG emission reductions. Such programmes are developed in the field of renewable energies, energy efficiency or municipal waste management.

More recently, several updates of air quality and climate policy plans and sectoral mobility and energy plans have been published[21].

[21] Sustainable Urban Mobility Plan of the Ljubljana Urban Region (2018), https://www.rralur.si/sites/default/files/CPS%20LUR%20z%20ovitkom_november2018.pdf, Strategic plan Energetika Ljubljana https://www.energetika-lj.si/sites/www.jhl.si/files/energetika_lj_si/stran/datoteke/strateski_nacrt_jpe_2017-2021_povzetek.pdf, Public transport company strategic plan, https://www.lpp.si/o-druzbi/strateski-nacrt-2, Public parking company strategic plan http://www.lpt.si/zgodovina_podjetja/lpt/uploads/cms/file/STRATESKI%20NACRT%202017-2021.pdf, Update of urban master plan in 2018, https://www.ljubljana.si/sl/moja-ljubljana/urbanizem/obcinski-prostorski-nacrt/, Strategic projects and documentation, https://www.energetika-lj.si/energetika-ljubljana/o-druzbi/strateski-nacrt/strateski-projekti, Energy action plan projects, https://www.ljubljana.si/sl/moja-ljubljana/ljubljana-zate/projekti-mol/energetika-ljubljana and https://www.ljubljana.si/sl/moja-ljubljana/varstvo-okolja/energetska-ucinkovitost/, Energy for the City of the Future – Sustainable Energy Action Plan of the City of Ljubljana (2011-2020), Vision of Ljubljana 2025, Urban Master Plan – Strategic Plan and Impelmenting Plan 2011-2027

4 Citizens’ views on cleaner air and carbon policies in Ljubljana

In Ljubljana, the ClairCity Delphi process led to 199 responses out of a city population of 280,210 in 2016. 58% of the respondents were female, with an under-representation of the oldest and youngest age categories: more than two thirds of respondents were aged 25-50, compared to 38% in this category in the city as a whole. The respondents were highly educated, with 65% holding a university education compared to only 24% of the city population.

The ClairCity Delphi sample hence represents only a small and non-representative part of the Ljubljana population, with a response rate lower than in other ClairCity cities. It nevertheless gives some insights into behaviours and visions of the Ljubljana population. The respondents were interviewed for their commuting, shopping, leisure and heating behaviours as well as for their preferences regarding these practices for the future.

4.1 Views of citizens on their own transport and heating behaviour in the future

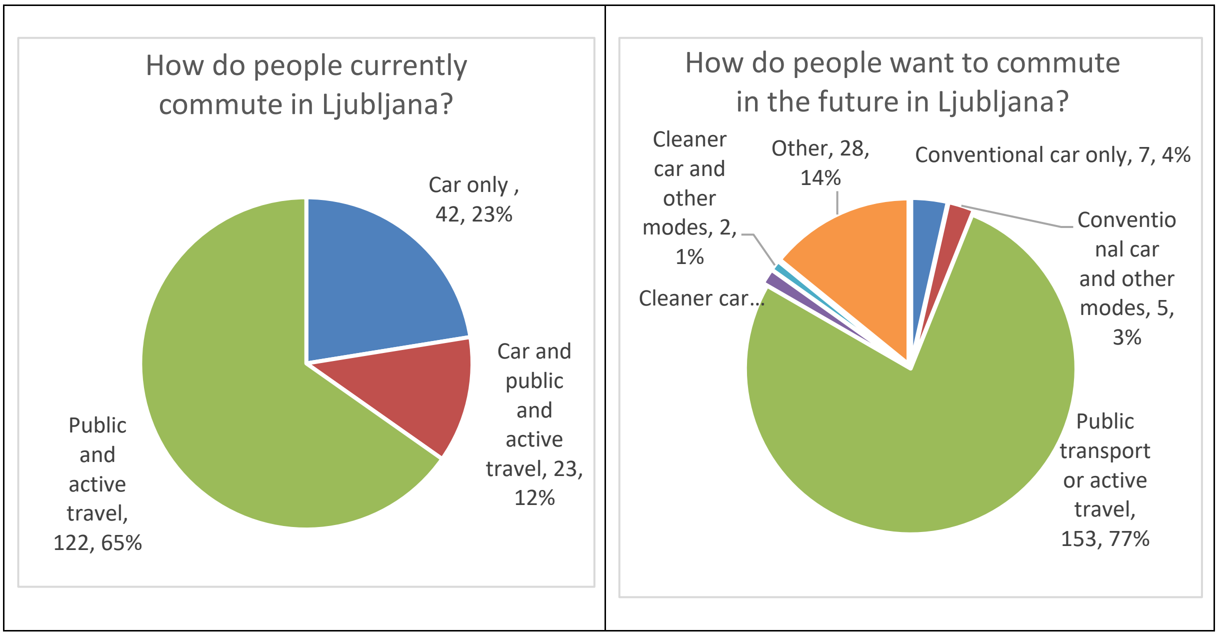
A large part of the interviewed sample of the Ljubljana population already either uses public or active travel for commuting (65%). In the future, the share of public and active travel users will increase to 77%. Remarkable is that hardly any of the commuters expects to use a conventional car in the future (4% conventional car only, and 3% conventional car and other modes of transport). At present, 35% of the commuters still use either car only or car and other modes of transport[22].

31 of the respondents indicated to use a car only at present and want to switch to alternative means of transport in the future. The most frequently indicated reasons that prevented them from doing so already at present were related to negative comments about public transport (20 responses). None of the complaints about public transport from this group mentioned the cost. The majority, 15 respondents, referred to the slowness and the amount of time they wasted if they used it: “too long a trip, less comfort, poor connectivity” and “Public transport is currently 3 to 6 times slower, which is absurd.” There were also 7 references to a lack of service or unreliability, for example “bad and irregular connections, uncertainty in the schedule”.

Both of the comments about poor infrastructure referred to a lack of cycle paths: “Unregulated bicycle infrastructure” and “risk of life on non-cycling routes; pavement instead of cycling routes…” were their complaints. In terms of “time/distance,” comments were short but stated issues like “too much, too far” [to cycle] and “waste of time” [walking rather than driving].

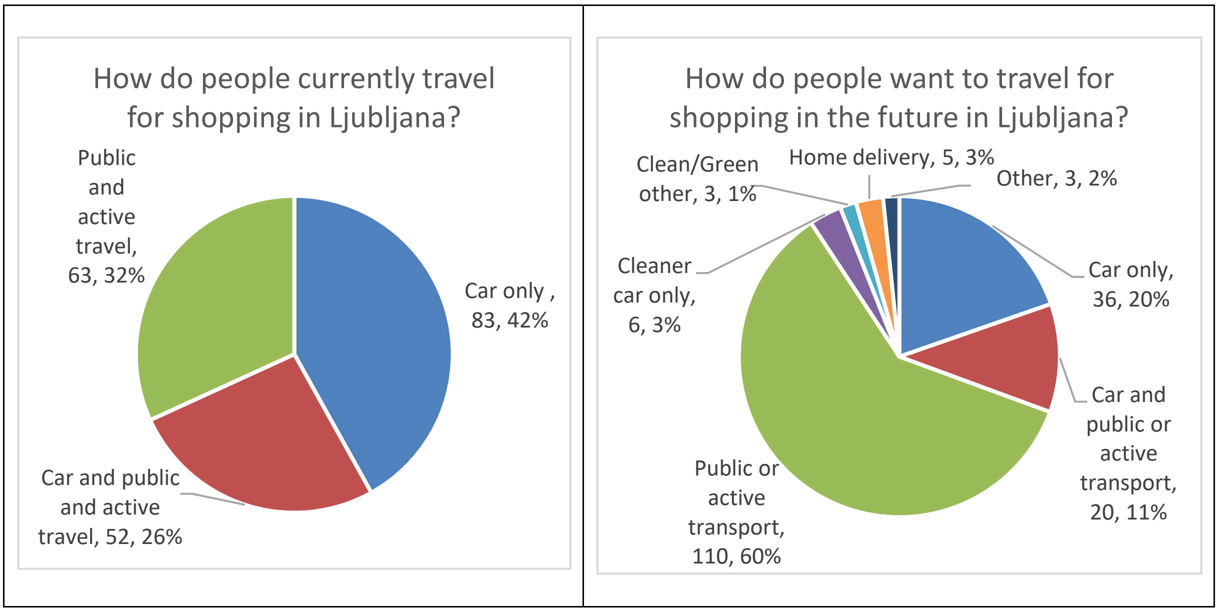
[22] See ClairCity report D4.4 Pilot Cities Delphi evaluation report, www.claircity.eu

Figure 4-1 Current and desired future commuting behaviour in Ljubljana (source: ClairCity Delphi)



For shopping, the percentage of citizens that at present only uses public and active travel is much lower than for commuting (32%, see Figure 4-2). Yet, looking at expressed desire for behavioural change the percentage shift is much higher (from 32 to 60%). Still some 31% of the interviewees either expects to exclusively use a conventional car for shopping or to use it alternated with public and active transport in the future.

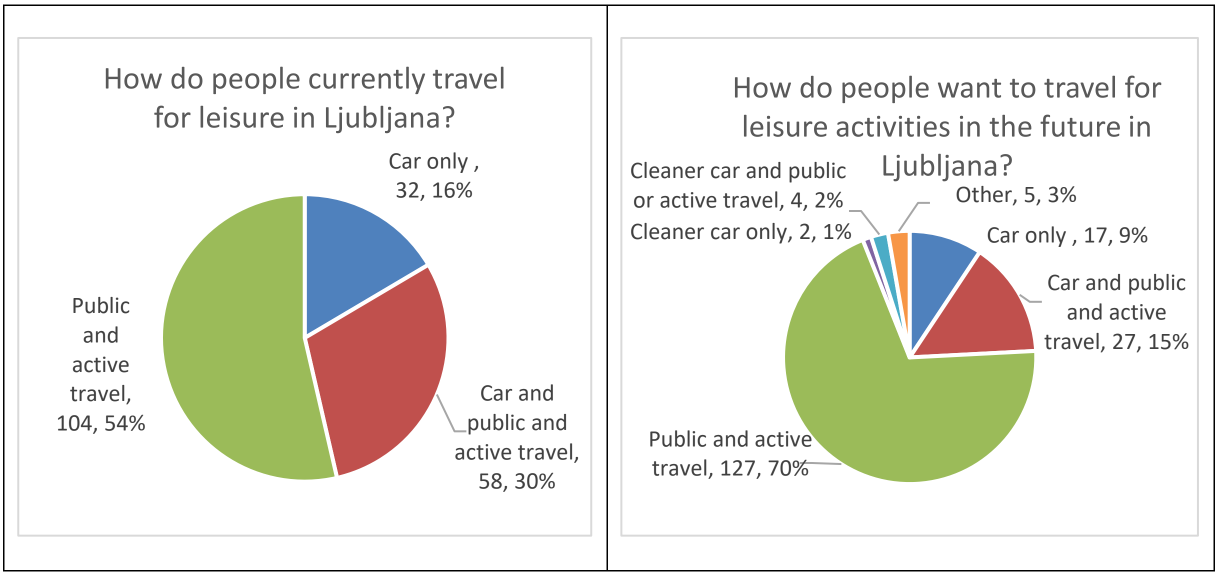
Figure 4-2 Current and desired future shopping behaviour in Ljubljana (source: ClairCity Delphi)



Figures for present and preferred future leisure transport behaviour of Ljubljana citizens are in between those of commuting and shopping behaviour (Figure 4-3). 54% of the respondents indicates to use public and active transport for leisure at present, while 70%

would like to do so in the future. While 46% of the interviewees at present uses the car exclusively or together with public and active travel, in the future still 24% expects to do so.

Figure 4-3 Current and desired future leisure behaviour in Ljubljana (source: ClairCity Delphi)



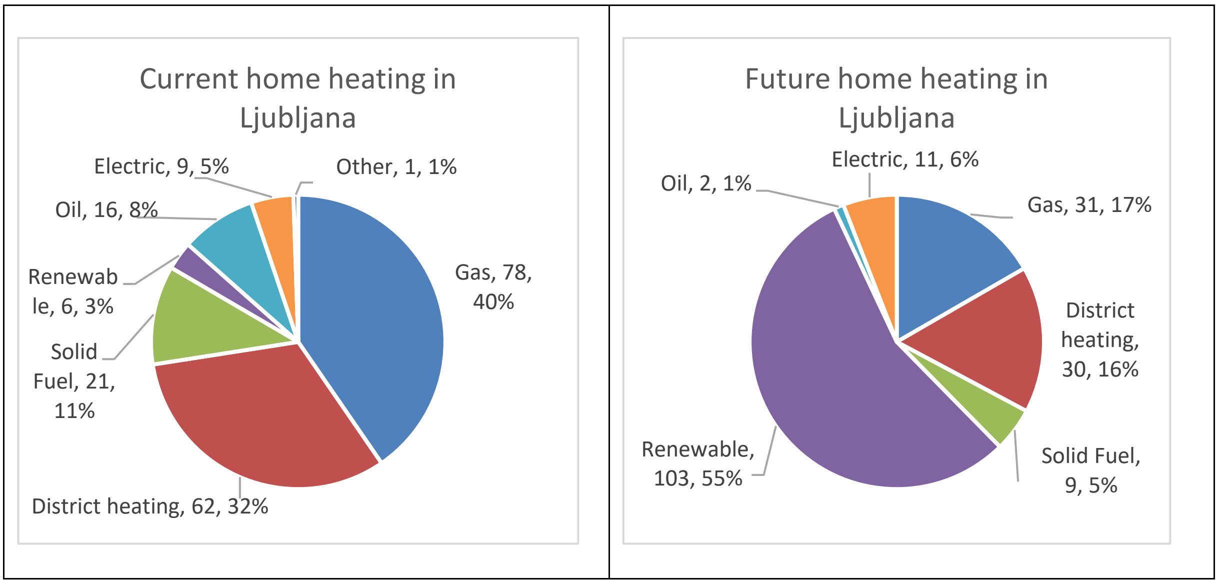
Gas (40%) and (coal-fired) district heating (32%) are the main sources of energy for home heating in Ljubljana at present. Both sources will be used much less in the future according to indicated future home heating behaviours of the respondents (17 and 16% of interviewees respectively). The majority of respondents (55%) expects to heat their homes with renewables in the future (currently 3%).

ClairCity explored the reasons why those who were currently using solid fuel heating systems wanted to change or felt they could not (or were not interested) in changing to a less polluting source. 176 respondents answered both their present and future heating choices. It was examined where respondents were moving away from the “polluting” source (solid fuel use, which could include wood, coal or other) to any other heat source.

Overall, the direction of desired change in Ljubljana was found to be moving away from polluting heating sources. The five respondents who wanted to stay using solid fuels included three who gave no reason for their choice. The other two mentioned cost as a reason, with one also stating that they felt it was more environmental: “Solar cells and all modern technology do not pay for their lifetime, it's expensive to maintain, coming from different parts of the world ... it's more environmentally friendly to use biomass from the nearby forest than having the most advanced technology”.

For those who were “looking for positive change”, cost was the most significant reason that they had not already switched away from solid fuel. The “environmental” response related to using wood cleared under forest management practices. The person indicating that they were “happy with current situation” response located their fuel choice in a wider political landscape, stating “Wood is the only source of heat which is independent of global trends and national ideas.” One “Other” coding related to a respondent currently on biomass and gas, who wanted heat pump and solar. They explained “Just a few years ago we switched to gas heating”.

Figure 4-4 Current and desired future home heating behaviour in Ljubljana (source: ClairCity Delphi)



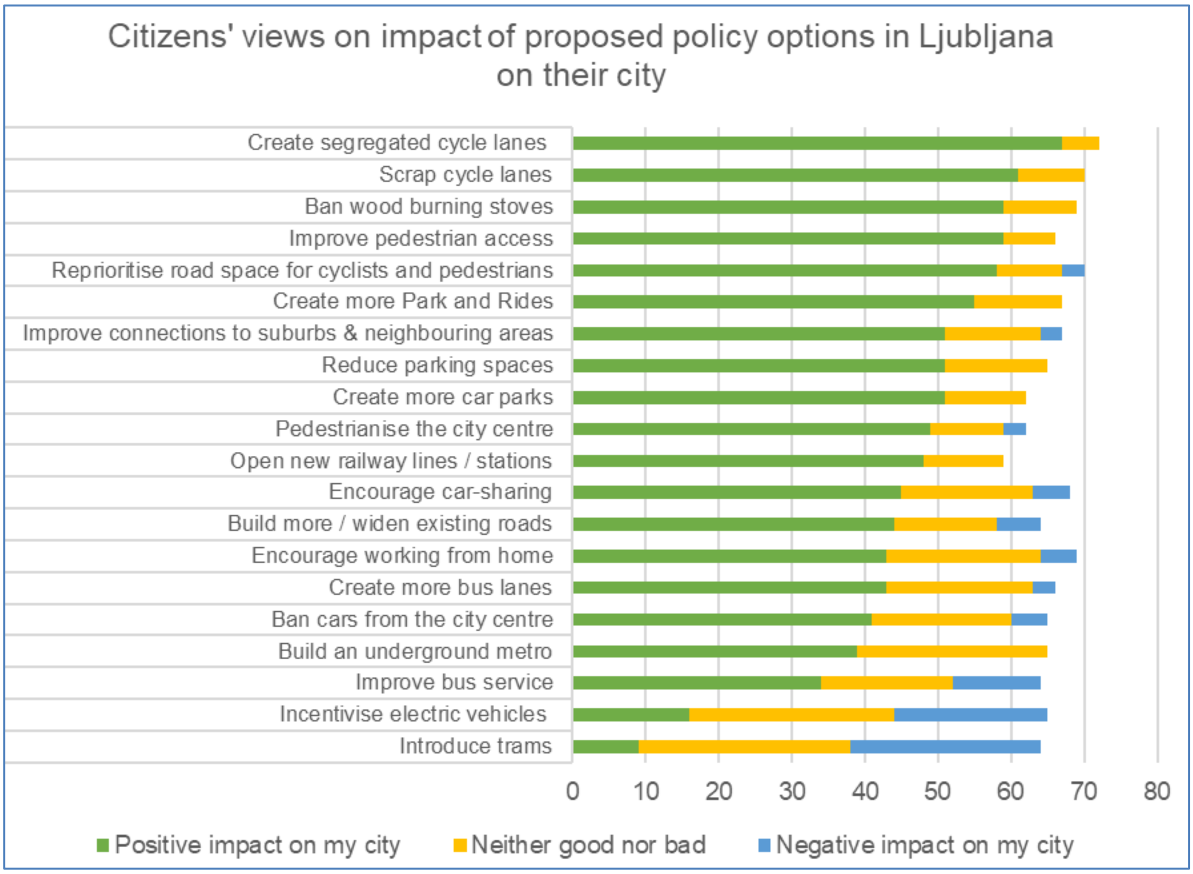
4.2 Views of citizens on future policies in Ljubljana

The ClairCity team also asked Ljubljana citizens for the preferred future air quality and carbon policies in the city (Figure 4-5)[23].

In Ljubljana, among individuals there is strong support for improving connections to suburbs and neighbouring areas and building more, or widening existing, roads. There is also an interest in encouraging car share and for reprioritising road space for cyclists and pedestrians, and creating more bus lanes and segregated cycle lanes. Interestingly others would prefer to scrap the existing cycle lanes. More people would prefer to increase the car parking in the area than want to reduce it, although both options received very few detractors. There is quite a lot of support (and no detractors) for a new underground metro, although less support for improving the bus service, introducing trams or opening new railway lines or stations. There was support for improving pedestrian access but less for further pedestrianisation of the city centre. Encouraging working from home and banning cars from the city centre were the most unpopular options for individuals. Banning wood burning stoves was generally found acceptable.

[23] See ClairCity report D4.4 Pilot Cities Delphi evaluation report, www.claircity.eu

Figure 4-5: Citizens' views on the impact that proposed policy options in Ljubljana would have on their city



Ten of the most popular measures that were indicated by the Ljubljana respondents were used as an input for a ‘Stakeholder Dialogue Workshop’ in which Ljubljana citizens and other stakeholders could participate. Participants in the workshop had to choose between three different ambition levels for each measure: one level lower than current policy ambitions; one level similar to these ambitions; and, one level higher than the policy ambitions. From their choices, two different coherent scenarios were produced by the ClairCity team, one merging all selected lowest ambition levels by participants (Scenario ‘LOW’), and one merging all selected highest ambitions (Scenario ‘HIGH’). For the scenarios only transport measures were selected, as transport was considered a more urgent policy problem than energy by the Ljubljana team. The two scenarios were then discussed by policy makers, which could choose either of the two scenario options for each measure and could provide comments and tips for implementation (Table 4-1).

Table 4-1 Overall preferred policy measures of Ljubljana citizens

#	Measure	Low option	High option	Preferred option of policy makers
1	Green fleet for the Ljubljana Passenger Transport (LPP)[24]	Half of the public transport fleet fulfils standard EURO VI by 2025	Low-emission public transport fleet until 2027	Low
2	Higher frequency of buses and inclusion of train transport in city traffic	Increase of public transport for 10% by 2027	Increase of public transport for 100% by 2027	Medium (30 % by 2027)
3	Cheaper public transport	Public transport is made 50% more expensive to finance and co-finance other sustainable transport solutions in the city.	Public transport is made 50% cheaper for all.	Medium
4	New areas for non-motorized traffic (pedestrian and bicycling areas)	Maintaining the current range of pedestrian areas.	Designing new areas with limited access for vehicles and strengthen requirements for access to existing areas.	High
5	New cycling routes and connections	New and modified cycling routes - 10% by 2021.	New and renovated cycling routes - 50% by 2021.	Medium (30 % by 2021)
6	Safe cycling and walking in the city	No increase in the number of dead and injured pedestrians and cyclists until 2027 within the ring road.	0 dead or heavily injured pedestrians and cyclists until 2027 within the ring road.	Medium
7	Independence from the car	Car sharing is left to the market.	Incentives and subsidies for car-free neighbourhoods by 2027.	High
8	E-mobility	Electromobility is left to the market.	Each neighbourhood has a mobility plan and shared ownership of e-vehicles by 2050.	Low
9	Change of parking norms	Parking norms remain the same (1 parking space per 1 new apartment).	Parking norms reduced to 0.5 per new apartment by 2020.	High
10	Regional public passenger transport	Expansion of motorway and AC ring.	Implementation of the Railhub solution by 2027.	High

4.3 Reflections from Ljubljana policy makers

Ljubljana policy makers could react on the outcomes of the citizen scenarios in a policy workshop[25]. This workshop was held on the 21st of June 2019 and was attended by 12 participants (7 male; 5 female) representing Ljubljana City municipal departments and units responsible for energy efficiency, planning, environment, transport, EU cohesion and EU projects, urban institutes on national, regional and city level, representative of Ljubljana public transport. One representative from the Ljubljana City Hall and one ClairCity team member facilitated the session.

For four of the ten measures that were part of the citizen scenarios, policy makers selected the high ambition level, for two a low ambition level was preferred and for four measures a medium ambition level was chosen as a compromise between the lower and higher option (Table 4-1). Measures were a higher ambition level was considered appropriate were increasing pedestrian and cycling areas, incentives for car-free neighbourhoods, less space

[24] Public transport company
[25] See ClairCity report D6.6 Policy Workshops – Last City, www.claircity.eu

for private car parking and improving regional train transport. Low ambition levels were chosen for greening the public transport fleet and e-mobility.

Main comments made by policy makers in the workshop regarding implementation were:

Public transport

- Public transport is the backbone for the transportation in Ljubljana, but the Slovene rail company is not prepared to take the transport from the regional and even wider area to Ljubljana. As such, smaller buses with higher frequency should be introduced in Ljubljana for within the city travel.
- There is a need to investigate the construction of a metro in Ljubljana.
- There are discrepancies between national and municipal decision makers around transport policies.
- The eligibility criteria for the Eco-fund calls should be adapted so public companies can also apply. This doesn't guarantee lower transport prices as efficiency is not a criteria taken into account for granting subsidies (so the criteria for efficiency should be made mandatory when tendering). Currently, yearly losses of the transport company are covered by the municipality.
- A decrease in the price of transport would not necessarily lead to an increase use of public transport, so the ambition of the chosen measure is medium.
- Another possibility is to have free transport and to pay the compensation subsidies' amount directly to public company. Vulnerable groups, like unemployed and disabled have free transport already.
- The majority of employees are compensated for transport as part of their income and they don't want to exchange the cash money received for access to public transport.
- The population of students is expected to rise radically in the next 5 years. Pressure on regional public passengers' transport may be doubled in the next 5 years. This peak will last for 8-10 years. The city is not ready for that and yet there is no discussion about this challenge at the moment. It should be investigated how current public transport should be adjusted to the future situation and where the bottlenecks are.

Active transport

- New areas for non-motorized traffic should be introduced in particular outside the city center and the frequency of buses would need to be increased.
- The policy of penalties against offenders should be clearly defined and then also implemented.
- An integrated territorial plan has been drafted and includes also new cycling routes. More cycle lanes will lead to more cyclists.
- The largest challenge is how to integrate lanes for bikes with car roads. There is currently also tension between pedestrians and cyclists. The width of the lanes for buses and cars need to be adjusted.
- The law does not follow technology. Modern electric vehicles (like scooters and boards) are supposed to go on the sidewalk and not on bike lanes -according to the

law- whereas they can readh higher speeds than bikes themselves. The legal system should be flexible and should accommodate new technological development.

Private car

- E-mobility is hampered by a lack of electricity charging stations and the high investments needed for those. Elektro Ljubljana just started to charge for the charging of electric vehicles.
- An integral assessment should be performed to understand the impacts of e-mobility on air quality.
- To tackle the problem of massive amounts of delivery vans – coexisting with pedestrians in rush hour- good practices from other cities should be explored (e.g. pickup points and delivery by city carts with manual delivery).
- The commitment is zero deaths the inner ring. That would need to implement a real speed limitation to 50 km/h in the inner ring and 30 km/h in the city centre.
- A roadmap for car-free neighbourhoods should be prepared. If we want neighborhoods without cars, this means that people do not own their cars. Instead there would be car-sharing.
- Developers should allocate money into a fund that helps finance the mobility plan for the neighbourhood. In parallel, an awareness campaign has to be carried out.
- Construction of houses require until today the building of parking places. This will now be changed from municipality spatial plans.
- However, there is uncertainty whether there is enough capacity for daily commuters, now estimated to be about 160.000. This holds even despite the fact that Ljubljana has “park and ride” areas at the main entrances to Ljubljana which are also frequently used.

5 Impacts of implementing citizens' views

This chapter discusses the potential impacts of implementing the citizens' views on future policies on air quality (section 5.1), health (section 5.2), carbon emissions (section 5.3) and on costs (section 5.4). It is based on ClairCity modelling, to which the disclaimer formulated in Textbox 5-1 applies.

Textbox 5-1 Disclaimer ClairCity modelling versus national modelling

> "ClairCity modelling differs from local and national models in the ClairCity countries due to different modelling assumptions and inputs. Although the utmost care has been taken to calibrate the ClairCity models to local conditions, a detailed comparison of ClairCity modelling assumptions to those of local and national models in each country was considered to be outside the scope of this project. Therefore ClairCity modelling outcomes cannot be one-to-one compared with the outcomes of national and local models; they should be regarded as indicative and can deviate from locally measured and modeled concentrations."

The modelled potential impacts are based on a 'Unified Policy Scenario' (UPS) that was prepared by combining citizen preferences for future policy measures with policy maker reflections as expressed in the policy workshop and quantifying them where possible. Main assumptions made for preparing the UPS are given in Annex C. The impacts of the UPS are compared with those of a 'Business-As-Usual' scenario (BAU) that is based on all city policy measures implemented in Ljubljana in the base year 2015[26].

5.1 Impacts on air quality

ClairCity models NO_x, PM_{10} and $PM_{2.5}$ as air pollutants. Measures implemented in the business-as-usual (BAU) scenario starting in 2015 would reduce NO_x emissions to about 80% of 2015 levels in 2025 and to about 65% of the base year value in 2050 (Figure 5-1). The UPS scenario measures as modelled do not lead to a further decrease of NO_x emissions compared to BAU. This is mainly due to the fact that the selected measures and ambition levels are already partly included in the BAU or do result in one combined mode shift effect[27].

Figure 5-1 also shows that PM emissions in the BAU scenario would fall to some 55% in 2025 compared to 2015 and to some 45% compared to the base year in 2050. In the UPS scenario, the PM emissions are only slightly more reduced than in the BAU scenario for the same reasons as mentioned for NOx. Figure 5-1 also shows that for PM-emissions the

[26] Policy changes implemented in Ljubljana since 2015 could not be incorporated in the baseline. This obviously affects the differences between BAU and UPS scenario.

[27] see Table 4-1: measure 1, 'greening of public transport', is already foreseen in BAU, measure 6; 'safe cycling', does not contribute to further emission reductions compared to BAU, neither does the selected ambition level of measure 8, 'leaving e-mobility to the market'. Measures 2,, 3, 4, 5, 6 and 7 together are assumed to result in a mode shift effect to public transport of 30% in 2027. Measure 9, 'change of parking norms' is assumed to contribute a further 50% to the reductions of car use foreseen in BAU, and measure 10 'improving regional transport' is assumed to lead to a reduction in travel time by train with 10%. A slight increase in emissions in UPS compared to BAU can be seen because of a modal shift from active to public transport.

emission reductions achieved by BAU and UPS are limited, mostly due to the large share of industrial emissions on the outskirts of the modelling domain.

In more detail, from Figure 5-1, a steady trend in improving NOx emission in the BAU can be observed. This decreasing trend is less explicit compared to other ClairCity cities, mainly due to the large share of NOx-emissions from industry which are not changing over time. All reduction in the BAU in this case is derived from decreasing transport emissions. Remarkably, the UPS scenario has almost no effect on the NOx emissions and in fact causes a slight increase of NOx emission compared to the BAU. This can be explained as follows: All measures are related to transport, so industrial, residential and commercial emissions will not change compared to the BAU. In the transport emissions, we observe a decrease of car emissions and an increase of emissions from buses. The measures in the UPS to large extent cause a modal shift toward bus. Public transport in this case is made so attractive that it causes a shift from pedestrians to public transport, thus shifting zero-emission transport (walking) to low-emission transport. Overall, the reduction of car NOx emissions is not sufficient to offset the increase in emissions from buses. This is because car emissions are expected to decrease strongly already in the BAU, while no extra measures are taken in the UPS to ensure zero-emission bus transport.

We observe a similar trend for PM-emissions, although reductions are stronger already in the BAU. Key sources are residential solid fuel consumption and the industrial sector. Both improve in the BAU, but no further in the UPS due to lack of specific measures targeting these emissions. Unlike for NOx, PM emissions from transport in total decrease marginally in the UPS compared to the BAU.

Figure 5-1 Trend of PM10 and NOx emissions in the UPS scenario (citizens measures), compared to the BAU scenario (Ljubljana policies as of 2015) (source: ClairCity modelling)

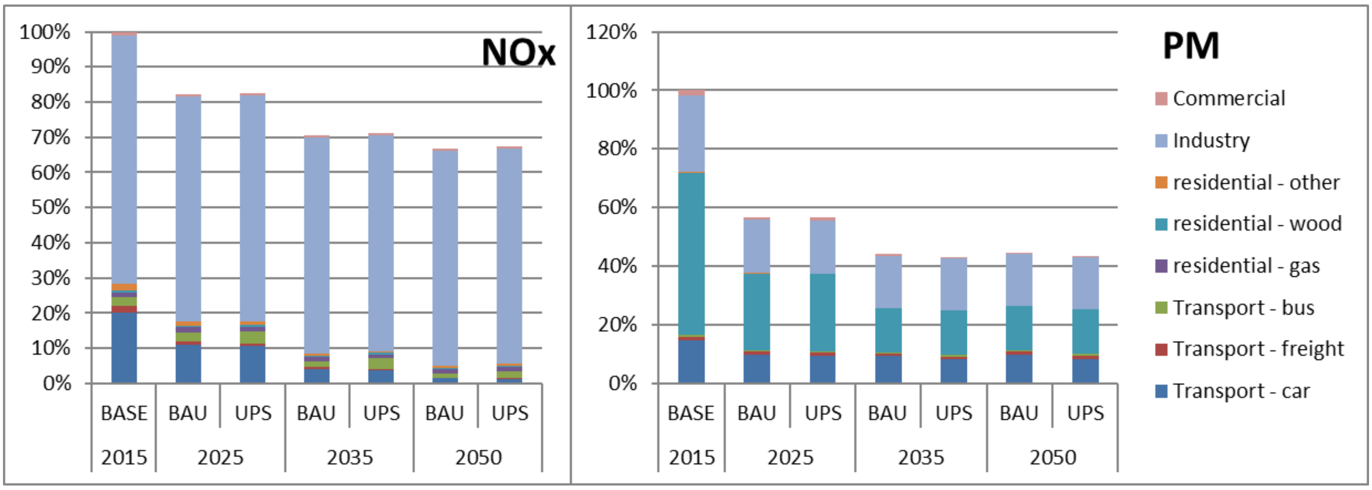
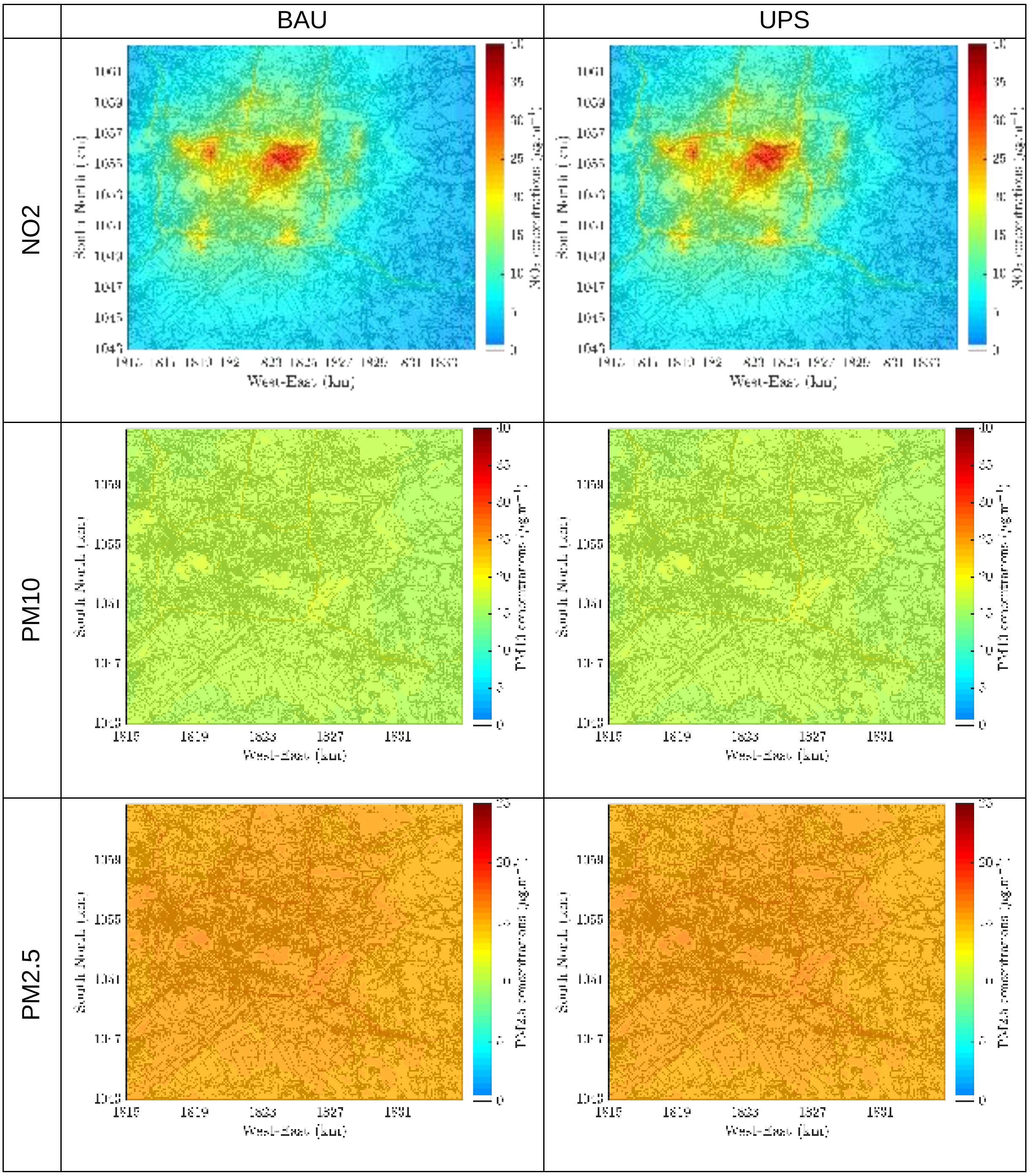


Figure 5-2 gives an overview of modelled NO_2, PM_{10} and $PM_{2.5}$ concentrations in the BAU and UPS scenario in 2050. More detailed concentration modelling results can be found in Annex C. Because of the very limited differences between BAU and UPS emissions, also the reductions in concentrations of air pollutants in the city would be almost equal.

Figure 5-2 NO_2, PM_{10} and $PM_{2.5}$ concentrations in the BAU and UPS scenario in 2050



Comparing UPS and BAU modelling results with legal limit values and WHO guideline values further shows that:

– **Both BAU and UPS scenarios lead to compliance with EU legal NO_2 limit values as well as WHO guideline values in 2050[28].** In that year, the maximum values correspond

[28] NO2: both values are the same, 40 µg.m-3 annual mean

to respectively 32.9 µg.m $^{-3}$ (BAU) and 33.3 µg.m $^{-3}$ (UPS), both below the EU limit value. However, in earlier years still exceedances of limit values in some grid cells are found. In 2025, in the BAU scenario the maximum NO_2 concentration found equals 53.8 µg.m $^{-3}$. In the UPS scenario, the maximum NO_2 concentration is equal to 55.3 µg.m $^{-3}$ in the same year. The UPS scenario will reduce the maximum NO_2 concentrations by 27.9 and 56.6% respectively in 2025 and 2050, as compared to the base year 2015. BAU reduction values are almost the same: 29.9% in 2025 and 57.2% in 2050.

– **For PM_{10}, the BAU and UPS scenario comply with the EU legal limit values as well as with the WHO guidelines in 2025 and 2050[29].** The maximum values in the UPS scenario correspond to 19.3 µg.m $^{-3}$ in 2025 and to 18.8 µg.m $^{-3}$ in 2050, translating into a 15.6% and 17.5% reduction of the maximum concentration compared to 2015. When comparing the UPS scenario with the BAU scenario, the maximum concentrations will be the same in 2025 and 2050 (maximum concentration of 16.7 µg.m $^{-3}$ in 2025, and 16.5 µg.m $^{-3}$ in 2050). Main reason for the fact that concentrations in 2025 and 2050 are the same, while emissions still decrease (see figure 5-1), are the high background concentrations that overshadow the decrease in emissions.

– **For $PM_{2.5}$, BAU and UPS scenarios comply with EU legal limit values, but even in the UPS scenario there are still significant exceedances of WHO guideline values for $PM_{2.5}$ in 2050[30].** In 2025, the maximum value modelled in a grid cell of the UPS scenario corresponds to 17.1 µg.m $^{-3}$, and to 16.6 µg.m $^{-3}$ in 2050. Compared with the WHO guidelines, all the grid cells will still show exceedances in the UPS scenario in 2050. When comparing the UPS scenario with the BAU scenario, the maximum concentrations will be the same in 2025 and 2050 (maximum concentration of 15.5 µg.m $^{-3}$ in 2025, and 15.4 µg.m $^{-3}$ in 2050).

5.2 Impacts on health

Table 5-3 shows the comparison between the UPS and BAU scenario, assessing the health impact benefits of the emission levels proposed by the scenarios. **The resulting relative health improvements benefit of both scenarios are almost exactly the same, independently of the health impact indicator: number of premature deaths or number of year life lost [31].**

The health benefit from implementing the control measures behind the future emission scenarios is considerable. In 2015, the number of premature deaths as a result of NO_2, PM_{10} and $PM_{2.5}$ is 219, 185, and 169 respectively. The BAU scenario reduces these numbers by 67%, 5%, and 3% in 2050 respectively, and the UPS scenario reduces the impact on health due to exposure to NO_2 in 64%, 5% for PM_{10}, and 3% for $PM_{2.5}$.

[29] PM10: EU legal limit 40 µg.m-3 annual mean, WHO guideline value 20 µg.m-3 annual mean
[30] PM2.5: EU legal limit 25 µg.m-3 annual mean, WHO guideline value 10 µg.m-3 annual mean
[31] See Annex C for the methodology on the health impact assessment and results

The health benefit from the reduction on the emissions is in line with the reduction of concentration levels predicted for Ljubljana. However, for particulate matter the reduction of the number premature deaths and the numbers of years of life lost is much lower than maximum concentration levels reduction. This might point to a lower reduction of concentration levels at sites where population density is higher[32].

Table 5-3 Benchmarking the UPS, low and high emission scenarios in 2025, 2035, and 2050 against the baseline scenario in terms of health indicators (%) related to $PM_{2.5}$, PM_{10} and NO_2 exposure.

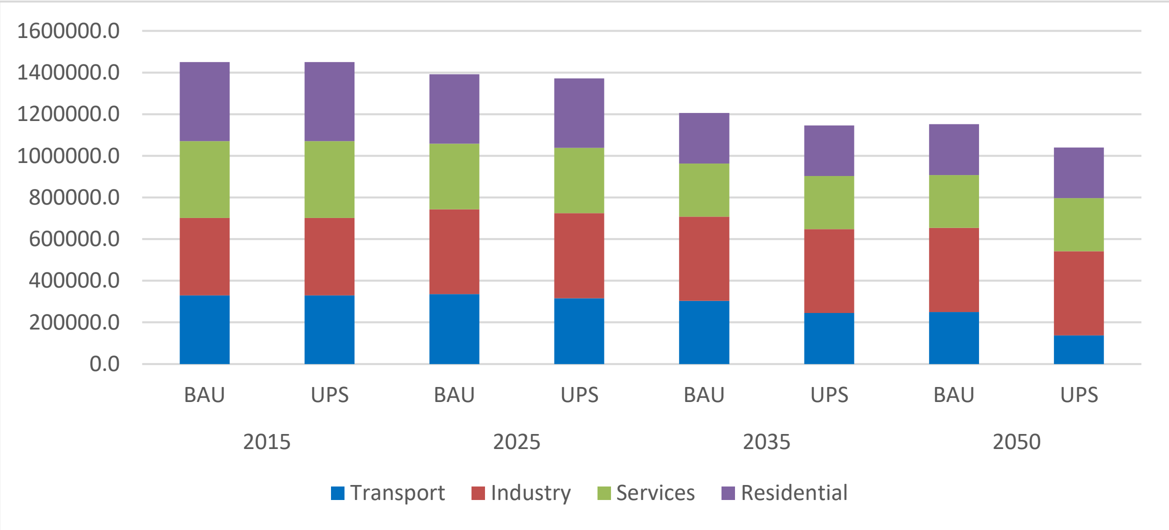
	PM2.5			PM10			NO2		
scenario	2025	2035	2050	2025	2035	2050	2025	2035	2050
BAU	-3	-3	-3	-4	-5	-5	-33	-58	-67
UPS	-3	-3	-3	-4	-5	-5	-31	-54	-64

5.3 Impacts on carbon emissions

Figure 5-4 shows the impacts of UPS measures compared to the BAU scenario in terms of Carbon Footprint.

The figure shows that BAU in 2050 reduces CO2 emissions to about 80% of the level in 2015. In line with the findings in section 5.1 and 5.2, the UPS measures have also a limited impact on CO2 emissions compared to BAU: the UPS measures would reduce the CO2 emissions to some 75% of the 2015 emissions. The reductions are limited to the transport sector, since the UPS measures only refer to this sector.

Figure 5-4 Carbon emissions of UPS scenario compared to BAU (tonnes of CO_2-eq on life cycle)



[32] Also, data of the Copernicus Urban Atlas for Ljubljana that were used for the population calculations are of limited quality. See https://land.copernicus.eu/local/urban-atlas

5.4 Impacts on cost

Table 5-4 gives a qualitative estimate of the cost of the measures in the UPS scenario versus the BAU. More detail on the method applied can also be found in Annex C. We distinguish between estimated monetary costs to citizens, costs for government/city council (no distinction is made between different levels of government) and a net total cost to society, summing up both. On top of that, for an exact calculation of benefits also the indirect benefits of health improvement of citizens (saved public health costs) have to be taken into account. This was beyond the scope of the ClairCity modelling.

In total, net monetary cost effects of the 10 UPS measures vary substantially. Many measures cannot be assessed with the available data. Others, in particular investments in infrastructure, will result in net negative direct effects for society. However, this balance would be more positive if also the indirect health benefits of improved health of citizens would be added.

Table 5-4 Estimated cost impacts of citizen measures that are part of the UPS scenario in Ljubljana

#	Policy measure	Citizens	Government	Society
1	Green transport park for public transport LPP	0	0	0
2	Higher frequency of buses and inclusion of train transport in city traffic	+	-	-
3	Cheaper public transport	+	--	-
4	New areas for non-motorized traffic (pedestrian and bicycling areas)	n/a	n/a	n/a
5	New cycling routes and connections	n/a	n/a	n/a
6	Safe cycling and walking in the city	n/a	n/a	n/a
7	Independence from the car	n/a	n/a	n/a
8	E-mobility	0	0	0
9	Change of parking norms	0	0	0
10	Regional public passenger transport	+	-	-

(+) assumed net positive effect/ benefits for target group; (-) assumed net negative effect / costs for target group; n/a effect of measure cannot be assessed

We can broadly distinguish 2 types of measures: public investment in public transport, either via direct subsidy, increased service frequency or service connectivity and secondly measures that affect infrastructure investment. The former will be beneficial to citizens but will require additional resources for the government, to be generated by taxation. The cost impact of the latter and the infrastructure investment depend on the additionality or shift of the available infrastructure funds.

The assumed cost effects per measure are explained in more detail below:

1. Cleaner buses require extra investment at a cost to the government (-) without a cost effect on citizens (0), leading to an overall net negative cost effect on society (-). However, the level of ambition of this measure (half of busses is EURO VI compliant by

2025) is such that it will likely in full already be achieved in the BAU, thus entailing no additional cost compared to the BAU.

2. A higher frequency of public transport services requires a higher subsidy for buses to be provided by government (-). This measure leads to a cost decrease for citizens as PT becomes an attractive alternative at times and locations currently not the case (+). Yet, this is at a greater expense for the government as incremental model shift to public transport is assumed to require a larger subsidy. The overall societal cost effect is therefore considered to be negative (-).
3. Cheaper public transport requires a higher subsidy for buses to be provided by government (-). This measure leads to a cost decrease for citizens (lower fares) (+), yet at a greater expense for the government as incremental model shift to public transport is assumed to require a larger subsidy. The overall societal cost effect is therefore considered to be negative (-).
4. (and 5,6,7). These are all infrastructure related or “soft” measures, the cost impact of which cannot be assessed without extra information. When assuming a reallocation of the (fixed) investment fund in infrastructure (i.e. from road for cars to infrastructure for walking and cycling), there is no extra cost. When assuming an aggressive investment strategy in new walking/cycling infrastructure, this measure would come at an (extra) cost to the government. Therefore, we did not consider this measure to have a direct measurable cost effect.
8. Incentivize/promote the use of electrical vehicles (EVs) is left to the market. No subsidies or mandatary targets are set. As such we assume no change compared to the BAU.
9. Changing parking norms for new buildings will lead to a gradual change in the available parking spaces. As this involves only new or replacement investemnt in the housing stock, this does not have a measurable cost impact. Investment cost my drop because less space is needed for parking spots, yet this is expected to have a marginal impact on overall project costs. We assume no measurable cost impact for this measure.
10. Finally, a regional hub requires an additional investment and will make public transport (PT) more attractive, inducing a larger subsidies requirment for PT. Investment is borne by government (-), benefits citizens (better connectivity/lower time costs) (+), yet at a greater expense for the government as the investment and the additional model shift to public transport is assumed to require a larger subsidy. The overall societal cost effect is therefore considered to be negative (-).

6 Ljubljana and other ClairCity cities – Mutual learning

In this chapter, main institutional conditions and barriers for implementing citizen policy preferences are discussed (section 6.1). Possible lessons from other ClairCity cities for Ljubljana are outlined in section 6.2 and lessons from Ljubljana for other ClairCity cities in section 6.3.

6.1 Institutional conditions and barriers for citizen-inclusive policies in Ljubljana

Political framing

Zoran Janković is the Mayor of the City of Ljubljana since 2006 as a head of the party Positive Slovenia. He was a former entrepreneur and director of the largest retail organisation of Slovenia. While in the past there have been discussions about alleged corruption cases, this has not withstood his large popularity in the city since his first election[33]. After 2006 he has been reelected in the fisrt round with large majorities four times by the citizens of Ljubljana, lastly in 2018. Janković has initiated policies with strong environmental ambitions which resulted in Ljubljana gaining the title "European Green Capital"[34] in 2016. He also initiated the successful pedestrianisation of the city centre.

Figure 6-1 Ljubljana mayor Zoran Janković

Finance

Ljubljana has been very successful in acquiring European funds for projects, which in turn have a positive effect on the city's green development. Since 2006, there were more than 1,800 green projects in Ljubljana implemented[35], part of which with European funding. However, the Ljubljana policy makers taking part in the ClairCity policy workshop foresee

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[33] https://en.wikipedia.org/wiki/Zoran_Jankovi%C4%87_(politician)
[34] https://ec.europa.eu/environment/europeangreencapital/winning-cities/2016-ljubljana/
[35] Naomi Larsson. "The greenest city mayors take home the fight against climate change",30 November 2015. Accessed at: https://www.theguardian.com/public-leaders-network/2015/nov/30/green-city-mayors-climate-change-paris-cop21.

limitations of city budgets to invest in new green infrastructures in the future. Therefore they were very cautious not to support the high ambition options of in particular the infrastructural measures that were popular by citizens.

Citizen engagement culture

The City council takes a large effort to engage with citizens regarding environmental issues. Engagement methods vary from websites to events, surveys, public discussions, proposals and a city office for citizens' initiatives[36]. Also, the Mayor has a very specific style of personal engagement with citizens, engaging in direct discussions with them and inviting them to air their personal experiences and grievances at bi-weekly open doors meetings. However, the long-term popularity of the Mayor also runs the risk that oppositional voices are less heard. According to some NGOs, formal and legal requirements of citizen involvement are generally followed, but often only in a relatively late stage of policymaking where major decisions have already been taken. Informal contacts to policymakers are therefore a key method of making citizen opinions heard in Ljubljana, with the risk to create a 'closed system', in which opinions that are not expressed within the inner circle of informal policy discussions are not heard[37].

Links with other governance levels and stakeholders

The Ljubljana urban region has a dominant position in Slovenia as an economic and governance hub. Where Ljubljana seems to take the lead in environmental policy making, the surrounding more rural regions seem less progressive. Integration of Ljubljana policy making therefore seems a major precondition for successful further development of environmental policies, in particular as biomass burning in the surrounding areas seems to contribute substantially to air pollution in the city. The integration of regional transport with urban or city's public transport is an important precondition for further modal shift towards public transport of commuters and others entering the city from elsewhere.

6.2 Lessons from other ClairCity cities for Ljubljana

Two general lessons from the other ClairCity cities that could be relevant for Ljubljana are fostering civil society and opposition, and contributing to citizen awareness of the relationship between air quality and health. Furthermore, the examined ClairCity cities could provide several successful implementation examples in the areas of public transport, car and active transport and energy.

Fostering civil society and opposition

In Poland as well as in the Netherlands, NGOs have contributed substantially to overcoming barriers to further development of national and local air quality and climate legislation and

[36] See the Claircity Ljubljana policy baseline report D6.2, www.claircity.eu
[37] See the Claircity Ljubljana policy baseline report D6.2, www.claircity.eu

policies, the latter in particular in Sosnowiec[38]. The specific cases of these NGOs could stimulate Ljubljana to maintain an even stronger relationship with its own NGOs and opposition and thereby find new incentives for furthergoing policies - even more so as the long term dominance of one political party and mayor could run the risk of funneled policy making.

Public awareness of air quality and health

The air pollution indication system that was integrated in the electronic information panels of public transport in Sosnowiec could also be an asset for Ljubljana and all other ClairCity cities when trying to increase citizen awareness of air pollution in the city and its relation to health. This could add to the efforts already undertaken by Ljubljana in this direction, such as daily updated online information on current air quality in the city on various websites and the Ljubljana magazine.

Public transport

Train transport and integration of regional and urban transport seem a remaining vulnerable spot in Ljubljana. The expansion of the national transport infrastructure is a national competence that does not always seem to be synchronised with local developments. So far, the investments in the rail system for instance have been very limited compared to the massive expansion of the road infrastructure in the past decades.

Car and active transport

In ClairCity many citizens expressed to be in favour of expanding the number of cycling lanes in city roads, but there were also many citizens against this measure, as the cycling lanes will reduce the accessibility of roads for cars. Judging from these ambivalent opinions of citizens on the integration of new cycling lanes with private car transport, Ljubljana might take benefit from the experiences in other ClairCity cities where such integration of cycling with car transport already has taken place, notably Amsterdam.

Energy

Further expansion of the urban district heating system and reduction of biomass burning are two measures that could contribute to local air quality and carbon policies in Ljubljana. ClairCity cities Bristol and Amsterdam are also considering substantial expansion of their urban district heating systems. Likewise, the Aveiro region faces similar problems with regional biomass burning as Ljubljana. Mutual exchange of success stories and lessons learned therefore could possibly benefit Ljubljana as well as the other ClairCity cities.

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[38] Alarm Smogovy, with a local branch also in Sosnowiec, with its protests against the bad air quality and smog in Polish cities has been a main reason for the implementation of new regional and national air quality legislation in Poland. The NGO is also involved in local action in Sosnowiec. In the Netherlands, the Dutch NGO Urgenda has forced national government by a court case to stick to implementation of its own climate goals set.

6.3 Lessons from Ljubljana for other cities

Pedestrian zone

The pedestrian or ecological zone in Ljubljana is a particularly successful measure, which is supported by most citizens. Other ClairCity cities could learn from the stepwise process of implementation of this zone. It was introduced in 2007 and expanded over various years with an accompanying package of supportive measures such as a free bikesharing system (from 2011), electrical taxi-like transport free of charge within the pedestrian zone, improved public transport and the construction of underground car parks. The pedestrian zone combines a reduction of air pollution and carbon emissions with improved living conditions in the city centre and with making the city more attractive to tourists. The latter in turn is very beneficial for the economic development of the city.

Notable is also the start of the pedestrian zone in Ljubljana, where the Mayor took creative action in order to test and overcome initial public resistance to the zone. When several streets in the centre once were closed for sewage works, the mayor initiated that the streets remained closed slightly longer than strictly necessary in order to see what public resistance would result[39]. When it turned out that public resistance was managable, a permanent closure of some of the streets was ordered as a start of the pedestrian zone in Ljubljana. Indeed, now an overwhelming majority of the population supports the pedestrian zone that was gradually implemented and expanded over several decades.

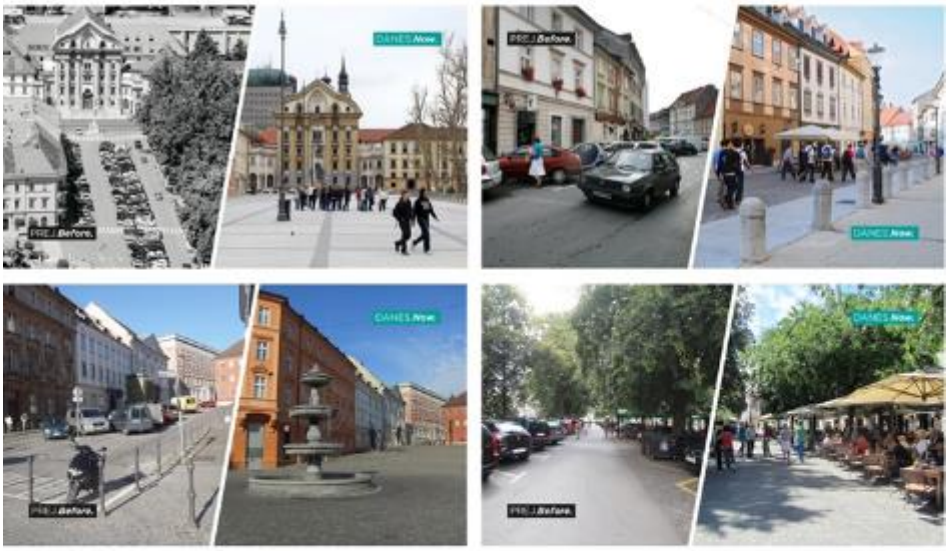


Figure 6-2 Ljubljana pedestrian zone

[39] See the Claircity Ljubljana policy baseline report D6.2, www.claircity.eu

Transport regulation

The pedestrian zone measures were complemented by a city ring, introduction of yellow lanes reserved for public transport on main entry roads, regulation of junctions so that pedestrians and cyclists have priority and a reorganisation of roads into one-way traffic zones and 30 km/h zones. Further, the public transportation system was equiped with an electronic payment system (Urbana smart card), the munical public fleet became all electric or gas, public transport routes were optimised and transport on demand was introduced.

7 Citizen-inclusive air quality and carbon policies in Ljubljana: Conclusions and recommendations

The ClairCity project has set up an innovative citizen engagement process and verified implementation possibilities of policy desires of citizens with that of stakeholders and policy makers. The project has also modelled the likely consequences of the consolidated citizen scenario for air quality and carbon emissions.

In this chapter we draw the main conclusions and propose recommendations to Ljubljana policy makers. These have to be understood within two main limitations of the ClairCity project:

− Despite the large and varied number of engagement methods, the sample of respondents in Ljubljana is not fully representative for the whole city population.

− ClairCity modelling assumptions do not fully correspond with those of local modelling. The quantitative outcomes of modelling the citizen policy measures in terms of emissions, concentrations and health cannot be directly compared with those of local models.

Despite these limitations, however, the ClairCity project gives an overall indication of how Ljubljana citizen behavioural practices and anticipated future behaviours might affect policy making. The project also gives a view on what citizens in Ljubljana think of future policies and what might be the consequences of implementing these views, callibrated by policy maker comments, into actual policies.

7.1 Conclusions

7.1.1 Current city policies in Ljubljana

- **The main air quality issue related to citizens seems PM and biomass burning outside the city, although NO_2 might be also still an issue for the future.**

  Ljubljana has been continuous measuring air pollution in the city for over 45 years. The city has initiated and strenghened large number of environmental measures over the last decades, with as most prominent measure the introduction of a large pedestrian zone in the city centre. Particulate matter emissions and resulting concentrations, to a large extent caused by biomass burning outside the city, are noted as a main air quality problem. This holds in particular when comparing concentrations to the much stricter WHO guideline values and more for $PM_{2.5}$ than for PM_{10}. However, ClairCity modelling suggests that also NOx emissions and resulting NO2 concentrations at some hotspots could be an issue when comparing them to legal limit values.

7.1.2 Current behaviour of citizens in Ljubljana

- **Current transport behaviour of Ljubljana citizens is already quite environmentally friendly, with shopping as the least environmentally friendly transport activity**

  Of the ClairCity respondents, 42% currently uses only their private car for shopping, compared to 23 and 16% for commuting and leisure. Also, a much smaller number (32%) presently only uses public transport and active travel for shopping, compared to 65% for commuting and 54% for leisure.

7.1.3 Behavioural preferences of Ljubljana citizens for the future

- **Comparing stated intentions of respondents for behavioural change with the policy ambition of the city council to achieve 2/3 active transport, suggests that this could be in line with citizens' intentions for commuting and leisure, but for shopping behaviour achieving the policy target might be more difficult.**

  When asking respondents for their behavioural preferences in the future, 77% indicated preferring to use only public and active transport for commuting in the future, 70% did so for leisure and 60% for shopping transport needs. Equally, of the respondents 4% indicated wanting to use only their private car for commuting, 9% did so for leisure and 20% for shopping.

- **While expansion of district-heating is an option that could contribute to reducing air pollution in the future, the expansion of district-heating does not seem popular with respondents.**

  District heating can be an environmentally friendly option for the heating of private homes, provided that the heat is generated for instance from renewables or waste heat from industry. 32% of the ClairCity respondents indicated to be currently connected to the district-heating system, but only 16% wanted to use district-heating in the future.

7.1.4 Policy preferences of Ljubljana citizens for the future

- **Expansion of cycling lanes in streets at the cost of space for motorised traffic seems controversial.**

  Out of the selected most popular policy measures of citizens for their city in the future, the expansion and the scrapping of cycling lanes showed to be almost equally popular with respondents.

- **The impacts of citizen policy measures as compared to a business-as-usual policy scenario for Ljubljana are small due to the nature of the finally selected measures and ambition levels finally selected by policy makers.**

  Policy makers had a relatively large influence on the impacts of the citizen policy measures compared to other ClairCity cities. Firstly, input measures for the policy workshop were limited to transport measures only, giving an indication where current policy priorities in Ljubljana are. Secondly, policy makers in Ljubljana, contrary to many of the other ClairCity cities, selected low or medium ambition levels for many of the measures preferred by citizens.

- **Costs of policy measures are a key concern to Ljubljana policy makers.**

  The main reason for selecting low or medium ambition levels for preferred measures of citizens given by policy makers are the concerns about costs, as the infrastructural measures preferred by citizens would often incur high costs.

7.1.5 Institutional conditions and barriers for implementation of citizen policies

- **The integration of local policy measures with the region needs attention**

  The urban area of Ljubljana is surrounded by mostly rural areas. Integration of policy measures with those in the region is therefore a key issue, for instance to integrate regional with urban public transport (bus and train) and to address mostly rural biomass burning – next to industrial background emissions - that impact air quality in the city.

- **Civil society and NGOs need to be fostered**

  In Ljubljana, the mayor is in office for many years and was re-elected several times. In this situation, civil society and NGOs indicate that it is sometimes difficult to make their voices heard. Hence, care has to be taken that also citizen inputs given through these channels remain to be considered in policy decisions taken.

7.2 Recommendations

Based on the conclusions of the Amsterdam ClairCity analysis several recommendations for more citizen-inclusive policy making can be given:

7.2.1 Tailoring policies to current behaviours and to preferred future behaviours of citizens

- **Address in particular shopping behaviour, next to other transport behaviours**

  Since shopping behaviour from the ClairCity research appears a main area where behavioural change towards public and active transport is difficult for citizens, a specific campaign could be directed at facilitating non-car shopping transport, e.g. by promoting (electrical) transport bikes, public transport rebates provided by shopping centres and increasing parking fees in shopping areas. Also, home delivery by electric vans could be stimulated.

Figure 7-1 Supermarket home delivery service by electrical bike in the Netherlands (De Stentor - F. Schinkel, 2018)

- **Make citizens aware of the advantages of district heating to combine with renewables**

Increasing awareness of the positive environmental aspects of district heating – if realised with renewables, waste heat from industry or geothermal heat sources – could make citizens easier accept a switch to this heat source.

- **Discuss the impacts of cycling lanes with citizens**

Increasing the number of cycling lanes seems controversial with Ljubljana citizens, as it will decrease road space for cars. While this is an intended effect in order to stimulate modal shift from private cars to bikes, it could be investigated where specific hotspots are that are particularly controversial and it could be discussed with citizens what are the intended impacts of the cycling lanes and why.

7.2.2 Addressing institutional barriers and mutual learning

- **Increase measuring and modelling facilities in Ljubljana, for instance by stimulating citizen science measurements**

Stimulating citizen science measurements of air quality is a cheap way of increasing the number of measuring spots in the city, that simultaneously increases awareness of citizens of live air quality conditions. Several other cities in Europe, including ClairCity cities Amsterdam and Bristol, are already experimenting with such approaches.

- **Integrate policy measures with those in the regions bordering to Ljubljana and disseminate the successes of the Ljubljana approaches**

Integration of regional and urban public transport could for instance be studied from the Bristol Metrobus system. A systematic study of integration approaches throughout Europe and their applicability to Ljubljana could be made.

- **Show live air quality conditions in the city in order to increase awareness of citizens of the health benefits of clean air**

ClairCity city Sosnowiec has integrated live air quality information into the public transport timetable information system. Amsterdam is experimenting with an approach that expresses health benefits of clean air in the reduction of number of sigarettes smoked per year. Similar approaches could be applied in Ljubljana, on top of the approaches already applied in the city, such as the 'Cyanometer' art sculpture in the city, that gives an indication of air quality in the city in an artistic way.

Figure 7-2 Live air quality information in ClairCity city Sosnowiec

- **Communicate successes of the 'European approach' in Ljubljana to other cities**

Ljubljana has been very successful over the last years to attract European projects that contributed to greening the city. Ljubljana also has been 'European Green Capital' in 2016. The lessons and successes of this approach could be communicated more extensively to other cities in order to strengthen mutual relationships, which in turn could be used further to attract new European projects.

- **Investigate success stories of integration of train transport in the overall transport system in other countries and regions**

Expansion of train transport is a particular area of interest in Ljubljana. Other ClairCity cities already have extensive experience with integration of train and active transport, for instance Amsterdam.

- **Make sure that voices of civil society and opposition remain to be heard and discussed**

Existing exchanges between policy makers and civil society should be fostered and could from time to time be rechecked if they fulfill their purpose for both sides.

Annex A. The ClairCity project in detail

This annex explains in more detail the ClairCity process and the positioning of this 'Ljubljana policy package report'.

The ClairCity project consists of three phases and seven work packages (Figure A-1):

Phase 1: Establish the Baseline Evidence

The primary aim of Phase 1 is to understand and quantify the baseline status of air quality, carbon emissions and related public health in our cities. Phase 1 is achieved with the following main activities:

1. **Benchmarking behaviour**: Understanding the local demographic data and establishing the citizen practice-activity data to feed into the air quality models.
2. **Quantify the baseline**: Quantification of the baseline air quality emissions and concentrations, carbon emissions and public health impacts in a city.
3. **Assessment of Policy**: Collation and analysis of current policies (local, regional, national and EU) that influence the city.

Phase 2: Citizen and Stakeholder Engagement & Co-creation of Scenarios

Phase 2 has three key aims: (1) understand citizens' current behaviours, practices and activities, (2) enable citizens and stakeholder to co-create and visualise their low carbon, clean air, future city and (3) raise awareness of the environmental challenges and their solutions. Phase 2 utilised evidence from Phase 1 to help frame and inform the engagement activities. Phase 2 is achieved with the following main activities:

Citizen and stakeholder engagement & co-creation

1. The ClairCity Delphi method uses citizens as local experts to generated qualitative evidence of their entrenched behaviours and what enabling interventions would allow them to act and behave differently in future (WP4).
2. The Mutual Learning Workshop brings citizens and stakeholders together to debate the challenges facing the city and co-create policy interventions for cleaner, healthier futures (WP4).
3. The ClairCity Skylines Game 'crowd-sources' the public perceptions and public acceptability of difference policy interventions (WP4)
4. Citizens and stakeholders come together in a Stakeholder Dialogue Workshop to review and debate the Delphi, Mutual Learning Workshop and ClairCity Skylines evidence and co-create scenarios for a low carbon, clean air, health futures (WP4 and WP7).
5. The scenarios generated in the Stakeholder Dialogue Workshop go through a rapid quantification step (WP5) and are then returned to the local citizens/stakeholders to discuss in a Policy Workshop (WP6) and to agree a single Unified Policy Scenario (WP7).

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 689289

Public Engagement & Awareness: Additional awareness raising activities are also implemented across the project in each city (WP4). These include:

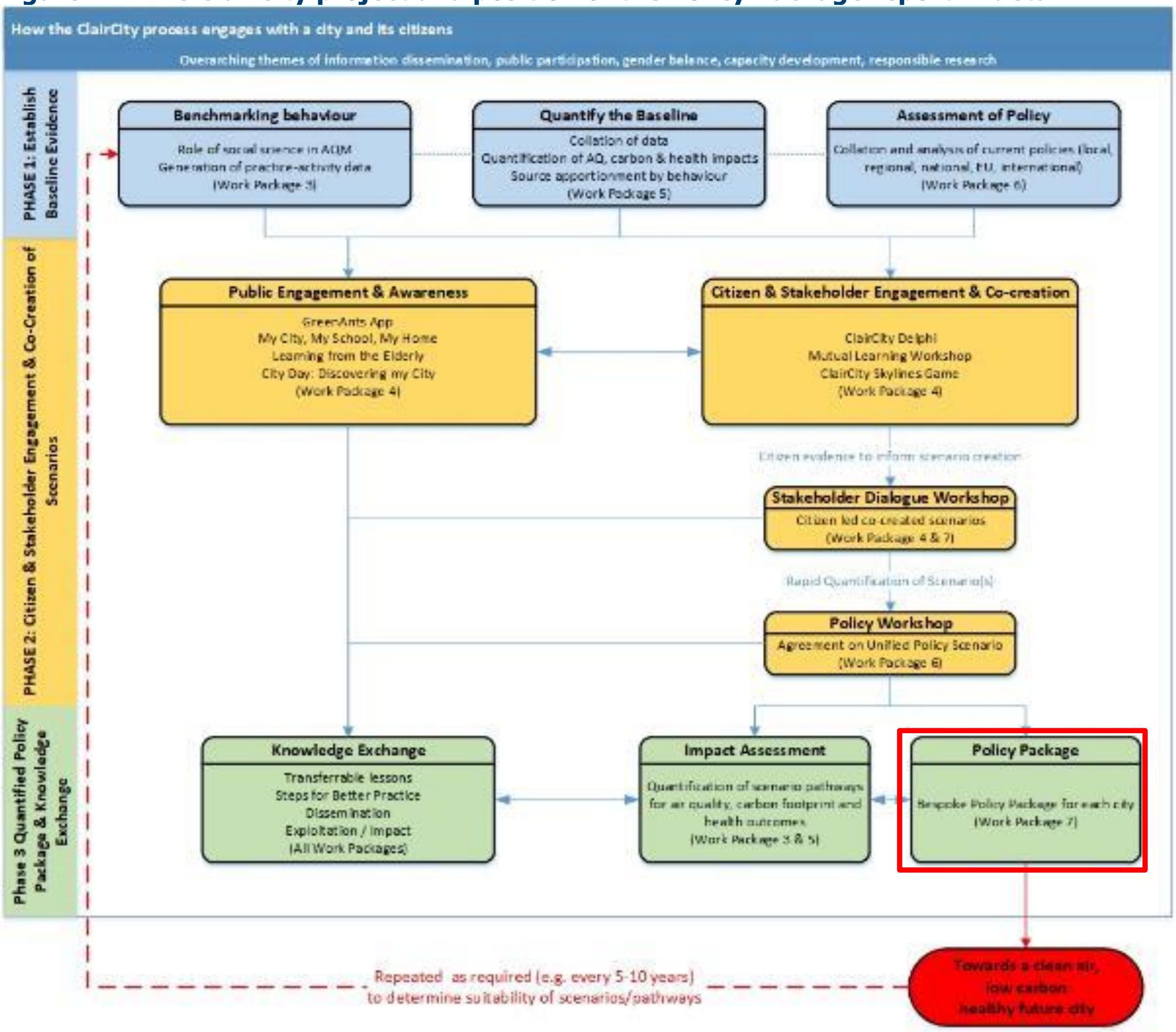
6. The GreenAnt App which allows citizens to become a citizen scientist and monitoring their transport activities, emission generation and exposure using mobile GPS data.
7. The School Competition: My City, My School, My Home engages young people in the air quality, carbon and public health debate utilising an online platform for the students to select the interventions that influence their housing, transport and use of resources in order to be able to design tools for change towards smart consumption, reduced emissions and healthy lifestyles.
8. Learning from the elderly filming activity engages the older, potentially vulnerable, community to talk about the changes in their city, their personal mobility and the steps they take to minimise their exposure to air pollution.
9. The City Day: Discovering my City helps disseminate the final project results and provide healthy and smart tips to promote non-motorised mobility of citizens by highlighting availability and benefits of walking and cycling routes in the city.

Phase 3: Quantified Policy Package & Knowledge Exchange

The primary aim of the final Phase 3 is to collate the evidence and lessons learned from Phase1 and Phase 2 to generate a quantified, bespoke, citizen-led and citizen-inclusive policy package for each city. Phase 3 is achieved with the following main activities:

1. **Knowledge Exchange**: Collation of transferrable lessons and steps for better practice based on the experiences of the ClairCity project to inform other environmental and public health practitioners (WP3, WP4, WP5, WP7).
2. **Impact Assessment**: Rapid quantification of the scenarios generated in the Stakeholder Dialogue Workshop (WP4) and detailed impact assessment of the final Unified Policy Scenario generated in the Policy Workshop (WP6). This quantification includes an assessment of the source apportionment by behaviour or purpose; air quality emissions and concentrations, carbon emissions, air pollution related health impact and interventions cost analysis (WP5).
3. **Policy Package**: Development of a bespoke Policy Package for each city drawing together the findings from across the whole project (WP7).

Figure A-1 The ClairCity project and position of the Policy Package report in detail



Annex B. The ClairCity citizen engagement process

The citizen engagement process developed by ClairCity consisted of policy focused activities and of awareness raising directed activities. In annex B-1 the former are discussed in some more detail, in annex B-2 the latter. For an even more comprehensive overview and analysis in addition the more detailed ClairCity reports on each activity can be consulted.

B.1 Policy related engagement activities

Three main engagement activities directly informed the policy workshop and the policy recommendations: the Mutual Learning Workshop, the Delphi process and the Skylines game.

Mutual Learning Workshop (MLW)

The MLW in Ljubljana was attended by 16 participants. The attendees were asked to imagine how Ljubljana would look in 2050, including any changes they expect to see.

The participants defined the Priority actions and measures:

By 2020

- Promotion of adopted strategies – policy measure: closing of the roads for individual transport for several days,
- Vegetation of riparian area - measure: continuous and round cycling routes
- Improvement of quality of living - measure: more green elements in the traffic streets, more stations for bicycle, promotion of sustainable mobility

By 2030

Ljubljana city for all generation - measure: increase of green spaces and green infrastructure with multifunctional role

Sustainable mobility - measure: relieve of Zois street for traffic

Burn calories not gas - measure: spread of inner pedestrian ring, car sharing

By 2050

Strategy for implementation of adopted strategies - measure: the center of city is free of cars, the delivery is arranged

Modern, innovative city - measures: Complete electrification of public transport, hyper mobility, bicycle is the engine for development, work from home, reduction of needs

Main barriers identified were:

- To establish the final vision of the area of interest,
- to increase the traffic free zone to the wider area,
- to establish the sharing space which is in use on very busy area of Ljubljana,
- to increase the number of Bicycle (the bicycle) stations,
- to introduce the transport on the Ljubljanica river regular stations,
- to replace all public transport with electric buses and cars,
- to increase the number of vehicles for older and other in need (Kavalir type of individual transportation linking the public transportation).
- in addition, city would need to work on restoration of green areas, including new water elements (fountains and drinking water areas).

- another systematic <u>solution for cleaner air</u> is a complete public heating system which is currently not available.

Delphi Process

The Delphi process in Ljubljana consisted of two survey rounds followed by a Stakeholder Dialogue Workshop.

In Ljubljana, 199 responses were received out of a city population of 280,210 . 58% of the respondents were female. There was an under-representation of the oldest and youngest categories, with more than two thirds of respondents aged 25-50 compared to 38% in this category in the city as a whole. The respondents are highly educated, with 65% holding a university education compared to only 24% of the city population. A third of Ljubljana residents have vocational education qualifications, but only 1% of our survey respondents have this. In Slovenia the national or cultural identities of citizens is a politically charged topic due to the histories of Former Yugoslavian populations. As a consequence for ethical reasons we nationality nor ethnicity were used as a demographic identifier for population sampling in Ljubljana.

The majority of respondents were female, making up 68% of the Round 2 respondents. The 37-50 age category were a disproportionate set in the data, at 51% compared to only 24% of the total population. This was at the cost of older people, with only 3% of the Round 2 sample over 65, compared to 15% of the city. The data also represents the highly educated more than the average citizens, with 85% holding some form of higher education certificate, compared to only 31% of the general population.

The Stakeholder Dialogue Workshop (SDW) was organized in Ljubljana on the 18th of April 2019 as part of WP4 - Citizens and Stakeholder Engagement, Task 4.1: Citizen Delphi Engagement. The event was entitled as »SKUPAJ Z VAMI ZA ŠE ČISTEJŠI ZRAK V LJUBLJANI« (in translation “Together with you for cleaner air in Ljubljana”). The aim of the SDW was to synthesize the evidence streams from the ClairCity process such as the Delphi, Mutual Learning Workshop and Game to allow city stakeholders to generate a number of potential future scenarios for a low carbon, clean air pathways in the short-medium and long term to 2050. The event was organised on the premises of Ljubljana municipality City Hall.

Figure B-1 Ljubljana Stakeholder Dialogue Workshop

The SDW was attended by 26 participants, with 2 persons from academia, 8 from authorities, 1 city councilor, 5 from SME, 4 from NGOs 2 from citizens community biro and 4 from media. The attendees were having background from geography, architecture, health, medicine, economy, landscape and urbanists, security, physics and chemistry.

The SDW was divided in several parts, first covering the ongoing projects relevant for the city and presenting some of the recent national and international projects. The second part was devoted to moderated discussions between the representative of the municipality bodies and participants. Third part was focused on the interactive workshop in which participants discussed the policy measures and ambitions which would be in a short, medium and long term implemented in the city. The policy measures were discussed in relation to the public transport, walking and cycling and car use, the policies were evaluated based on the ambition of participants to achieve. Also, the interdependences of measures were taken into account by understanding of the impacts which the implementation of measures can bring and economics behind. The event finished with the guided cycling tour in which the vice mayor of Ljubljana presented some of the challenges and solutions for improvement of cycling in Ljubljana.

Skylines game

ClairCity Skylines is a ‘serious game’, designed to capture citizen decision making about issues in their city, where players travel between areas representing a city’s environment, economy and its citizen’s health & satisfaction, and at the same time gatheringa ideas for low carbon, clean air, healthy future policies before 2050 (Figure B-2).

Bristol was the first of the six partner cities to to be included in the game, and launched in April 2018. An updated, localised version of ClairCity Skylines was launched in Amsterdam following a significant database upgrade in November 2018 based on the findings of the Bristol pilot. The upgrade allowed the final 4 cities/regions to launch simultaneously in Ljubljana, Sosnowiec, Aveiro and Liguria in January 2019, with primary data capture closing at the end of March 2019. The game includes English, Dutch, Slovenian, Polish, Italian and Portuguese localisations for game text, UI and the policy database.

The total number of players in Ljubljana was 24, as compared to 949 in Sosnowiec, 836 in Bristol, 371 in Amsterdam, 243 in Aveiro, 66 in Liguria and 307 in other cities.

Figure B-2 Logo of the Ljubjana version of the Skylines game

Figure B-3 Total number of Skylines players per city

Location	Number of users	Percentage
Sosnowiec	949	33.9
Bristol	836	29.9
Amsterdam	371	13.3
Other	307	11.0
Aveiro	243	8.7
Liguria	66	2.4
Ljubljana	24	0.9
No response	4	0.1

B.2 Awareness related engagement activities

Three activities in the ClairCity engagement process were mainly awareness related: the secondary school activities directed at young people, the film competition for the elderly and the city day.

Reason for the focus on young people and the elderly is that ClairCity builds on the WHO Policy Framework and the European Commission's Clean Air Policy Package that promote public health by paying special attention to more vulnerable groups, such as children and senior citizens. The aim is to empower these citizens to better understand the specific challenges and opportunities that their city currently offers and to engage them into moving towards reduced air pollutant emissions and carbon footprints. The project has therefore collected their perceptions and ideas on sustainable lifestyles and a 'better quality of life' within their city in the future.

Young people

The Ljubljana project team tested and launched the Slovenian version of the school software and contacted four schools (age 11-13 years old). However, finalisation of this activity was delayed due to the 2020 Corona crisis. Therefore information on the activity could not be included in this report.

Elderly

In Ljubljana, three videos were prepared by elderly. The topics of the videos were the following:

- cycling and walking across the city: video shows the alternative mobility options in the city
- health benefit of non-motorised transportation: video explains the preventive aspects of healthy mobility
- sustainable mobility in the city: video shows the alternative possibilities for mobility and promote cycling and walking in broader sense

The videos were promoted via the project website and social media to receive feedback on the content and format of the short video. All videos received positive feedback by the followers and the project team.

The videos were uploaded to the ClairCity project website, Facebook, YouTube and linked to the city website.

The videos were uploaded to the ClairCity project website, Facebook, YouTube and linked to the city website.

Link to the project website: http://www.claircity.eu/take-action/communities/

Link to YouTube:
https://www.youtube.com/watch?v=_wsvEfxLmFs

https://www.youtube.com/watch?v=d8Fuw9vO4TQ

One of the most interesting topics of the films is the cycling access in Ljubljana for the citizens. The self-service bicycle rental system BicikeLJ was set up in May 2011 and since then the city has recorded over six million bike rentals. The last station was incorporated into the system on 3rd June, on World Bicycle Day, it was set up in front of the Mercator retail store on Celovška Cesta 163.

In addition to this, Ljubljana was ranked as one of the most bicycle friendly cities in 2019. The ClairCity project filming activity promoted cycling and walking to increase the sustainable mobility in the city. Interesting to learn that the Copenhagen Index is the most comprehensive and holistic ranking bicycle friendly cities on earth. The Index's smallest city, Ljubljana was described as a breeze to visit: green, liveable, bike-friendly.

City Day

The City Day was organised on 21st September 2019 during the ‘mobility week’. The agenda of the mobility week focused on several activities to promote sustainable lifestyles, the active travel, the improvement of the actions of the city social networks. The City Day fits to the agenda of the ‘mobility week’ with raising awareness of environmental challenges and their solutions through proactive dissemination of the project outcomes. The ClairCity project goals and outcomes on the citizens led air pollution reduction options were disseminated during the city day for a few hundred participants.

Annex C. Ljubljana citizen engagement impacts: scenarios and modelling

C.1 Overview of modelling activities

To understand the impact of the policies the citizens put forward, we assessed the impact of policies on emissions, air quality, health and costs in three steps:

1. Step 1: Reproduce the air quality situation as it is currently, in a modelling environment (“baseline”): First, estimate total emissions from different sources, in line with statistics (by sector, by time of day, link with behaviour); Second, model the air quality and validate the modeling ouput with with observations; Third, assess exposure and health impact with common indicators.

2. Step 2: Estimate future emissions in a scenario with existing policy measures and model the resulting air quality. This business-as-usual scenario (BAU Scenario) aims to capture the changes in air quality if no further measures are taken, only accounting for changes in the emissions due to policy measures made in the past and expected technological and/or behavioural changes.

3. Step 3: Estimate future emissions in a scenario with additional policy measures as aimed for by Ljubljana citizens and commented by Ljubljana policy makers (Unified Policy Scenario, or short UPS Scenario). We follow the same route, from estimating the impact of the measures on emissions, to air quality and health impact.

The three steps are explained in more detail in section C.2. Section C.3 gives further results from the behavioural modelling / source apportionment approach carried out with the data in order to relate air quality emissions and concentrations to citizens’ behavioural activities.

C.2 Results

The results of the modelling exercise consist of three parts:

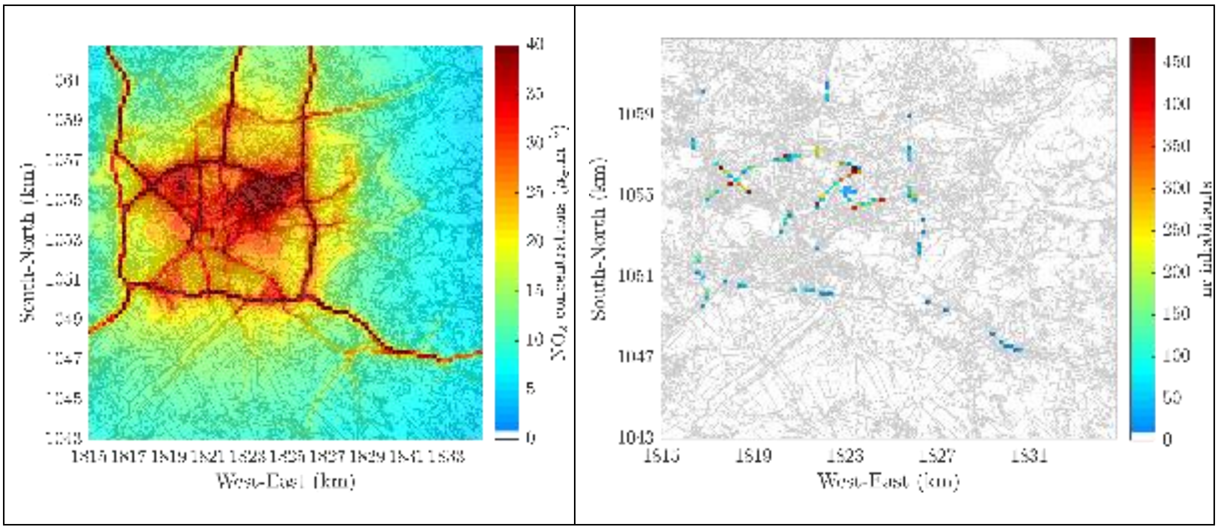
- Results for the situation as it is (baseline)
- Expected future without future action (BAU)
- Future with additional policy action (UPS)

C.2.1 Air quality for the baseline

The second-generation Gaussian model URBAIR was setup and run at an urban scale for the computational domain over the urban area of Ljubljana. The baseline simulations were performed for the full-year using the meteorological vertical profiles from the WRF-CAMx system and the emissions available on the ClairCity emissions database. Background concentrations were added to the URBAIR model results. For that purpose, it was established a single value to apply to each grid cell. This value is the average concentration from the transboundary transport obtained from the WRF-CAMx results using the source apportionment tool. In addition, the simulation results together with the added background concentrations were calibrated against the measurements[40] through the adjustment procedure. For NO_2 concentrations, a slope of 1.7 obtained from the linear regression is applied as a correction factor over all the domain. In case of particulate matter, PM10 and PM2.5 concentrations the slope obtained from the linear regression is equal to 0.7 for PM10 and 0.4 for PM2.5 concentrations.

Figure C-1 a) shows the resulting NO_2 annual average concentrations. Figure C-1 b) points out the population potentially exposed to NO_2 concentrations above the EU legal limit value of 40 µg.m $^{-3}$.

Figure C-1 NO_2 contour maps: a) annual average of NO_2 concentrations and b) number of inhabitants within the cells exceeding the EU annual limit value of 40 µg.m^{-3} in 2015

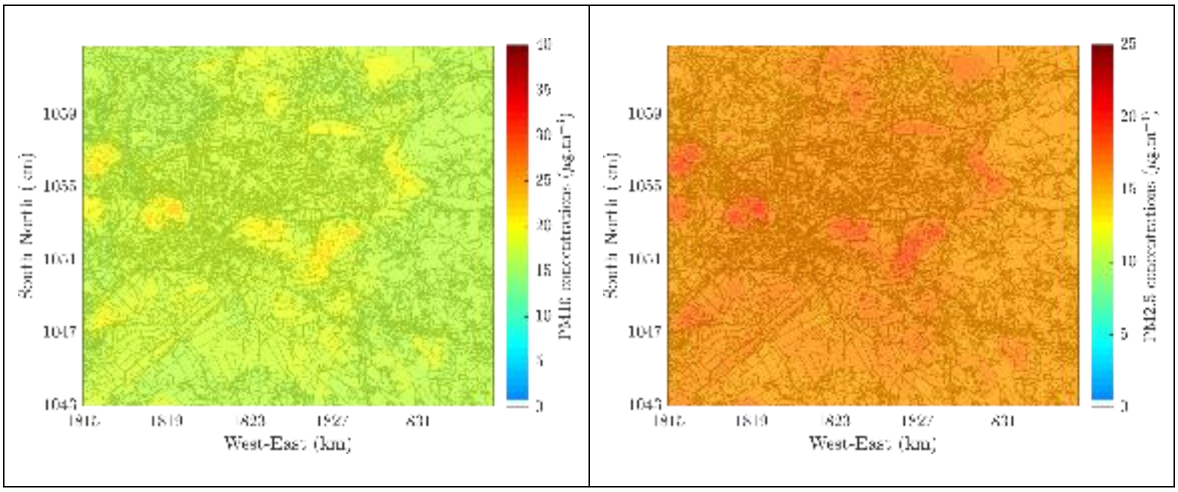


The simulation results indicate a maximum concentration of 76.8 µg.m^{-3} over the urban area of Ljubljana, with several hot-spots linked to road traffic patterns. The EU annual legal limit value for NO_2 annual concentrations is exceeded in 304 cells, out of which 170 with permanently resident population allocated to them. This corresponds to around 5% of the total population within the urban area potentially exposed to those concentrations.

[40] The NO_2 observations available for 2015 include measurements from 3 continuous measurements from the Polish monitoring network: 1 road traffic site, and 2 urban background sites. Similarly, the PM10 observations available include measurements from the same 3 continuous sites. PM2.5 observations are only available for the road traffic site.

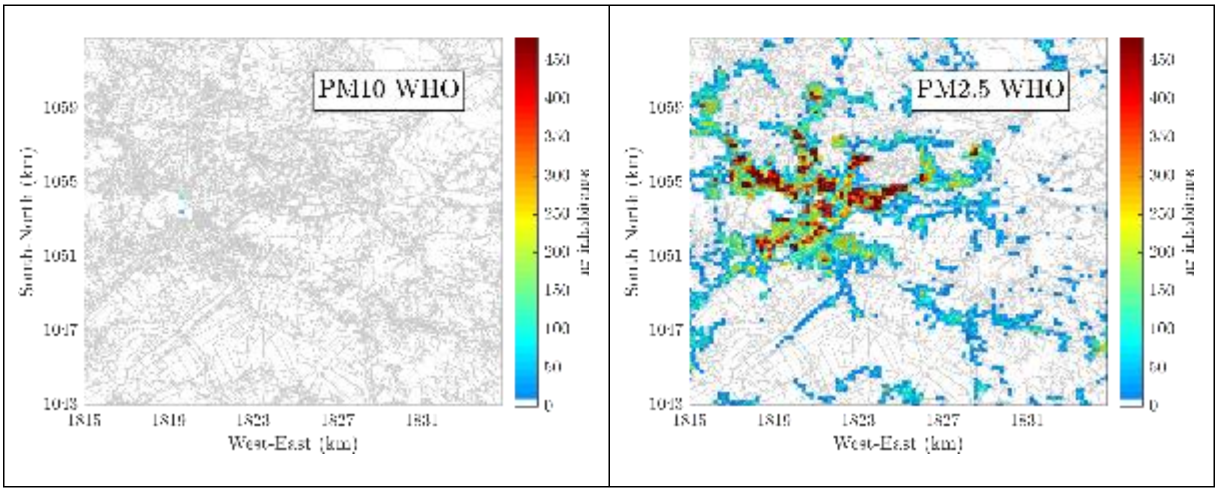
Figure C-2 presents the PM_{10} annual average concentrations (Figure C-2 a)) and the $PM_{2.5}$ annual average concentrations (Figure C-2 b)).

Figure C-2 (a) PM_{10} annual average concentrations and (b) $PM_{2.5}$ annual average concentrations in 2015



The maximum value of PM_{10} concentrations is equal to 22.7 µg.m $^{-3}$, which is simulated over the urban area of Ljubljana with several hot-spots related with the residential and commercial emission sector, with a contribution of 96.5% to the average concentrations simulated over the whole urban area. The simulated maximum concentration of $PM_{2.5}$ equals 19.5 µg.m^{-3}. The PM concentration contour maps point out no exceedances to the EU legal limit values for PM_{10} and $PM_{2.5}$, equal to 40 µg.m $^{-3}$ and 25 µg.m $^{-3}$. However, despite the compliance of the EU legal limit values, both the annual PM_{10} and $PM_{2.5}$ concentrations indicate exceedances of the WHO guideline values. In the urban area of Ljubljana 100% of the total population are potentially exposed to $PM_{2.5}$ concentrations exceeding the WHO recommendations.

Figure C-3 Number of inhabitants within the cells exceeding the WHO air quality guideline values: a) of 20 µg.m^{-3} for PM_{10} concentrations, and b) of 10 µg.m^{-3} for $PM_{2.5}$ concentrations in 2015



Assessment of health impacts for the baseline

The health benefits related to air pollution were illustrated by calculating health impact indicators for different air pollutants (NO_2, PM_{10}, and $PM_{2.5}$): the number of premature deaths and years of life lost (YLL). Premature mortality is a standard measure of the burden of the population's health, as it is expected that most deaths are preventable before a person reaches an expected age. YLL is defined as the years of potential life lost due to premature deaths. Since YLL takes into account the age at which deaths occur, relative to life expectancy, higher weight is given to deaths at a younger age than at an older age (de Leeuw and Horálek, 2016). Mortality indicators are not the only indicators available for the burden of disease related to air quality but are certainly the ones with higher external costs to society (OECD, 2016).

The burden of disease associated with ambient air pollution is estimated by relating air concentrations to health outcomes. Gridded annual averages were used as input to quantify the relative risk in a population, based on concentration-response functions (CRF). CRFs reflect the effect of a pollutant on a health outcome, e.g., NO_2 on mortality from cardiopulmonary diseases, typically expressed as the increase in incidence or prevalence per unit increase in concentration. Table C-1 describes the risk ratios, the mortality causes, age interval, and concentration threshold consider when calculating the health outcomes for each air pollutant. The threshold concentration is the concentration level below which no health effects are expected.

Table C-1 Risk ratios (RR) for mortality

Pollutant	Value [per 10 μg/m3]	Type	Reference
PM2.5	RR 1.062 (95 % CI 1.040-1.083) No threshold	All-cause (natural) mortality in ages above 30 (ICD-10 codes A00-R99).	WHO 2013a
PM10	RR 1.04 (95% CI, 1-1.09) No threshold		Beelen et al., 2014
NO2	RR 1.055 (95 % CI 1.031-1.08%) Threshold: 10 μg/m^3		WHO 2013a

Premature deaths can be estimated at the grid-cell level by multiplying the population attributable fraction (PAF), the crude death rate (CDR), and the total population for every cell. PAF is defined as the reduction in population mortality if exposure to a risk factor was reduced to an ideal exposure scenario (e.g., concentrations equal to zero). PAF can be calculated from the relative risk, assuming an exponential behaviour. CDRs were calculated based on natural all-cause mortality in 2015 (WHO, 20019, ICD codes A00-R99) and country level population (UN, 2019a), broken down by age and sex. Here it is assumed that CDR is constant across the country's population. YLL is calculated at the grid cell level by multiplying premature deaths with life expectancy by age and sex. Life expectancy data is based on data published by the UN (2019b).The expected burden of disease attributable to air pollution in a specific area can finally be estimated by summing over all grid cells in the area of interest for the indicator of interest.

The results for the baseline scenario indicate there has been 219, 185, and 169 premature deaths atributed to NO_2, PM_{10} and $PM_{2.5}$ polution levels in Ljubljana in 2015, respectively. For the same pollutants, 2306, 1950, and 1781 years of potential life lost were estimated for Ljubljana in 2015.

C.2.2 BAU

BAU impacts on air quality

The reductions of the NO_x emissions in the BAU scenario will lead to significant reductions of the NO_2 concentrations. Figure C-4 presents as example the NO_2 annual average concentrations considering the impacts of BAU scenarios for 2025 and 2050. The maximum NO_2 concentration will be equal to 53.8 µg.m $^{-3}$ in 2025 and to 32.9 µg.m $^{-3}$ in 2050, corresponding to an overall reduction of the maximum concentration of 39% (from 2025 to 2050). In the BAU scenario, the NO_2 concentrations will still exceed in 2025 the EU limits and WHO guidelines.

Figure C-4 NO_2 annual average concentrations for the BAU scenarios: a) 2025 and b) 2050.

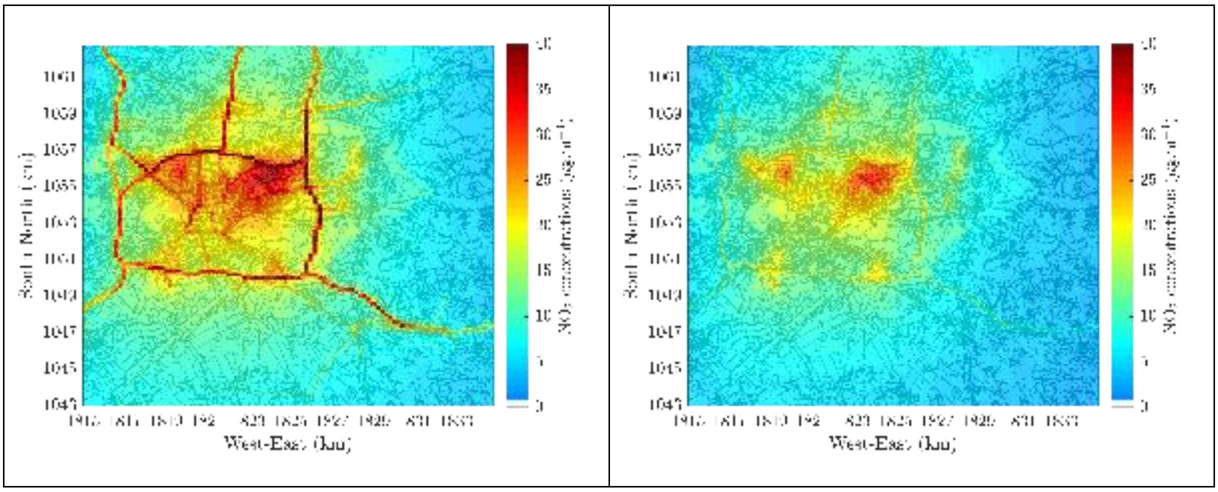
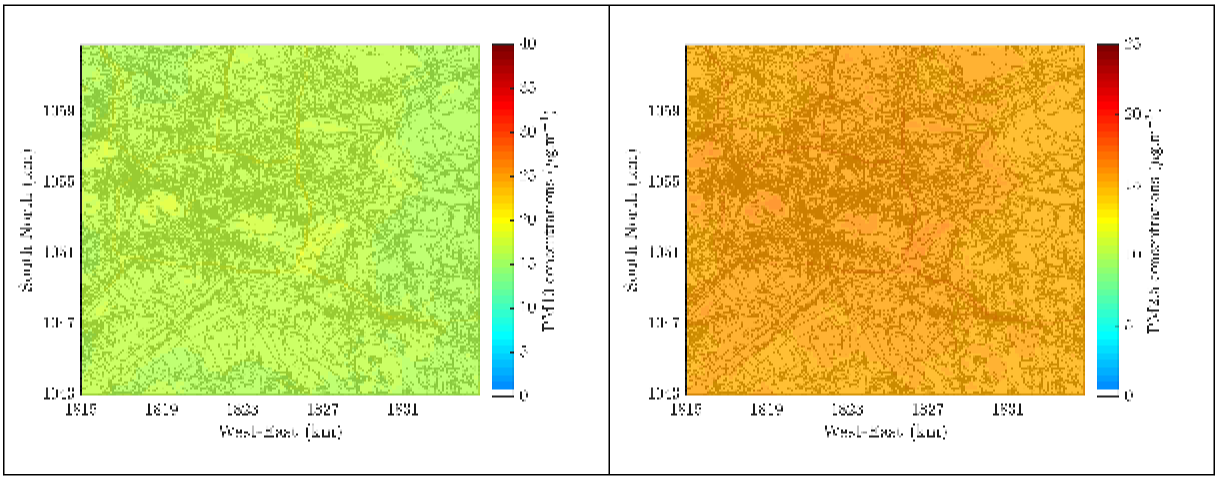


Figure C-5 (a) presents the PM_{10} annual average concentrations for 2050 and (b) the $PM_{2.5}$ annual average concentrations for the same year. The simulated maximum values of PM_{10} concentrations range from 19.3 to 18.8 µg.m $^{-3}$ between 2025 and 2050, while the simulated maximum concentration of $PM_{2.5}$ vary from 17.1 to 16.6 µg.m $^{-3}$. Therefore, the BAU scenarios will lead to the reduction of PM_{10} concentrations showing compliance with EU limit values and with the WHO guideline values already in 2025. The BAU scenarios will lead to the reduction of $PM_{2.5}$ concentrations showing compliance with EU limit values in 2025. However, for the WHO guideline values all grid cells will still exceed this limit in 2050.

Figure C-5 Particulate matter annual average concentrations for the BAU scenario in 2050. a) PM_{10} and b) $PM_{2.5}$ concentrations.



BAU impacts on health

The results for the BAU scenario indicate there has been 146, 177, and 164 premature deaths and 1542, 1868, and 1731 years of life lost atributed to NO_2, PM_{10} and $PM_{2.5}$ polution levels in Ljubljana in 2025 respectively. Estimations for 2035 indicate that 92, 176, and 163 premature deaths and 970, 1851, and 1720 years of life lost atributed to NO_2, PM_{10} and $PM_{2.5}$ polution levels,respectively, and 72, 176, and 163 premature deaths and 754, 1854, and 1721 years of life lost atributed to NO_2, PM_{10} and $PM_{2.5}$ polution levels in 2050.

C.2.3 UPS

UPS impacts on air quality

The very small reductions of the NO_x emissions in the UPS scenario comparing with the BAU scenarios will lead to an neglectable increase of the NO_2 concentrations (in the UPS when compared to the BAU scenarios). Figure C-6 shows for example the NO_2 annual average concentrations considering the impacts of UPS scenarios for 2025 and 2050. In 2025 the maximum NO_2 concentration will be equal to 55.3 $\mu g.m^{-3}$ and in 2050 equal to 33.3 $\mu g.m^{-3}$. Comparing UPS and BAU scenario in 2050, the maximum concentrations will be at 56.6 and 57.2% compared to 2015.

Figure C-6 NO_2 annual average concentrations for the UPS scenarios: a) 2025 and b) 2050.

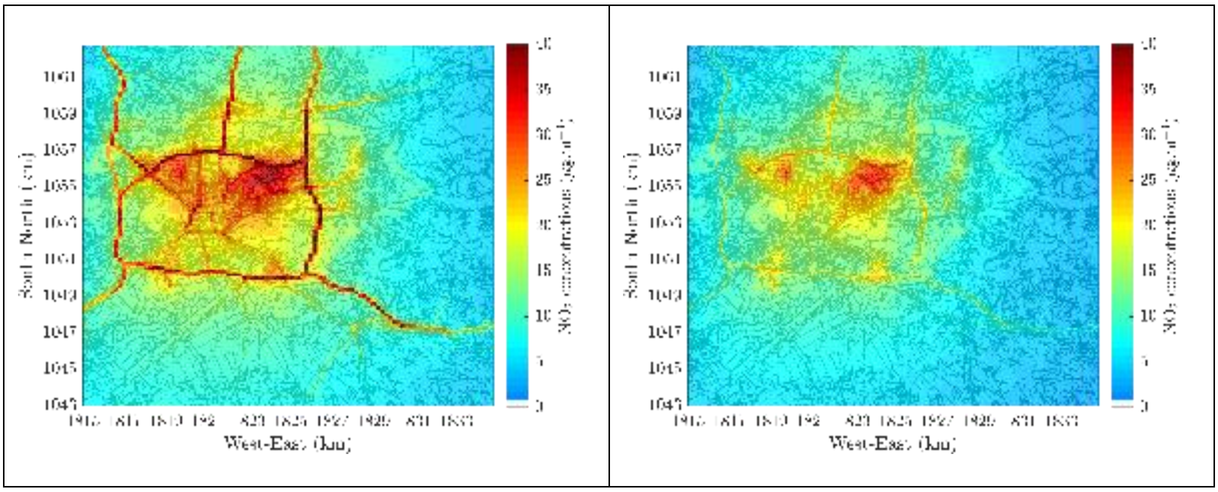


Figure C-7 presents the UPS PM_{10} annual average concentrations (a) in 2025 and (b) in 2050. For PM_{10}, in 2025 the maximum value corresponds to 19.3 µg.m $^{-3}$ and 18.8 µg.m $^{-3}$ in 2050. This means that there are any exceedances, neither to the EU limit value, nor to the WHO guidelines. Compared to the BAU scenario, the UPS scenario will not further reduce the maximum concentrations.

Figure C-7 PM10 annual average concentrations for the UPS scenario: a) in 2025 and b) in 2050.

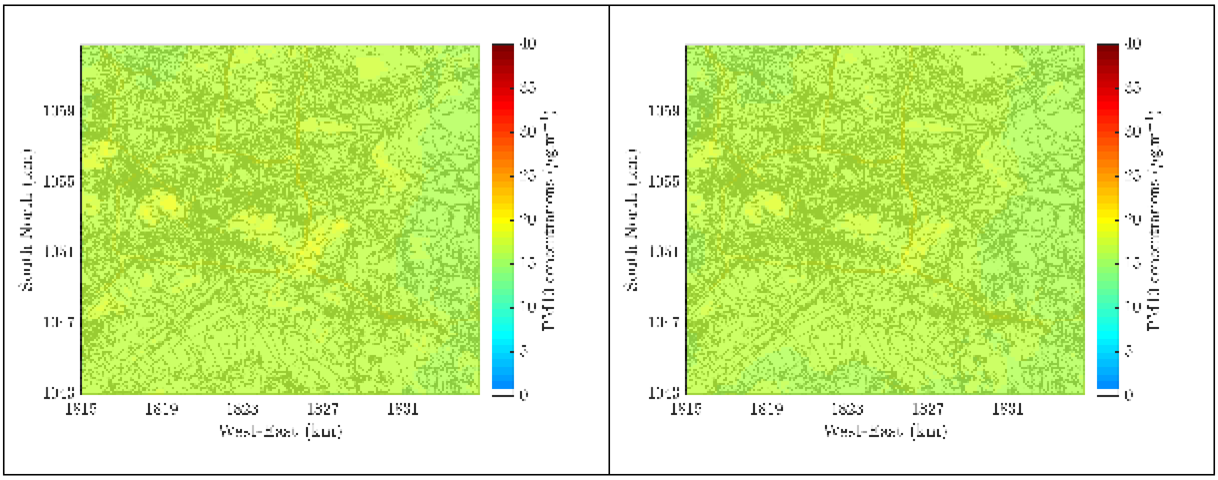
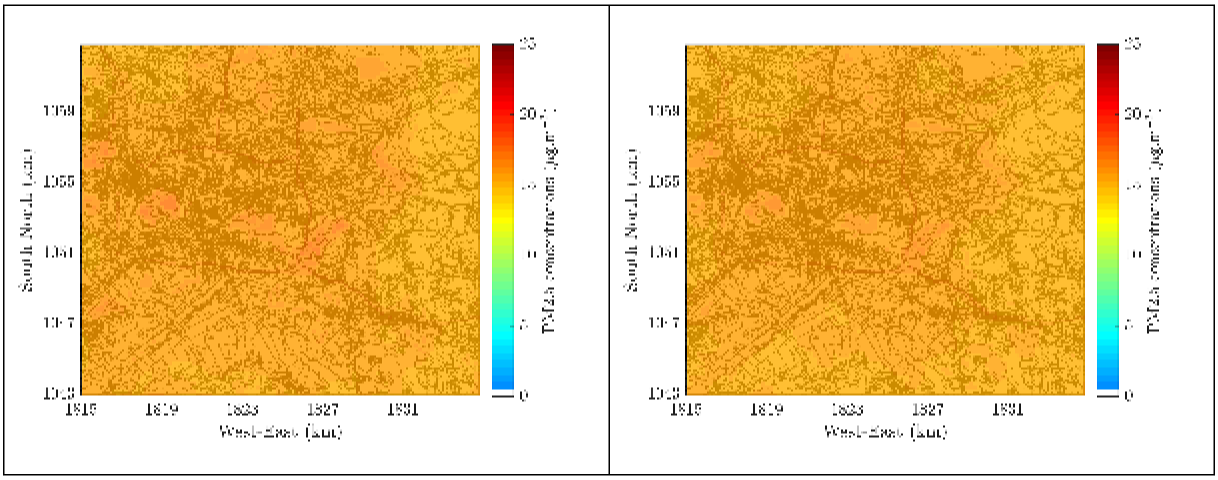


Figure C-8 presents the $PM_{2.5}$ annual average concentrations in the UPS scenario (a) in 2025 and (b) in 2050. For $PM_{2.5}$, in 2025 the maximum value corresponds to 17.1 µg.m $^{-3}$ and 16.6 µg.m $^{-3}$ in 2050, translating into no further reduction of the maximum concentration compared to BAU. Based on the WHO guidelines in 2025 and 2050 all the grid cells will be exceeding these recommendations.

Figure C-8 PM2.5 annual average concentrations for the UPS scenario: a) in 2025 and b) in 2050.



UPS impacts on health

The results for low, high and final UPS scenarios for 2025, 2035 and 2050 are presented in Table C-2 for premature deaths, and Table B-II for years of life lost.

Table C-2 Number of remature deaths related to PM2.5, PM10 and NO2 exposure for the UPS, low and high emission scenarios in 2025, 2035, and 2050.

	PM2.5			PM10			NO2		
scenario	**2025**	**2035**	**2050**	**2025**	**2035**	**2050**	**2025**	**2035**	**2050**
UPS	164	163	163	177	176	176	151	100	78

Table C-3 Number of years of life lost related to PM2.5, PM10 and NO2 exposure for the UPS, low and high emission scenarios in 2025, 2035, and 2050.

	PM2.5			PM10			NO2		
scenario	**2025**	**2035**	**2050**	**2025**	**2035**	**2050**	**2025**	**2035**	**2050**
UPS	1731	1720	1722	1868	1852	1855	1590	1057	821

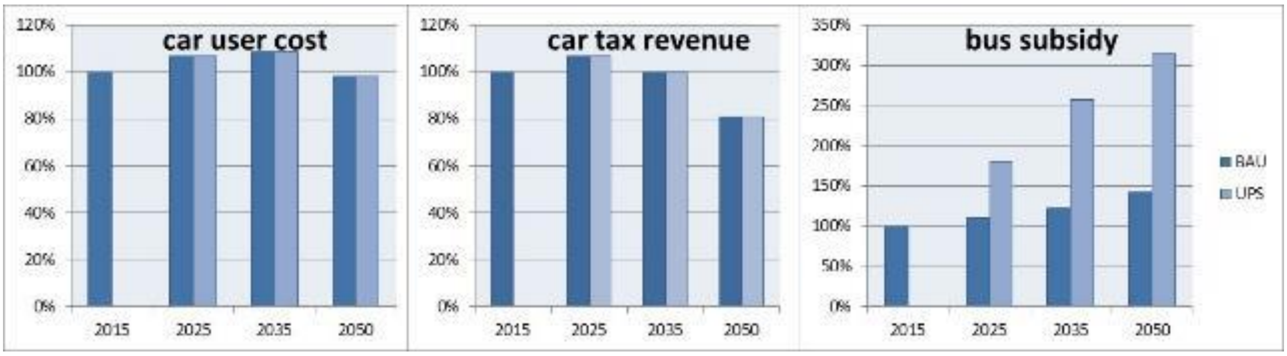
UPS impacts on costs

For the assessment of costs, we used 3 indicators:

1. The car user cost: to what extend does the cost to drive a car changes relatively over time in the BAU as well as under influence of the scenario's
2. The government tax revenue from car transport, combing fuel excises, registration taxes as well as any levy's (e.g. cordon charge)
3. The government expenditure on public transport, i.e. bus subsidies

The indicators on tax revenue or subsidy expenditure do not distinguish between different types of government (local, regional, national). With these indicators, we assessed qualitatively the likely costs of measures for citizens, government and society at large. Costs for society were assumed to be the net sum of citizen and government costs. The cost estimations must be order-of-magnitude estimations only, as the real costs until 2050 will depend on many variables that were not included in the ClairCity modelling. Figure B-13 gives an overview of these order of magnitude costs of the UPS scenario compared to the BAU scenario.

Figure C-9 trends of user cost (left), government tax revenue (mid) and bus subsidy (right) in all scenario's



Car user cost

The car private user cost is expected to increase slightly and then decrease in the BAU. Slovenia is expected to only slowly adopt EV's and fleet turn-over rate is relatively low. As such, it will not benefit immediately from the lower car user cost associated with more fuel-efficient cars (fuel savings offset the higher purchase cost) as well as the uptake of electric vehicles (EVs) that are becoming ever cheaper in the future. The savings of (more) fuel efficient vehicles and EV's only manifests itself from 2035 onwards.

Given that there are no measures that affect the car fleet in the UPS, we observe the same in the UPS compared to BAU.

Car tax revenues

We assume no changes compared to the current situation, so tax revenues follow suit with the user cost. This relates to excise fuel duty and other taxations. The drop in 2050 is due to low-taxed EV's entering the market in large volumes after 2035

Bus subsidies

Bus subsidy follow increasing demand in the BAU. The increase is modest of 10% in 2025, 22% in 2035 and 42% in 2050. However, due to several measures to promote public transport in the UPS, this will lead to higher subsidy levels in the UPS. The massive modal shift in the UPS (mainly by facilitating public transport and reducing the accessibility of car) will lead to huge increase in bus subsidy costs. We estimate that up to a factor 2.5 in 2035, and 3 in 2050, additional subsidy compared to the base year would be needed for public transport to satisfy demand at the lower ticket cost in the UPS. This is likely to be unsustainable from a public spending perspective.

ClairCity: Citizen-led air pollution reduction in cities

D7.5 Final City Policy Package – Sosnowiec

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Document Details

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V2	Irati Artola	November 2019	Modelling inputs from Vera Rodrigues (UAVR) added to V1
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V2	Irati Artola	December 2019 – January 2020	Bringing inputs together; drafting analysis, conclusions, recommendations.
V3	Irati Artola, Stephan Slingerland	February – March 2020	Draft final with inputs from local partner i.e. Sosnowiec
V4	Irati Artola	March 2020	Final draft after last round of comments and feedback
V5	Irati Artola	June 2020	Revision based on further feedback from Edyta Wykurz (Sosnowiec City Hall)

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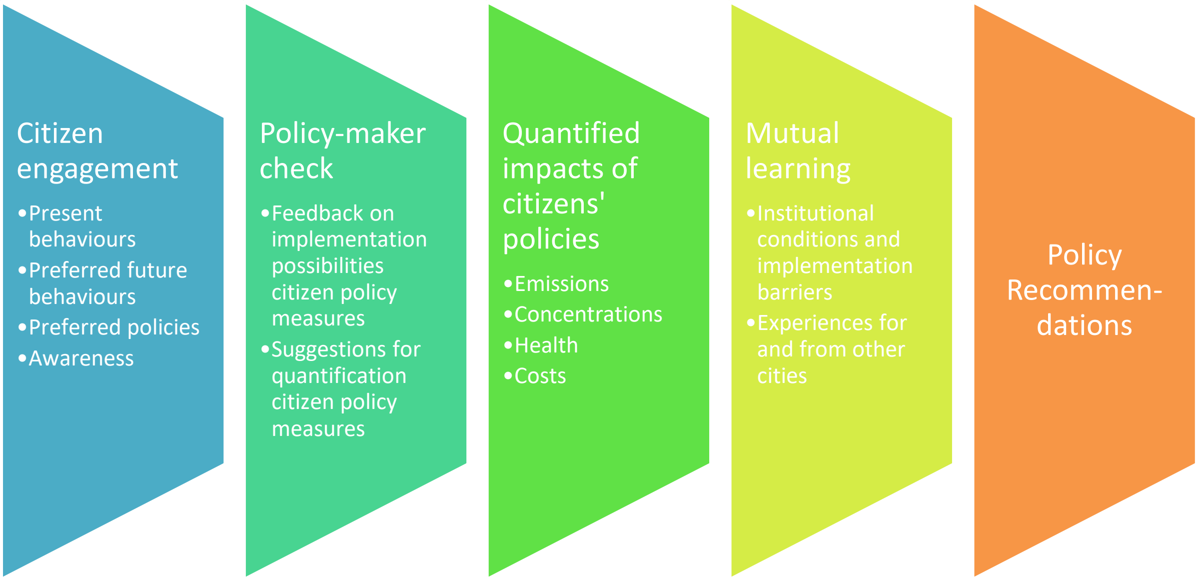
Quality Assurance	Hans Bolscher (Trinomics)
Final editing	Tatum Jak (Trinomics)
Project internal comments	Natalia Dziurowicz (Sosnowiec) Eva Csobod (Trinomics subcontract, formerly REC) Kris Vanherle (TML) Vera Rodrigues (UAVR)

Contents

Executive Summary

The ClairCity Horizon2020 project aims to contribute to citizen-inclusive air quality and carbon policy making in middle-sized European cities. It does so by investigating citizens' current behaviours as well as their preferred future behaviours and policy measures in six European cities[1] through an extensive citizen and stakeholder engagement process. The project also models the possible future impacts of citizens' policy preferences and examines implementation possibilities for these measures in the light of the existing institutional contexts in each city (Figure 0-1). **This report summarises the main policy results for Sosnowiec (Poland**).

Figure 0-1: The ClairCity method in brief



The methodological understanding as developed in the ClairCity project of what citizen-inclusive policy-making is, is given in Textbox 0-1.

Textbox 0-1 Citizen-inclusive policy-making according to ClairCity

- Tailor local policies based on detailed knowledge of behavioural practices of citizens;
- Engage with citizens via a diversity of methods, paying particular attention to hearing the voice of 'hard-to-reach' groups;
- Ask citizens for their preferred future behaviours and barriers to behavioural changes. Address the perceived barriers of citizens by concrete measures or initiate dialogue with citizens about misconceptions concerning air quality and climate change;
- Ask citizens for their preferred future policies for the city, examine potential impacts of these policies and discuss with stakeholders and policy makers their implementation possibilities;

[1] Bristol, Amsterdam, Sosnowiec, Ljubljana,Aveiro/CIRA region, Genoa/Liguria region

- Examine and address potential implementation barriers for preferred citizen policy measures beyond citizen perceptions;
- Experiment, and exchange experiences with other cities that are also aiming to implement citizen-inclusive policies;
- Citizen-inclusive policies are not to be confused with populist policies. Take full responsibility for democratically implementing popular or unpopular measures considered appropriate, after having been extensively informed about citizens' views and behaviours.

In total, during the period 2017-2019, over 1 500 stakeholders, primarily citizens, were reached by the various ClairCity citizen engagement methods in Sosnowiec (Table 0-1).

While this sample is not fully representative of the Sosnowiec population as a whole[2], it gives an indication of support for policy measures and intentions for behavioural change that can be used by policy makers to inform future policies.

Table 0-1: Number of participants in ClairCity stakeholder engagement methods in the Sosnowiec

Citizen engagement activity	Participants engaged
Delphi Process (Rounds 1, 2 & 3)	432
Skylines Game	949
Mutual Learning Workshop	19
Stakeholder Dialogue Workshop	23
Schools activity	62
Film competition	2
Policy Workshop	20
Total	**1 507**

Conclusions and recommendations for Sosnowiec

The main conclusions and recommendations from the ClairCity project for citizen-inclusive policy making in Sosnowiec are:

Current air quality and carbon situation in Sosnowiec

The air quality situation in Sosnowiec is more concerning than in other ClairCity case studies (and than in most European cities). The main sources of air pollution are residential heating boilers and stoves followed by central district heating boilers and some major industrial emitters. Some air pollution emissions (SOx, NOx, NH_3) have declined in the last decades.

[2] The Delphi Process for instance, which was one of the main means to gather data, relied on the responses / participation of 432 citizens out of a city population of 204 013. Respondents were also disproportionately young (with a high response rate in the 16-24 years old category), the elder (65+) were underrepresented, and respondents were highly educated compared to the city average.

However, the emissions the harmful carcinogenic pollutant benzo(a)pyrene are increasing. Particularly PM10 and benzopyrene remain relatively high and are the main concern. With the use in winter of inefficient heating systems and poor quality fuels (e.g. domestic coal, wood) and in some cases household waste, as the main source of these pollutants, the air pollution problem is very seasonal. The dominance of the residential sector for PM emissions is striking compared to other cases, where industry and transport are a more dominant source. In addition, it is also the cheapest fuel option for citizens. NO_2 limit values are also exceeded in Sosnowiec and are expected to continue to be exceeded, even in the most ambitious of scenarios presented in this report. In Sosnowiec transport, is the most important source of emissions of NOx with emissions coming mostly from diesel cars, buses and freight vehicles.

Figure 0-2: Main features of the current Sosnowiec air quality and carbon situation

NO_2	PM	CO_2	BaP
• Has declined over past decades • Exceedances occur but in comparison to PM, NO2 is not a big problem • Main source: transport	• Main problem pollutant (albeit seasonal) • Main source: residential heating	• Large decline since 1990 • Source: transport, electricity and district heating (coal-powered)	• Emissions increasing in past decades • Main problem pollutant (albeit seasonal) • Main source: residential heating

To reduce air pollution from heating, building renovation and expansion of district heating is taking place and heavy subsidies (80%) to modernise coal-powered home heating systems to more efficient private gas boilers are available. There are also stricter rules on solid fuels quality implemented by the regional air quality resolution (anti-smog resolution)[3]. Regarding transport, Sosnowiec has a good reputation with tram and bus infrastructure present in the city, a programme to upgrade buses and trams, and an online digital public transport information system. New park and ride facilities are planned to be introduced, financed by EU funding (but the needs and future use of these by citizens are a point of discussion). Further, a city bike-sharing scheme has been introduced in Sosnowiec mid-2018 and the first bike paths have been constructed.

Current behaviours of Sosnowiec citizens

Current travel and heating practices of citizens substantially contribute to air pollution and carbon emissions in the city. A relatively high percentage of citizens ‘always’ use a car at present for commuting to work (41%) and going shopping (41%). Almost half the population use public transport ‘always’ for going to work and leisure activities.

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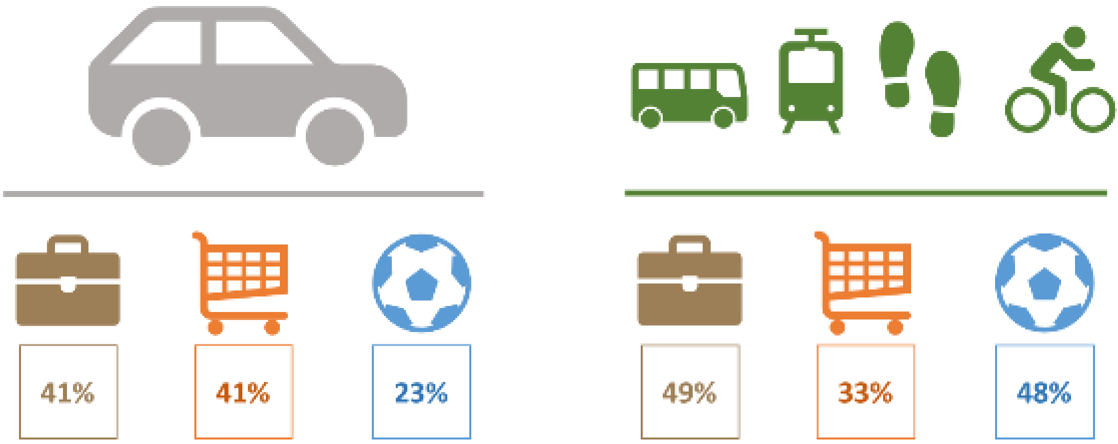
[3] Resolution of the Parliament of the Silesian Voivodship regarding the introduction in the area of Of Silesia restrictions on the operation of installations in which fuel is burned (anti-smog resolution)

Figure 0-3 Percertage of citizens 'always' using a car for commuting to work, shopping or leisure



The majority (64%) of Sosnowiec citizens are on district heating networks, with gas and solid fuel use at 15% and 14% each respectively. Solid fuel use is mainly coal and otherwise wood.

Preferred future behaviours of Sosnowiec citizens for the future

There is continued support for current transport behaviour (and thus little willingness to change). Over 40% of citizens in Sosnowiec go to work, shopping and leisure always by car and there is virtually no willingness to change modes in the future. Virtually the same number of people using a car at present, would like to use a car in the future. The main barrier for car users to switch to alternative modes of transport concern time/distance, but also to a large extent, a lack of services. For commuting, a latent demand for greener cars was found. ClairCity also found that from those who opt for active travel to commute to work, several would like to cycle instead in the future.

Figure 0-4: Proportions of present and future car use of commuters in Sosnowiec

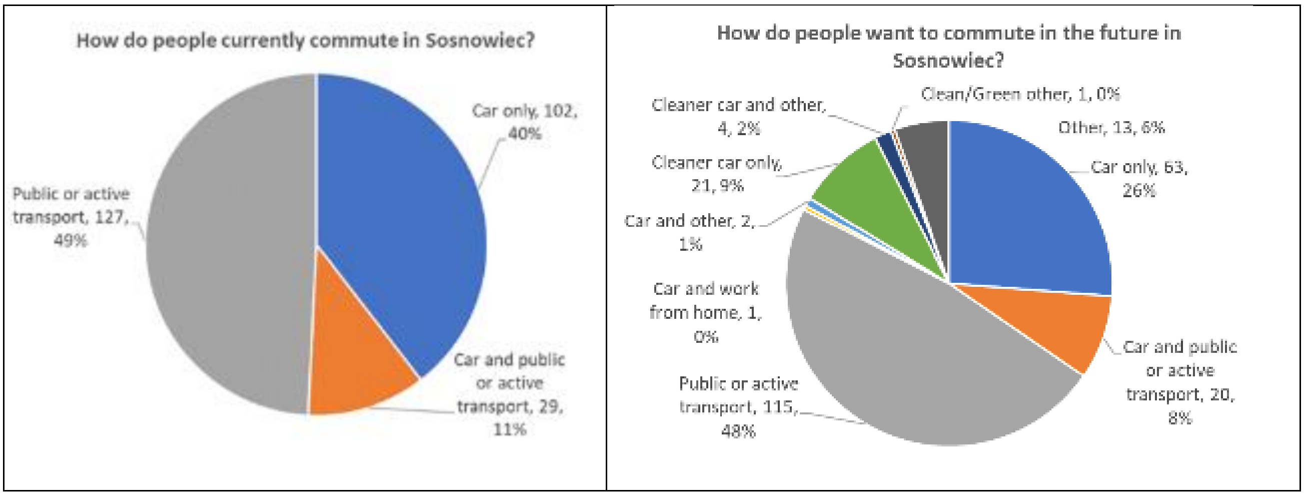


Figure 0-5: Current and future transport choices for shopping in Sosnowiec

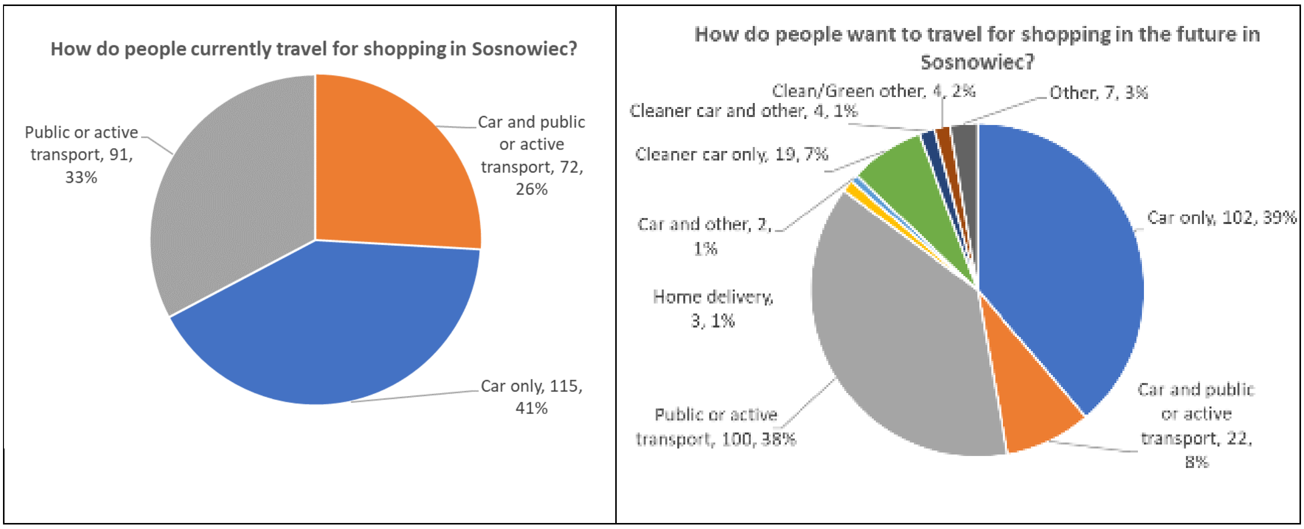
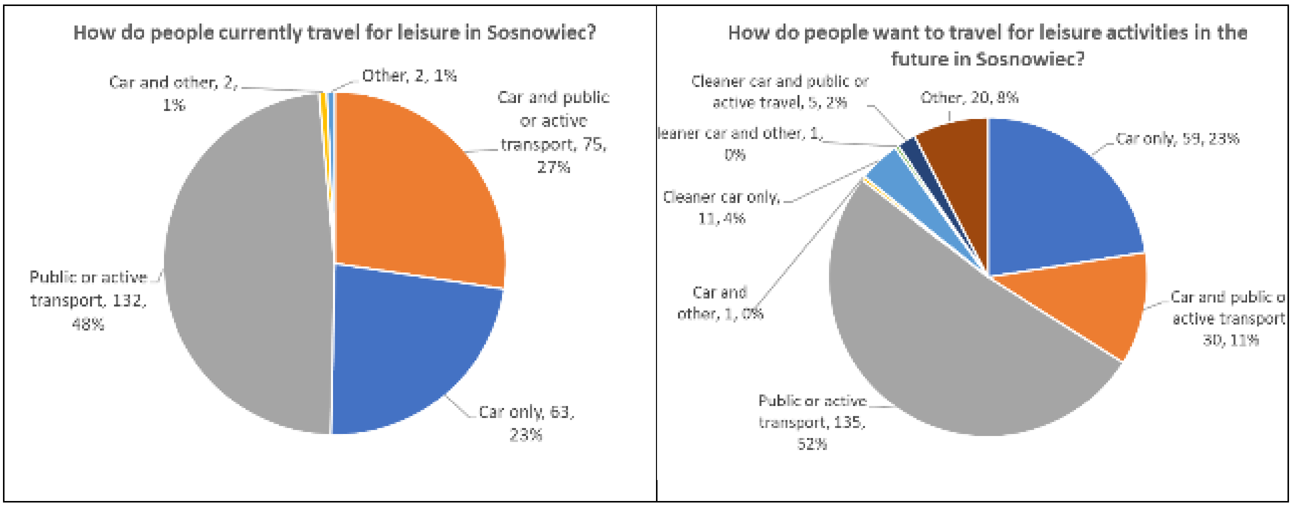
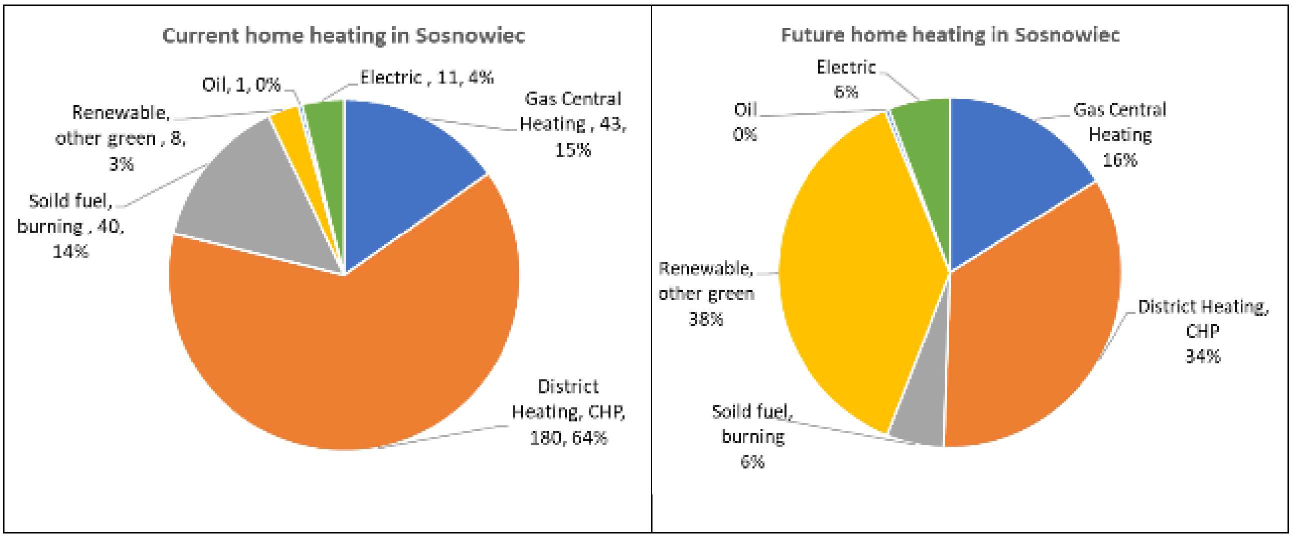


Figure 0-6: Current and future transport choices for leisure in Sosnowiec



There is also a large mismatch between current heating behaviour and how citizens would like to heat their homes in the future. While district heating (non-renewable) is currently predominant (64%), several citizens would rather heat their homes differently in the future. When asked about their preferences, a strong swing of citizens towards renewable energy is perceived (from 1% currently to 38% in the future), away from district heating and solid fuel. The majority of respondents want to stay away from solid fuel. The reason not to take action accordingly is primarily cost. Not just the cost of a new heating sytem but also the higher fuel costs of gas (in comparison to coal), are responsible for the sales of the new stoves to remain limited.

Figure 0-7 Current and future choices for home heating in Sosnowiec



Preferred future policies of Sosnowiec citizens and reflections by policy makers

- **Citizens favour public transport related measures including measures that affect private cars, despite this is not in line with their preferences for the future**
  Public transport are the most popular (making public transport free/cheaper, reducing emissions from public transport and improving the public transport service/connectivity) including awareness raising to stimulate a modal change towards public transport (and active travel). Sosnowiec citizens are not generally keen on measures that would impact private cars (this is in line with current transport behaviour of citizens) with the exception of restricting the most polluting vehicles. Incentivising EVs was also a measure put forward by citizens. Citizens also wish to have cycling infrastructure expanded. The pace at which this is already being done will probably lead to realising the citizens' highest ambitions.

- **Citizens would like to see measures to reduce emissions from domestic heating and replace old domestic heating systems, but cost is an issue for them**
  ClairCity research showed that there is strong willingness from citizens for change regarding heating behaviour provided that the price difference between current and possible future alternative fuels becomes smaller. The replacement old domestic heating systems is a priority. Both citizens and policymakers place high priority on the replacement old domestic heating systems and aim for the replacement 100% of the heating systems that are >10 years old by 2021. This is in fact a binding measure already imposed by the anti-smog resolution.

Table 0-2 Sosnowiec citizen policy measures

#	Policy area	Detailed policy measure for modelling of the Unified Policy Scenario
1	Make public transport free/cheaper	**Free public transport on days with high level of air pollution by 2020**
2	Reduce emissions from public transport	**Replace 10% public transport fleet with zero-emission vehicles by 2030**

3	Improve the public transport service/connectivity	**90% public transport journeys on schedule and most areas catered for by 2020**
4	Create/increase cycle lanes and infrastructure (storage, security)	**20 km of new cycle lanes and 15 new cycle parking spaces by 2020**
5	Encourage/incentivise electric vehicles	**Replace 10% cars with EVs and 100 EV charging points installed by 2025**
6	Restrict (polluting) vehicles	**Ban diesel cars from the city centre on days with level of air pollution by 2050**
7	Modal shift from private car to public transport	**80% modal shift from private to public transport or active travel by 2025**
8	Reduce emissions from domestic heating	**Ban on domestic coal heating in districts with the highest concentration of air pollution by 2025**
9	Replace old domestic heating systems	**Replace 100% heating systems > 10 years old by 2021**
10	Reduce industrial emissions	**Reduce industrial emissions by 25% by 2025**

Policymakers in Sosnowiec showed less ambitious than citizens, only agreeing in ambition for the three policies regarding the expansion of cycle lanes and infrastructure (#4), the need for modal shift from private to public transport or active travel (#7) and the replacement old domestic heating systems (#9). Reflections of policy makers concerning these measures are presented the following table:

Table 0-3 Main reflections of policy makers to citizen measures

Policy area	Main reflections of policy makers
Public transport	- Free public transport is too costly to implement for all the local government, transport companies and for the metropolis, so it's not an option. - Ticket prices at the moment are not high and there are already discounts for youth, free transfers for senior citizens, monthly and quarterly passes. - Free public transport passes would probably not increase the number of people using public transport. - The biggest constraint of shifting to electric buses are costs and the fact that there is a lack of charging stations. The transport company has also recently purchased new diesel buses. - Citizens do not want to give up the comfort that the private car offers at present. Poor quality of public transport (low frequency, bad accessibility) are reasons why citizens prefer the car.
Active transport	- No barriers for implementing citizens' highest ambitions. The current program is going well, it has almost already reached the targets set by citizens.
Private car	- Electric cars involve high costs for individuals and so purchase needs to be subsidied by the govenent. - Restricting polluting vehicles is not a realistic option but policy makers would like to ban diesel cars by 2025, on days with high levels of pollution.

Modelled impacts of the combined citizen and policy maker measures

If implemented, the measures proposed by citizens (i.e. the Unified Policy Scenario - UPS) would result in notable health improvements for citizens compared to the situation in the baseline year 2015.

- According to the ClairCity modelling, citizens measures (i.e. the UPS) would lead to a significant decrease of NOx emissions over time mainly due to decreasing transport emissions as citizens shift from car use towards cycling and public transport.
- Citizens measures lead to a similar downward trend of PM emissions until 2050, albeit more moderate. The reduction of residential emissions as a result of the

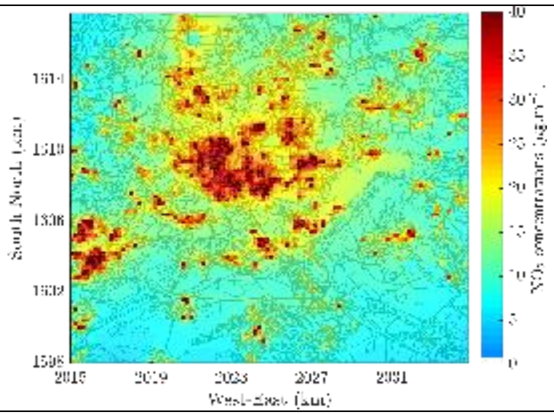
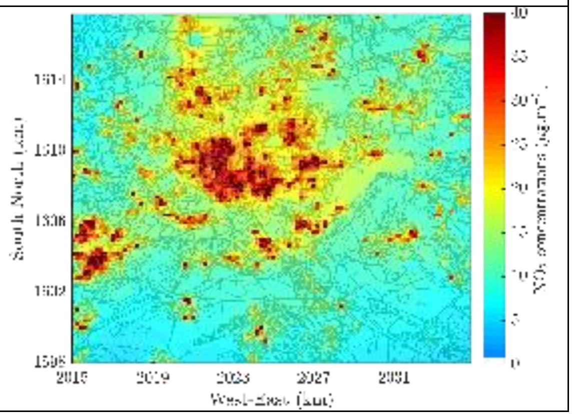
ambitious replacement of residential heating systems towards more fuel-efficient options adds further to the decrease in NOx emission.

- The UPS scenario reduces the number of premature deaths from air pollution by 41% for NO_2, 21% for PM_{10}, and 19% for $PM_{2.5}$ by 2050. The health benefits of implementing the measures under the UPS are therefore considerable for NO_2 but not as significant for neither PM_{10} nor $PM_{2.5}$. The reduction on premature deaths and years of life lost as consequence of emissions reduction are much higher than average concentration levels reduction. This is because emission reduction measures will be implemented in high(er) populated areas.

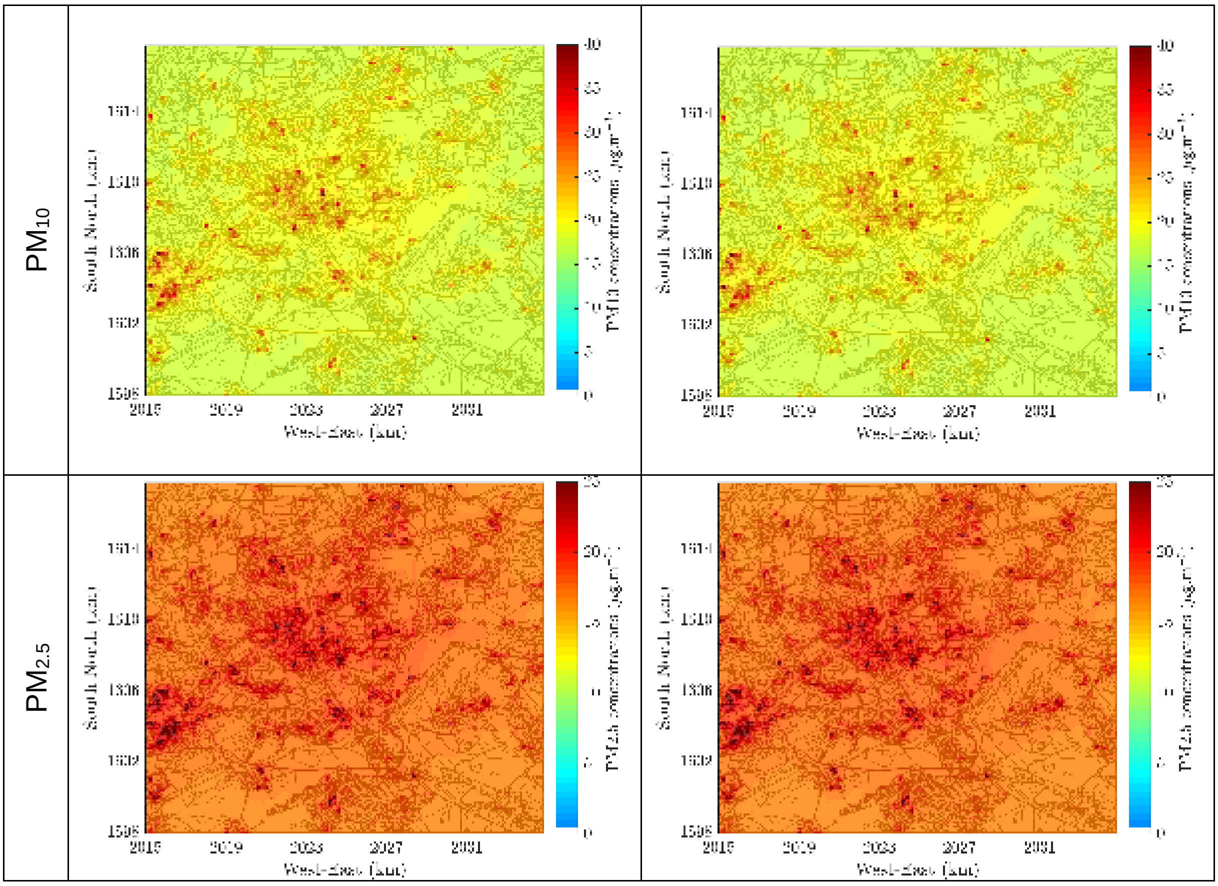
ClairCity modelling has concluded that neither the measures currently planned by the local government (BAU scenario), nor the ambition levels that policymakers opted for the measures proposed by citizens (UPS scenario), will lead to compliance of legal EU limit values for PM and NO_2 everywhere in Sosnowiec, not even by 2050 (and so Sosnowiec air quality will remain far from the guidance values by the World Health Organisation). **The UPS in fact offers just a moderate improvement over the Business As Usual (BAU) scenario.** In other words, it does not lead (by 2025, 2035 and 2050) to significantly better results for air quality than the measures already implemented by the region will. This is partly explained by the fact that policy makers chose for the low ambition options of citizens measures.

As such, more (stringent) effective measures are required in order to ensure the health of citizens in Sosnowiec.

Figure 0-8 NO_2, PM_{10} and $PM_{2.5}$ concentrations in Sosnowiec in the BAU and UPS scenario in 2050[4]

	BAU	UPS
NO_2		

[4] ClairCity modelling results cannot be directly compared to the national models due to different modelling approaches.



Institutional characteristics and mutual learning for implementing citizen-inclusive policies in Sosnowiec

The economic fabric of Sosnowiec and financial limitations are possibly the most determinant current institutional conditions in Sosnowiec.

- Economic restructuring in Sosnowiec is still ongoing, with the city and region changing from coal and heavy-industry dominated to a more services-oriented situation. Whereas the city is doing relatively well in the national context, it lags somewhat behind neighbouring cities in the regional context.
- The relatively low income of citizens in Sosnowiec[5] plays an important role in the choice of fuels (i.e. mainly domestic coal but also wood) and boilers for domestic heating, which is the main source of air pollution in Sosnowiec. With the lack of quality and/or efficiency standards for commercial heating fuels and stoves until recently, Sosnowiec citizens are used to poor quality fuels and combustion.
- Financial barriers – on both the city as well as citizens side - are the main factor hindering the greening of public transport, private car-fleet and residential heating.
- There is a single national air quality monitoring station in Sosnowiec, and a few passive collectors. This is quite limited in comparison to other ClairCity case studies which have a much wider network of air quality measuring stations.

[5] Compared to neighbouring town and cities, and European average

There are several aspects concerning transport and energy that Sosnowiec can learn from the other ClairCity cities. Sosnowiec in turn is interesting for other cities / regions due to its established distric heating network (non-renewable powered at the moment) and its real-time information of air quality to citizens.

- Some of the main lessons that Sosnowiec could learn from other ClairCity cities include the large-scale pedestrianisation of the city centre including solutions for the people in need of motorised transport (Ljubljana), how to engage children in cycling (Aveiro Region), integrating local and regional transport (Bristol) and the integration of large-scale cycling infrastructure and public transport in the city, the gradual reduction of road space and increase in parking tariffs for private cars (Amsterdam). The long-standing cooperation of the 11 municipalities in the Aveiro Region could also be useful for the Silesian Region.
- ClairCity (and other) cities could learn from Sosnowiec how wood and waste burning can have massive detrimental impacts on air quality and cause winter smog. Sosnowiec has also substantial experience with district heating and are considering expansion of their heating networks. Further, Sosnowiec provides real-time air quality information to citizens through the electronic transport information system in the city. This serves to raise awareness, which has been identified as necessary policy measures that ClairCity case studies widely need to implement across all cities.

The ClairCity Sosnowiec Action Plan

For citizen-inclusive city air quality and carbon policies.

- **Promote renewable energy and raise awareness on the negative health effects of biomass burning.** The ClairCity engagement process showed that there is strong willingness from citizens for change regarding heating behaviour towards renewable energy provided that the price difference between current and possible future alternative fuels becomes smaller. Supporting rooftop solar PV, increasing rooftop solar on public buildings and supporting local citizen cooperatives for renewables generation could be measures that the government should consider to facilitate this. Also increase awareness that district heating can be a positive environmental option, if connected to renewables, waste heat or geothermal. Tackling this issue may also involve measures that may not be well received by all citizens at first (e.g. because they involve costs). Providing information and awareness raising therefore essential to increase acceptance of policy measures. In addition, the dangers of biomass burning for air quality and health should be further communicated to citizens.

- **Improve public transport coverage and frequency, facilitate cycling through expanding the current cycling network and infrastructure and promote these.** To encourage modal change away from cars, first and foremost public transport and active travel need to be made more convenient and attractive. Bus and train services need to be improved, including connections to suburban districts and neighbouring cities. Expanding the urban cycling infrastructure is also necessary for everyone to be able to cycle wherever they need to on a daily basis, whether that is for work, groceries shopping or leisure. In addition, a transport card / ticketing system which works for all modes of transport as well as bike rental options close to bus and train stops (that integrates cycling with public transport) are ways to facilitate intermodal transportation. Facilitating access to a bike by for instance subsidising bike purchase for the poorer groups should be considered. Public transport and bike infrastructure (including municipal biking systems) and any improvements to these, will require effective promotion from the local government (for example through an awareness raising campaign), in order to inform citizens and encourage them to opt for those modes. The attractiveness of walking can also be promoted by awareness campaigns that stress its health benefits.

- **Introduce measures to discourage car use and incentivise electric vehicles.** Efforts to improve public transport should go hand in hand with measures that make private car driving less attractive. ClairCity research shows that otherwise, uptake of public transport / active travel is less likely to happen, even if public transport tickets are cheap. Examples to achieve this are restrictions of parts of the city to cars (at the same time this gives pedestrians and other modes of transport more space), limiting parking spaces in the city centre and making parking more expensive. Higher parking fees are an excellent way for local governments to collect extra revenues which can in turn be used to fund further transport measures. In addition, considering citizens' support for continued car use, and their wish to drive in cleaner vehicles, subsidising electric vehicles is an avenue to explore. The city should also ensure that there are enough charging points. Another policy that could be considered to reward those switching to EVs is making parking free for these type of vehicles (and charging high fees for conventional cars).

- **The 'health' frame should be as much as possible exploited in Sosnowiec when implementing air quality and carbon related policies.** Winter smog is a clearly perceivable phenomenon in Sosnowiec and high exceedances of PM limit values during smog days can be easily related to health consequences. Domestic heating impacts these emissions most and so interventions in this area are needed. Given that citizens have direct influence on this source of pollution, communicating the health benefits of policies directed at domestic heating (and the negative effects of air pollution) is essential in order to encourage citizens to act, and defend and justify any stricter government rules for domestic heating systems and or fuels. Tackling domestic heating is also beneficial for climate. With climate change gaining traction at both the political and citizen levels, besides 'health', 'climate' can also be used as hook as well for putting policies forward. Considering the 'seasonal' aspect of domestic heating pollution, it is probably worth implementing measures and focusing any awareness campaigns in the winter months, when the problem is most visible. An additional potentially suitable frame for policies could be related to a 'better living', for example, by stressing the side benefits to overall quality of city life resulting from larger pedestrian zones and less cars or the comfort of better insulated housing which has less heating needs.

- **Work closely together with NGOs to create citizen awareness in Sosnowiec.** Citizen interest in air quality and carbon emissions in Sosnowiec is relatively low and limits possibilities for policy action. This can be related to a lack of knowledge. For instance, the limited citizen interest to exchange domestic boilers for more efficient ones, despite the relatively generous subsidies currently in place, may be partially justified (besides costs) by the fact citizens are not aware or the dangers of solid fuel burning at home. Education and awareness raising are important enablers identified in Sosnowiec in order to motivate and engage with citizens to shift to sustainable mobility and heating modes. If policy measures affecting citizens' lives are to be implemented, citizens need to be aware and understand why those measures are important or even necessary, and how they can affect their lives for the better (e.g. beneficial for health, pleasant environment). Against this backdrop, NGOs can play an important role in creating public awareness around air quality. Close cooperation of policy makers with the local NGOs (in Sosnowiec, Smog-Alert) can be a way to engage with citizens.

- **Intensify cooperation with employers, schools, destinations of leisure and shopping to minimise car travel.**
  A large percentage of people in Sosnowiec use their car to access their work, leisure activities and shopping. Although there is little willingness expressed by citizens to change that in the future, it is the duty of local governments to provide alternatives and encourage more sustainable behaviours. When there are good alternatives to the car, people may change their minds. The promotion of active travel and public transport can be stimulated in cooperation with big employers as well as destinations of leisure and shopping (e.g. retailers, shopping malls, sports clubs, theaters or cinemas). Options for bus stops and bike parking next to these destinations, together with biking infrastructure to get there should be considered. Engagement of schools is also essential. These could take the societal role of encouraging children and parents to avoid travelling to school by car. Further, city planning should consider encouraging more jobs, leisure and shopping options close by to where people live.
- **Reallocate costs or compensate costs of required heating and transport measures through revenue generating local financial instruments and communicate the need for such instruments.**
  Financial barriers – on both the city as well as citizens side - are the main factor hindering the greening of public transport, private car-fleet and residential heating in Sosnowiec. Finance is a key institutional condition that determines the possibilities for implementing citizen-inclusive policies. Subsidising heating systems, modes and/or fuel change, as well as public transport improvements are all costly. These costs can be compensated by generating local funding through for example parking fees and permits, congestion levies or workplace parking levies. Such financial instruments tend to be less popular with citizens, hence there is a need to properly communicate such measures. Authorities should consider possibilities to reward behavioural change (e.g. bike parkings and rentals offering discounts at local shops). Costs can also be additional to current investments or simply a reallocation of existing investment funds. The costs of new walking/cycling infrastructure (e.g. expanding the cycling network) for instance, can be (partly) offset by reallocating funds currently dedicated to road infrastructure for cars, to infrastructure for walking and cycling.

- **Explore the potential for an environmental zone / clean air zone that is gradually introduced and offer alternatives for those who need motorised transport**
  Several types of environmental areas or so-called Clean Air Zones (CAZ) with bans of different kinds of vehicles (e.g. mopeds, buses, taxis and freight transport), including private cars in some cases, were found in the ClairCity cities (Amsterdam, Ljubljana and Genoa, with Bristol working on a CAZ as well). This intervention has proven beneficial not only for air quality but also for quality of life as streets become more pleasant for walking and cycling. CAZ can stimulate the economy as well for example, by shops that attract more pedestrians and/or by the city becoming more appealing for tourism because of being more "walkable" and pleasant. Evidence from ClairCity case studies suggests that a gradual introduction (over time, for a certain type of vehicles at a time) is important for acceptance. ClairCity also found that some political courage is essential at the start, in order to overcome initial resistance. To cater for the needs of everyone alternatives should be offer for those who need motorised mobility (e.g. elderly, handicapped) for instance by offering an on-demand free electric taxi that one can call.

- **Consider expanding current air quality monitoring**
  Comprehensive air quality monitoring is essential to spot problems (hotspots) and make good policy decisions. Bad air quality (and related health risks) somewhere can be a good reason for implementing measures and so an argument that the local government could use to push for behaviour change or measures. At the moment in Sosnowiec there is a single national air quality monitoring station, complemented by a

few passive collectors. Whilst the regional monitoring agents are satisfied with this, local citizens united in an air quality NGO have expressed concerns over local air quality monitoring network (the location and ‘unrealistic’ results from monitoring). As such, building more monitoring stations is something the city should consider. Through NGOs, the city can also explore options for citizens measuring air quality themselves, like Amsterdam for instance has done.

1 Introduction to this report

This chapter provides the context for the ClairCity project (section 1.1), introduces the project objectives and process (section 1.2) and provides a reading guide for this report (section 1.3).

1.1 Context

In 2015, the Paris climate agreement set the goal to reduce global greenhouse gas emissions to keep global temperature rise this century to well below 2 degrees Celsius above pre-industrial levels[6]. A similar binding agreement for global air quality is lacking, but in 2005 the World Health Organisation formulated guidelines for ambient air quality aiming to improve health and reduce premature death caused by air pollution throughout the world. In 2016, 91% of the world population was living in places where the WHO air quality guidelines levels were not met.[7] Numerous countries and the European Union have set air quality targets that are often not as ambitious as the WHO guideline values, yet provide a legally binding framework for emission and concentration reductions of air pollutants.

Cities are the main contributors to the emissions of greenhouse gases and air pollutants, and many have set stricter local goals for emission reductions of greenhouse gases and air pollutants than the national or EU targets. Improving air quality and reducing carbon emissions as a contribution to the global, national and local targets and ambitions therefore will be a huge challenge for cities all over the world in the years to come.

Citizens living in these cities do not only cause an important part of these emissions through their daily behaviours, they can also play a key role in solving these issues. This can be via a change in behaviour and through providing democratic support for policy measures to be implemented that will affect their daily lives. ‘Citizen-inclusive policy making’ is therefore a crucial prerequisite for future air quality and carbon policies in cities to be successful in reducing emissions and reaching targets set on the local, national and global scales.

[6] https://unfccc.int/process-and-meetings/the-paris-agreement/the-paris-agreement
[7] https://www.who.int/en/news-room/fact-sheets/detail/ambient-(outdoor)-air-quality-and-health

1.2 The ClairCity Project

The **ClairCity Project**[8] puts citizens' behaviours and views central in city air quality and carbon policies. It addresses citizens' daily activities in cities, and their impacts on carbon emissions,air pollution and health. It also investigates what views citizens have on future air quality and carbon policies in their city.

'Citizen-inclusive policy making' in the ClairCity project is defined as:

1. Tailoring city air quality and carbon policy measures based on a detailed knowledge of current behavioural practices of citizens;
2. Asking citizens for their preferences regarding own future behavioural changes and taking these preferences into account in policy making;
3. Asking citizens for their preferences regarding future air quality and carbon policy measures in their city and also taking these into account in policy making.

In ClairCity, the views of citizens on future air quality and carbon policies in their city are investigated through an innovative suite of citizen engagement activities in six European cities[9]. As a result of the project, policy makers in each city receive a calibrated and quantified[10] set of preferred policies suggested by citizens. The project also identifies for each city separately the behaviours that citizens would be willing to change in order to contribute to such policies. Furthermore, overarching lessons from the six pilot cities for other cities aiming for citizen-inclusive air quality and carbon policies are presented in a final report and conference.

Figure 2-1 shows the **five-step process** in which the policy recommendations for city policy makers in Sosnowiec were prepared.

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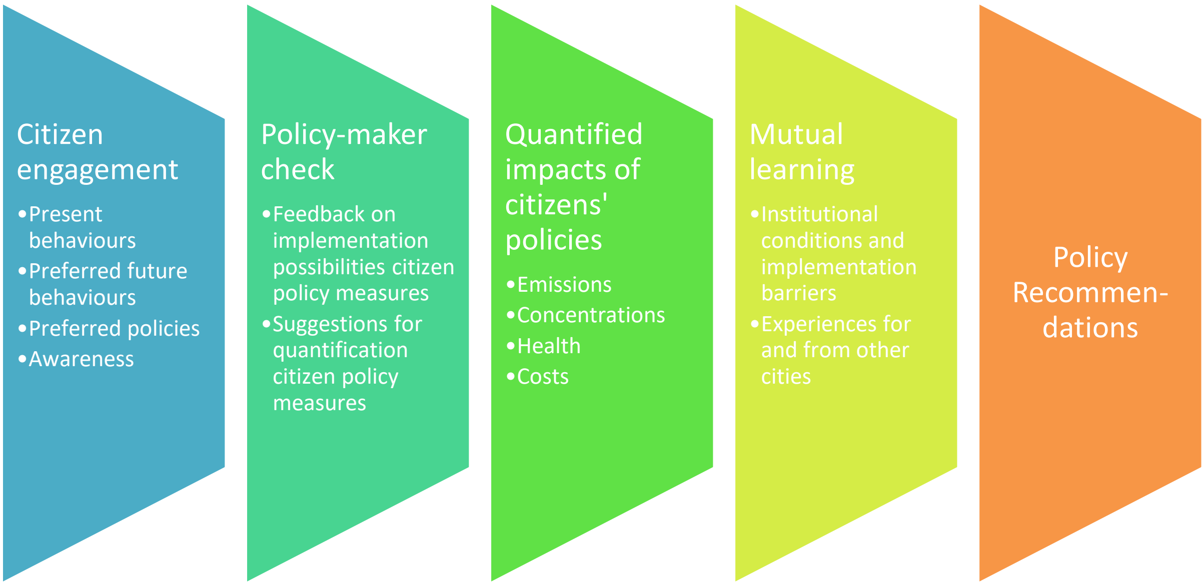
[8] The ClairCity project ('Citizen Led Air pollution Reduction in the City') is funded under the EU Horizon2020 programme, grant agreement nr 689289. It started in May 2016 and runs until May 2020. ClairCity website: www.claircity.eu.
[9] Amsterdam (Netherlands), Bristol (UK), Ljubljana (Slovenia), Sosnowiec (Poland), Aveiro / CIRA Region (Portugal) and Genua/ Liguria Region (Italy).
[10] Including views of other stakeholders and preliminary modelled data to give an outline of possible impacts on air quality and carbon emissions

Figure 1-1: ClairCity process including key phases and activities and chain of evidence leading to ClairCity policy recommendations



First, in the ClairCity engagement process citizens were consulted in order to examine their present behavioural practices, their preferences for future behaviours and their preferences for future policies. The process by itself contributed to citizen awareness of air quality and carbon issues and policies in the city and also included some activities specifically directed at awareness building.

Second, feedback was obtained on implementation possibilities of the citizen policy preferences through a workshop with local and regional policy makers involved in air quality and carbon related policies. In the workshop, the policy measures that evolved from the engagement process were further developed and partly quantified.

Third, from the more detailed citizen policy measures a ‘Unified Policy Scenario’ was constructed. In this scenario the impacts were modelled regarding emissions and concentrations of air pollutants and greenhouse gases, health impacts and costs to citizens and city. These impacts were compared to a business-as-usual scenario with city policy measures implemented and specified in the base year 2015.

Fourth, the specific institutional conditions and barriers for implementation of the citizen measures in Sosnowiec were examined. These consisted of political framing, financial conditions, multilevel policies and other conditions. These were compared with the experiences in the other ClairCity cities to examine what lessons could be learned from and for Sosnowiec regarding promising ways for implementation of the citizen measures.

The detailed policy recommendations for Sosnowiec were prepared taking the four aforementioned steps into account.

1.3 This report

This report is the ClairCity "**City Policy Package Report**" for Sosnowiec, the last city for which the ClairCity engagement process has been completed[11]. It provides a summary of the lessons learned for local air quality and carbon policy making in Sosnowiec. The primary target group of this report are therefore Sosnowiec policy makers and politicians. The report can be further of interest to politicians and policy makers in other cities, to national and regional policy makers, to EU policy makers, and not least to stakeholders and citizens in Sosnowiec and elsewhere engaged or interested in improving air quality and reducing carbon emissions in their city.

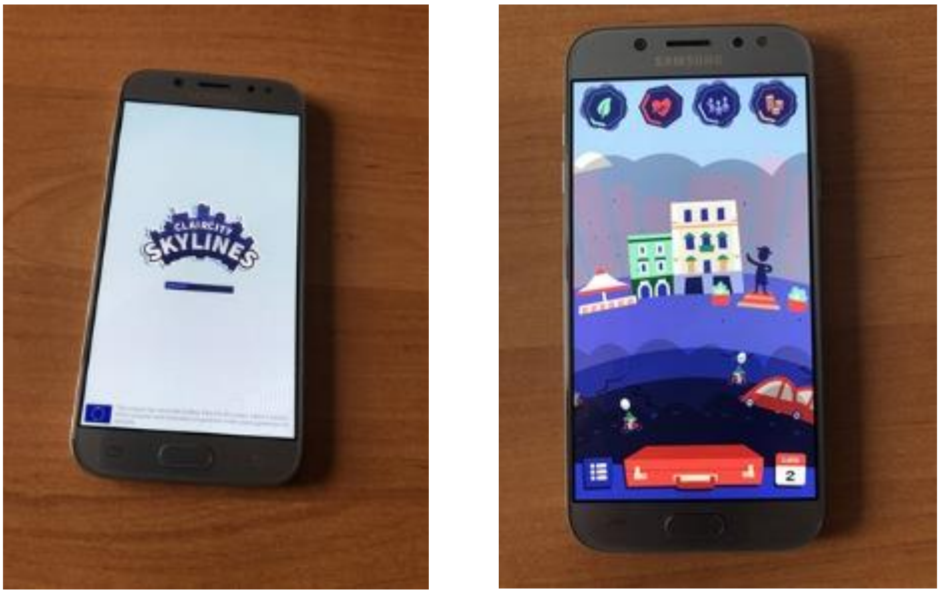
Chapter 2 of this report discusses the ClairCity citizen engagement methods that were applied and tested in Sosnowiec. Chapter 3 analyses the current air quality and carbon situation in Sosnowiec and looks into current behaviours of citizens that contribute to air pollution and carbon emissions. Chapter 4 examines what behavioural changes Sosnowiec citizens envisage for themselves in the future and what preferences they have for policy measures. It also shows what reflections Sosnowiec policy makers have on the views of citizens. Chapter 5 quantifies potential consequences of the citizens' preferences in terms of emissions and concentrations of air pollutants and of carbon dioxide, in terms of health and in terms of costs of measures. Chapter 6 discusses specific institutional conditions and barriers for citizen-inclusive policies found in Sosnowiec as well as mutual learning possibilities in order to remove these barriers. Chapter 7 finally gives the main conclusions and policy recommendations that follow from the ClairCity citizen engagement and analysis in Sosnowiec.

[11] In the ClairCity project, this report is part of deliverable D7.5

2 ClairCity engagement in Sosnowiec

The ClairCity project developed a suite of citizen engagement methods, aiming to involve a broad cross-section of the the Sosnowiec population. This mix of proven policy related engagement methods includes a three-step ‘Citizen Delphi Process’ consisting of proven methods such as online surveys and workshops to engage citizens and other stakeholders such as experts. Also, an innovative game for mobile phones was developed (ClairCity Skylines) that allows citizens to state their policy preferences for the city in a creative context.

Figure 2-1: ClairCity ‘Skylines’ Game presentation in Sosnowiec



Further, a schools activity and a filming activity were designed and implemented in order to improve the awareness of young and elderly people respectively. An overview of citizen engagement methods designed and applied in ClairCity is given in Table 2-1.

Table 2-1: ClairCity’s citizen engagement activities in Sosnowiec

Objective	Method	Citizens, general	Specific citizen groups[1)]	Stake-holders[3)]	Policy makers
Policy related	Online surveys	X			
	Street interviews	X			
	Workshops	X		X	X
	Serious gaming	X			
Awareness related	Schools activity		X[1)]		
	Film competition		X[2)]		

1) Pupils secondary school
2) Elderly
3) NGOs, business

In total, during the period 2017 – 2019, over 1 500 Sosnowiec citizens were engaged across the various ClairCity activities (Table 2-2). While this sample is not fully representative of the Sosnowiec population as a whole[12], it gives an indication of support for policy measures and intentions for behavioural change that can be used by policy makers to inform future policies.

Table 2-2: Number of participants in ClairCity stakeholder engagement methods in Sosnowiec

Citizen engagement activity	Participants engaged
Delphi Process (Rounds 1, 2 & 3)	432
Skylines Game	949
Mutual Learning Workshop	19
Stakeholder Dialogue Workshop	23
Schools activity	62
Film competition	2
Policy Workshop	20
Total	**1 507**

[12] The Delphi Process for instance, which was one of the main means to gather data, relied on the responses / participation of 432 citizens out of a city population of 204 013. Respondents were also disproportionately young (with a high response rate in the 16-24 years old category), the elder (65+) were underrepresented, and respondents were highly educated compared to the city average.

3 Current air quality and carbon situation in Sosnowiec

In the ClairCity project, the existing air quality and carbon status and policies in Sosnowiec were identified in order to establish a baseline against which the impacts of citizen desires for the future of their city could be compared and contextualised.

3.1 Current concentrations and emissions

The air quality situation in Sosnowiec (and Poland overall) is more concerning than in most European cities. Unlike in the other case study cities, smog episodes and air quality related health impacts are evident in Sosnowiec. An analysis of Sosnowiec policy documents[13] shows that air pollutants as well as carbon emissions in Sosnowiec have been declining in the last decades due to closure and modernisation of industries after the political and economic change of the 1990s. Some specific facts are spelled out below:

- The main sources of air pollution are residential heating boilers and stoves. These are fuelled mainly by Polish coal, which has a relatively high sulphur content. Other major sources are central district heating boilers and some major industrial emitters (coal, steel, logistics and bricks industries).
- Some air pollution emissions (SOx, NOx, NH_3) have declined significantly in the last decades. However, the emissions of the harmful carcinogenic pollutant benzo(a)pyrene are increasing.
- PM_{10} and benzo(a)pyrene are the main concern, with use of inefficient heating systems and poor quality fuels (and in some cases household waste) in winter as the main source of these.
- The air pollution problem is very seasonal. This is illustrated by the fact that annual mean air quality for PM is within limit values over the full year, while 24-hour exceedances on winter days are significantly higher than the limits.
- NO_2 limit values are also exceeded in Sosnowiec, but in comparison to the low-stack emissions, the problem is far smaller. The main source of NOx in Sosnowiec is transport.
- CO_2 emissions are mainly caused by transport fuels, electricity and district heating, which are to a great extent coal-powered. The long-term decline in CO_2 emissions can be explained by the (slow) decarbonisation of electricity generation; the modernisation of transport infrastructure; the modernisation of industry and heavy industry; closure of the last coal mines; and, the increasing average efficiency of buildings, vehicles and appliances in line with newer EU efficiency standards.

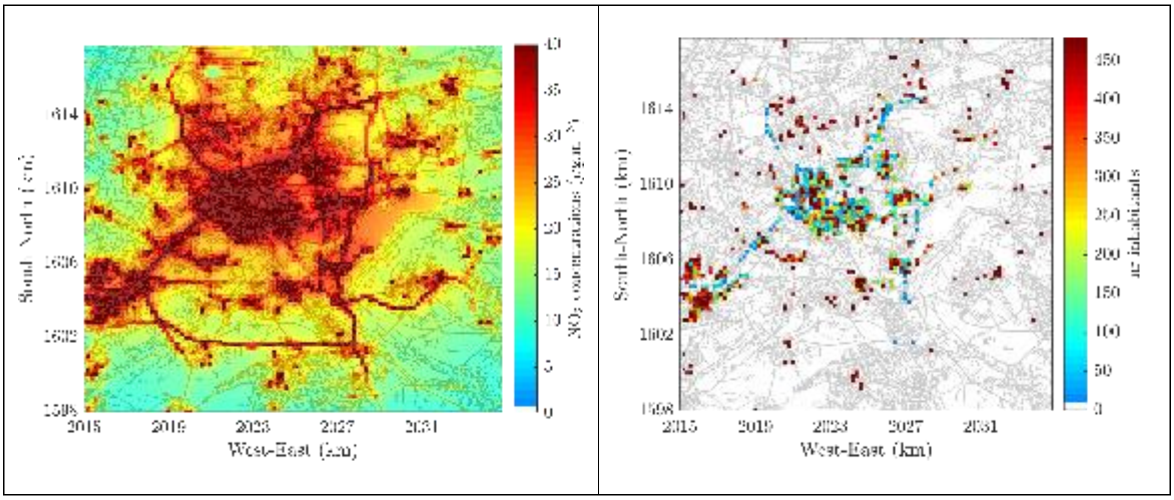
[13] For the detailed analysis of air pollutants and carbon emissions trends and sources refer to D6.2 Policy Baseline Report – Last City.

Figure 3-1 Main features of the current Sosnowiec air quality and carbon situation

NO_2	PM	CO_2	BaP
• Has declined over past decades • Exceedances occur but in comparison to PM, NO2 is not a big problem • Main source: transport	• Main problem pollutant (albeit seasonal) • Main source: residential heating	• Large decline since 1990 • Source: transport, electricity and district heating (coal-powered)	• Emissions increasing in past decades • Main problem pollutant (albeit seasonal) • Main source: residential heating

The ClairCity modelling also reflects the exceedances monitored across the Silesian Region. Figure 3-2a below shows that there are widespread exceedances of NO_2 limit values in the current situation. The simulation results indicate a maximum concentration of 207.7 µg.m^{-3} over the urban area of Sosnowiec. The contribution to this come up to 85.8% from the residential sector; 11.4% from the industrial sector; and only 2.8% comes from transport sector. The level of concentrations is considerably higher than the current EU annual legal limit value for NO_2 annual concentrations (40 µg.m^{-3}). According to the modelling, the legal NO_2 limit value is exceeded in 1043 grid cells of 200 x 200 metres in Sosnowiec[14] (Figure 3-3b). This translates into 59% of the population within the area potentially exposed to those concentrations.

Figure 3-2 NO_2 contour maps for Sosnowiec in current situation (reference year 2015): a) annual average of NO_2 concentrations and b) number of inhabitants within the cells exceeding the EU annual limit value of 40 µg.m^{-3}.

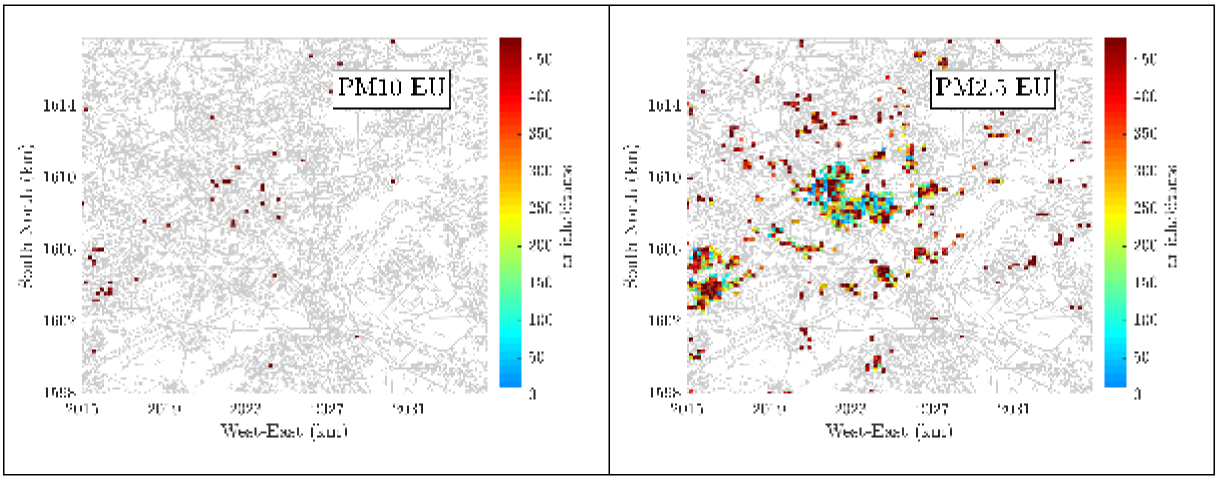


The modelling results also indicate several exceedances of PM_{10} and $PM_{2.5}$ concentrations, both above WHO guidelines and the EU legal limit (Figure 3-3 and

[14] A 'cell' refers to the 200 m x 200 m modelling domain that was utilsed by ClairCity

Figure 3-4). The EU annual legal limit value for PM_{10} concentrations is exceeded in 46 cells, which represents 12.7% of the population[15] within the urban area potentially exposed to those concentrations (Figure 3-3). The EU annual legal limit value for $PM_{2.5}$ concentrations is exceeded in 372 cells, corresponding to 45.7% of the population potentially exposed to those concentrations (Figure 3-3b).

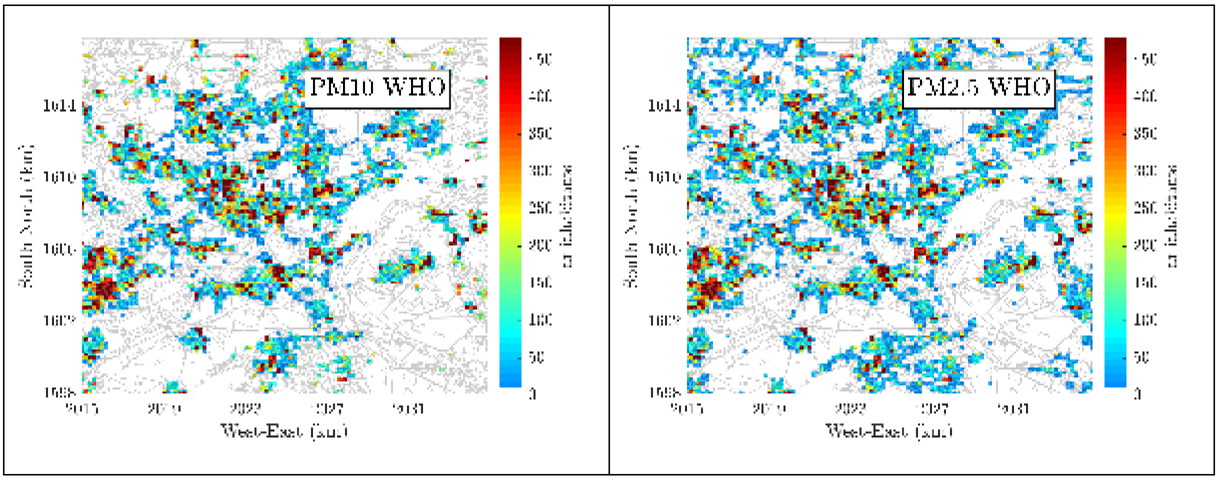
Figure 3-3: Number of inhabitants within the cells exceeding the EU legal limit values: a) of 40 µg.m^{-3} for PM_{10} concentrations, and b) of 25 µg.m^{-3} for $PM_{2.5}$ concentrations.



In the urban area of Sosnowiec respectively 95% and 100% of the total population are potentially exposed to PM_{10} and $PM_{2.5}$ concentrations that exceed the WHO guidelines (

Figure 3-4).

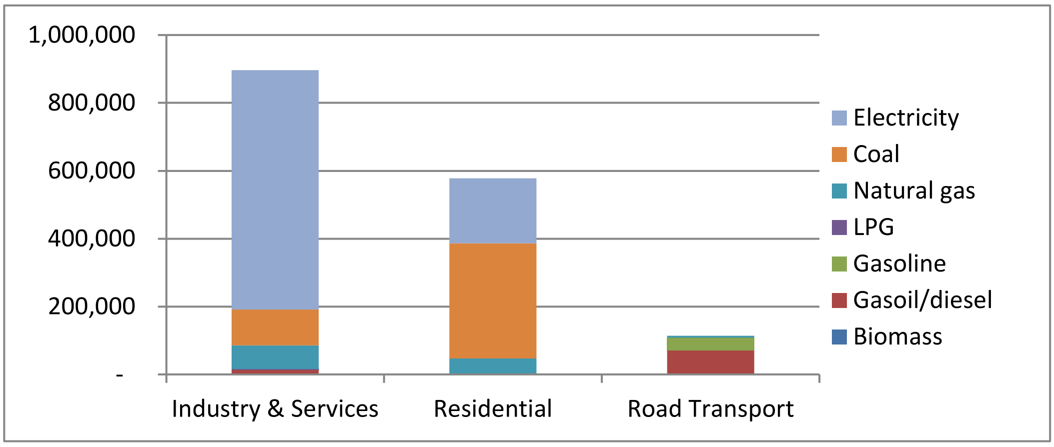
Figure 3-4 Number of inhabitants within the cells exceeding the WHO air quality guideline values: a) of 20 µg.m^{-3} for PM_{10} concentrations, and b) of 10 µg.m^{-3} for $PM_{2.5}$ concentrations.



[15] Note that this refers to the 'annual' mean, while on winter days, presumably several more people would be exposed to 24-hour exceedances that are well above the limit.

In Figure 3-5, the Carbon Footprint expressed as tonnes CO_2 equivalent on Life Cycle is reported by fuel and sector.[16]. The figure shows that the primary responsible for Sosnowiec's carbon footprint are the industry and services sectors[17]. Almost 80% of the carbon footprint of industry and services is due to electricity mainly originating from coal.[18] Next to this, the residential sector causes the largest part of the (lifecycle adjusted) greenhouse gas emissions in Sosnowiec. In the case of the residential sector, the main contributor to the carbon footprint is coal, followed by electricity. Compared to these sectors, the contribution of road transport to the carbon footprint in Sosnowiec (and in general in Poland) is marginal.

Figure 3-5: Carbon Footprint in Sosnowiec in 2015 expressed as tonnes CO_2-eq on Life Cycle by fuel and sector (source: ClairCity modelling)



3.2 Existing air quality and carbon policies

Large smog problems in Polish cities led to citizen protests and to the creation of the NGO 'Smog Alert' in Krakow in 2013. Kraków Smog Alert was soon joined by a network of Local Smog Alerts, including one in Sosnowiec.

A council resolution and a comprehensive plan for a low-carbon economy in Sosnowiec (PGN) published in 2015 set the stage for more detailed policies in the fields of air quality and climate change, energy and transport. Air quality has further gained attention on the political agenda, following a relatively cold winter in 2017. That winter the city suffered from serious air pollution and unofficial measurements reported concentrations several times higher than air quality limits. NGO action putting air quality on the policy agendas gave rise to a new regional air quality resolution[19]. Climate change, which has not played a significant role in the political and public debate in the past, has become more prominent since 2016. At the moment climate change is discussed at the political level in Sosnowiec and even a

[16] The computed indicator takes into consideration the overall life cycle of the energy carrier. Therefore this approach includes not only the emissions of the final combustion, but also all emissions of the supply chain. It includes emissions from exploitation, transport and processing (e.g. refinery) steps in addition to the final combustion. Hence this includes also emissions that take place outside the location where the fuel is used.

[17] We present these sectors together as the data source we have use aggregate values for industry and services fuel consumption. For Polland the share of insutry is 63% and of services 37%.

[18] Electricity production in Poland is mainly generated by coal (about 85% of energy input in transformation), mainly bituminous coal (57%) and secondary lignite (28%) as seen in Eurostat (https://ec.europa.eu/eurostat/web/energy/data/energy-balances)

[19] Resolution of the Parliament of the Silesian Voivodship regarding the introduction in the area of Of Silesia restrictions on the operation of installations in which fuel is burned (anti-smog resolution)

Plenipotentiary of the Mayor for Adaptation of the City of Sosnowiec to Climate Change has been appointed.

Policies to reduce air pollutants include measures targeting several areas. There is building renovation and expansion of district heating going on; heavy subsidies (80%) to modernise coal-powered heating systems to more efficient private gas boilers. However, due to the higher fuel costs of gas (in comparison to coal), the sales of the new stoves remain limited. Sosnowiec has important coal reserves and coal is commonly promoted as a domestic energy source. Other measures are the stricter rules on solid fuels quality implemented by the anti-smog resolution. This aim of this is to eliminate some of the most polluting substances emissions, although there remains some uncertainty on the extent to which municipal authorities are successful in enforcing this.

Regarding transport, Sosnowiec has a good reputation with tram and bus infrastructure present in the city, a programme to upgrade buses and trams, and an online digital public transport information system. The city bus operator is nationally known for innovation, efficiency and good service and also operates new (hybrid and electric as well as Euro VI) buses. In addition, new park and ride facilities are planned to be introduced, financed by EU funding (but the needs and future use of these by citizens are a point of discussion). Further, a city bike-sharing scheme has been introduced in Sosnowiec mid-2018. At present there are 130 bikes and 10 bike stations with stations planned. In the period that the system has been in operation, over 10 800 people have already registered and the bikes were rented almost 75 400 thousand times. This development has gone hand in hand with the first developments of infrastructure. In total around 34 km of cycling lanes have been realised in various stages and further expansion is planned. [20]

[20] Information provided by ClairCity local City Partner from Sosnowiec City Hall

4 Citizens’ views on cleaner air and carbon policies in Sosnowiec

The ClairCity citizen engagement process in Sosnowiec, and in particular the Delphi process, gave insights into the degree that citizens want to change their behaviour in ways that will contribute to cleaner air and lower carbon emissions in Sosnowiec. It also investigated the views that citizens have about future policies. Section 4.1 of this chapter analyses preferred future behaviours of Sosnowiec citizens and Section 4.2 does so for citizens future policy preferences. Section 4.3 gives the reflections of Sosnowiec policy makers on the citizen policy preferences.

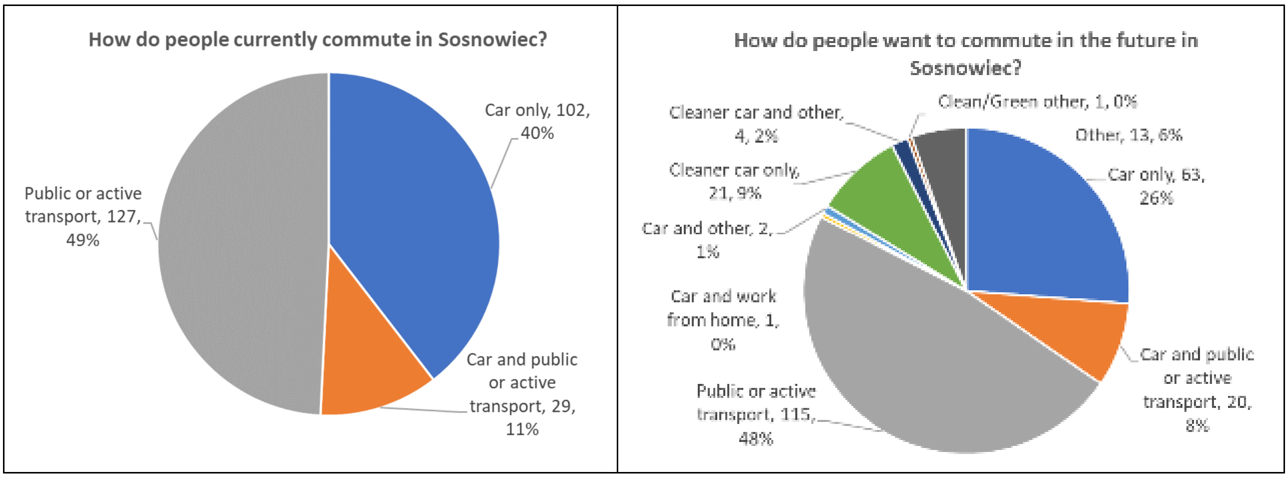
4.1 Views of citizens on their own transport and heating behaviour

In the Delphi process, citizens were asked to what extent they wanted to change their own transport and heating behaviour in the future. Below the results are given for the sample of 220-250 citizens consulted.

4.1.1 Commuting behaviour

Forty percent (40%) of our respondents in Sosnowiec always use the car for their commute. Almost half of the population on the contrary, always go to work by public transport or via active travel (mainly walking). In other words, currently 49% of respondents do not use a car to commute to work. Less than 5% cycled and no respondents worked from home.

Figure 4-1: Proportions of present and future car use of commuters in Sosnowiec



When analysing the preferences of commuters in Sosnowiec for the future, no considerable wish for change is found. The proportion of people wanting to use public transport and active travel versus private vehicles is similar to the present. However fewer want to use a conventional car in the future, and approximately 10% want to use a cleaner car[21]. The proportion who want to use public transport remains static, but the proportion who would like to cycle triplicates (from 4% of respondents cycling currently to 11% who would like to cycle to work in the future). Conversely, approximately half of the proportion who currently walk, no longer want to include walking in their commute in the future.

Table 4-1: Matrix of modal change desires for commuting trips in Sosnowiec[22]

Total = 222	High polluting choice in future (conventional car only)	Low polluting choice in future (car and walk; walk and bus, online deliveries, EV etc)
High polluting choice in present (conventional car only)	21 Entrenched	61 Looking for positive change
Low polluting choice in present (car and walk; walk and bus, online deliveries, EV etc)	42 Getting worse	98 Staying positive

A detailed look at demographics of respondents shows that young people aged 16-24 are highly represented in the "Getting worse" category, making up 79% of this group. This suggests that many young people would like to be driving or using private transport, but potentially are not able to afford it in the present. The gender split in the "Getting worse" category is the same as the overall sample; This suggests that gender is not a determining factor in people choosing conventional cars in the future.

The reason why car users that are looking for positive change are not able to switch to alternative modes of transport concern complains about public transport concerning mainly time/distance, but also to a large extent, a lack of services:

> *"Traveling by public transport often takes twice as long as, for example, by car or even on foot."*

> *"There is one bus line running to the workplace, but it runs every 50 minutes"."*

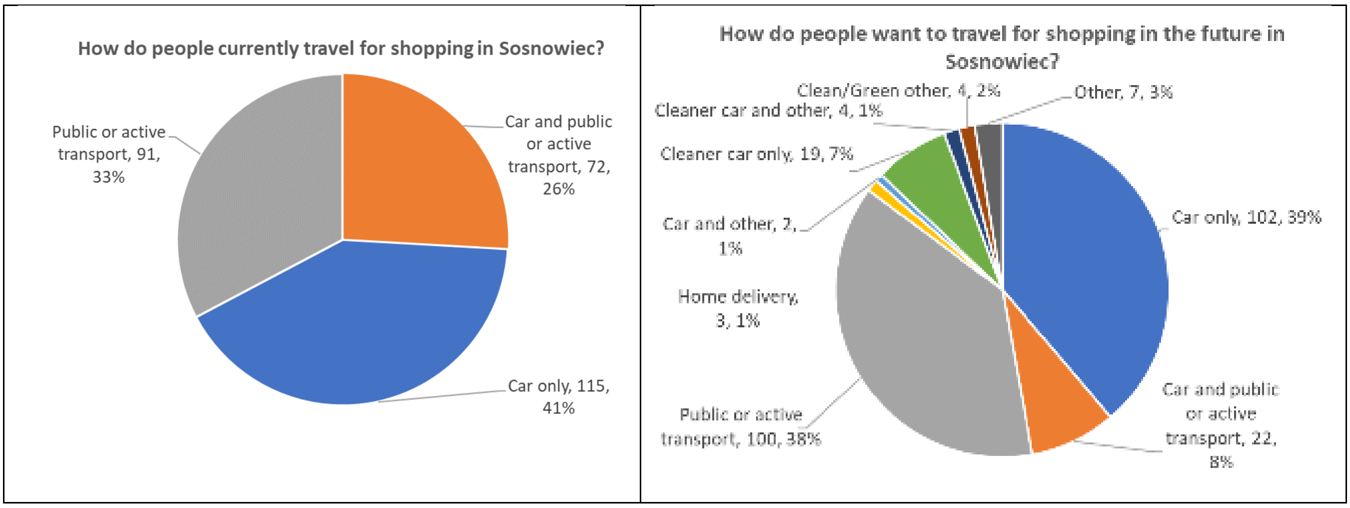
4.1.2 Shopping and leisure behaviour

At present the majority of people use public transport or opt for active travel at least occasionally for going shopping. Still over 40% always go by car.

[21] "Cleaner car" refers to electric or hybrid vehicles. "Conventional car" to petrol or diesel. Where respondents did not mention a fuel type, they were assumed to be conventional.

[22] *Entrenched:* those who only use a conventional (fossil fuel) car in the present and would like to continue to only use a conventional car in the future. *Looking for positive change:* those who only use a conventional car in the present but would like to use additional means next to or instead of a conventional car (i.e. public transport, active travel, online delivery or electric vehicle) in the future. *Getting worse:* those who use alternative means as well as cars in the present but would like to only use a conventional car in the future. *Staying positive:* those who use alternative means next to conventional cars in the present and would like to continue to use additional means as well as or instead of a conventional car in the future.

Figure 4-2: Current and future transport choices for shopping in Sosnowiec



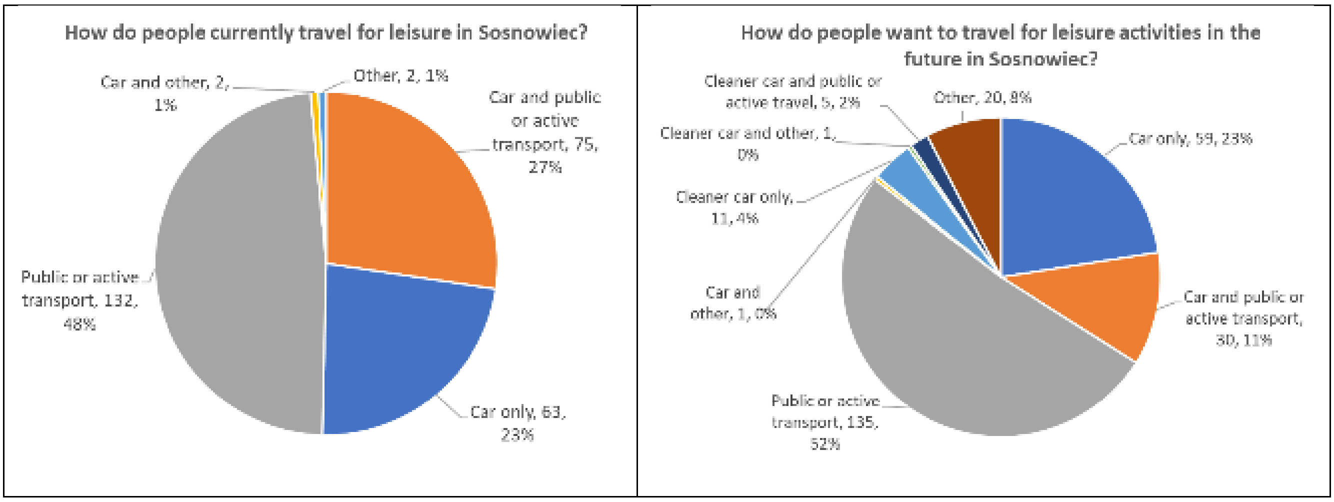
When asked about their preferences, about the same amount of people would like to use their car alone for going shopping. On the positive side, there is a slight increase of citizens who want to just either use public transport or walk/cycle to the shops. A new emerging group is that of citizens who would like to shop with a cleaner car. Overall, the number of citizens that are "getting worse" in their shopping transport behaviour is considerably larger than the number of citizens "looking for positive change".

Table 4-2: Matrix of modal change desires for shopping trips in Sosnowiec

Total = 253	High polluting choice in future (conventional car only)	Low polluting choice in future (car and walk; walk and bus, online deliveries, EV etc)
High polluting choice in present (conventional car only)	58 Entrenched	26 Looking for positive change
Low polluting choice in present (car and walk; walk and bus, online deliveries, EV etc)	44 Getting worse	125 Staying positive

For leisure, more than 75% of the citizens at least occasionally use public transport or active travel, while nearly half always use public transport or active travel.

Figure 4-3: Current and future transport choices for leisure in Sosnowiec



Patterns for change are similar to those observed for shopping. The amount of car users remains the same when asking citizens how they would like to travel in the future. The amount of people who want to use public transport or active travel alone, increases slightly. In addition, the emergence of people who want a cleaner car is observed. There are more or less as many citizens "looking for positive change" as there are citizens that are "getting worse".

Table 4-3: Matrix of modal change desires for leisure trips in Sosnowiec

Total = 254	High polluting choice in future (conventional car only)	Low polluting choice in future (car and walk; walk and bus, online deliveries, EV etc)
High polluting choice in present (conventional car only)	25 Entrenched	34 Looking for positive change
Low polluting choice in present (car and walk; walk and bus, online deliveries, EV etc)	33 Getting worse	162 Staying positive

4.1.3 Home Heating behaviour

The majority (64%) of households are on district heating networks, with gas and solid fuel use at 15% and 14% each respectively. In solid fuel use, there was a mix of those using coal and wood, with more using some form of coal. When asked how they would like to heat their homes in the future, there was a strong swing of citizens towards renewable energy, away from district heating and solid fuel. The majority of respondents want to stay away from solid fuel. More than half of all of those "looking for positive change", gave cost as a reason why they had not already changed.

Figure 4-4: Current and future choices for home heating in Sosnowiec

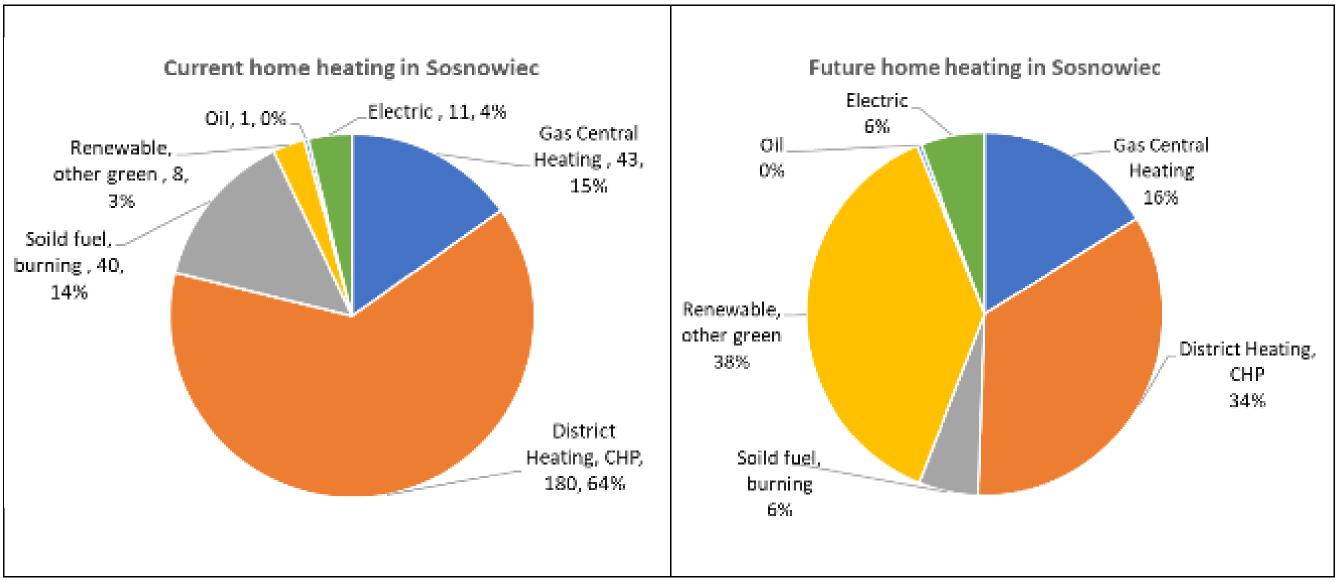


Table 4-4: Matrix of modal change desires for home heating in Sosnowiec

Total= 283	Solid fuel in the future	Not solid fuel in the future
Solid fuel in the present	9 Entrenched	31 Looking for positive change
Not solid fuel in the present	5 Getting worse	238 Staying positive

4.2 Views of citizens on future policies in Sosnowiec

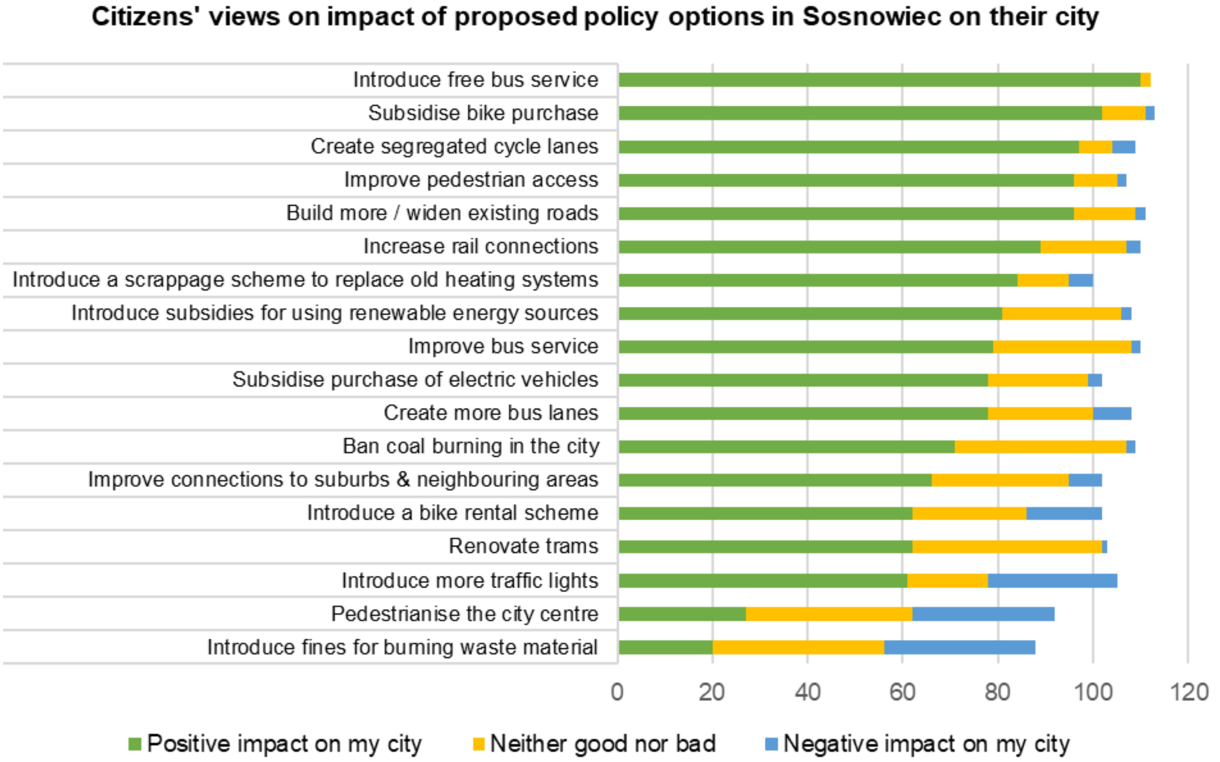
ClairCity confronted a sample of 120 Sosnowiec citizens with travel and heating related policy measures asking them to respond whether those would make the city better or worse.

Some of the most popular measures amongst respondents from Sosnowiec revolved around expanding public transport. Particularly popular were the introduction of a free bus service and increasing rail connections. Improving the bus service was also favoured by several citizens. Measures to promote cycling such as subsidies for bike purchase and the creation of segregated cycle lanes were also popular.

There is support for continued car use, albeit potentially cleaner vehicles, with subsidising electric vehicles proving popular. In line with this, citizens are not keen on pedestrianising the city centre. Citizens want more or wider roads and would like to see improvement in the connections to suburban districts and neighbouring cities.

The least popular measure from the perspective of citizens was the introduction of fines for burning waste material. Other heating related measures however (e.g. banning coal, subsidies for renewables and a scrappage scheme to replace old heating systems) were generally well-supported.

Figure 4-5: Citizens' views on the impact that proposed policy options would have in Sosnowiec



4.3 Reflections from the Sosnowiec policy makers

The ten preferred policy measures[23] of the Sosnowiec citizens were discussed with 20 representatives of the Sosnowiec City Council.[24] These representatives included 11 councillors as well as plenipotentiaries of the Mayor for various fields (Air Quality, External Funds and Social and Municipal Policy) and Heads of several relevant local government departments in the areas of environment, health, transport and budget among others.

For each of the measures, policymakers were asked to choose between two concrete measures: a specific measure that represented a low ambition level and a specific measure that represented a high ambition level. The ten concrete policy measures chosen by policymakers were put together in a “Final ClairCity Unified Policy Scenario” or “UPS” that has been modelled (see next Chapter).

Overall policymakers backed more ‘low ambition’ policy options than ‘high ambition’ options. It can be argued that the ambition is highest for policies that are already binding (e.g. Replacing 100% of the heating systems that are >10 years old by 2021 is already imposed

[23] The ClairCity team reformulated measures into the following based on the inputs obtained in the trajectory engaging citizens (as shown in Annex B-1): 1. Make public transport free/cheaper; 2. Reduce emissions from public transport; 3. Improve the public transport service/connectivity; 4. Create/increase cycle lanes and infrastructure (storage, security); 5. Encourage/incentivise electric vehicles; 6. Restrict (polluting) vehicles; 7. Raise public awareness of health/environmental impacts of air pollution; 8. Reduce emissions from domestic heating; 9. Replace old domestic heating systems; 10. Reduce industrial emissions

[24] For the detailed results and discussions of policymakers in Sosnowiec refer to D6.6 Policy Workshop – Last City.

by the anti-smog resolution) or underway to being achieved (e.g. cycling has already high acceptance and is expanding fast enough to rich the high ambition option). The reason to opt for the low ambition counterpart in the remainder of the policies was mostly cost (a financial barrier has been identified for ‘Make public transport free/cheaper’, ‘Reduce emissions from public transport’, ‘Encourage/incentivise electric vehicles’ and ‘Reduce emissions from domestic heating’). Another justification to opt for the low option was the fact that the timeframe proposed by the high ambition scenario is unrealistic (this is the case for ‘Improve the public transport service/connectivity’ and ‘Reduce emissions from domestic heating’). Education / awareness raising is an important enabler identified in Sosnowiec in order to convince citizens about sustainable mobility and heating options.

Overall the feeling of the policymakers participating was that current policy is not enough to achieve goals set by the city. Air quality and adaptation to climate change policies are expensive for citizens and so more subsidies for homeowners are needed in order to improve their heating systems. At the same time those are expensive policies for the city, whose funds are limited.

“The interest of residents in the exchange of stoves is high, but there is a serious financial barrier (it is not profitable for citizens because stove exchange also requires the involvement of citizens’ own resources”

Table 4-5: Sosnowiec's policy makers choice on preferred citizen measures: Final ClairCity Unified Policy Scenario for Sosnowiec

#	Policy area	Low ambition measure	High ambition measure	Chosen	Comments ('Main barriers to be overcome, ways to overcome these barriers = 'implementation plan')
1	Make public transport free/cheaper	Free public transport on days with high level of air pollution by 2020	Free public transport by 2025	Low ambition	• Too big of a financial barrier. The local government is not able to cover the costs of implementing free public transport from its own budget. For transport companies and for the metropolis, which is responsible for organizing the public transportation in the region, it will be too costly. • Ticket prices are not high plus there are already discounts for youth, free transfers for senior citizens, monthly and quarterly passes. • Free public transport passes would probably not increase the number of people using public transport.
2	Reduce emissions from public transport	Replace 10% public transport fleet with zero-emission vehicles by 2030	Replace 50% public transport fleet with zero-emission vehicles by 2022	Low ambition	• The biggest constraints are the lack of charging stations (plan being prepared at the moment) and costs. • For private vehicles, the barrier is also economic – it is hard to convince people to replace their diesel cars with expensive electric cars.
3	Improve the public transport service/connectivity	90% public transport journeys on schedule and most areas catered for by 2020	100% public transport journeys on schedule and most areas catered for by 2020	Low ambition	• Low scenario has been chosen because the timeframe proposed by citizens (2020) is too short for implementing this measure. To reach 100% of journeys that are on schedule and with connections in most areas, a longer time perspective is needed.
4	Create/increase cycle lanes and infrastructure (storage, security)		20 km of new cycle lanes and 15 new cycle parking spaces by 2020	High ambition	• No barriers. The program of bicycle lanes expansion in Sosnowiec is going very well. The city is almost reaching the 'ambitious' scenario (20 km).[25]
5	Encourage/incentivise electric vehicles	Replace 10% cars with EVs and 100 EV charging points installed by 2025	Replace 50% cars with EVs and 500 EV charging points installed by 2030	Low ambition	• Financial barrier – high costs of buying electric cars for individuals – it needs government subsidy for purchase as well as for the construction of charging points enabling traveling on longer distances.
6	Restrict (polluting) vehicles	Ban diesel cars from the city centre on days with level of air pollution by 2050	100% ban on fossil fuelled vehicles by 2025	Low ambition	• Participants have chosen the low ambition, but they would like to ban diesel cars from the city centre on days with level of air pollution by 2025. Public transport would be exempted because the transport company has just bought new diesel buses. • The way to overcome the barrier is education of residents, consulting the plans for introducing the ban with them and gradually convincing them to such solution.
7	Modal shift from private car to public transport	10% modal shift from private to public transport or active travel by 2030	80% modal shift from private to public transport or active travel by 2025	High ambition	• The main barrier is the lack of support from residents, who do not want to give up the convenience cars offer. • Another obstacle is poor quality of public transport – low frequency, bad accessibility in some areas. • The city intends to allocate funds for social campaigns aimed at convincing residents to give up driving a car and and to more frequently use public transport, cycle or walk.
8	Reduce emissions from domestic heating	Ban on domestic coal heating in districts with the highest concentration of air pollution by 2025	100% ban on domestic coal heating by 2020	Low ambition	• A low scenario has been chosen because 2020 is too short for implementing this measure. • Participants decided, however, that it should be possible to introduce such a ban sooner than the low scenario assumes.

[25] This was at the time the Policy Workshop was held. As stated earlier in this report, Sosnowiec has around 34 KM cycling path at the time of the publication of this report.

					• The ban should cover the entire city. Introducing it only in specific districts, where the greatest emission of pollutants from coal-fired households occurs, will not bring the expected results, because the wind transfers pollution. • The main barriers relate to finance - as already mentioned earlier, the costs of installation and subsequent exploitation are high - and the associated resistance of residents. In addition, from the next year, co-financing from the municipal budget for replacement of the furnace will not include coal-fired furnaces (currently old coal stoves are replaced with newer-generation coal stoves). The municipal financing program will be continued on changed conditions. • Another barrier is the fact that heating networks are not available everywhere.
9	Replace old domestic heating systems	Replace 75% heating systems > 10 years old by 2025	Replace 100% heating systems > 10 years old by 2021	High ambition	• The high scenario has been chosen because the measures contained in it are imposed by the binding anti-smog resolution. • Obstacles hindering the implementation of this scenario is social resistance and associated financial barrier (financial situation of both residents and municipality) - stoves replacement is in 80% co-financed by the city. • Ways to overcome barriers: through an educational campaign, convincing residents of the benefits of such a solution for their health and quality of life, and the introduction of a control system and penalties for residents polluting the air – municipality will continue activities related to the control of stoves exchange and enforce it from residents.
10	Reduce industrial emissions	Reduce industrial emissions by 25% by 2025	Reduce industrial emissions by 50% by 2025	Low ambition	• The low ambition has been chosen because the high one is unrealistic. Industrial plants are concerned with increasing their production, which causes more pollution. In addition, Sosnowiec is also polluted by plants from other cities that are in the immediate vicinity of Sosnowiec. • Legal barrier: the municipality does not have legal means to enforce the reduction of emissions. Sosnowiec cannot impose greater reduction of emissions from plants than the legal provisions regulate.

5 Impacts of implementing citizens' views

This chapter discusses the potential impacts of implementing the citizens' views on future policies on air quality (section 5.1), health (section 5.2), carbon emissions (section 5.3), and on costs (section 5.4).

Textbox 5-1 Disclaimer ClairCity modelling versus national modelling

> ClairCity modelling differs from regional and national models in Sosnowiec due to the different modelling assumptions and inputs used. Out modeled concentrations can deviate from national and regional models and so should be considered indicative. Although the utmost care has been taken to calibrate the ClairCity models to local conditions, a detailed comparison of ClairCity modelling assumptions to those of local and national models in each ClairCity case study country was outside the scope of this project. Therefore ClairCity modelling outcomes cannot be one-to-one compared with the outcomes of national and local models.

The potential impacts are based on a 'Unified Policy Scenario' (UPS) consisting of ten measures (see table below) that was prepared by combining citizen preferences for future policy measures with policy maker reflections and quantifying them where possible (please refer to previous chapter for further detail on why these measures were chosen). The main assumptions made for preparing the UPS can be found in Annex C. The impacts of the UPS are compared with those of a 'Business-As-Usual' scenario (BAU)[26].

Table 5-1: Sosnowiec's Final Unified Policy Scenario (UPS) for Sosnowiec

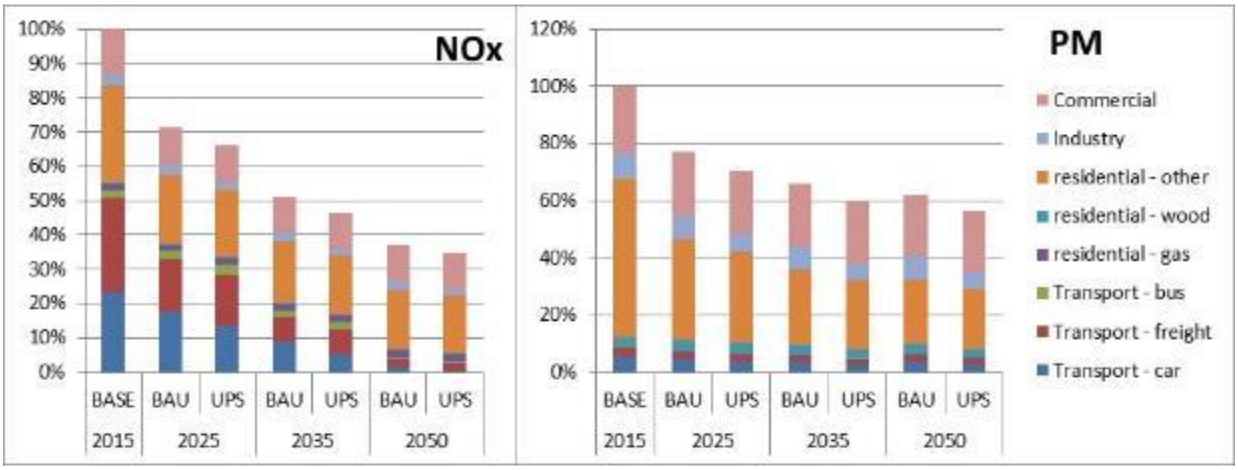
#	Policy area	UPS measure (chosen policy measure for modelling)
1	Make public transport free/cheaper	**Free public transport on days with high level of air pollution by 2020**
2	Reduce emissions from public transport	**Replace 10% public transport fleet with zero-emission vehicles by 2030**
3	Improve the public transport service/connectivity	**90% public transport journeys on schedule and most areas catered for by 2020**
4	Create/increase cycle lanes and infrastructure (storage, security)	**20 km of new cycle lanes and 15 new cycle parking spaces by 2020**
5	Encourage/incentivise electric vehicles	**Replace 10% cars with EVs and 100 EV charging points installed by 2025**
6	Restrict (polluting) vehicles	**Ban diesel cars from the city centre on days with level of air pollution by 2050**
7	Modal shift from private car to public transport	**80% modal shift from private to public transport or active travel by 2025**
8	Reduce emissions from domestic heating	**Ban on domestic coal heating in districts with the highest concentration of air pollution by 2025**
9	Replace old domestic heating systems	**Replace 100% heating systems > 10 years old by 2021**
10	Reduce industrial emissions	**Reduce industrial emissions by 25% by 2025**

[26] The Business-As-Usual' scenario (BAU) scenario concerns the set of strategies/policy measures which are already formally and politically agreed upon at European, national or regional level but may yet be implemented in the baseline year 2015 and thus only have an effect on emissions in the future.

5.1 Impacts on air quality

Implementing the suggested policy measures of citizens as quantified in the UPS, and thereby enabling alternative behaviours and activities, would result in substantially better air quality and a reduction in the number of premature deaths caused by air pollution in the city as compared to the baseline year, 2015. The ClairCity UPS scenario results in slight further reduction of both NOx and PM than the BAU.

Figure 5-1: Trend of PM and NOx emissions in the policy scenario, compared to the business as usual scenario

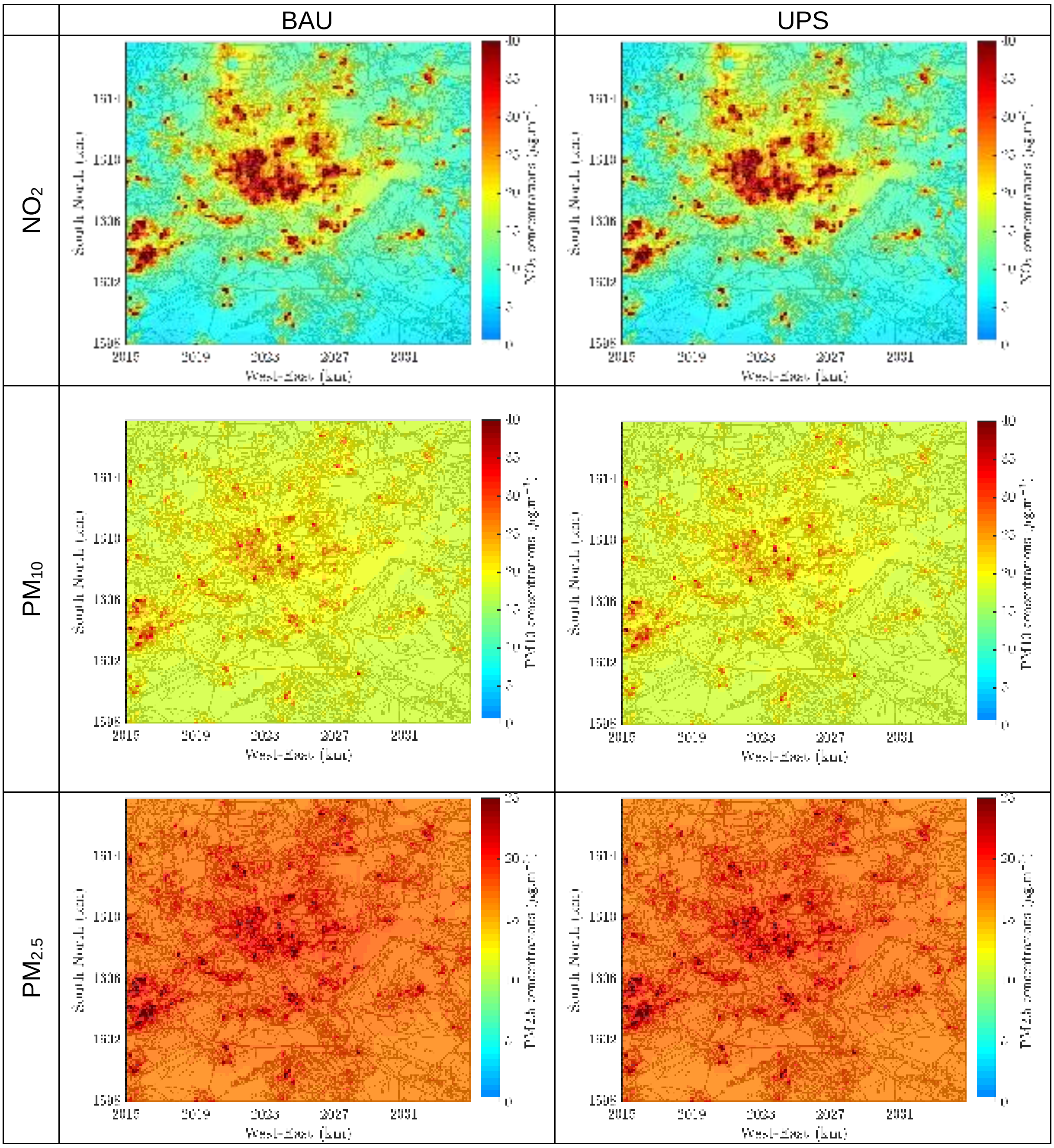


As shown in Figure 5-1, there is a clear trend in improving NOx emissions, already in the BAU by 2025. The UPS scenario adds an additional (albeit limited) decrease in emissions (e.g. around 5% in the short term and less in the longer term) beyond the reductions in the BAU. This decrease is mainly due to further decreasing transport emissions through measures pushing citizens away from car use towards cycling and public transport, the latter being cleaner compared to the BAU due to additional investments in zero-emission buses. The reduction of residential emissions adds further to the decrease in NOx emission as a result of the adoption of more fuel-efficient heating systems and though limited in total, the industrial emissions are slightly further reduced (-0.7%) as well in the UPS.

A similar downward trend is observed for PM emissions. In Sosnowiec, the PM problem is mostly related to commercial emissions, industrial emissions and above all residential emissions. The main driver for the reduction in this case is the reduction in residential emissions, which are linked to heating. Already in the BAU, gradual improvement is expected; In comparison, the UPS will lead to strong decreases in overall emissions, mostly through more ambitious replacement of residential heating sources. PM emissions from transport are a minor part of the total PM emissions. The UPS will generate an additional decrease in PM emissions compared to the BAU. However, decrease in PM emissions from transport will continue to have a limited impact on the emissions total.

Figure 5-2 gives an overview of modelled NO_2, PM_{10} and $PM_{2.5}$ concentrations in the BAU and UPS scenario in 2050 (all the figures concern annual averages). More detailed modelling results can be found in Annex C. The pictures clearly shows that air quality will remain (quite a big) problem in 2050 both in the BAU scenario as in the UPS. This means that neither the measures currently being implemented in Sosnowiec (BAU) neither the more ambitious measures that citizens would like to see taking place (UPS) will be enough to comply with air quality limit values and WHO standards.

Figure 5-2: NO_2, PM_{10} and $PM_{2.5}$ concentrations in the BAU and UPS scenario in 2050



The overall analysis of modelling results, comparing UPS and BAU modelling results with legal limit values and WHO guideline values, shows that:

Neither the BAU nor the UPS scenarios will lead to compliance[27] of legal NO_2 limit values, not even by 2050. In the BAU scenario, the maximum NO_2 concentration will be equal to 168.2 µg.m $^{-3}$ in 2025 and 143.3 µg.m $^{-3}$ in 2050. In the UPS scenario, the maximum NO_2 concentration will be equal to 166.8 µg.m $^{-3}$ and 141.7 µg.m $^{-3}$ in 2025 and 2050. The UPS scenario will reduce the maximum NO_2 concentrations by less than 1% and 1.2% respectively by 2025 and 2050, as compared to the BAU scenario.

The UPS scenario will lead to an average reduction over all the domain of 40.4% by 2050, when compared to the baseline situation.

- **Neither the BAU nor the UPS scenarios will lead to compliance of EU legal PM_{10} limit values, not even by 2050.** In 2025 the maximum value in the UPS scenario corresponds to 58.9 µg.m $^{-3}$ and to 45.2 µg.m $^{-3}$ in 2050, translating into a 21.8% (in 2025) and 40.0% (in 2050) reduction of the maximum concentration compared to baseline. When comparing the UPS scenario with the BAU scenario, the maximum concentrations will be reduced by 1.2% and 1.1% respectively, by 2025 and 2050. In 2050 there are some exceedances of PM_{10} concentrations above EU limit values, corresponding to 1.6% of the total population potentially exposed to those concentrations. **Still in 2050, over 70% of the total population will be potentially exposed to PM_{10} concentrations above the WHO guidelines.**

- **For $PM_{2.5}$, even in the UPS scenario there are still significant exceedances of the EU legal limit values in 2050.** In 2025 the maximum value in the UPS scenario corresponds to 49.2 µg.m $^{-3}$ and 38.4 µg.m $^{-3}$ in 2050, translating into a 20.3% (in 2025) and 38.2% (in 2050) reduction of the maximum concentration compared to baseline. When comparing the UPS scenario with the BAU scenario, the maximum concentrations will be reduced by 1.2% and 1% respectively, by 2025 and 2050. Based on the EU limit values, in 2050 there are still several exceedances of $PM_{2.5}$ concentrations, corresponding to 12.5% of the total population being potentially exposed to those concentrations. **In 2050 100% of the total population will still be potentially exposed to $PM_{2.5}$ concentrations above the WHO guidelines.**

5.2 Impacts on health

The UPS scenarios significantly improve human health compared to the current situation. The UPS however offers just a moderate improvement over the BAU. Please refer to Annex C for the methodology on the health impact assessment and results**.** Table 5-2 shows the comparison between the current situation and BAU and current situation and UPS, assessing the health impact benefits of the emission levels in each scenario. The health benefits from implementing the control measures behind the future emission scenarios (BAU and UPS) are considerable for NO_2 but not as significant for neither PM_{10} nor $PM_{2.5}$. In 2015, the number of premature deaths as a result of NO_2, PM_{10} and $PM_{2.5}$ is 1 194, 664, and 879 respectively. The BAU scenario reduces these numbers by 40%, 21%, and 18% by 2050 respectively. The UPS scenario reduces them by 41% for NO_2, 21% for PM_{10}, and 19% for

[27] If there are exceedances of annual limit values (i.e. concentrations above 40 µg.m -3 annual mean) in one grid cell, this means there is ‘no compliance’.

$PM_{2.5}$. The UPS does therefore not lead to significant impact when compared to the results of the BAU scenario.

The health benefits (i.e. reduction of premature deaths and of years of life lost) from the emissions reduction are much higher than average concentration levels reduction. This is explained by the fact that the emission reduction measures would target the more densely populated areas, thus benefiting a larger part of the population.

Table 5-2 Benchmarking the UPS in 2025, 2035, and 2050 against the baseline scenario in terms of health indicators (%) related to $PM_{2.5}$, PM_{10} and NO_2 exposure

	$PM_{2.5}$			PM_{10}			NO_2		
Scenario	**2025**	**2035**	**2050**	**2025**	**2035**	**2050**	**2025**	**2035**	**2050**
BAU	-9	-16	-18	-11	-18	-21	-21	-34	-40
UPS	-10	-16	-19	-12	-19	-21	-24	-37	-41

5.3 Impacts on carbon emissions

Figure 5-3 shows the impacts of UPS measures compared to the BAU scenario in terms of Carbon Footprint. The figure shows that the UPS measures have a limited impact as compared to the BAU scenario. The small differences between UPS and BAU are limited to the transport sector (as the UPS contains no measures addressing fossil fuel consumption in the other sectors).

Figure 5-3 Carbon emissions of UPS scenario compared to BAU (tonnes of CO_2-eq on life cycle)

5.4 Impacts on costs

Table 5-3 gives a qualitative estimate of the cost of the measures in the UPS scenario versus the BAU. We distinghuish between estimated monetary costs to citizens, costs for government / city council[28] and a net total cost to society, summing up both. An exact calculation of benefits and the indirect benefits of health improvement of citizens (saved public health costs) should also be taken into account but it is beyond the scope of the ClairCity modelling.

In total, net monetary cost effects of the 10 UPS measures vary substantially and will sometimes result in additional costs and other times in net benefits for citizens and for government. Exact costs will also depend on how measures are designed in detail. Further detail of the assumptions made is given in Annex C. The annex also gives an order-of-magnitude cost estimate of car user costs, car charging revenues and bus subsidies in the UPS compared to the BAU scenario.

However, the overall balance of direct costs of all measures in the citizens' UPS scenario together suggests that a cost effective execution of the UPS for citizens and city council / government is very well possible, as measures with a net direct cost to society can be balanced by measures with net revenues. This balance would be even more positive if also the indirect health benefits of improved health of citizens would be added.

Table 5-3 Estimated cost impacts of citizen measures that are part of the UPS scenario in Sosnowiec

#	Policy measure	Citizens	Government	Society
1	Make public transport free/cheaper	+	-	-
2	Reduce emissions from public transport	0	-	-
3	Improve the public transport service/connectivity	n/a	n/a	n/a
4	Create/increase cycle lanes and infrastructure (storage, security)	n/a	n/a	n/a
5	Encourage/incentivise electric vehicles	+/-	+/-	+/-
6	Restrict (polluting) vehicles	0	0	0
7	Raise public awareness of health/environmental impacts of air pollution	n/a	n/a	n/a
8	Reduce emissions from domestic heating	-	0	-
9	Replace old domestic heating systems	+	0	+
10	Reduce industrial emissions	0	0	-

(+) assumed net positive effect/ benefits for target group; (-) assumed net negative effect / costs for target group; n/a effect of measure cannot be assessed

The assumed cost effects per measure are explained in more detail below:

1. Cheaper public transport requires a higher subsidy for buses to be provided by government (-). This measure leads to a cost decrease for citizens (lower fares) (+), yet at a greater expense for the government as incremental model shift to public transport is

[28] No distinction is made between different levels of government.

assumed to require a larger subsidy and coincides with a drop of government income from other alternatives (i.e. cars). The overall societal cost effect is therefore considered to be negative (-).

2. Cleaner buses require extra investment at a cost to the government (-) without a cost effect on citizens (0), leading to an overall net negative cost effect on society (-).
3. (and 4 and 7) The cost impact of improving public transport connectivity and cycling infrastructure cannot be assessed without extra information. When assuming a reallocation of the (fixed) investment fund in infrastructure (i.e. from road for cars to infrastructure for walking and cycling), there is no extra cost. When assuming an aggressive investment strategy in new walking/cycling infrastructure, this measure would come at an (extra) cost to the government. Therefore, we did not consider this measure to have a direct measurable cost effect.
5. Incentivizing/promoting the use of electrical vehicles (EVs) can be achieved with a subsidy for electric vehicles at as cost for the government (-), leading to lower prices for EVs, a benefit for citizens (+). As long as EVs are more expensive than conventional cars over their lifetime, this implies a net cost for society, as a high subsidy will be necessary to overcome the price differential with conventional cars. EVs can also be promoted through a mandatory target at no cost to the government and a cost or a benefit to the citizen, depending on the timing of the mandate (at a time when EVs are more expensive than conventional cars over a lifetime[29], this will be a cost for citizens). The overall societal effect depends on the cost differential between conventional cars and electric cars. Currently, EV's are still more expensive, so an incentive scheme leads to a net negative societal effect (-). This will change in the future as EVs will then become more cost-competitive (-/0/+).
6. Banning polluting cars in principle leads to early scrappage of the existing car fleet, and hence to a loss of capital for private owners (-). However, the measure only includes a ban on polluting cars on days with poor air quality. Assuming these are relatively rare events, which clearly depends on the threshold set for "poor air quality", this will not lead to early scrappage but mode choice changes during those days. As such, we conclude this measure would not lead to early scrappage (and loss of capital) and thus has no considerable cost impact.
8. Banning low quality fuel (coal) has a negative cost impact for households (-) as they will need to resort to more expensive higher quality fuel.
9. Although requiring an upfront investment, in the long run increased heating efficiency is leading to cost benefits for citizens (+). The initial investment cost will be offset by lower fuel cost, leading to a net benefit for citizens. There is no subsidy from the government in this case, thus cost-neutral for the government (0) and a net benefit for society (+)
10. Reducing industrial emissions requires investment in exhaust treatment technology, a cost borne by the industry, with no cost impact on citizen or government (0).

Measures are not detailed enough to be able to produce a definite assessment of the cost impacts. Several measures can be achieved in different ways. For example, the cost of incentivizing EV's can depend on the instrument used (e.g. legislation, subsidy, taxation of non-EV) and on the timing of the measure. The same goes for infrastructure investments

[29] EV's will still be more expensive in purchase, but cheaper in use (when electricity is cheaper than diesel/petrol)

which can be additional to current investments (higher cost) or simply a reallocation of existing investment funds.

While difficult to assess, we can make a rough assessment of the relative cost of measures compared to each other. For example, making public transport cheaper would come at high cost for the government, while banning poor quality fuels in the residential sector, although likely to be unpopular, would entail limited additional cost for the government.

6 The Sosnowiec and other ClairCity cities – Mutual learning for citizen-inclusive policy making

In this chapter, the main institutional conditions and barriers for implementing citizen policy preferences in Sosnowiec are discussed (section 6.1), as well as lessons from Sosnowiec citizen-inclusive policy making in other cities (section 6.2) and lessons from other ClairCity cities for Sosnowiec (section 6.3).

6.1 Institutional conditions and barriers for citizen-inclusive policies in Sosnowiec

Economy

- Economic restructuring in Sosnowiec is still ongoing, with the city and region changing from coal and heavy-industry dominated to a more services-oriented situation. Whereas the city is doing relatively well in the national context, it lags somewhat behind neighbouring cities in the regional context.
- In comparison to neighbouring towns and cities, Sosnowiec has a below average income as it has experienced significant de-industrialisation and closure of its coal mines.
- The relatively low income of citizens in Sosnowiec plays an important role in the choice of fuels and boilers for domestic heating, which are the main source of pollution in the relatively frequent cold winter days of the continental climate of Silesian region that includes Sosnowiec.

Governance

- Sosnowiec is part of the larger Upper-Silesian urban conglomeration, centred on Katowice and with a population of around 2.7 million. Since July 1st 2017, a new regional entity, the Upper Silesian – Zagłębie Metropolis area, was created which began implementing its statutory tasks on 1st January 2018.
- National carbon policy is weak, with little attention paid to it by the current government which is sceptical of climate change and keen to support the domestic coal sector and conscious of energy affordability for poor households. Poland is also the only EU-28 country who has not committed to the European Council objective of achieving a climate-neutral EU by 2050 (with this issue planned to be revisited in June 2020). National policy actively discourages renewable energy, as this is viewed as too expensive for Poland and competing with the domestic coal sector. Further, national

and regional (voivodeship) politics and policies sometimes conflict, with more ambitious regions having little freedom to deviate from national policy.

Finance

- Sosnowiec is experiencing population decline, with young people migrating to other EU countries which is also resulting in an increase in average age of the population.
- However, the city budget is currently very high (due to EU funds and new foreign investors) and the level of municipal investments are also high.[30]
- Policy makers is Sosnowiec seem aware that current measures to tackle air quality are not enough, but at the same time feel very much constrained by cost issues. Financial barriers – on both the city as well as citizens side - are the main factor hindering the greening of public transport, private car-fleet and residential heating.
- Currently EU funding is a key catalyst for air quality and carbon policy action and implementation in Sosnowiec (and overall in Poland). The Silesia region receives significant EU and national funding for environmental protection.
- The establishment of the Upper Silesian – Zagłębie Metropolis area is expected to lead to greater investments for integrated regional transport planning.

Other

- There is a single national air quality monitoring station in Sosnowiec, and a few passive collectors. Whilst the regional monitoring agents are satisfied with this, local citizens united in an air quality NGO have expressed concerns over local air quality monitoring network (the location and 'unrealistic' results from monitoring).
- Until recently there was a lack of quality and/or efficiency standards for commercial heating fuels and stoves, leading to poor quality fuels and combustion.

6.2 Lessons from Sosnowiec for other cities

Sosnowiec can be seen as case study for other (EU) cities struggling with major winter smog problems and health impacts in the context of changing economic circumstances. Sosnowiec shows that wood and waste burning can have strong detrimental impacts on air quality. This has to be taken into account in particular as wood burning is at present often seen as a positive measure from a climate policy point of view. Biomass burning is a policy measure that deserves attention in the future, as it is assumed to be positive for climate change targets but has also negative impacts for air pollution.

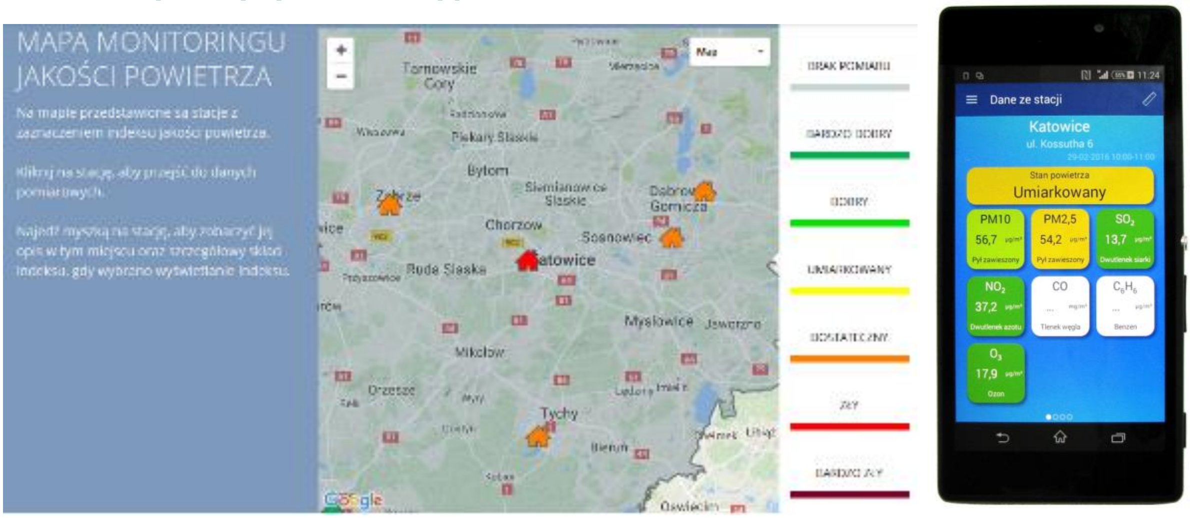
In addition, Sosnowiec has substantial experience with district heating and are considering expansion of their heating networks. Considering that all ClairCity cities are working on expanding energy efficiency of their housing stock.

Awareness raising measures have been identified as policy measures that ClairCity case studies widely need to implement across all cities. Sosnowiec provides real-time air quality

[30] Insights for ClairCity City Partner from Sosnoweic City Hall.

information to citizens through the electronic transport information system in the city. In this way, awareness of changes in air quality in the city is increased. The monitoring information gathered by the Regional Inspectorate for Environmental Protection (WIOS) can be accessed in real-time from a website[31]. This provides a traffic-light style information system on air quality. There is also an app for smart phones which provides similar more detailed information based on current location.

Figure 6-1: Live monitoring information from the Regional Inspectorate for Environmental Protection (WIOS) system and app



6.3 Lessons from other ClairCity cities for Sosnowiec

Sosnowiec could learn from good examples across the other ClairCity cities in the areas of transport and heating. The most relevant policies and examples from within ClairCity ranging from environmental zones / clean air zones, to initiatives to encourage cycling, and good practices regarding public transport are spelled out below.

Environmental zones / clean air zones

The ClairCity research suggests that exceedances of NO_2, which are largely caused by transport, will persist in 2050 even when the policy measures advocated by citizens are taken on top of already existing measures. This shows that tackling NO_2 will require more and or stricter measures. Example of stricter transport policies found across the ClairCity case studies are so-called Clean Air Zones or environmental zones, and bans for motorised vehicles, which a few ClairCity cities already have in place. Evidence from these cities suggests that a gradual introduction and some political courage to overcome initial resistance – without going too much against dominant public culture in the city - contribute to a successful implementation of a so-called ‘environmental zone’ or ‘clean air zone’. None of the ClairCity case study cities had a congestion management or charging system though.

[31] http://powietrze.katowice.wios.gov.pl/

Textbox 6-1 Relevant experiences from ClairCity environmental zones / Clean Air Zones

- In **Amsterdam**, the environmental zone was introduced gradually for different types of vehicles, initially not implementing a ban for private cars. Now that citizens are used to the zones for mopeds, buses, taxis and freight transport and these zones are more or less accepted, also a ban for polluting private cars will be implemented, making the city centre 'emission free' by 2030.
- **Ljubljana** has converted its city centre into a pedestrian zone. The city offers a free biking scheme and free electrical short-distance taxis ('cavalier') for people who need a transport option (for example the elderly, disabled people). Initial resistance of citizens and business against the pedestrianisation has now turned into massive support, as closing streets to cars have led to increased living quality and economic development in the form of tourism. Initial concerns of local commerce over potential reduced number of customers visiting the shops proved wrong.
- **Genoa** wanted to introduce a clean air zone ban of older Vespas. Strong resistance against this ban from Vespa-drivers in the city of origin of the Vespas meant that the proposed ban was withdrawn. Only recently has it been reconsidered.

Encouraging cycling

The experiences in other ClairCity cities suggest that effective modal shift policies towards cycling tend to consist of a combination of education and awareness raising (e.g. at schools) accompanied by large-scale infrastructural enablers such as sufficient bike parking spots and increasing road space for cycling to ensure safety and comfort. In Sosnowiec, the first step has already been taken with the municipal bike-sharing scheme and first network of cycling lanes introduced in April 2018. Cycling infrastructure overall is however limited still.

Textbox 6-2 Relevant experiences from ClairCity for stimulating active transport

- In the **Aveiro Region** a couple of small-scale initiatives are aiming to revive the cycling culture of the past by targeting the youngest groups. As school children in Portugal are almost always brought to school by car, a local NGO initiated a group for children and parents to cycle together to school. The same NGO initiated a 'Bike buddy' project, in which people who did not feel safe to bike alone were accompanied by cycling 'buddies'. In addition, a school a teacher set up a workshop to repair bikes where kids can repair old bikes and create new ones with old spare parts.
- In **Amsterdam**, cycling is already a central part of city transport culture. Cycling traffic lights, bike lanes and paths as well as an integrated train and bike-rent system are already implemented since several years. Providing sufficient bike parking facilities, reducing car road space in favour of bikes, and spatial planning for short as well as long-distance biking are now central elements in further scaling up of cycling in Amsterdam.

Public transport improvement

Public transport provision in Sosnowiec is relatively good but could learn from experiences of the other ClairCity case studies. ClairCity found that one ticket for all public transport and integration of the public transport ticket with bike rent are helpful in stimulating public transport due to the convenience they offer. Better connections to suburban areas and nearby cities are wishes expressed by citizens to ClairCity. Sosnowiec can also learn from the train and bus developments that other cities have recently implemented in order to link less inhabited areas to the main city hubs.

Textbox 6-3 Relevant experiences from ClairCity for stimulating public transport

- **Ljubljana** has integrated its city and regional transport, which can now be travelled with one ticket. According to interviewees, commuting by public transport into the city has been much facilitated in this way.
- **Amsterdam** and the Netherlands have a popular integrated train, bus and bike-rent system that can be travelled with one ticket, which facilitates door-to-door transport.
- **Bristol** has recently implemented large-scale improvements of public transport to connect the city and the metropolitan area: the MetroBus (a bus service for the larger Bristol area which works with 'buy before you

board' ticketing to ensure limited stopping, faster boarding and shorter journey times) and MetroWest (project that improves rail connections in the region).

Greening private transport and promoting a modal shift

Modal shifts require carrots and sticks. Measures for improving public transport need to go hand in hand with measures that make private car access to the city less attractive ("sticks"), e.g. through increasing parking tariffs or introducing and/or reducing the number of residents' parking permits, reducing space for cars in the city (e.g. cycle lanes, reducing car parking space). These measures are likely to find resistance from the share of citizens who want to keep using their car. ClairCity evidence suggests that a potential way to mitigate this and contribute to the attractiveness of electric cars, is to reserve scarce public parking space for electrical vehicle recharging ("carrots").

Textbox 6-4 Relevant experiences from ClairCity for stimulating cleaner private transport

- In **Amsterdam** the scarcity of parking space in the city has led some car owners to switch to an electrical car in order to be able to park their car at a parking space reserved for electrical car recharging. In addition, through high parking tariffs for the city centre (7 euros an hour) and reducing the number of residents' parking permits, access to the city by car is made less attractive.

Engaging citizens, including the most deprived groups

ClairCity has found that NGOs overall are a very important intermediate in engaging citizens (in Sosnowiec as well as in the other ClairCity case studies). In Poland, NGO work has even influenced air quality legislation. Given the low citizen policy involvement and awareness of air quality and carbon issues in Sosnowiec, maintaining good relationships with NGOs (such as the group 'Smog Alert' run by a small group of dedicated citizens, is part of a larger national network) seems to be an important way to stimulate citizen-inclusive policies. In addition, the transition to low-carbon heating modes in Sosnowiec is expected to be a financial challenge for all but particularly for the poorest households. Against this backdrop the city could benefit from the experience that Bristol has specific attention to deprived groups.

Textbox 6-5 Other relevant experiences from ClairCity for engaging citizens

- In **Amsterdam**, an active network of citizens measure air quality at home with low-cost equipment. These measurements supplement the official air quality measurements in the city.
- In the **Aveiro Region** a NGO is driving change with regards to cycling and the engagement of kids and parents in this (see Textbox 6-2).
- In **Bristol** specific attention is given to deprived groups in air quality and carbon policy making. For instance, when the feasibility study for the Bristol clean air zone found that it would negatively affect the possibilities for for poorer groups in the city to enter the city by car, the design of the zone was changed.

Measuring air quality

"Measuring is knowing" and so having a wide monitoring network can help better understand the actual air quality situation, sources affecting that and in so doing, shed light on measures that should be taken.

Textbox 6-6 Air quality measuring experiences from ClairCity

- **Amsterdam** had a wide air quality measuring network consisting of 12 automatic monitoring stations (measuring NO_2, $PM_{2.5}$, PM_{10} and Soot). In addition NO_2 is measured with passive sampling at 106 locations in Amsterdam. This network was instrumental in defending 80 km/h speed limits on the Amsterdam urban motorways against national political opposition, as well as in identifying the main local air quality hotspots.
- **Bristol** measures NO, NO_2 and NOx widely (that is not the case for PM). The city has six monitoring networks currently active (plus an extra national one measuring also O_3, PM_{10} and $PM_{2.5}$). In addition to automatic monitoring, the City Council also uses more than 100 passive diffusion tubes for measuring NO_2.

Regional cooperation involving citizens

Given the newness of the Silesian Region, Sosnowiec could feel inspired by the ClairCity case of the Aveiro Region. The Aveiro Region as such exists since a decade. However, the eleven municipalities that compose it have a long tradition of cooperation between them on environmental issues due to the Ria (lagoon). Also, a so-called Agency for Sustainability and Competitiveness[32] aims to help municipalities in the Region of Aveiro to work towards sustainable development goals. The Agency is formed by citizens representing each one of the Aveiro Region municipalities and the Region itself. Their work is structured around 7 themes (Policies for the Green Economy, Energy Efficiency, Water Efficiency, Waste Valorisation, Sustainable Construction, Climate Change Adaptation and Sustainable Mobility and Ecotourism).

7 Innovative citizen-inclusive air quality and carbon policies in Sosnowiec: Conclusions and recommendations

This chapter outlines the main conclusions of the ClairCity citizen engagement process in Sosnowiec and the results of the modelling and analysis thereof. Section 7.1 provides main conclusions; Section 7.2 gives the main recommendations for future policy making in Sosnowiec.

7.1 Conclusions

activities: analysing the detailed current behaviours of citizens, asking citizens about their preferences for their own future behaviours and enquiring about their preferred city policies for the future. Preferred policies of citizens were discussed with policy makers, quantified and assessed for their impacts in three different ways: regarding emissions and concentrations of air pollutants and CO_2, regarding health and regarding costs. Institutional conditions and barriers for implementing citizen measures were examined and compared with experiences in other ClairCity cities. The main conclusions of all these activities are discussed below.

7.1.1 Current air quality situation and city policies in Sosnowiec

The air quality situation in Sosnowiec (and Poland overall) is more concerning than in the other ClairCity case studies (and most European cities). The main sources of air pollution are residential heating boilers and stoves followed by central district heating boilers and some major industrial emitters. Some air pollution emissions (SOx, NOx, NH_3) have declined in the last decades. However, the emissions the harmful carcinogenic pollutant benzo(a)pyrene are increasing. Particularly PM_{10} and benzopyrene remain relatively high and are the main concern. With the use of inefficient heating systems and poor quality fuels (e.g. domestic coal, wood) in winter as the main source of these pollutants, the air pollution problem is very seasonal. The dominance of the residential sector for PM emissions is striking compared to other cases, where industry and transport are a more dominant source. Sosnowiec has important coal reserves and coal is commonly promoted by the national government as a domestic energy source. Coal is also the cheapest fuel option for citizens. In comparison to the PM low-stack emissions, NO_2 emissions are less of a problem in Sosnowiec. However, NO_2 limit values are at present exceeded in Sosnowiec and are expected to continue to be exceeded, even in the most ambitious of scenarios presented in this report. In Sosnowiec transport is the most important source of emissions of NOx with emissions coming mostly from diesel cars, buses and freight vehicles.

A council resolution and a comprehensive plan for a low-carbon economy in Sosnowiec (PGN) published in 2015 set the stage for more detailed policies in the fields of air quality and climate change, energy and transport. Air quality has gained attention on the political agenda, following a relatively cold winter in 2017. A regional air quality resolution[33] also

[33] Resolution of the Parliament of the Silesian Voivodship regarding the introduction in the area of Of Silesia restrictions on the operation of installations in which fuel is burned (anti-smog resolution)

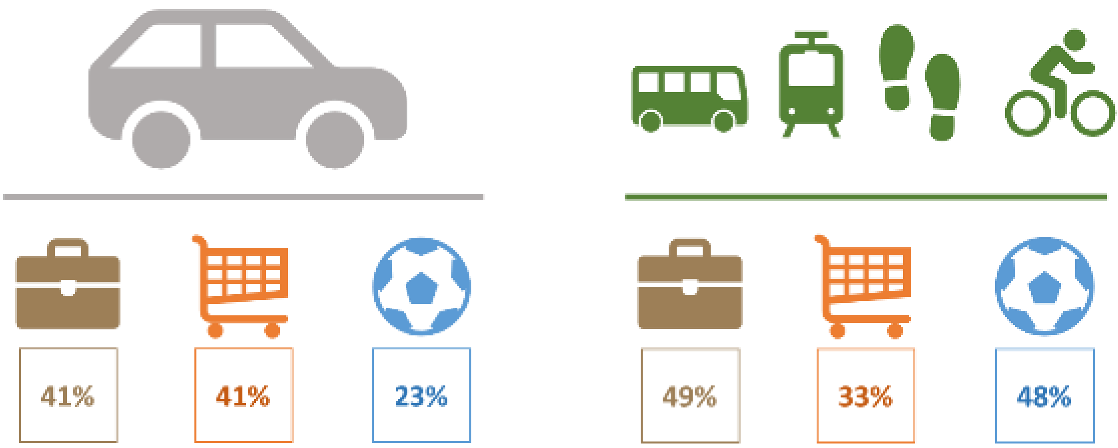
helped to raise attention on the issue. Climate change, which has had a more significant role in the political and public debate in the past, has become more prominent since 2016.

To reduce air pollution from heating, building renovation and expansion of district heating is taking place and heavy subsidies (80%) to modernise coal-powered domestic heating systems to more efficient private gas boilers are available. There are also stricter rules on solid fuels quality implemented by the anti-smog resolution. Regarding transport, Sosnowiec has a good reputation with tram and bus infrastructure present in the city, a programme to upgrade buses and trams, and an online digital public transport information system. New park and ride facilities are planned to be introduced, financed by EU funding (but the needs and future use of these by citizens are a point of discussion). Further, a city bike-sharing scheme has been introduced in Sosnowiec mid-2018.

7.1.2 Current behaviours of citizens

Current travel and heating practices of citizens substantially contribute to air pollution and carbon emissions in the city. A relatively high percentage of citizens use 'always' a car at present for commuting to work (41%) and going shopping (41%). Almost half the population use public transport 'always' for going to work and leisure activities (this is in line with the average found in ClaiCity case studies).

Figure 7-1 Percertage of citizens in Sosnowiec 'always' using a car for commuting to work, shopping or leisure vs those 'always' using public transport, walking or cycling



The majority (64%) of Sosnowiec citizens are on district heating networks, with gas and solid fuel use at 15% and 14% each respectively. Solid fuel use is mainly coal and otherwise wood.

7.1.3 Behavioural preferences of citizens for the future

There is continued support for current transport behaviour (and thus little willingness to change) but there is also a large mismatch between current heating behaviour and how citizens would like to heat their homes in the future.

- **There is little additional demand for public transport and active travel in the future.**
  Over 40% of citizens in Sosnowiec go to work, shopping and leisure always by car and there is virtually no willingness to change modes in the future. Virtually the same number of people using a car at present, would like to use a car in the future. The main barrier for car users to switch to alternative modes of transport concern mainly time/distance, but also to a large extent, a lack of services. For commuting, a latent demand for greener cars was found though. ClairCity also found that from those who opt for active travel to commute to work, several would like to cycle instead in the future.

- **There is high interest from citizens for renewables for residential heating.**
  An example of the mismatch is the observed predominance of district heating (non-renewable) currently (64%), while in the future a lot less citizens would like to heat their home this way. Instead a strong swing of citizens towards renewable energy is perceived (from 1% currently to 38% in the future), away from district heating and solid fuel. The majority of respondents want to stay away from solid fuel. The reason for those “looking for positive change” not to take action accordingly is primarily cost. Not just the replacement but also the higher fuel costs of gas (in comparison to coal), are responsible for the sales of the new stoves to remain limited.

7.1.4 Policy preferences of citizens for the future

The policy priorities that citizens as well as policy makers agree on are the expanson of cycle lanes and infrastructure, the need for modal shift from private to public transport or active travel and the replacement old domestic heating systems.

- **Citizens favour public transport related measures including measures that affect private cars despite this is not in line with their preferences for the future**
  Public transport are the most popular (making public transport free/cheaper, reducing emissions from public transport and improving the public transport service/connectivity) including awareness raising to stimulate a modal change towards public transport (and active travel). Sosnowiec citizens are not generally keen on measures that would impact private cars (this is in line with current transport behaviour of citizens) with the exception of restricting the most polluting vehicles. Incentivising EVs was also a measure put forward by citizens. Citizens also wish to have cycling infrastructure expand. The pace at which this is already being done will probably lead to realising the citizens’ highest ambitions.

- **Citizens would like to see measures to reduce emissions from domestic heating and replace old domestic heating systems but cost is an issue for them**

ClairCity research showed that there is strong willingness from citizens for change regarding heating behaviour provided that the price difference between current and possible future alternative fuels becomes smaller. The replacement old domestic heating systems is a priority. Both citizens and policymakers place high priority on the replacement old domestic heating systems and aim for the replacement 100% of the heating systems that are >10 years old by 2021. This is in fact a binding measure already imposed by the anti-smog resolution.

7.1.5 Consequences of the policy preferences

According to the ClairCity modelling, **citizens measures (i.e. the UPS) would lead to a significant decrease of NOx emissions over time** mainly due to further decreasing transport emissions through measures pushing citizens away from car use towards cycling and public transport. The reduction of residential emissions as a result of the adoption of more fuel-efficient heating systems adds further to the decrease in NOx emission. **PM emissions follow a similar downward trend until 2050, albeit more moderate.** In the case of PM emissions the main driver for the reduction in this case is the reduction in residential emissions, linked to the ambitious replacement of residential heating sources.

ClairCity modelling has concluded that neither the measures currently planned by the local government (BAU scenario), nor the ambition levels that policymakers opted for the measures proposed by citizens (UPS scenario), will lead to compliance of legal EU limit values for PM and NO_2 everywhere in Sosnowiec, not even by 2050 (and so Sosnowiec air quality will remain far from the guidance values by the World Health Organisation).

If implemented, the measures proposed by citizens (Unified Policy Scenario - UPS) would result in considerable improvement for human health compared to the baseline year, 2015. The UPS scenario reduces the number of premature deaths from air pollution by 41% for NO_2, 21% for PM_{10}, and 19% for $PM_{2.5}$ by 2050. The health benefits of implementing the measures under the UPS are therefore considerable for NO_2 but not as significant for neither PM_{10} nor $PM_{2.5}$. The reduction on premature deaths and years of life lost as consequence of emissions reduction are much higher than average concentration levels reduction. This is because emission reduction measures will be implemented in high(er) populated areas.

It should be noted that the UPS however offers just a moderate improvement over the Business As Usual (BAU) scenario. In other words, the UPS does not lead (by 2025, 2035 and 2050) to significantly better results for air quality than the measures already implemented by the region will. This is partly explained by the fact that policy makers chose for the low ambition options of citizens measures. More (stringent) effective measures are required in order to ensure the health of citizens in Sosnowiec.

7.2 Policy recommendations

The following recommendations are tailored to Sosnowiec based on the analyses of current behavioural practices, preferred future behaviours and preferred future policies of citizens, as well as of impact and an institutional context carried out by ClairCity.

7.2.1 Policies to address current behavioural practices and preferred future behaviours

From the detailed analysis of current and preferred future behaviours of citizens we conclude that the following mix of policy measures are worth considering. The measures should be taken alltogether for optimal result.

- **Promote renewable energy and raise awareness on the negative health effects of biomass burning.** The ClairCity engagement process showed that there is strong willingness from citizens for change regarding heating behaviour towards renewable energy provided that the price difference between current and possible future alternative fuels becomes smaller. Supporting rooftop solar PV, increasing rooftop solar on public buildings and supporting local citizen cooperatives for renewables generation could be measures that the government should consider to facilitate this. Tackling this issue may also involve measures that may not be well received by all citizens at first (e.g. because they involve costs). Providing information and awareness raising is therefore essential to increase acceptance of policy measures. In addition, the dangers of biomass burning for air quality and health should be further communicated to citizens.

- **Improve public transport coverage and frequency, facilitate cycling through expanding the current cycling network and infrastructure and promote these.** To encourage modal change away from cars, first and foremost public transport and active travel need to be made more convenient and attractive. Bus and train services need to be improved, including connections to suburban districts and neighbouring cities. Expanding the urban cycling infrastructure is also necessary for everyone to be able to cycle wherever they need to on a daily basis, whether that is for work, groceries shopping or leisure. In addition, a transport card / ticketing system which works for all modes of transport as well as bike rental options close to bus and train stops (that integrates cycling with public transport) are ways to facilitate intermodal transportation. Facilitating access to a bike by for instance subsidising bike purchase for the poorer groups should be considered. Public transport and bike infrastructure (including municipal biking systems) and any improvements to these, will require effective promotion from the local government (for example through an awareness raising campaign), in order to inform citizens and encourage them to opt for those modes. The attractiveness of walking can also be promoted by awareness campaigns that stress its health benefits.

- **Introduce measures to discourage car use and incentivise electric vehicles.** Efforts to improve public transport should go hand go hand in hand with measures that make private car driving less attractive. ClairCity research shows that otherwise, uptake of public transport / active travel is less likely to happen, even if public transport tickets are cheap. Examples to achieve this are restrictions of parts of the city to cars (at the same time this gives pedestrians and other modes of transport more space), limiting parking spaces in the city centre and making parking more expensive. Higher parking fees are an excellent way for local governments to collect extra revenues which can in turn be used to fund further transport measures. In addition, considering citizens' support for continued car use, and their wish to drive in cleaner vehicles, subsidising electric vehicles is an avenue to explore. The city should also ensure that there are enough charging points. Another policy that could be considered to reward those swtiching to EVs is making parking free for these type of vehicles (and charging high fees for conventional cars).

- **The 'health' frame should be as much as possible exploited in Sosnowiec when implementing air quality and carbon related policies.** Winter smog is a clearly perceivable phenomenon in Sosnowiec and high exceedances of PM limit values during smog days can be easily related to health consequences. Domestic heating impacts these emissions most and so interventions in this area are needed. Given that citizens have direct influence on this source of pollution, communicating the health benefits of policies directed at domestic heating (and the scary facts of air pollution) is essential in order to encourage citizens to act, and defend and justify any stricter government rules for domestic heating systems and or fuels. Tackling domestic heating is also beneficial for climate. With 'climate change' gaining traction at both the political and citizen levels, both 'climate' and 'health' can be used as hooks for putting policies forward. Considering the 'seasonal' aspect of domestic heating pollution, it is probably worth implementing measures and focusing any awareness campaigns in the winter months, when the problem is most visible. An additional potentially suitable frame for policies could be related to a 'better living', for example, by stressing the side benefits to overall quality of city life resulting from larger pedestrian zones and less cars or the comfort of better insulated housing which has less heating needs.

- **Work closely together with NGOs to create citizen awareness in Sosnowiec.** Citizen interest in air quality and carbon emissions in Sosnowiec is relatively low and limits possibilities for policy action. This can be related to a lack of knowledge. For instance, the limited citizen interest to exchange domestic boilers for more efficient ones, despite the relatively generous subsidies currently in place, may be partially justified (besides costs) by the fact citizens are not aware or the dangers of solid fuel burning at home. Education and awareness raising are important enablers identified in Sosnowiec in order to motivate and engage with citizens to shift to sustainable mobility and heating modes. If policy measures affecting citizens' lives are to be implemented, citizens need to be aware and understand why those measures are important or even necessary, and how they can affect their lives for the better (e.g. beneficial for health, pleasant environment). Against this backdrop, NGOs can play an important role in creating public awareness around air quality. Close cooperation of policy makers with the local NGOs (in Sosnowiec, Smog-Alert) can be a way to engage with citizens.

- **Intensify cooperation with employers, schools, destinations of leisure and shopping to minimise car travel.**
  A large percentage of people in Sosnowiec use their car to access their work, leisure activities and shopping. Although there is little willingness expressed by citizens to change that in the future, it is the duty of local governments to provide alternatives and encourage more sustainable behaviours. When there are good alternatives to the car, people may change their minds. The promotion of active travel and public transport can

be stimulated in cooperation with big employers as well as destinations of leisure and shopping (e.g. retailers, shopping malls, sports clubs, theaters or cinemas). Options for bus stops and bike parking next to these destinations, together with biking infrastructure to get there should be considered. Engagement of schools is also essential. These could take the societal role of encouraging children and parents to avoid travelling to school by car. Further, city planning should consider encouraging more jobs, leisure and shopping options close by to where people live.

7.2.2 Addressing institutional barriers and mutual learning

- **Reallocate costs or compensate costs of required heating and transport measures through revenue generating local financial instruments and communicate the need for such instruments.**
  Financial barriers – on both the city as well as citizens side - are the main factor hindering the greening of public transport, private car-fleet and residential heating in Sosnowiec. Finance is a key institutional condition that determines the possibilities for implementing citizen-inclusive policies. Subsidising heating systems, modes and/or fuel change, as well as public transport improvements are all costly. These costs can be compensated by generating local funding through for example parking fees and permits, congestion levies or workplace parking levies. Such financial instruments tend to be less popular with citizens, hence the need to properly communicate such measures. Authorities should consider possibilities to reward behavioural change (e.g. bike parkings and rentals offering discounts at local shops). Costs can also be additional to current investments or simply a reallocation of existing investment funds. The costs of new walking/cycling infrastructure (e.g. expanding the cycling network) for instance, can be (partly) offset by reallocating funds currently dedicated to road infrastructure for cars, to infrastructure for walking and cycling.

- **Explore potential for an environmental zone / clean air zone that is gradually introduced and offers alternatives if applicable**
  Several types of environmental areas or so-called Clean Air Zones (CAZ) with bans of different kinds of vehicles (e.g. mopeds, buses, taxis and freight transport), including private cars in some cases, were found in the ClairCity cities (Amsterdam, Ljubljana and Genoa, with Bristol working on a CAZ as well). This intervention has proven beneficial only for air quality but also for quality of life as streets become more pleasant for walking and cycling. CAZ can stimulate the economy as well for example, by shops that attract more pedestrians and/or by the city becoming more appealing for tourism because of being more “walkable” and pleasant. Evidence from ClairCity case studies suggests that a gradual introduction (over time, for a certain type of vehicles at a time) is important for acceptance. ClairCity also found that some political courage is essential at the start, in order to overcome initial resistance. To cater for the needs of everyone alternatives should be offer for those who need motorised mobility (e.g. elderly, handicapped) for instance by offering an on-demand free electric taxi that one can call.

- **Consider expanding current air quality monitoring into a network**
  Comprehensive air quality monitoring is essential to spot problems (hotspots) and make good policy decisions. Bad air quality (and related health risks) somewhere can be a good reason for implementing measures and so an argument that the local government

could use to push for behaviour change or measures. At the moment in Sosnowiec there is a single national air quality monitoring station, complemented by a few passive collectors. Whilst the regional monitoring agents are satisfied with this, local citizens united in an air quality NGO have expressed concerns over local air quality monitoring network (the location and ‘unrealistic’ results from monitoring). As such, building more monitoring stations (to create a network) is something the city should consider. Through NGOs, the city can also explore with citizens measuring air quality themselves, like Amsterdam for instance has done.

Annex A. The ClairCity process in detail

This annex explains in more detail the ClairCity process and the positioning of this 'Sosnowiec policy package report'.

The ClairCity project consists of three phases and seven work packages (Figure A-1):

Phase 1: Establish the Baseline Evidence

The primary aim of Phase 1 is to understand and quantify the baseline status of air quality, carbon emissions and related public health in our cities. Phase 1 is achieved with the following main activities:

1. **Benchmarking behaviour**: Understanding the local demographic data and establishing the citizen practice-activity data to feed into the air quality models.
2. **Quantify the baseline**: Quantification of the baseline air quality emissions and concentrations, carbon emissions and public health impacts in a city.
3. **Assessment of Policy**: Collation and analysis of current policies (local, regional, national and EU) that influence the city.

Phase 2: Citizen and Stakeholder Engagement & Co-creation of Scenarios

Phase 2 has three key aims: (1) understand citizens' current behaviours, practices and activities, (2) enable citizens and stakeholder to co-create and visualise their low carbon, clean air, future city and (3) raise awareness of the environmental challenges and their solutions. Phase 2 utilised evidence from Phase 1 to help frame and inform the engagement activities. Phase 2 is achieved with the following main activities:

Citizen and stakeholder engagement & co-creation

1. The ClairCity Delphi method uses citizens as local experts to generated qualitative evidence of their entrenched behaviours and what enabling interventions would allow them to act and behave differently in future (WP4).
2. The Mutual Learning Workshop brings citizens and stakeholders together to debate the challenges facing the city and co-create policy interventions for cleaner, healthier futures (WP4).
3. The ClairCity Skylines Game 'crowd-sources' the public perceptions and public acceptability of difference policy interventions (WP4)
4. Citizens and stakeholders come together in a Stakeholder Dialogue Workshop to review and debate the Delphi, Mutual Learning Workshop and ClairCity Skylines evidence and co-create scenarios for a low carbon, clean air, health futures (WP4 and WP7).
5. The scenarios generated in the Stakeholder Dialogue Workshop go through a rapid quantification step (WP5) and are then returned to the local citizens/stakeholders to discuss in a Policy Workshop (WP6) and to agree a single Unified Policy Scenario (WP7).

Public Engagement & Awareness: Additional awareness raising activities are also implemented across the project in each city (WP4). These include:

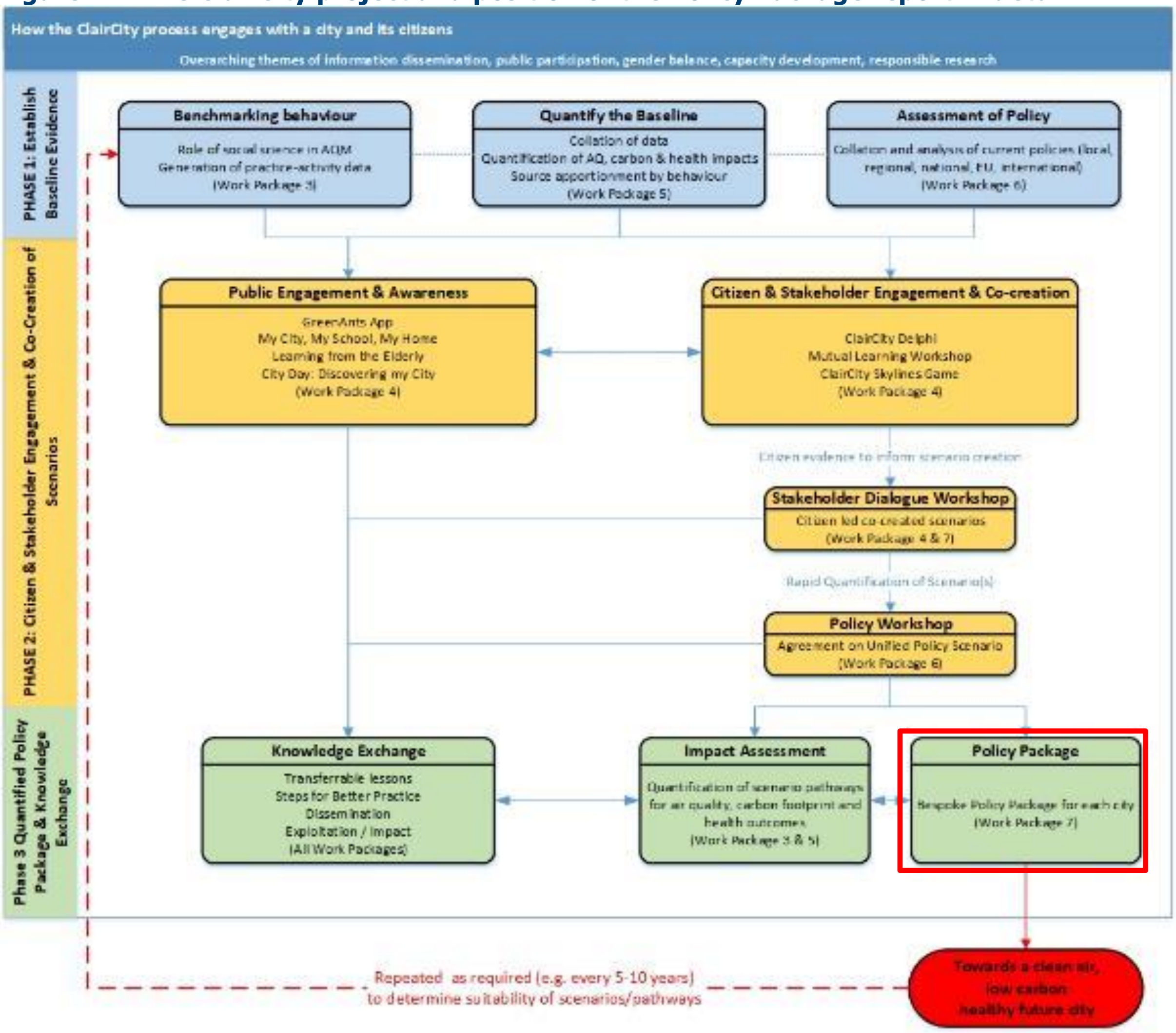
6. The GreenAnt App which allows citizens to become a citizen scientist and monitoring their transport activities, emission generation and exposure using mobile GPS data.
7. The School Competition: My City, My School, My Home engages young people in the air quality, carbon and public health debate utilising an online platform for the students to select the interventions that influence their housing, transport and use of resources in order to be able to design tools for change towards smart consumption, reduced emissions and healthy lifestyles.
8. Learning from the elderly filming activity engages the older, potentially vulnerable, community to talk about the changes in their city, their personal mobility and the steps they take to minimise their exposure to air pollution.
9. The City Day: Discovering my City helps disseminate the final project results and provide healthy and smart tips to promote non-motorised mobility of citizens by highlighting availability and benefits of walking and cycling routes in the city.

Phase 3: Quantified Policy Package & Knowledge Exchange

The primary aim of the final Phase 3 is to collate the evidence and lessons learned from Phase1 and Phase 2 to generate a quantified, bespoke, citizen-led and citizen-inclusive policy package for each city. Phase 3 is achieved with the following main activities:

1. **Knowledge Exchange**: Collation of transferrable lessons and steps for better practice based on the experiences of the ClairCity project to inform other environmental and public health practitioners (WP3, WP4, WP5, WP7).
2. **Impact Assessment**: Rapid quantification of the scenarios generated in the Stakeholder Dialogue Workshop (WP4) and detailed impact assessment of the final Unified Policy Scenario generated in the Policy Workshop (WP6). This quantification includes an assessment of the source apportionment by behaviour or purpose; air quality emissions and concentrations, carbon emissions, air pollution related health impact and interventions cost analysis (WP5).
3. **Policy Package**: Development of a bespoke Policy Package for each city drawing together the findings from across the whole project (WP7).

Figure A-1 The ClairCity project and position of the Policy Package report in detail



Annex B. The ClairCity citizen engagement and awareness process

The citizen engagement process developed by ClairCity consisted of policy focused activities and of awareness raising directed activities. These are discussed in Annex A. For a more comprehensive overview and analysis, the more detailed ClairCity reports on each activity can be consulted on the ClairCity website: http://www.claircity.eu/reports/

B.1 Policy focused engagement activities

Three main engagement activities directly informed the policy workshop and the policy recommendations: the Mutual Learning Workshop, the Delphi process and the Skylines game.

Mutual Learning Workshop

The Sosnowiec Mutual Learning Workshop (MLW) engaged with a variety of stakeholders from different sectors and organisations (Table B-1).

Table B-1 Participants in the Sosnowiec Mutual Learning Workshop

Stakeholder group	Number of participants	Organisations
Science/Academia	2 (9%)	Humanitas University, Institute of Occupational Medicine and Environmental Health
Civil/Civic Society (including NGOs)	2 (9%)	Senior City Council, Zagłębie Smog Alert
Policy Makers (including public servants)	13 (59%)	City Hall (Property and Environment Management Department, Road and Traffic Management Department, Health Department, Project Implementing Unit, External Funds and Cooperation Department), Regional Inspectorate for Environmental Protection, Upper Silesian–Zagłębie Metropolis - Member of the Board
Munipal organisations	4 (18%)	Public transport company, Municipal Waste Management Company, Municipal Property Management Office, Silesian Marshal Office - Environmental Protection Department
Other	1 (4%)	Silesian trams

In Sosnowiec the MLW proved a good example of how to engage stakeholders on the air quality, climate change and public health discussion today and with perspective for the future (2020, 2030, 2050).

Futures envisioned

The discussions concluded that by 2020 little will change. The most important changes will take place by 2030. It was noted that the strategy for Sosnowiec should not happen in isolation, and should therefore consider the region, with cities agreeing on common policies for example in the field of transport. A vision for 2050, as the most distant, was difficult to predict.

By 2020 mainly a first set of public transport and active transport related measures and improvements are expected (cleaner buses, modernisation of the tram, bike lanes). By 2020 as well several awareness raising activities are predicted around health and environmental issues to inform citizens and induce their behaviour change. Subsidies for heating may stimulate change towards more energy efficient boilers and more sustainable ways of heating.

By 2030 major changes are expected in terms of transport, as cars are expected to become banned in the city centre (except electric cars). Large scale replacement of heat sources (towards low-emission modes of heating) is expected to occur throughout the city and renewable energy (photovoltaics, wind energy and heat pumps) will gain traction.

By 2050, fossil fuels will be past, and heating will be powered by renewables majorly. Houses will have been renovated to ensure proper thermal insulation and new houses will be built ‘passive’ from the start. Only electric and hydrogen cars will move along the streets. The city will be very green and liveable.

Barriers perceived

Barriers to the aforementioned visions by 2020, 2030 and 2050 concern legal, financial and awareness aspects.

Currently, polish law is not stable enough. People are afraid to invest in modern solutions subsidised today, afraid that law will change and additional fees will be imposed to them - in the near future.

Citizens cannot bear the costs of shifting to other home-heating mode. Earnings of Polish residents are lower than the income of Western European citizens. Co-financing of, for example, replacement of a furnace with a modern one is not sufficient, as the cost of fuel for a new boiler is often too high for residents. Heating homes with coal thus, is cheaper for citizens. The introduction of new solutions in the field of thermal energy, albeit considered extremely important and a priority, can be a big problem especially for the poorest social groups. In addition, in the area of transport, moving by car is not only cheaper but also faster. Added to that there is the believe that in an aging society, social resistance will not allow complete elimination of car traffic in the city centre.

Society is not fully aware of the consequences of their own actions. There is no knowledge about the health consequences of burning low quality fuels or rubbish. Local government employees seldom join courses offered by universities on the topic and the assumption is that they may lack knowledge about renewable energy sources.

Further, there are a lack of enablers to encourage sustainable behaviour. For example, in order to make cycling attractive, employees should be able to shower and store their bicycles at work.

Solutions

The aforementioned barriers can be firstly tacked with more legislation (e.g. on quality standards for solid fuels) and policy measures (e.g. more charging stations for EVs). Also, more stable legislation would be required. Next to that maintaining financial help (i.e. subsidies) for sustainable measures such as cleaner boilers would be necessary, as well as introducing financial help (e.g. co-financing) for the purchase of fuel. Lastly, a lot of awareness raising / education efforts are needed to inform and engage citizens in changing their lifestyle.

Delphi process

The Delphi process consisted of two broad survey rounds of Sosnowiec citizens, a workshop with citizens and concluded with a 'Stakeholder Dialogue Workshop' (SDW). The surveys and events resulted in the following participation:

- 283 responses to Round 1 survey which included a mix of open and closed questions presented online and face-to-face by interviewers and in self-completed forms

- 120 responses to Round 2 survey which included a mix of open and closed questions including measures (generated based on Round 1 responses, to be rated by citizens in this second round)

- 1 face-to-face workshop with 29 citizens intended to work out in more detail the citizens' measures, enablers and constraints before handing them to policy makers.

- At the SDW, 23 participants discussed priority policy measures derived from the questionnaires in the Delphi process and created various scenarios (Table B-2). These measures are the ones taken one step further and discussed with policy makers.

The results of the Delphi Process have been reported in ClairCity Deliverables D4.3, D4.4 and D4.6.

Table B-2 Policy measures discussed in Stakeholder Dialogue Workshop and proposed LOW and HIGH ambitions for each policy

	Measure	Proposed scenario LOW	Proposed scenario HIGH
1	Make public transport free/cheaper	Free public transport on days with high level of air pollution by 2020	Free public transport by 2025
2	Reduce emissions from public transport	Replace 10% public transport fleet with zero-emission vehicles by 2030	Replace 50% public transport fleet with zero-emission vehicles by 2022
3	Improve the public transport service/connectivity	90% public transport journeys on schedule and most areas catered for by 2020	100% public transport journeys on schedule and most areas catered for by 2020
4	Create/increase cycle lanes and infrastructure (storage, security)		20 km of new cycle lanes and 15 new cycle parking spaces by 2020
5	Encourage/incentivise electric vehicles	Replace 10% cars with EVs and 100 EV charging points installed by 2025	Replace 50% cars with EVs and 500 EV charging points installed by 2030

6	Restrict (polluting) vehicles	Ban diesel cars from the city centre on days with level of air pollution by 2050	100% ban on fossil fuelled vehicles by 2025
7	Raise public awareness of health/environmental impacts of air pollution	10% modal shift from private to public transport or active travel by 2030	80% modal shift from private to public transport or active travel by 2025
8	Reduce emissions from domestic heating	Ban on domestic coal heating in districts with the highest concentration of air pollution by 2025	100% ban on domestic coal heating by 2020
9	Replace old domestic heating systems	Replace 75% heating systems > 10 years old by 2025	Replace 100% heating systems > 10 years old by 2021
10	Reduce industrial emissions	Reduce industrial emissions by 25% by 2025	Reduce industrial emissions by 50% by 2025

Skylines Game

ClairCity Skylines is a ‘serious game’, designed to capture citizen decision making about issues in their city, where players travel between areas representing a city’s environment, economy and its citizen’s health & satisfaction, collecting ideas for policies to enact to achieve a low carbon, clean air, healthy future before 2050 (Figures B-1 and B-2).

Figure B-1: Google Play Store listing

Figure B-2: Six playable cities completed

In Sosnowiec the ClairCity Skylines was launched in January 2019, with primary data capture closing at the end of March 2019. The game includes English, Dutch, Slovenian, Polish, Italian and Portuguese localisations for game text, UI and the policy database.

B.2 Awareness related engagement activities

At the time of writing this report, four ClairCity awareness related engagement activities had been implemented: a school competition, a film activity for the elderly, a so-called ‘city day’ and the GreenAnts app. The reason for the focus on young people and the elderly is that

ClairCity builds on the WHO Policy Framework and the European Commission's Clean Air Policy Package that promote public health by paying special attention to more vulnerable groups, such as children and senior citizens. The aim is to empower these citizens to better understand the specific challenges and opportunities that their city currently offers and to engage them into moving towards reduced air pollutant emissions and carbon footprints. The project has therefore collected their perceptions and ideas on sustainable lifestyles and a *'better quality of life'* within their city in the future.

Schools Competition

The schools competition designed by ClairCity aimed to raise awareness of children on air quality and climate issues and to engage them in practices that lead to a 'healthier city' in terms of better environment and low carbon emissions.

The schools competition in Sosnowiec took place between November 2018 and February 2019. Thirteen (13) teams of teenagers aged between 13 and 16, from eleven (11) different schools participated in the activity.

The teachers of these schools were provided with an online tool (created by ClairCity) and detailed information package.

The results of the activity show that the three (3) teams with the biggest number of points were the oldest students. This is no surprise as it is logical that older students are more knowledgeable, however was a good opportunity for younger children to expand their knowledge on the topic.

The announcement of the winners was done at a 'Gala of Good Initiatives', that took place on 21st March 2019. At the gala, the kids were asked to come into stage and say some words about the activity. The prize for the winning team members were sports backpack designed to be worn when running or cycling. The members of the second winning team were given a reusable water bottle each and a training sack each.

Elderly film competition

ClairCity activities with the elderly focused on promoting non-motorised mobility of citizens to show the health, environmental and social benefit of active travel. The activity, which run between May 2018 and March 2019, invited local older citizens to tell about their experiences in short films. The information about the film competition was featured on the dedicated city website of ClairCity:
http://www.sosnowiec.pl/aktualnosci/id,14468,nakrec_film_proekologiczny_w_ramach_projektu_clair_city.html

In Sosnowiec, in order to be able to launch the film activity, a few formal and legal preparations had to be handled. These aspects concerned aspects related to the publication of personal data, and dissemination of image and copyright that the municipality required. As a result, a package of information for participants was created and disseminated from 28th May 2018 onwards.

A total of two videos was collected. The elderly made their films with the help of representatives of the Youth City Council. The cooperation between The Youth Council and the Senior City Council was successful in the promotion of the video competition. The youth helped in the video campaign and also gave technical help for senior people in filming and editing. Initially, it had been planned that only the winner would receive a prize and the victory would be determined by the number of likes, but only two films were made, so both participants were honoured and received awards.

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Some common themes and ideas shared in the videos by the participants are as follows:

- Jogging is an active, healthy form of spending free time for seniors;
- Seniors are able to achieve successes in sports activities;
- Outdoor activities have a positive impact on mental health and improve concentration;
- Outdoor activities affect positively the whole organism;
- Being active outdoors, gives the opportunity to admire nature and come across objects aspects of your city which you do not see every day.

The Sosnowiec ClairCity videos can be found here:
https://www.youtube.com/playlist?list=PLtz0rUQvSHEDXgSKWoSK4NAC29uYD_Gaa

City Day

The Sosnowiec City Day took place on March 21st, 2019 at the Concert Hall 'Muza', ul. Warszawska 2 in Sosnowiec. The City Day piggy banked into the event "Gala of Good Initiatives", an annual meeting of Sosnowiec NGOs, representatives of local government and residents. The gala, organised by the Sosnowiec Center of Non-Governmental Organizations, aimed at honouring citizens who have proven special social responsibility and have strived to improve the level and quality of life of the community, for example through doing voluntary work. The number of people present at the gala was around 400 people.

Both the winners of the ClairCity school competition as well as the participants of the elderly film competition were announced and awarded at this event.

The event was successful for ClairCity Sosnowiec because citizens had occasion to learn about the ClairCity project, see how it engages various social groups (i.e. youth and elderly), and experience how engaging in the fight for clean air can be fun.

GreenAnts App

GreenAnt provides insight into people's daily travel habits and their reaction to changes. It visualizes how people's everyday travel impact air quality and what people can do to reduce negative impact.

The GreenAnt system consists of:
1. a website for creating a user profile and accessing data
2. a smartphone application for Android and iOS devices for data collection.

To use the system, it is necessary to register zones on the web tool named ANTS, where you want to collect data about how people travel. Users can assign themselves to the zone by downloading the GreenAnt smartphone app. When the user is within the zone, route and transportation data will be collected and later stored on the server.

The testing of the GreenAnts system in Sosnowiec took place in November 2019. A limited number people were invited to the test because of privacy issues. ClairCity data protection policy had to be further adapted to comply with the City Hall data protection requirements.

The feedback received from testers in Sosnowiec show that the app is not ready to be launched to a larger population yet. If Sosnowiec (or another city) wants to make use of the app, the accuracy of results, usefulness and user-friendliness will have to be further developed, and local air quality Information (concentration fields) will have to be integrated. This falls out of the scope of ClairCity and would require additional funds.

Annex C. Sosnowiec citizen engagement impacts: scenarios and modelling

C.1 Modelling impacts of the citizen scenarios

To understand the impact of the policies the citizens put forward, we assessed the impact of policies on emissions, air quality, health and costs in three steps:

1. Step 1: Reproduce the air quality situation as it is currently, in a modelling environment ("baseline"):
    a. First, estimate total emissions from different sources, in line with statistics (by sector, by time of day, link with behaviour)
    b. Secondly, model the air quality and validate the modelling output with with observations
    c. Finally: assess exposure and health impact with common indicators
2. Step 2: Estimate future emissions in a scenario with existing policy measures and model the resulting air quality. This business-as-usual ("BAU") scenario aims to capture the changes in air quality if no further measures are taken, only accounting for changes in the emissions due to policy measures made in the past and expected technological and/or behavioural changes.

3. Step 3: Estimate future emissions in a scenario with **additional** policy measures as aimed for by Sosnowiec citizens. We follow the same suite, from estimating the impact of the measures on emissions, to air quality and health impact.

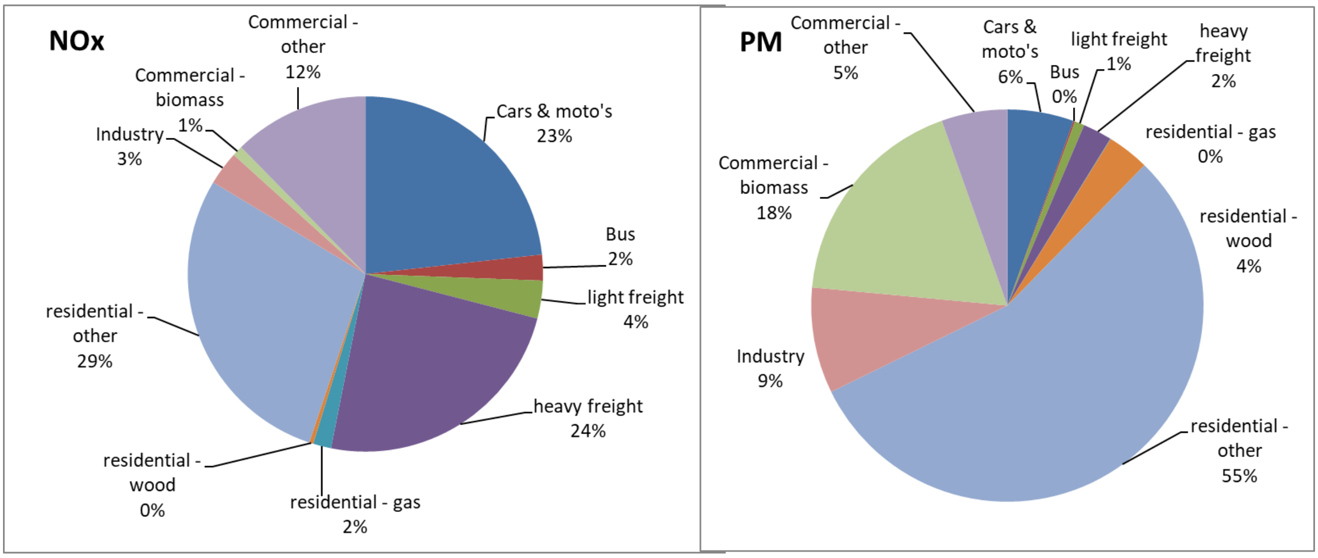
The results of the modelling exercise consist of three parts:

1. Results for the situation as it is (baseline)
2. Expected future without future action (BAU)
3. Future with additional policy action (UPS)

C.1.1 Air quality for the baseline

Figure C-1 shows the emissions by source in the baseline situation (year 2015), for two key pollutants namely NOx and $PM_{2.5}$.

Figure C-1 relative importance of different sectors for NOx and PM emissions



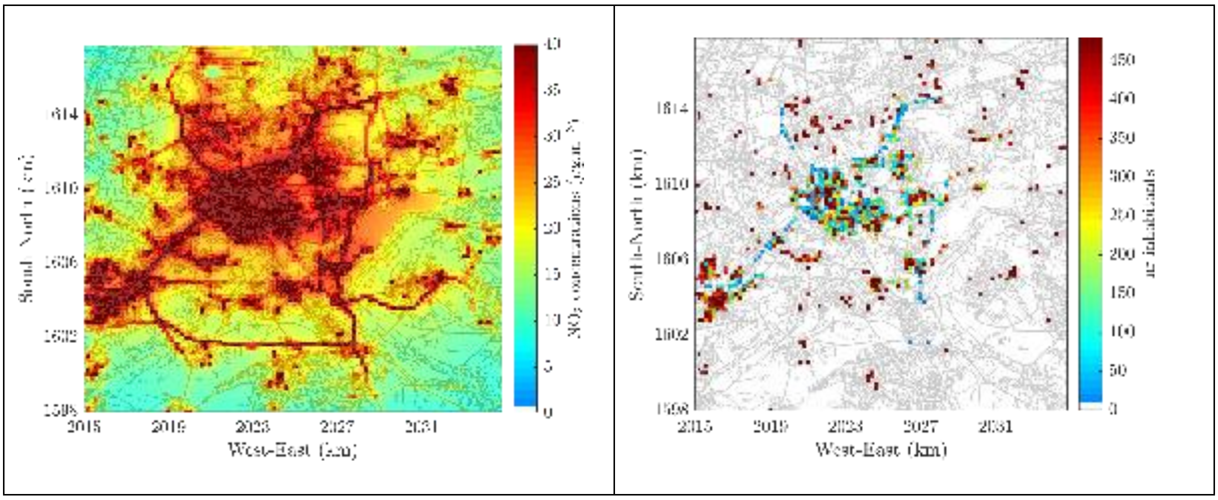
The figure shows that for NOx, the transport sector is the most important source of emissions, accounting for about 53% of total emissions. This is due to NOx-emissions from mostly diesel cars, busses and freight vehicles. Other sources of NOx-emissions are mostly residential heating. For PM, the share of transport emissions is small (9%) while the dominant source of emissions is residential heating, accounting for over half the of total emissions (55%).

The dominance of the residential sector for PM emissions in Sosnowiec is striking (industry and transport are often dominant sources instead). This is particularly related to the use of solid fuel (e.g. coal, wood) of poor quality for heating purposes.

The second-generation Gaussian model URBAIR was setup and run at an urban scale for the computational domain over the urban area of Sosnowiec. The baseline simulations were performed for the full-year using the meteorological vertical profiles from the WRF-CAMx system and the emissions available on the ClairCity emissions database. Background concentrations were added to the URBAIR model results. For that purpose, it was established a single value to apply to each grid cell. This value is the average concentration from the transboundary transport obtained from the WRF-CAMx results using the source apportionment tool. In addition, the simulation results together with the added background concentrations were calibrated against the measurements[34] through the adjustment procedure. For NO_2 concentrations, a slope of 2.2 obtained from the linear regression is applied as a correction factor over all the domain. In case of particulate matter, PM_{10} and $PM_{2.5}$ concentrations the slope obtained from the linear regression is equal to 1.1 for PM_{10} and 0.9 for $PM_{2.5}$ concentrations.

Figure C-2 a) shows the resulting NO_2 annual average concentrations. Figure C-2 b) points out the population potentially exposed to NO_2 concentrations above the EU legal limit value of 40 µg.m^{-3}.

Figure C-2 NO_2 contour maps: a) annual average of NO_2 concentrations and b) number of inhabitants within the cells exceeding the EU annual limit value of 40 µg.m^{-3} in 2015

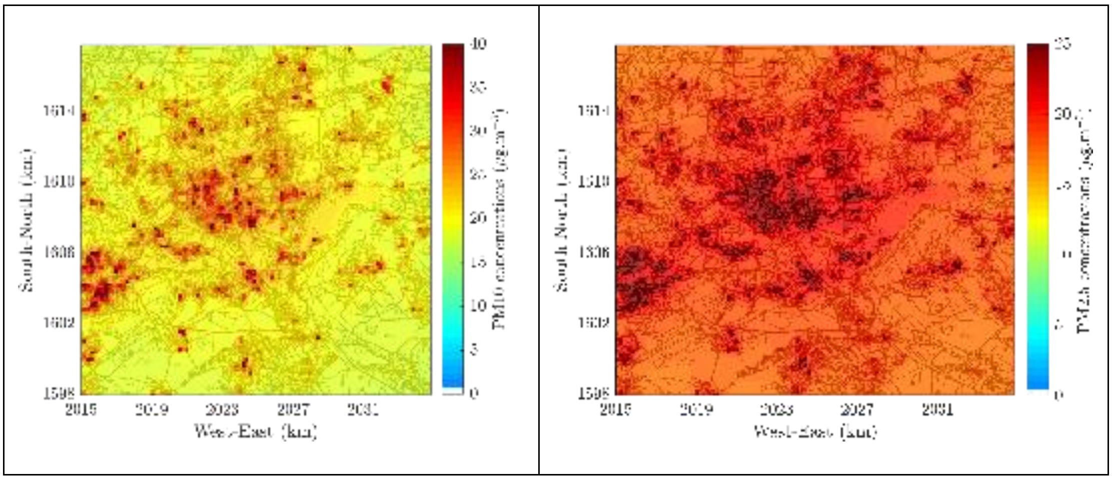


The simulation results indicate a maximum concentration of 207.7 µg.m^{-3} over the urban area of Sosnowiec, with several hot-spots linked with distinct residential and industrial areas, as well as over the main road links of the urban area. The EU annual legal limit value for NO_2 annual concentrations is widely exceeded in 1043 cells corresponding to more than a half (59%) of the total population within the urban area potentially exposed to those concentrations.

Figure C-3 presents the PM_{10} annual average concentrations (Figure B-2 a)) and the $PM_{2.5}$ annual average concentrations (Figure B-2 b)).

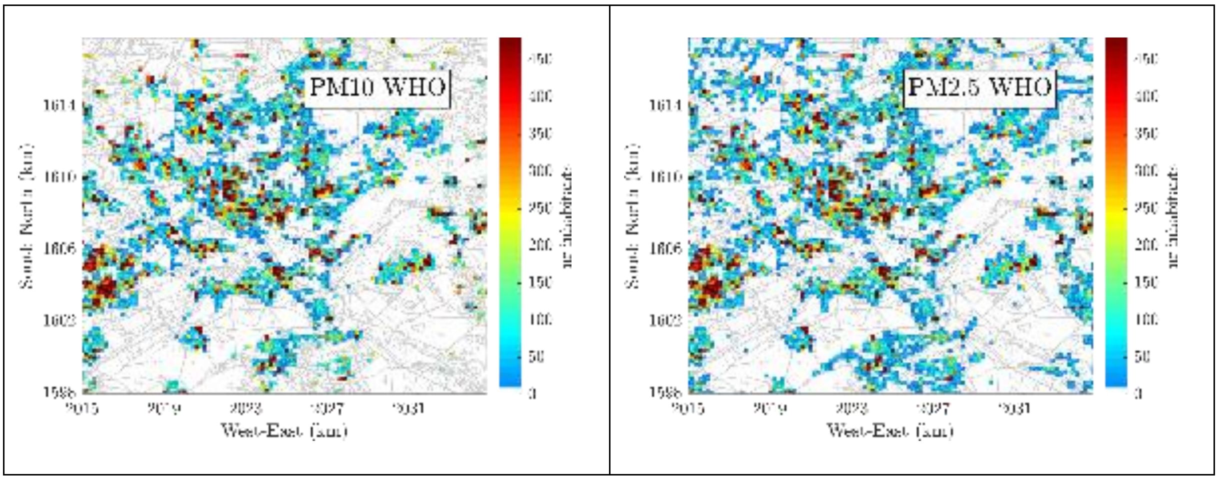
[34] The NO_2 observations available for 2015 include measurements from 3 continuous measurements from the Polish monitoring network: 1 road traffic site, and 2 urban background sites. Similarly, the PM10 observations available include measurements from the same 3 continuous sites. PM2.5 observations are only available for the road traffic site.

Figure C-3 (a) PM$_{10}$ annual average concentrations and (b) PM$_{2.5}$ annual average concentrations in 2015



The maximum value of PM$_{10}$ concentrations is equal to 75.3 µg.m^{-3}, which is simulated over the urban area of Sosnowiec with several hot-spots related with the residential and commercial emission sector, with a contribution of 91.8% to the average concentrations simulated over the whole urban area. The simulated maximum concentration of PM$_{2.5}$ is equal to 62.1 µg.m^{-3}. The results indicate several exceedances of PM$_{10}$ and PM$_{2.5}$ concentrations, either to the EU legal limit, equal to 40 µg.m^{-3} and 25 µg.m^{-3}, and to the WHO guidelines. The EU annual legal limit value for PM$_{10}$ concentrations is exceeded in 46 cells, which represents 12.7% of the population within the urban area potentially exposed to those concentrations. The EU annual legal limit value for PM$_{2.5}$ concentrations is exceeded in 372 cells, corresponding to 45.7% of the population potentially exposed to those concentrations. In the urban area of Sosnowiec 95% and 100% of the total population are potentially exposed to PM$_{10}$ and PM$_{2.5}$ concentrations, respectively, exceeding the WHO recommendations.

Figure C-4 Number of inhabitants within the cells exceeding the WHO air quality guideline values: a) of 20 µg.m-3 for PM$_{10}$ concentrations, and b) of 10 µg.m-3 for PM$_{2.5}$ concentrations in 2015



Assessment of health impacts for the baseline

The health benefits related to reduced air pollution have been illustrated by calculating two health impact indicators for different air pollutants (NO_2, PM_{10}, and $PM_{2.5}$): the number of premature deaths and years of life lost (YLL). Premature mortality is a standard measure of population's health, as it is expected that most deaths are preventable before a person reaches an expected age. YLL is defined as the years of potential life years lost due to premature deaths. Since YLL takes into account the age at which deaths occur, relative to life expectancy, higher weight is given to deaths at a younger age than at an older age. Although mortality indicators are not the only indicators available for the burden of disease related to air quality, they are the ones with highest external costs to society. Hence the choice for these.

The burden of disease associated with ambient air pollution is estimated by relating air concentrations to health outcomes. Gridded annual averages have been used as input to quantify the relative risk in a population, based on concentration-response functions (CRFs). CRFs reflect the effect of a pollutant on a health outcome, e.g. NO_2 on mortality from cardiopulmonary diseases, typically expressed as the increase in incidence or prevalence per unit increase in concentration. Table C-1 describes the risk ratios, the mortality causes, age interval, and concentration threshold consider when calculating the health outcomes for each air pollutant. The threshold concentration is the concentration level below which no health effects are expected.

Table C-1: Risk ratios (RR) for mortality

Pollutant	Value [per 10 µg/m3]	Type	Reference
$PM_{2.5}$	RR 1.062 (95 % CI 1.040-1.083) No threshold	All-cause (natural) mortality in ages above 30 (ICD-10 codes A00-R99).	WHO 2013a
PM_{10}	RR 1.04 (95% CI, 1-1.09) No threshold		Beelen et al., 2014
NO_2	RR 1.055 (95 % CI 1.031-1.08%) Threshold: 10 µg/m^3		WHO 2013a

Premature deaths can be estimated at the grid-cell level by multiplying the population attributable fraction (PAF), the crude death rate (CDR), and the total population for every cell. PAF is defined as the reduction in population mortality if exposure to a risk factor was reduced to an ideal exposure scenario (e.g. concentrations equal to zero). PAF can be calculated from the relative risk, assuming an exponential behaviour. CDRs were calculated based on natural all-cause mortality in 2015 (WHO, 20019, ICD codes A00-R99) and country level population, broken down by age and sex. Here it is assumed that CDR is constant across the country's population. YLL is calculated at the grid cell level by multiplying premature deaths with life expectancy by age and sex. Life expectancy data is based on data published by the UN. The expected burden of disease attributable to air pollution in a specific area can finally be estimated by summing over all grid cells in the area of interest for the indicator of interest.

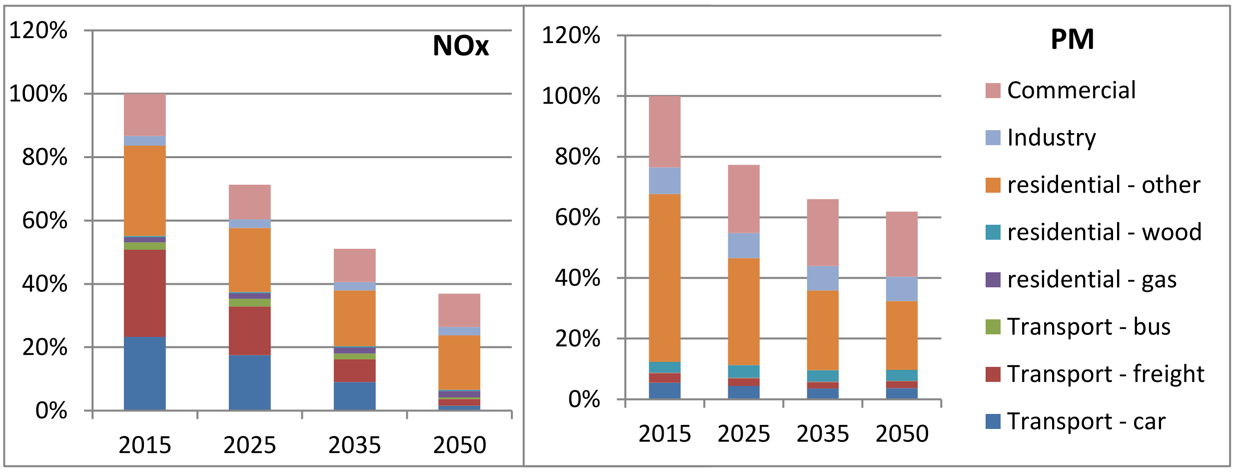
The results for the baseline scenario indicate there has been 1194, 664 and 879 premature deaths attributed to NO_2, PM_{10} and $PM_{2.5}$ pollution levels in Sosnowiec in 2015, respectively. For the same pollutants, 17 039, 9479, and 12 552 years of potential life lost were estimated for Sosnowiec in 2015.

C.1.2 BAU

In the BAU scenario we estimate future emissions for 3 future years: 2025, 2035, 2050. This includes technological changes (e.g. uptake of new technology) and behavioural elements (e.g. future demand for transport, by mode). The BAU-scenario includes all active policy measures agreed until 2015 that will take effect in the future. A typical example are emission standards for new vehicles that only gradually take effect as the car fleet is evolving over time.

Observed emission trends in the BAU scenario are presented in Figure C-5. For NOx we expect significant and steady reductions of the emissions in the BAU scenario throughout the years, in the transport sector. For PM, reductions in emissions will come from the residential sector, as the number of citizens burning coal for heating reduces. A small increase in the emissions of residential buildings using wood for heating purposes is observed, presumably due to citizens switching from coal to wood. The PM reductions from the transport sector are negligible.

Figure C-5 trend of PM and NOx emissions in a business as usual scenario



BAU impacts on air quality

The reductions of the NO_x emissions in the BAU scenario will lead to significant reductions of the NO_2 concentrations. Figure C-6 presents as example the NO_2 annual average concentrations considering the impacts of BAU scenarios for 2025 and 2050. The maximum NO_2 concentration will be equal to 168.2 µg.m $^{-3}$ in 2025 and to 143.3 µg.m $^{-3}$ in 2050, corresponding to an overall reduction of the maximum concentration of 15% (from 2025 to 2050). In the BAU scenario, the NO_2 concentrations will still exceed in 2050 the EU limits and WHO guidelines.

Figure C-6 NO_2 annual average concentrations for the BAU scenarios: a) 2025 and b) 2050.

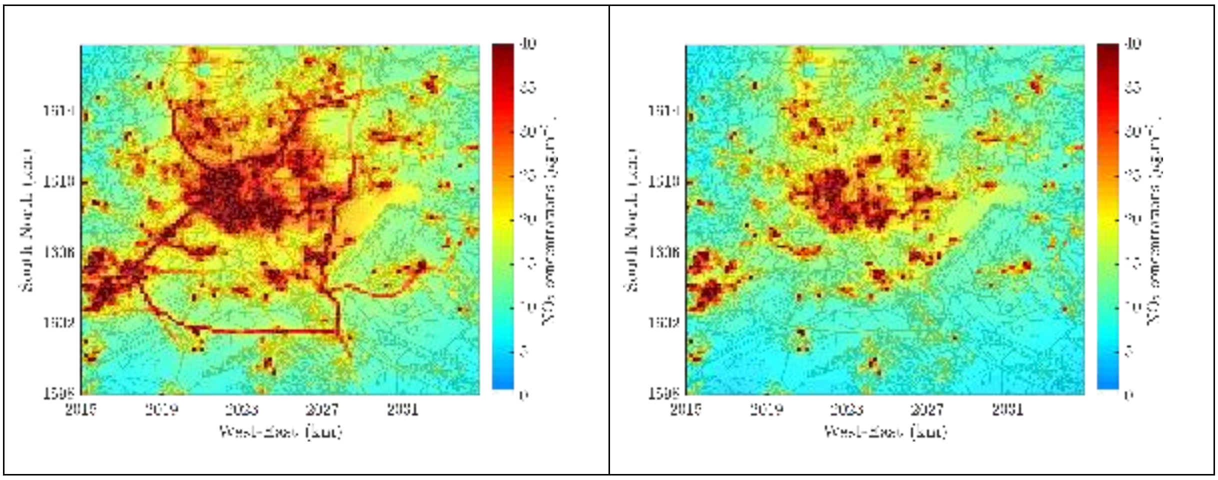
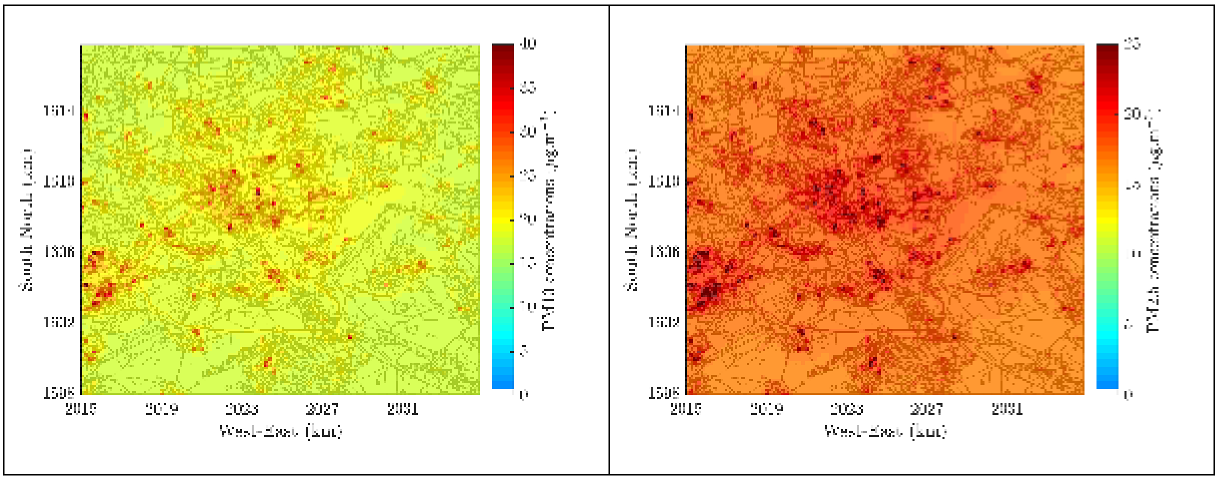


Figure C-7(a) presents the PM_{10} annual average concentrations for 2050 and (b) the $PM_{2.5}$ annual average concentrations for the same year. The simulated maximum values of PM_{10} concentrations range from 59.6 to 45.7 µg.m $^{-3}$ between 2025 and 2050, while the simulated maximum concentration of $PM_{2.5}$ vary from 49.8 to 38.8 µg.m $^{-3}$. Therefore, the BAU scenarios will lead to the reduction of PM_{10} concentrations showing 16 and 4 cells exceeding the EU limit values in 2025 and 2050, corresponding to 5.9% and 2% of the population potentially exposed to those concentrations. The BAU scenarios will lead to the reduction of $PM_{2.5}$ concentrations showing 170 and 47 grid cells exceeding the EU limit values in 2025 and 2050.

Figure C-7 Particulate matter annual average concentrations for the BAU scenario in 2050. a) PM_{10} and b) $PM_{2.5}$ concentrations.



BAU impacts on health

The results the BAU scenario for 2025, 2035 and 2050 are presented in Table C-2 for premature deaths, and Table C-3 for years of life lost.

Table C-2 Number of premature deaths related to $PM_{2.5}$, PM_{10} and NO_2 exposure for the BAU scenario in 2025, 2035, and 2050.

	$PM_{2.5}$	PM_{10}	NO_2

scenario	2025	2035	2050	2025	2035	2050	2025	2035	2050
BAU	796	742	720	591	545	526	945	787	721

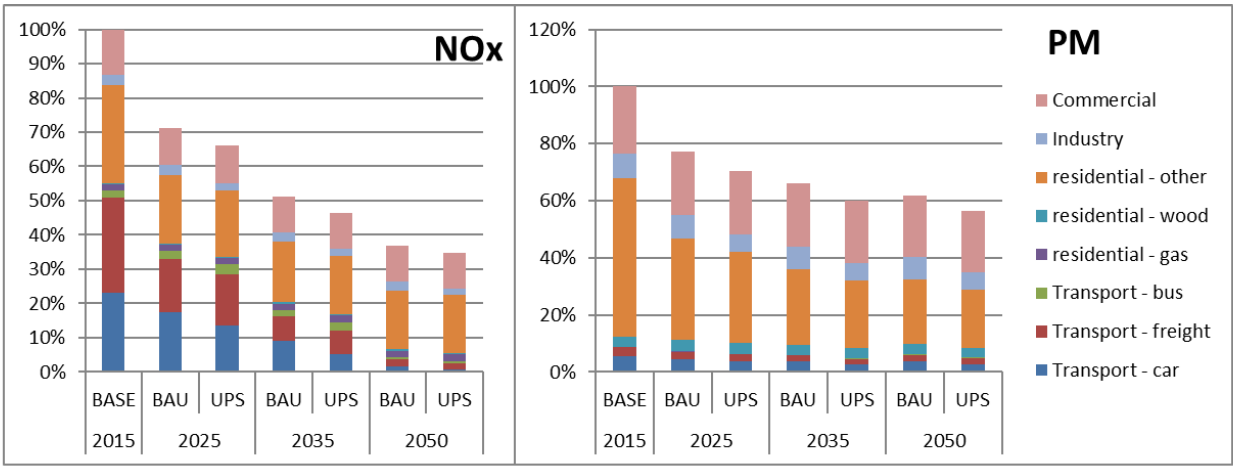
Table C-3 Number of years of life lost related to $PM_{2.5}$, PM_{10} and NO_2 exposure for the BAU emission scenarios in 2025, 2035, and 2050.

	$PM_{2.5}$			PM_{10}			NO_2		
scenario	**2025**	**2035**	**2050**	**2025**	**2035**	**2050**	**2025**	**2035**	**2050**
BAU	11368	10598	10284	8442	7778	7509	13483	11234	10297

C.1.3 UPS

In the UPS scenario, on top of the BAU scenario measures, the citizens' measures are also implemented. The combination of all these measures leads to the emission reductions shown in Figure C-8.

Figure C-6 trend of PM and NOx emissions in the UPS, compared to the business as usual scenario



From Figure C-8 it can be seen that the UPS scenario is succesful at further decreasing the emissions of both NOx and PM of particularly transport compared to the BAU.

UPS impacts on air quality

The UPS scenario for the measures focusing on the transport sector stablishes two levels of emission reduction, one to be applied for *bad air quality conditions*, and another one to be applied for *good air quality conditions*. The ClairCity quantification framework was adapted to consider these criteria. Therefore, the emission reduction targets from the bad air quality scenario were applied to the grid cells where the annual concentrations exceeded the EU limit value for NO_2, PM_{10} and $PM_{2.5}$ concentrations, while the good air quality scenario was applied to the grid cells below the legal limit.

Since the expected decrease in NOx 'emissions' in the UPS in comparison to that in the BAU is small, an even smaller decrease of NO_2 'concentrations' in the UPS is expected, when compared to BAU. Figure C-9 shows for example the NO_2 annual average concentrations considering the impacts of UPS scenarios for 2025 and 2050. In 2025 the maximum NO_2 concentration will be equal to 166.8 µg.m^{-3} and in 2050 equal to 141.7 µg.m^{-3}, showing several exceedances of the legal limit value still in 2050. Comparing UPS and BAU scenario in 2050, the maximum concentrations will be at 76 and 74% compared to 2015.

Figure C-9 NO_2 annual average concentrations for the UPS scenarios: a) 2025 and b) 2050.

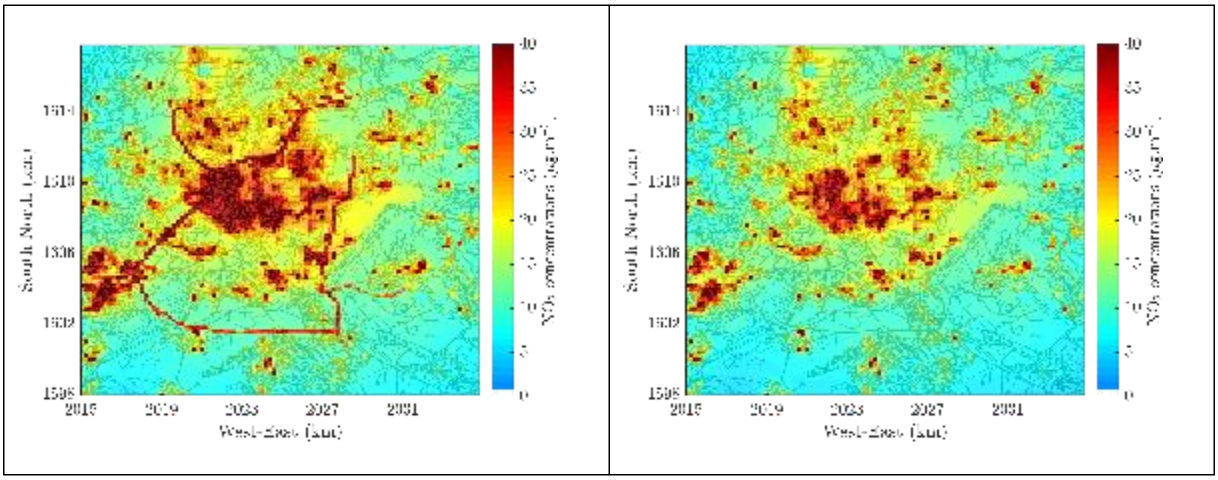


Figure C-10 presents the UPS PM_{10} annual average concentrations (a) in 2025 and (b) in 2050. For PM_{10}, in 2025 the maximum value corresponds to 58.9 µg.m^{-3} and 45.2 µg.m^{-3} in 2050. The EU legal limit value will be exceeded into 14 and 3 grid cells, corresponding to 5.3% annd 1.6% of the population potentially exposed to PM_{10} concentrations. Compared to the BAU scenario, the UPS will reduce the maximum concentrations by a further 1.2% and 1.1% in 2025 and 2050.

Figure C-10 PM_{10} annual average concentrations for the UPS scenario: a) in 2025 and b) in 2050.

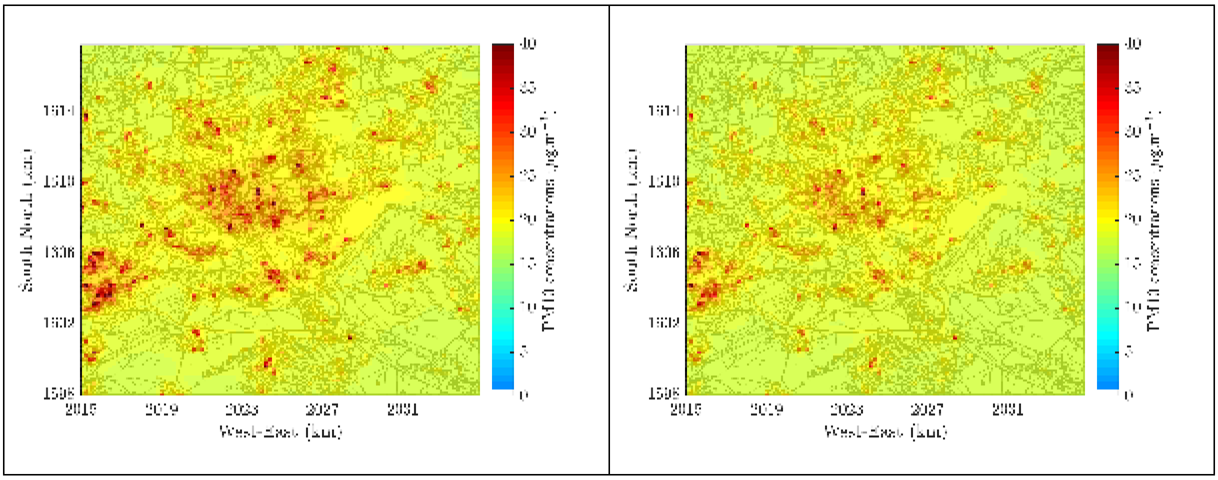
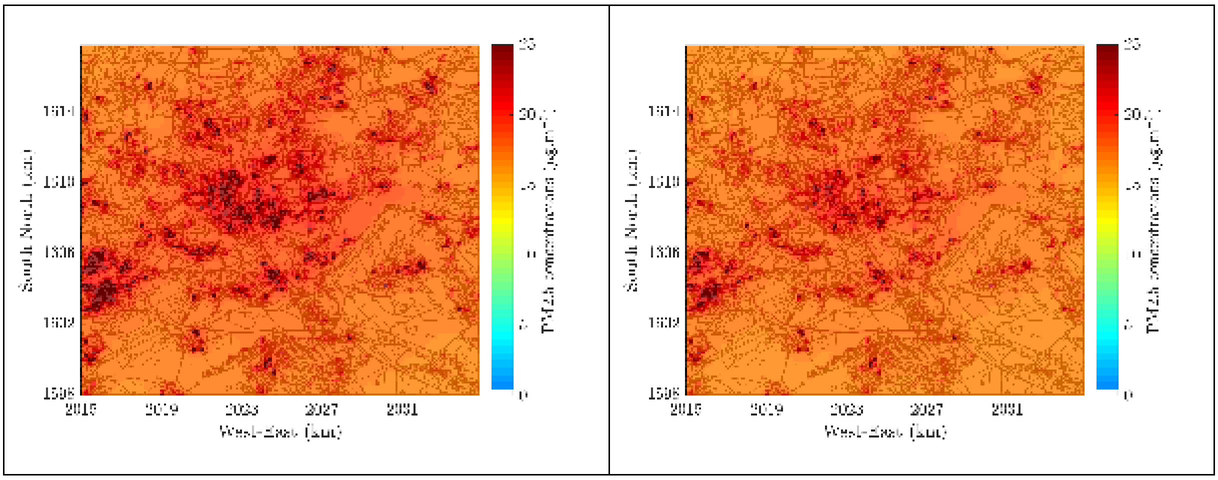


Figure C-11 presents the $PM_{2.5}$ annual average concentrations in the UPS scenario (a) in 2025 and (b) in 2050. For $PM_{2.5}$, in 2025 the maximum value corresponds to 49.2 µg.m^{-3} and 38.4 µg.m^{-3} in 2050, translating into a further 1% reduction of the maximum concentration compared to BAU. The UPS will reduce the maximum concentrations by a further 1.2 and 1% in 2025 and 2050 as compared to BAU. The UPS scenarios will lead to the reduction of $PM_{2.5}$ concentrations showing 155 and 45 grid cells exceeding the EU limit values in 2025 and

2050, corresponding to 27.7% and 12.5% of the population potentially exposed to those concentrations.

Figure C-11 $PM_{2.5}$ annual average concentrations for the UPS scenario: a) in 2025 and b) in 2050.



UPS impacts on health

The results the UPS scenario for 2025, 2035 and 2050 are presented in Table C-4 for premature deaths, and Table C-5 for years of life lost.

Table C-4 Number of premature deaths related to $PM_{2.5}$, PM_{10} and NO_2 exposure for the UPS, low and high emission scenarios in 2025, 2035, and 2050.

	$PM_{2.5}$			PM_{10}			NO_2		
scenario	**2025**	**2035**	**2050**	**2025**	**2035**	**2050**	**2025**	**2035**	**2050**
UPS	791	738	717	586	540	522	903	746	708

Table C-5 Number of years of life lost related to $PM_{2.5}$, PM_{10} and NO_2 exposure for the UPS, low and high emission scenarios in 2025, 2035, and 2050.

	$PM_{2.5}$			PM_{10}			NO_2		
scenario	**2025**	**2035**	**2050**	**2025**	**2035**	**2050**	**2025**	**2035**	**2050**
UPS	11292	10533	10230	8366	7713	7455	12884	10652	10110

UPS impacts on costs

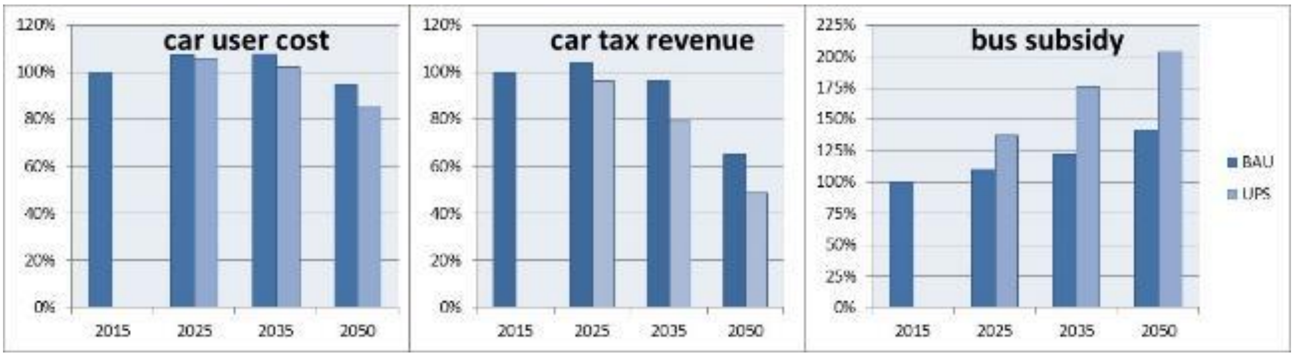
For the assessment of costs, we used 3 indicators:

1. The car user cost: to what extend does the cost to drive a car changes relatively over time in the BAU as well as under influence of the scenario’s
2. The government tax revenue from car transport, combing fuel excises, registration taxes as well as any levy’s (e.g. cordon charge)
3. The government expenditure on public transport, i.e. bus subsidies

The indicators on tax revenue or subsidy expenditure do not distinguish between different types of government (local, regional, national).

With these indicators, we assessed qualitatively the likely costs of measures for citizens, government and society at large. Costs for society were assumed to be the net sum of citizen and government costs. The cost estimations must be order-of-magnitude estimations only, as the real costs until 2050 will depend on many variables that were not included in the ClairCity modelling. Figure C-12 gives an overview of these order of magnitude costs of the UPS scenario compared to the BAU scenario.

Figure C-12 trends of user cost (left), government tax revenue (mid) and bus subsidy (right) in all scenario's



Car user cost
The car private user cost is expected to increase slightly and then decrease in the BAU. Due to the strong second-hand car market in Poland, Sosnowiec will not benefit immediately from the lower car user cost associated with more fuel-efficient cars (fuel savings offset the higher purchase cost) as well as the uptake of electric vehicles (EVs) that are becoming ever cheaper in the future. These cars have a higher upfront cost, but lower running cost to ultimately have a net lower cost over the lifetime. However, the higher upfront cost is holding uptake back, to the benefit of older second-hand cars which have a lower upfront cost, but a higher lifetime cost. This effect causes a delay in the uptake of new vehicles in Poland, therefore the savings of EV's only manifests from 2035 onwards.

The car private user cost in the UPS somewhat drops to the BAU in 2035 and 2050. This is in full linked to the stronger EV-uptake scenario in the UPS compared to the BAU, because the (general) incentives for EV's, which will push consumers earlier towards EV's.

Car tax revenues
After a minor increase, following suit with higher demand, the tax revenue decreases in the BAU. This decrease follows the lower tax revenue from electric vehicles and reduced income from excise duties on fuel as the fleet gradually electrifies and becomes more fuel efficient. Under current assumptions, the taxation of EV's is limited and as EV's enter the fleet, government revenue from taxing cars on average will shrink. Clearly, this is not sustainable, and it is expected to change as the decreasing tax revenue of excise duties on diesel and petrol will become apparent to public authorities. However, in our simulation, we've kept the taxation levels constant. The loss of tax revenue typically is a concern for central governments and not so much for local governments as the bulk of the revenue is collected at national level (fuel excise, registration/circulation taxes,).

The tax revenues from increased parking revenues add to the overall government revenue but is insufficient to offset the lack of taxation of EV’s.

Bus subsidies

Bus subsidy follow increasing demand in the BAU and are higher in the UPS both due to a reduction of ticket prices, because of the measures to make PT cheaper, as well as induced demand due to lower ticket prices. Assuming no other changes to the level of cost coverage, this leads to a doubling of the bus subsidies in the UPS by 2050.

ClairCity: Citizen-led air pollution reduction in cities

D7.5 Final City Policy Package – Aveiro Region

March 2020

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Document Details

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Version History

Version	Updated By	Date	Changes / Comments
V1	Irati Artola	September – October 2019	First draft
V2.0	Irati Artola	November 2019	Modelling inputs from Vera Rodrigues (UAVR) added to V1
V2.1	Irati Artola, Stephan Slingerland	December 2019	Included inputs from partners on Modelling (TML, Techne, NILU) and behaviour data (UWE). Further drafting.
V2.2	Irati Artola, Stephan Slingerland	January – February 2020	Finalising report based on inputs from UAVR and CIRA.
V3	Irati Artola, Stephan Slingerland	March 2020	Finalising report based on inputs from UAVR, CIRA

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Project internal comments	Vera Rodrigues, Myriam Lopes, Sandra Rafael (UAVR) Olga Cravo (CIRA)

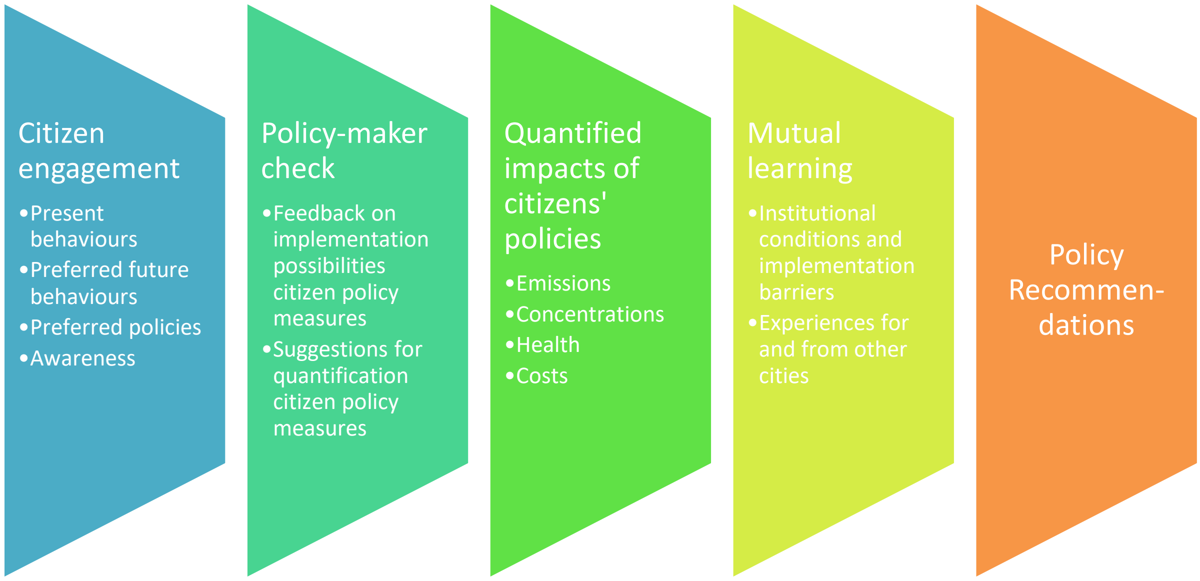
Contents

Executive Summary

ClairCity project and method

The ClairCity Horizon2020 project aims to contribute to citizen-inclusive air quality and carbon policy making in middle-sized European cities. It does so by investigating citizens' current behaviours as well as their preferred future behaviours and policy measures in six European cities[1] through an extensive citizen and stakeholder engagement process. The project also models the possible future impacts of citizens' policy preferences and examines implementation possibilities for these measures in the light of the existing institutional contexts in each city (Figure 0-1). **This report summarises the main policy results for the Aveiro Region.**

Figure 0-1: The ClairCity method in brief



The methodological understanding as developed in the ClairCity project of what citizen-inclusive policy-making is, and what it should and should not comprise, is given in Textbox 0-1.

Textbox 0-1 Citizen-inclusive policy-making according to ClairCity

- Tailor local policies based on detailed knowledge of behavioural practices of citizens;
- Engage with citizens via a diversity of methods, paying particular attention to hearing the voice of 'hard-to-reach' groups;
- Ask citizens for their preferred future behaviours and barriers to behavioural changes. Address the perceived barriers of citizens by concrete measures or initiate dialogue with citizens about misconceptions concerning air quality and climate change;

[1] Bristol, Amsterdam, Sosnowiec, Ljubljana,Aveiro/CIRA region, Genoa/Liguria region

- Ask citizens for their preferred future policies for the city, examine potential impacts of these policies and discuss with stakeholders and policy makers their implementation possibilities;
- Examine and address potential implementation barriers for preferred citizen policy measures beyond citizen perceptions;
- Experiment, and exchange experiences with other cities that are also aiming to implement citizen-inclusive policies;
- Do not confuse citizen-inclusive policies with populist policies. Take full responsibility for democratically implementing popular or unpopular measures considered appropriate, after having been extensively informed about citizens' views and behaviours.

In total, during the period 2017-2019, over 1 700 stakeholders, primarily citizens, were reached by the various ClairCity citizen engagement methods in the Aveiro Region (Table 0-1). While this sample is not fully representative of the Aveiro Region population as a whole, it gives an indication of support for policy measures and intentions for behavioural change that can be used by policy makers to inform future policies.

Table 0-1: Number of participants in ClairCity citizen engagement methods in the Aveiro Region

Citizen engagement activity	Participants engaged
Delphi Process (Round 1 & Round 2 surveys + Delphi workshop)	1 349
Skylines Game	243
Mutual Learning Workshop	13
Stakeholder Dialogue Workshop	12
Schools activity	Number of teams who have finalised the exercise through the tool: 19 Number of teachers: 10 Number of schools: 6 Number of municipalities: 6
Film competition	5
Policy Workshop	6

Conclusions and recommendations for the Aveiro Region

The main conclusions and recommendations from the ClairCity project for citizen-inclusive policy making in the Aveiro Region are:

Current air quality and carbon situation in the Aveiro Region

Air quality in the Aveiro Region is relatively good and compliant with EU limit values. $PM_{2.5}$ is probably the polutant of largest concern. The ClairCity modeling shows that 49% of the population in the Aveiro Region is exposed to $PM_{2.5}$ concentrations above WHO guidelines. For CO_2, there are no legal requirements on a local level, and unlike in other ClairCity cities, there is no climate neutrality ambition.

Overall currently air quality and climate policies are not high on the political agenda in the Aveiro Region. Improvement of (public) transport, on the other hand, is a priority and expected to evolve. A reduction of fares (50% by 2021) and the replacement of 30% of the public transport fleet with zero-emission vehicles (by 2030) are in the planning, next to bans on the oldest diesel cars and HGVs on urban areas (by 2030).

It seems unlikely that these measures alone will be able to achieve the very ambitious modal shift[2] envisaged both by citizens and policy makers. In particular, measures to make private car use less attractive are lacking.

Figure 0-2: Main features of the current Aveiro Region air quality and carbon situation

NOx	PM_{10}	O_3	CO_2
• Source: Road & rail traffic, followed by industrial combustion. • Aveiro city has the largest NOx emissions result also of maritime traffic	• Source: Domestic heating • There are exceedances	• High concentrations in the summer months	• Source: buildings, industry and transport • CO_2-eq emissions have increased

Current behaviours of the Aveiro Region citizens

Citizens substantially contribute to air pollution and carbon emissions in the city through driving their cars.

After industry, car transport is the main contributor to NOx emissions, and it also contributes to a reasonable share of PM_{10} emissions. A very high percentage of the citizens (surveyed by ClairCity) use currently 'always' a car for commuting to work (65%), going shopping (67%) or for leisure (44%). The number of citizens using 'public transport and active travel'[3] is really small compared to the other ClairCity case studies. Leisure is the activity for which public transport and active travel are most popular in the Aveiro Region citizens currently.

Figure 0-3 Percertage of citizens 'always' using a car for commuting to work, shopping or leisure

[2] 50% modal shift from private cars to active travel and public transport by 2030
[3] Note that this is a combined category in the survey

Preferred future behaviours of Aveiro Region citizens for the future

There is a mismatch between citizens transport and heating behaviour at present and how citizens would like to behave in the future regarding these. This indicates that many citizens would be willing to change their own transport and heating behaviours as a contribution to ambitious air quality and carbon policies if the Aveiro Region facilitates / enables that.

- **There is a huge demand for public transport and active travel in the future provided that current barriers are overcome**
  Despite the overwhelming reliance on cars in the present for commuting to work, shopping and leisure, respectively 75%, 56% and 68% of respondents does not want to be using a car for these activities in the future. This indicates a very large latent demand for alternatives in the Aveiro Region. The main barrier for the use of public transport is the convenience cars offer. Coverage, frequency and travel times of public transport are rather poor at the moment and therefore a disadvantage in comparison to the comfort a car offers. In addition, parking is easy and often free overall in the Aveiro Region. The main barrier for active travel is the fact that cycling infrastructure is not very developed yet.

Figure 0-4: Proportions of present and future car use of commuters in the Aveiro Region

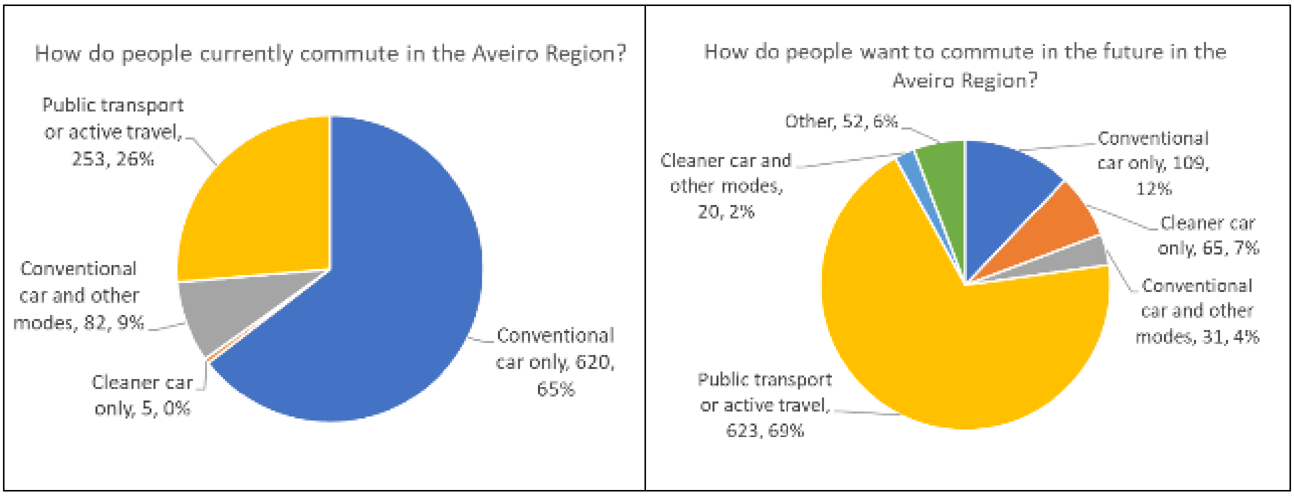


Figure 0-5: Current and future transport choices for shopping in the Aveiro Region

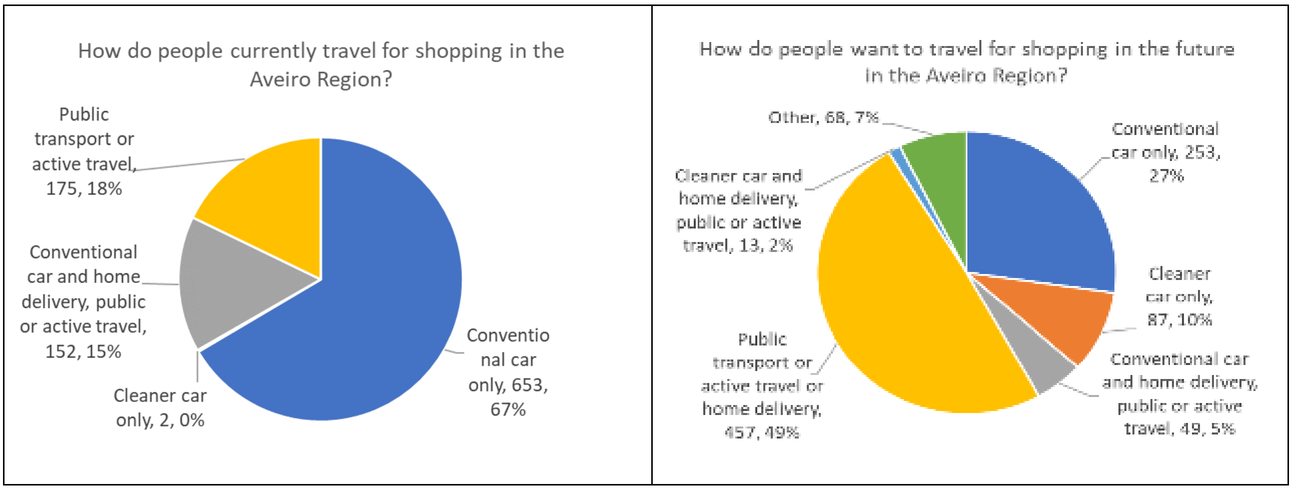
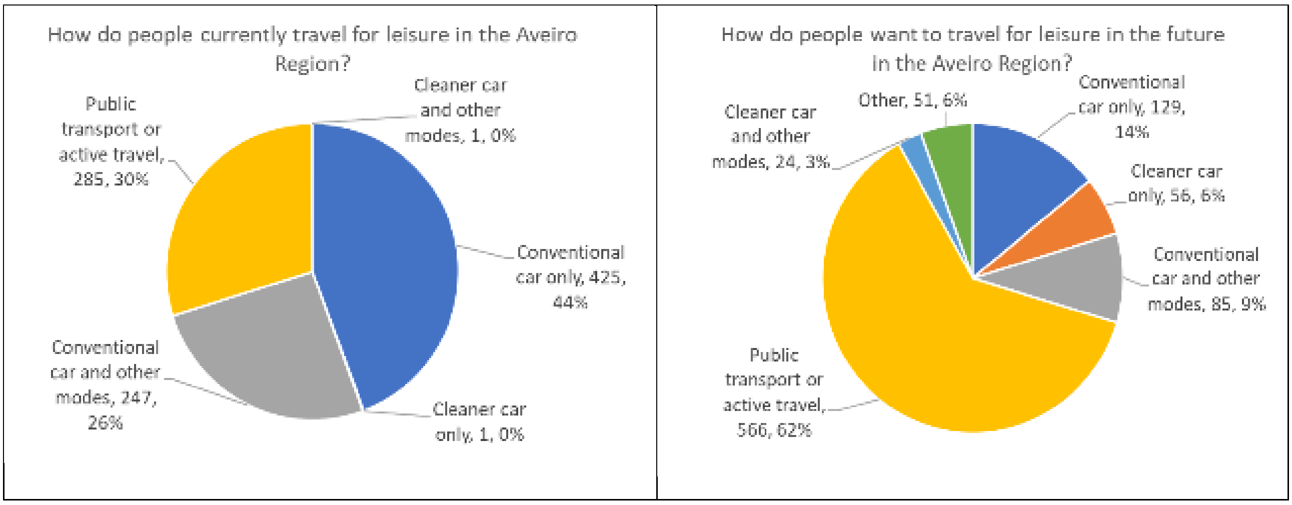
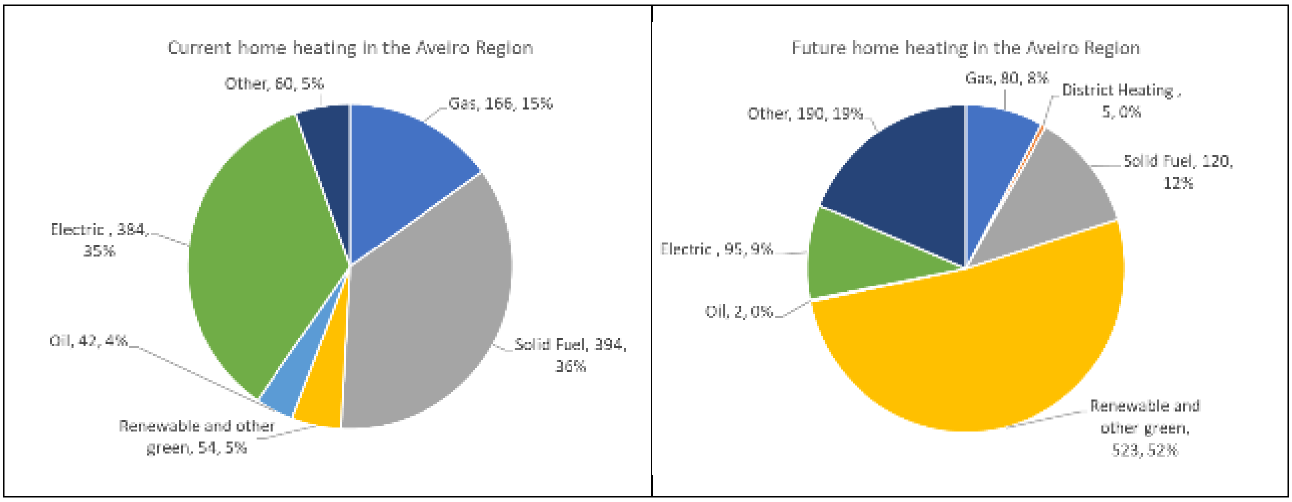


Figure 0-6: Current and future transport choices for leisure in the Aveiro Region



- **There is interest from citizens for renewables for residential heating**
  ClairCity identified a huge demand for renewables to heat homes in the future. This would go mostly at the expense of solid fuels. The main barrier for this from the perspective of the citizens is the cost. It should be noted that there are some citizens who are in favour of wood or pellets for they consider these an environmental or renewable heat source. In the context of this project they are identified as polluting due to the air quality issues they generate.

Figure 0-7 Current and future choices for home heating in the Aveiro Region



Preferred future policies of Aveiro Region citizens and reflections by policy makers

Aveiro Region citizens are urging mobility related policies – mainly to improve public transport. Policies affecting active travel and private car travel are also demanded. This means that besides the local and regional governments, also citizens have a role to play in terms of behaviour changes, as the policies they propose will affect their current habits.

- **Citizens favour transport related measures including measures that affect private cars despite their current behaviour says otherwise**
  Measures addressing public transport are the most popular, followed by active travel measures and measures to discourage conventional cars and other vehicles. It should be mentioned that this is at odds with current behaviour of citizens. Further, both citizens and policymakers agree making parking free *just* for EVs is a suitable measure to greening the car-fleet.
- **'Promoting working from home' and 'Increasing space for pedestrians' are relatively low hanging fruits according to policymakers**
  Promoting working from home' and 'Increasing space for pedestrians' are two measures proposed by citizens that policy makers consider "easy to implement". This is because provided that it is financed by the private sector (i.e. business) and citizens themselves, this would have no costs for the Aveiro Region. However it should be noted that there are a few preconditions for working from home to actually work. Working from home requires a main shift in working culture and a good internet infrastructure in place. I also requires citizens to create a suitable working environment at home. The measure may be trickier to implement in the public sector, where civil servants need to clock in and out of work. The measure would in this case imply costs for the regional government.
- **Although residential heating is a main source of PM emissions, this is not perceived as an air pollution source by Aveiro Region citizens**
  Citizens do not perceive heating / energy as a priority area for action. However home heating is the main source for PM_{10}, and so tackling this is presumably were most of the gains can be achieved for PM_{10} reductions. The fact that citizens have not come up with one single energy / heating measure is an indication either of lack of

knowledge (e.g. on how heating can be a source of polution, on alternatives heating options) or lack of empowerment to ask authorities to do something about it.

Table 0-2 Aveiro Region citizen policy measures

#	Policy area	Detailed policy measure for modelling
1	Build segregated urban cycle lanes and create secure cycle storage/parking	300 km of new urban cycle lanes and 200 number of new cycle parking spaces by 2035
2	Create school and workplace travel plans to increase uptake of active travel and public transport	50% modal shift from private cars to active travel and public transport by 2025
3	Reallocate road space to pedestrians and improve safety	100 km of new/renewed pedestrian routes by 2025
4	Ban diesel cars/HGVs in urban centres	10% ban of diesel cars and 25% HGVs in urban centres by 2025
5	Allow free parking for electric vehicles only	Transform 100% of the current parking spaces to free parking for EVs by 2035
6	Promote working from home	10% commuters work from home 1 day a week by 2030
7	Impose stricter regulation on polluting industries	Reduce industrial emissions by 15% by 2030
8	Encourage replacement of older public transport fleets	Replace 15% public transport fleets with zero-emission vehicles by 2030
9	Subsidise public transport tickets	Public transport fares reduced by 50% by 2021
10	Increase provision and reliability of public transport services	100% public transport journeys on schedule with all urban areas catered for by 2025

Policymakers agree with most of the citizens measures concerning the facilitation of active travel and improving public transport. Reflections of policy makers concerning these measures are presented the following table:

Table 0-3 Main reflections of policy makers regarding citizen measures

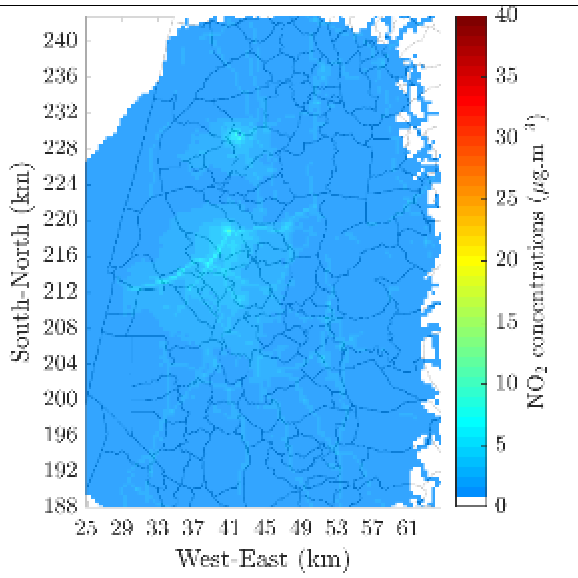
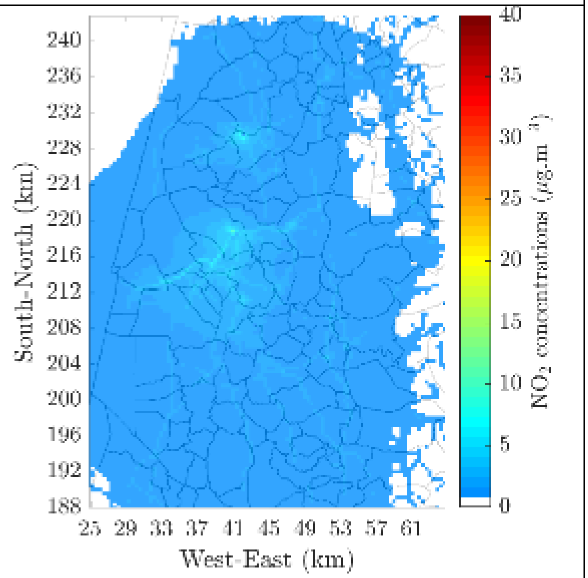
Policy area	Main reflections of policy makers
Public transport	- There is a cultural problem; public transport is unpopular and the use rate is low; - Unreliable schedules due to a variety of reasons (traffic, breakdowns, lack of drivers…) - The problem is associated with population density and dispersion in the territories which makes a wide network and service expensive. - There is lack of awareness among the youth on the benefits of public transport for the environment; - Present monopoly of 1 company with no competitive alternatives.
Active transport	- Financial effort of cycle lanes in urban areas is greater (greater constraints in the public space) when compared to cycle lanes in leisure areas; - At the moment, external factors such as the real estate situation seem favorable to stimulate investments; - There is a school transport service available financed by the Municipalities (for decades and with high cost) but currently it is not widely used; - Reallocating space to pedestrians seems easy to implement from the perspective of urban regeneration.
Private car	- Banning diesel cars/HGVs in urban centres brings challenges in terms of application and enforcement; - Parking is mostly for free. Paid parking is mostly managed by the private sector; - Free parking for EVs would be hard to enforce.
Other	- Promoting working from home has no big economic costs but mainly costs of adaptation.

Modelled impacts of the the combined citizen and policy maker measures

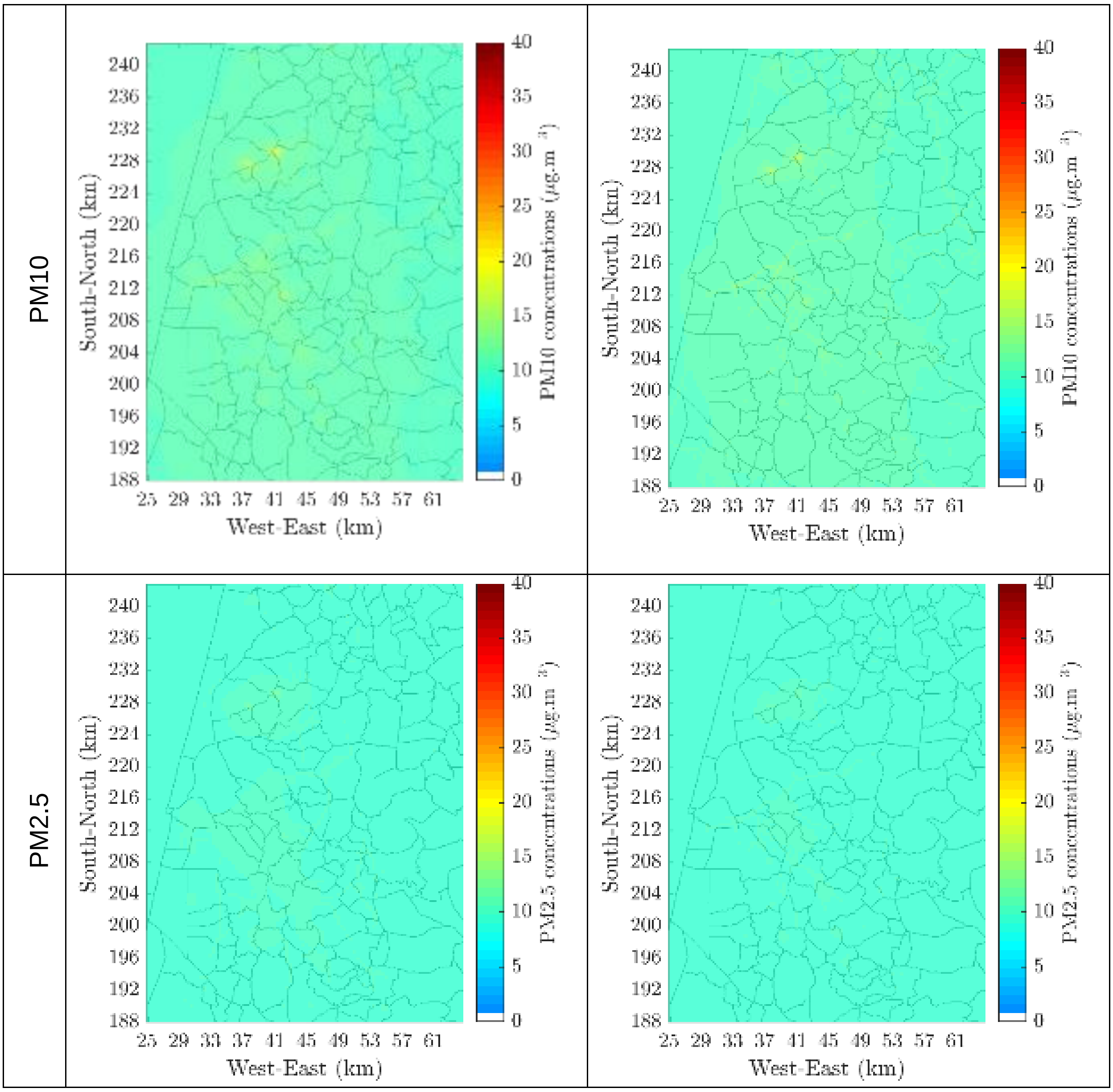
If implemented, the measures proposed by citizens (i.e. the Unified Policy Scenario - UPS) would result in notable health improvements for citizens compared to the situation in the baseline year 2015.

- According to the ClairCity modelling, citizens measures (i.e. the UPS) **would lead to a reduction of 100% premature deaths as consequence of NO_2, 7% reduction in premature deaths as consequence of PM_{10}, and 3% reduction for $PM_{2.5}$.** Citizen measures (i.e. the UPS) will also lead to significant carbon emission reductions.
- However it should be noted that the **additional health benefits of the UPS in comparison to the BAU are rather small** (as seen in Figure 0-6). In other words, citizen measures do not lead to significantly better results for air quality than the measures already implemented by the region will (by 2025, 2035 and 2050).
- In comparison to the baseline in year 2015, **both the UPS and BAU scenarios improve human health substantially when considering exposure to NO_2 concentrations despite concentrations do not decrease radically**. This is because NO_2 measures will be implemented in high(er) populated areas.

Figure 0-8 NO_2, PM_{10} and $PM_{2.5}$ concentrations in the Aveiro Region in the BAU and UPS scenario in 2050[4]

<table>
<tr><th></th><th>BAU</th><th>UPS</th></tr>
<tr><td>NO2</td><td>
</td><td>
</td></tr>
</table>

[4] ClairCity modelling results cannot be directly compared to the national models due to different modelling approaches.



Institutional characteristics and mutual learning for implementing citizen-inclusive policies in the Aveiro Region

Financial limitations and the limited public transport system are possibly the most determinant current institutional conditions in the Aveiro Region.

- Municipalities have limited financial means for the implementation of transport and heating measures to improve air quality. Currently an exception are investments for cycling lanes, as the current real state situation is favorable to this expansion of cycling lanes.
- The responsibility for public transport has only been transferred from the national to the local level in 2015. This is a very short time and therefore its evolution is still to be seen. This recent history makes also that local tendering processes for transport service providers are still new for municipalities.

- Although it is outside of the scope of this report to assess the quality of the air quality monitoring network, it should be noted that there are currently only three monitoring stations. This is quite limited in comparison to other ClairCity case studies which have a much wider network of air quality measuring stations.

There are several aspects concerning transport and energy that Aveiro can learn from the other ClairCity cities. Aveiro in turn may be inspiring for other cities / regions in terms of close cooperation between municipalities as well as initiatives to reintroduce cycling as a means of transport particularly among school-age children.

- Lessons that the Aveiro Region could learn from other ClairCity cities include the large-scale pedestrianisation of the city centre including solutions for the people in need of motorised transport (Ljubljana), integrating air pollution into the transport information system (Sosnowiec), integrating local and regional transport (Bristol) and the integration of large-scale cycling infrastructure in the city and its combination with public transport; the gradual reduction of road space and increase in parking tariffs for private cars (Amsterdam); creating large district heating networks (Sosnowiec, Ljubljana, Amsterdam).
- ClairCity (and other) cities could learn from Aveiro how to engage children in cycling. The Ciclaveiro (NGO) project ‘Cyclebus’ encourages children and parents cycle together to school in a group. ‘Bike buddy’ is another Ciclaveiro project in which people who didn’t feel safe to bike alone bike together with cycling ‘buddies’. Another remarkable initiative is the bike repair workshop initiated by a teacher at a school in Ilhavo. Kids can repair old bikes and assemble new ones (with old spare parts) in their free time. Also, the 11 municipalities in the Aveiro Region closely work together for decades. A so-called Agency for Sustainability and Competitiveness composed of citizens from the different municipalities aims to help municipalities in the Region of Aveiro to work towards sustainable development goals.

The ClairCity Aveiro Region Action Plan

For citizen-inclusive city air quality and carbon policies.

- **Facilitate cycling through developing an urban bike network and further promote walking**
  Cycling should be facilitated by infrastructural measures such as urban cycle lanes that reach where citizens want to get on a daily basis, as opposed to the leisure bike routes that currently dominate the Aveiro Region. Fostering intermodality that is, the integration of cycling with public transport, for instance, by offering bike rental options at popular train and bus stations, is also key. In order to make cycling safer, cycling traffic lights and bike parking facilities should be implemented. In addition, municipal bike systems should be widely promoted. The attractiveness of walking can be promoted by awareness campaigns that stress its health benefits. Expanding pedestrian zones and equipping them with electrical mini-taxis for residents in need (elderly, mother with a small kid etc) can be considered.

- **Public transport development and constant improvement needs to go along with other measures to discourage car use and collect revenues for financing public transport**
  To make public transport more feasible and therefore appealing, continued and further improvement of public transport is needed. This can be done by linking municipalities

and by offering more frequent and wider (more lines) services. What is key is that improvements in public transport go hand in hand with discouraging car use. Examples of this are expanding car-free, pedestrian zones; limiting parking spaces in the city centre of the Aveiro Region municipalities; and most importantly, making parking more expensive (higher fees where parking is already paid and starting to charge where parking is still free). Extra fees are excellent government revenue to fund further measures. A policy that could work to stimulate EVs would be paid to make parking free only for these type of vehicles (and high fees for the rest).

- **Promote alternatives to private car use and make public transport more attractive**
  A city transport plan and communications campaign that shows that a private car is not the only feasible way to get to work, shops or leisure is needed in the Aveiro Region. Next to financially punishing car use, promoting public transport is necessary to change well-rooted habits and address the status symbol that cars currently have in the Aveiro Region. Campaigns should be directed to promoting the alternatives to private car use, communicating widely about public transport services available, and about any improvements made in that regard. Promoting cycling not only for leisure, but also as an efficient and healthy way for commuting should be part of the campaign. The communications messages could also make reference to the cycling culture that the Aveiro Region had in the past. Such a campaign should also serve to tackle issues such as the fact that the school transport network in the Aveiro Region (financed by the Municipalities with high cost) is not widely used in practice.

- **Intensify cooperation with employers, schools, destinations of leisure and shopping to minimise car travel.**
  The promotion of active travel and public transport requires intensified cooperation with big employers as well as destinations of leisure and shopping (e.g. retailers, shopping malls, sports clubs, theaters or cinemas). Options for bus stops and bike parking next to these destinations, together with biking infrastructure to get there should be considered. Engagement of schools is also essential. These could take the societal role of encouraging children and parents to avoid travelling by car. School and workplace travel plans are mostly behaviour-related measures which entail no cost for the Aveiro Region government when these are promoted through awareness raising campaigns (the cost of campaigns is considered negligible) and when ultimately employers and schools are responsible for executing such. In addition, working from home is a measure citizens would be keen to see implemented. This has no cost neither for citizens nor for the regional / local governement when private business are financing the shift. Further, city planning should consider encouraging more jobs, leisure and shopping options close by to where people live.

- **Air quality should be integrated in the current educational offer and further promoted by NGOs**
  Air quality related education could be integrated as part of the sustainability education, already introduced in the local schools curricula. However, educational options are limited and largely voluntary. Giving sustainability education - and in turn air quality education - a more prominent place in the curriculum, is essential to raise awareness of the youngest generations and their parents. Air quality education should address directly the activities / sources of polution that citizens can relate to, which are also the most important local emission sources i.e. private cars and domestic heating. Addressing why it is important to go to school by public transport or active travel, should be part of sustainability education. These classes should also address the issues around biomass and raise awareness around the fact that home heating is currently the main source for PM_{10}. In addition, maintaining good relationships with environmental NGOs, as intermediates between authorities and citizens, is important, and so is liasing with them for educating children and society is considered useful.

- **Promoting energy efficient renovation of buildings, support local PV implementation and raised awareness on the negative health effects of biomass burning**
  Providing the existing building stock with thermal insulation would help bring down energy demand and reduce domestic heating bills at the same time. Setting standards for domestic heating fuels and devices would bring down local emissions as well and provide direct feedback on behaviour. However, this would probably have to be initiated at the national level. The ClairCity engagement process showed that many citizens want to change to renewables for home heating in the future. Dedicated spatial planning, promoting the expansion of national support for rooftop solar PV, increasing rooftop solar on public buildings and supporting local citizen cooperatives for renewables generation could be measures to achieve this. In addition, the dilemma of biomass burning (positive for climate, bad for air quality and thus health) should be seriously considered and communicated to citizens. Citizens are often not aware of the negative effects of biomass burning particularly in urban areas where people live close to each other.

- **Make citizen support for current and planned policies more explicit and accelerate policy implementation**
  The ClairCity analysis revealed that many citizens support not only the air quality and carbon policies that will bring direct benefits for them (e.g. improved public transport), but also support already happening / planned policies that will affect their lives (e.g. free parking only for EVs, reallocation of road space to pedestrians and improve safety). For public transport policies, citizens demand more ambition and speed in their implementation. Against this backdrop, communication of the citizen support for existing policies should be used to generate a wider acceptability of policies. Implementation can be facilitated by a detailed year-by-year implementation plan of long-term policy ambitions, as this could help identify where implementation can be accelerated.

- **‘Improving transport options’ rather than ‘improving air quality’ or ‘improving health’ is the best hook for framing air quality and carbon policies**
  Considering that neither awareness nor interest on air quality are high, and that air pollution is not accute in the Aveiro Region, other hooks (messages that resonate with citizens) need to be sought. Mobility, is in this case a suitable hook. Improvement of transport in the Aveiro Region municipalities and between them is a top priority and something citizens really look forward to. At the same time mobility tighly related to air quality.

- **Using public procurement to improve environmental performance and service of overall public transport**
  The opportunity that Aveiro Region has since 2015 to manage its public transport is a good opportunity for the region to set strict rules in tendering. In the free market where different companies compete in tendering, the Aveiro Region can require strict environmental performance (how clean the busses network has to be) and quality of transport (service provided in terms of coverage, frequency and travel times) from providers.

- **Compensate costs of required infrastructural measures by revenue generating local financial instruments and communicate the need for such instruments.**
  Finance is a key institutional condition that determines the possibilities for implementing citizen-inclusive policies. Wide public transport improvements for instance are costly and compensating its costs by generating local funding through for example parking fees and permits, congestion levies or workplace parking levies, could mitigate this hurdle. Such financial burden tends to be less popular with citizens, hence the to properly communicate the need for it. Also, authorities should consider possibilities to reward

behavioural change (e.g. bike parkings and rentals offering discounts at local shops). Next to that, whether current funds are being used in the most efficient way needs to be questioned (for example, if the government tariff reduction support program to encourage the use of public transport has effectively contributed to increasing the number of users or just benefited current users).

- **Continue with low-barrier, long-term relationships with other cities to encourage experimenting and mutual learning.**
  ClairCity shows many EU cities struggle with similar implementation issues for citizen-inclusive air quality and carbon policies. It is therefore recommended to maintain a regular and long-term exchange with other cities, both in the Region, in Portugal and in Europe. Particularly interesting for the Aveiro Region are cities that are trying to overcome / have overcome a long tradition of car use to transition towards a wide use of public transport and an increased use of active travel. Since cooperations are often dependent on project funding, in particular low-cost and little-effort opportunities for regular exchange beyond such funding (e.g. video-conferencing, informal networks) should be examined.

1 Introduction to this report

This chapter provides the context for the ClairCity project (section 1.1), introduces the project objectives and process (section 1.2) and provides a reading guide for this report (section 1.3).

1.1 Context

In 2015, the Paris climate agreement set the goal to reduce global greenhouse gas emissions to keep global temperature rise this century to well below 2 degrees Celsius above pre-industrial levels[5]. A similar binding agreement for global air quality is lacking, but in 2005 the World Health Organisation formulated guidelines for ambient air quality aiming to improve health and reduce premature death caused by air pollution throughout the world. In 2016, 91% of the world population was living in places where the WHO air quality guidelines levels were not met.[6] Numerous countries and the European Union have set air quality targets that are often not as ambitious as the WHO guideline values, yet provide a legally binding framework for emission and concentration reductions of air pollutants.

Cities are the main contributors to the emissions of greenhouse gases and air pollutants, and many have set stricter local goals for emission reductions of greenhouse gases and air pollutants than the national or EU targets. Improving air quality and reducing carbon emissions as a contribution to the global, national and local targets and ambitions therefore will be a huge challenge for cities all over the world in the years to come.

Citizens living in these cities do not only cause an important part of these emissions through their daily behaviours, they can also play a key role in solving these issues. This can be via a change in behaviour and through providing democratic support for policy measures to be implemented that will affect their daily lives. ‘Citizen-inclusive policy making’ is therefore a crucial prerequisite for future air quality and carbon policies in cities to be successful in reducing emissions and reaching targets set on the local, national and global scales.

[5] https://unfccc.int/process-and-meetings/the-paris-agreement/the-paris-agreement
[6] https://www.who.int/en/news-room/fact-sheets/detail/ambient-(outdoor)-air-quality-and-health

1.2 The ClairCity Project

The **ClairCity Project**[7] puts citizens' behaviours and views central in city air quality and carbon policies. It addresses citizens' daily activities in cities, and their impacts on carbon emissions,air pollution and health. It also investigates what views citizens have on future air quality and carbon policies in their city.

'Citizen-inclusive policy making' in the ClairCity project is defined as:

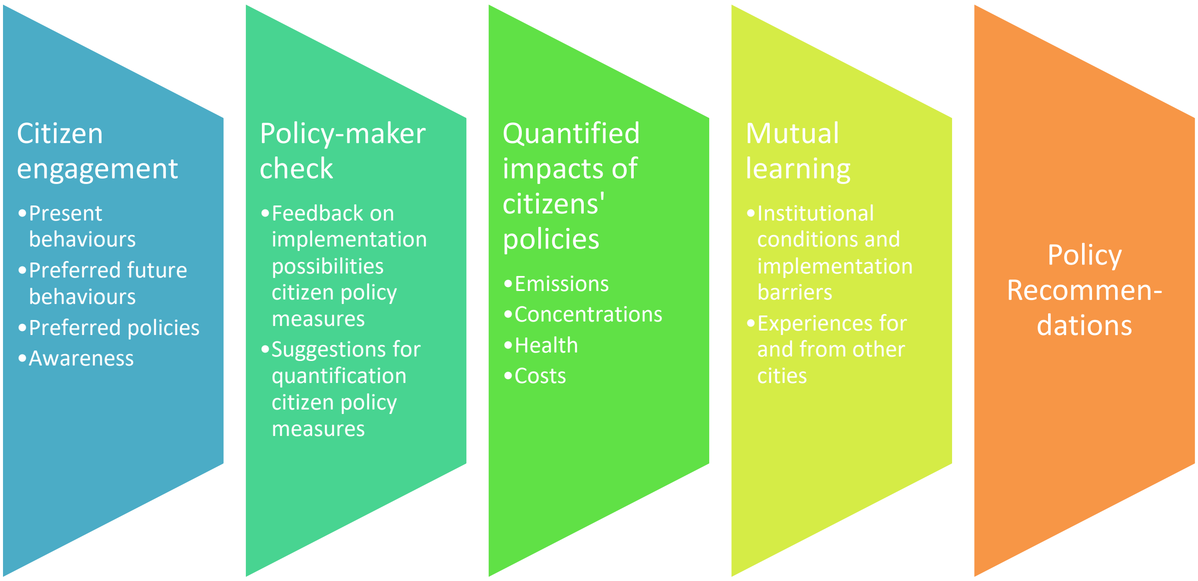
1. Tailoring city air quality and carbon policy measures based on a detailed knowledge of current behavioural practices of citizens;
2. Asking citizens for their preferences regarding own future behavioural changes and taking these preferences into account in policy making;
3. Asking citizens for their preferences regarding future air quality and carbon policy measures in their city and also taking these into account in policy making.

In ClairCity, the views of citizens on future air quality and carbon policies in their city are investigated through an innovative suite of citizen engagement activities in six European cities[8]. As a result of the project, policy makers in each city receive a calibrated and quantified[9] set of preferred policies suggested by citizens. The project also identifies for each city separately the behaviours that citizens would be willing to change in order to contribute to such policies. Furthermore, overarching lessons from the six pilot cities for other cities aiming for citizen-inclusive air quality and carbon policies are presented in a final report and conference.

Figure 2-1 shows the **five-step process** in which the policy recommendations for city policy makers in the Aveiro Region were prepared.

[7] The ClairCity project ('Citizen Led Air pollution Reduction in the City') is funded under the EU Horizon2020 programme, grant agreement nr 689289. It started in May 2016 and runs until May 2020. ClairCity website: www.claircity.eu.
[8] Amsterdam (Netherlands), Bristol (UK), Ljubljana (Slovenia), Sosnowiec (Poland), Aveiro / CIRA Region (Portugal) and Genua/ Liguria Region (Italy).
[9] Including views of other stakeholders and preliminary modelled data to give an outline of possible impacts on air quality and carbon emissions

Figure 1-1: ClairCity process including key phases and activities and chain of evidence leading to ClairCity policy recommendations



First, in the ClairCity engagement process citizens were consulted in order to examine their present behavioural practices, their preferences for future behaviours and their preferences for future policies. The process by itself contributed to citizen awareness of air quality and carbon issues and policies in the city and also included some activities specifically directed at awareness building.

Second, feedback was obtained on implementation possibilities of the citizen policy preferences through a workshop with local and regional policy makers involved in air quality and carbon related policies. In the workshop, the policy measures that evolved from the engagement process were further developed and partly quantified.

Third, from the more detailed citizen policy measures a ‘Unified Policy Scenario’ was constructed. In this scenario the impacts were modelled regarding emissions and concentrations of air pollutants and greenhouse gases, health impacts and costs to citizens and city. These impacts were compared to a business-as-usual scenario with city policy measures implemented and specified in the base year 2015.

Fourth, the specific institutional conditions and barriers for implementation of the citizen measures in the Aveiro Region were examined. These consisted of political framing, financial conditions, multilevel policies and other conditions. These were compared with the experiences in the other ClairCity cities to examine what lessons could be learned from and for the Aveiro Region regarding promising ways for implementation of the citizen measures.

The detailed policy recommendations for the Aveiro Region were prepared taking the four aforementioned steps into account.

1.3 This report

This report is the ClairCity "**City Policy Package Report**" for the Aveiro Region, the last city for which the ClairCity engagement process has been completed[10]. It provides a summary of the lessons learned for local air quality and carbon policy making in the Aveiro Region. The primary target group of this report are therefore the Aveiro Region policy makers and politicians. The report can be further of interest to politicians and policy makers in other cities, to national and regional policy makers, to EU policy makers, and not least to stakeholders and citizens in the Aveiro Region and elsewhere engaged or interested in improving air quality and reducing carbon emissions in their city.

Chapter 2 of this report discusses the ClairCity citizen engagement methods that were applied and tested in the Aveiro Region. Chapter 3 analyses the current air quality and carbon situation in the Aveiro Region and looks into current behaviours of citizens that contribute to air pollution and carbon emissions. Chapter 4 examines what behavioural changes Aveiro Region citizens envisage for themselves in the future and what preferences they have for policy measures. It also shows what reflections Aveiro Region policy makers have on the views of citizens. Chapter 5 quantifies potential consequences of the citizens' preferences in terms of emissions and concentrations of air pollutants and of carbon dioxide, in terms of health and in terms of costs of measures. Chapter 6 discusses specific institutional conditions and barriers for citizen-inclusive policies found in the Aveiro Region as well as mutual learning possibilities in order to remove these barriers. Chapter 7 finally gives the main conclusions and policy recommendations that follow from the ClairCity citizen engagement and analysis in the Aveiro Region.

[10] In the ClairCity project, this report is part of deliverable D7.5

2 ClairCity engagement in the Aveiro Region

The ClairCity project developed a suite of citizen engagement methods, aiming to involve a broad cross-section of the the Aveiro Region population. This mix of proven policy related engagement methods includes a three-step 'Citizen Delphi Process' consisting of proven methods such as online surveys and workshops to engage citizens, and other stakeholders such as experts. Also, an innovative game for mobile phones was developed (ClairCity Skylines) that allows citizens to state their policy preferences for the city in a creative context.

Figure 2-1: ClairCity 'Skylines' Game presentation in Aveiro

Further, a schools activity and a filming activity were designed and implemented in order to improve the awareness of young and elderly people respectively. An overview of citizen engagement methods designed and applied in ClairCity is given in Table 2-1.

Table 2-1: ClairCity's citizen engagement activities in the Aveiro Region

Objective	Method	Citizens, general	Specific citizen groups[1)]	Stake-holders[3)]	Policy makers
Policy related	Online surveys	X			
	Street interviews	X			
	Workshops	X		X	X
	Serious gaming	X			
Awareness related	Schools activity		X[1)]		
	Film competition		X[2)]		

1) Pupils secondary school
2) Elderly
3) NGOs, business

In total, in the period 2017-2019, over 1 700 stakeholders, primarily citizens, were reached by the various ClairCity citizen engagement methods in the Aveiro Region (Table 2-2). While this sample is not fully representative of the Aveiro Region population as a whole[11], the

[11] Based on the latest 2011 census, the Aveiro Region has 370,394 inhabitants.

ClairCity team in Aveiro did an excellent job in getting participants from across all municipalities in the region in all activities to ensure that no municipality was overrepresented. The female / male respondents split has also been balanced. As such, this sample used in ClairCity is used to gives an indication of support for policy measures and intentions for behavioural change that can be used by policy makers to inform future policies.

Table 2-2: Number of participants in ClairCity stakeholder engagement methods in the Aveiro Region

Citizen engagement activity	Participants engaged
Delphi Process (Round 1 & Round 2 surveys + Delphi workshop)	1 349
Skylines Game	243
Mutual Learning Workshop	13
Stakeholder Dialogue Workshop	12
Schools activity	Number of teams who have finalised the exercise through the tool: 19 Number of teachers: 10 Number of schools: 6 Number of municipalities: 6
Film competition	5
Policy Workshop	6

3 Current air quality and carbon situation in the Aveiro Region

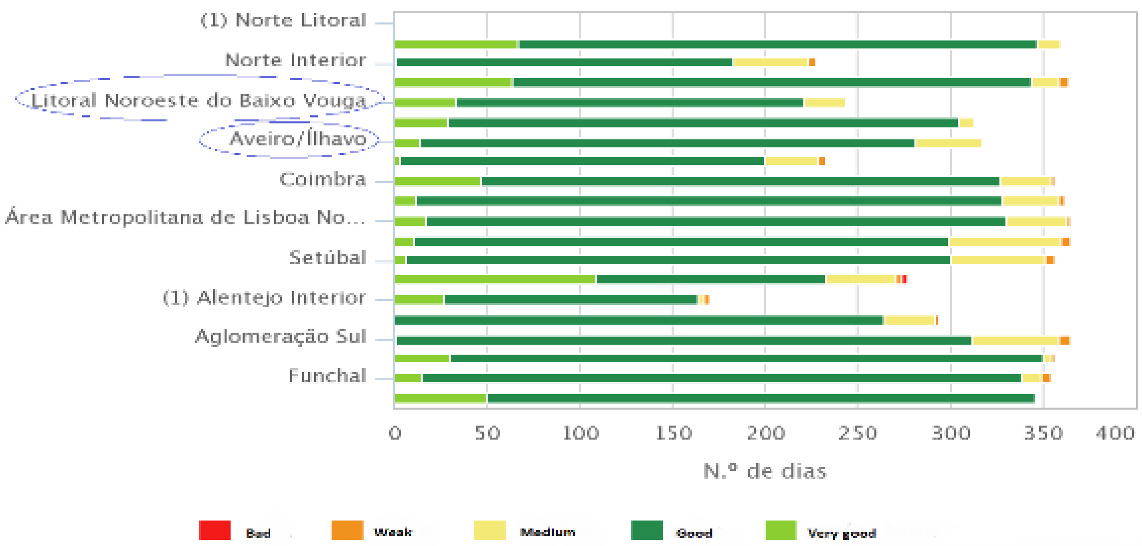
In the ClairCity project, the existing air quality and carbon status and policies in the Aveiro Region were identified in order to establish a baseline against which the impacts of citizen desires for the future of their city could be compared and contextualised.

3.1 Current concentrations and emissions

In the ClairCity Policy Baseline report as of March 2018[12], it was noted that:

"According to local monitoring data, the Aveiro Region is currently complying with EU limit values for all air pollutants and even with WHO guidelines for NO_2 and SO_2. Air quality in the Aveiro Region can therefore be considered relatively good. However, it should be noted that measurements in the region are limited (there are only three measuring stations across the whole region). Exceedances still happen for O_3 and PM_{10} mainly. The national air quality index (IQAr) of 2017, which measures CO, NO_2, PM_{10}, O_3 and SO_2, shows that the number of days with "Very Good" and "Good" air quality in the Aveiro Region overall decreased in 2017 compared to 2016, and that days with "Poor" and "Very Poor" air quality increased (Figure 3-1)."[13]

Figure 3-1 The national air quality index (IQAr) (Aveiro/Ilhavo and Litoral Noroeste do Baixo Vouga correspond to the Aveiro Region)[14]



[12] Please refer to D6.2 Policy Baseline Report – Last City which contains a whole detailed chapter on the Aveiro Region. Available on www.claircity.eu

[13] Bad-Weak-Medium-Good-Very good are determined depending on the minimum and maximum concentrations measured for which ranges are defined (e.g. for PM10, 'good' is between 20 and 34 µg/m3. The result is the based on the pollutant that presents the worst classification (example: if the average values recorded in a given area are SO2 - 35 µg/m3 (very good), NO2 - 180 µg/m3 (regular); CO - 6 mg/m3 (good), PM10 - 15 µg/m3 (very good) and O3 - 365 µg/m3 (bad), the IQar will be deemed "bad", due to ozone levels.

[14] REA (2018) Ar e Ruido. Indice de Qualidade do ar.

As explained in the ClairCity Policy Baseline report[15], the main air pollutants in the Aveiro Region are PM_{10}, NO_x, with high concentrations of O_3 in the summer months. The mix and sources of these vary across municipalities. Also the emissions of CO_2 also vary from municipality to municipality.

NO_x concentrations - The municipality with the largest emissions is Aveiro, where the main sources of NOx emissions are: maritime, road and rail traffic, industrial processes and industrial combustion. In the other municipalities, the main sources of NOx emissions are road and rail traffic, followed by industrial combustion.

PM_{10} concentrations - Overall, residential and commercial combustion units for heating, followed by combustion processes associated with industry, are the main source of PM_{10} in the Aveiro Region. An exception is the municipality of Estarreja, which is a nationally important industrial area, where industrial processes mainly release PM_{10}. A study focusing in the city of Aveiro corroborated the large impact of residential biomass burning on local air quality, causing air pollution hotspots where hourly concentrations can be ≃200µg/m3, five times higher than EU limit values.

SO_x Emissions - The main source of SOx emissions is industrial combustion, followed by small combustion sources**.** SO_x emissions in the municipality of Aveiro are highest as result of industrial combustion and processes, maritime traffic and small combustion sources.

CO_2 emissions - In the Aveiro Region CO_2 emissions have increased since 1990. CO_2 emission sources are primarily buildings (domestic energy use), industry and transportation. The municipality with the highest CO2-eq emissions is Aveiro city, while the municipality with the lowest is Murtosa.

Figure 3-2 Main features of the current the Aveiro Region air quality and carbon situation

NOx	PM_{10}	O_3	CO_2
• Source: Road & rail traffic, followed by industrial combustion. • Aveiro city has the largest NOx emissions result also of maritime traffic	• Source: Domestic heating • There are exceedances	• High concentrations in the summer months	• Source: buildings, industry and transport • CO_2-eq emissions have increased

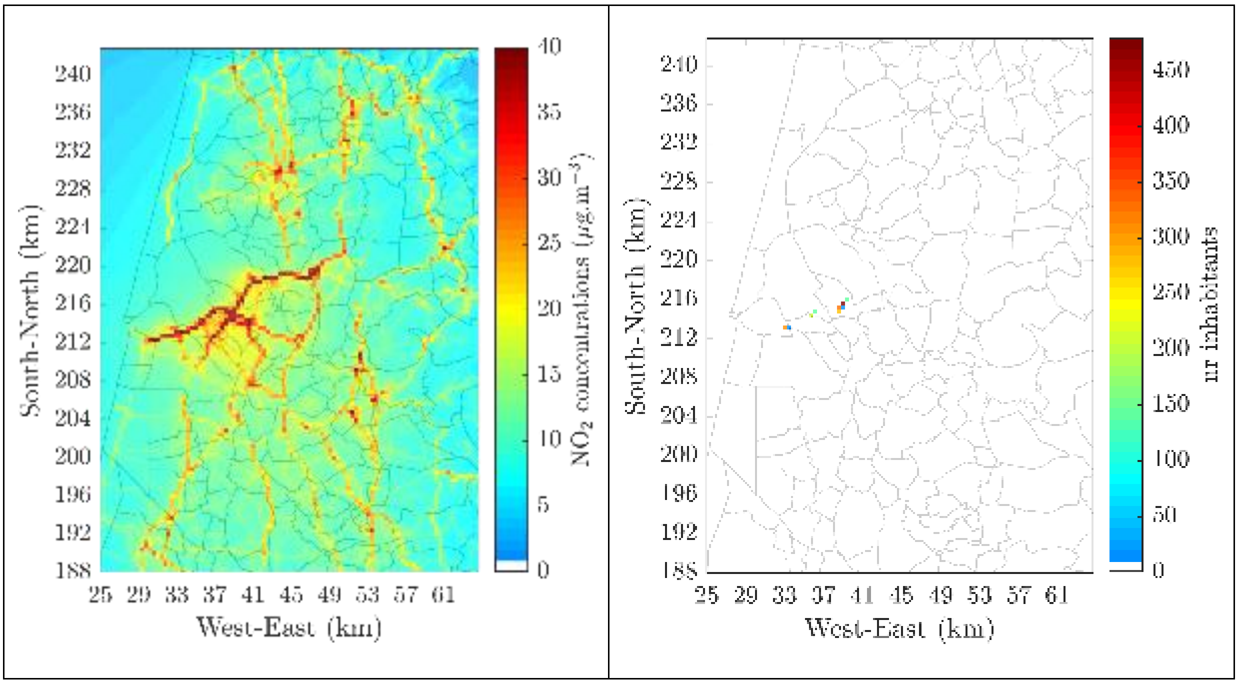
In the ClairCity project, concentrations of air pollutants were modelled for the base year 2015 in order to compare them to business-as-usual policies as known in 2015 as well as to the

[15] Please refer to D6.2 Policy Baseline Report – Last City which contains a whole detailed chapter on the Aveiro Region. Available on www.claircity.eu

measures jointly suggested by citizens and policy makers. Annex C gives more information of the ClairCity modelling assumptions[16].

Figure 3-3 a) shows the exceedances of NO_2 limit values in 2015 as modelled by ClairCity. The figure shows a clear visible correlation to the street pattern. ClairCity modelling also suggests that transport is the primary source of NO_2 pollution, with an overall contribution of 91% over the entire domain. The simulation results indicate a maximum concentration of 57.7 µg.m^{-3} within the urban area of Aveiro municipality, with an hot-spot over the highway A25 link. These concentrations are higher than the current EU annual legal limit value for NO_2 annual concentrations (40 µg.m^{-3}). According to the modelling, the legal NO_2 limit value is exceeded in 15 grid cells[17] of 200 x 200 metres in Aveiro Region (Figure 3-3 b). This means less than 1% (0.6%) of the total population within the entire Region are potentially exposed to those concentrations.

Figure 3-3 NO_2 contour maps for Aveiro Region in current situation (reference year 2015): a) annual average of NO_2 concentrations and b) number of inhabitants within the cells exceeding the EU annual limit value of 40 µg.m^{-3}.

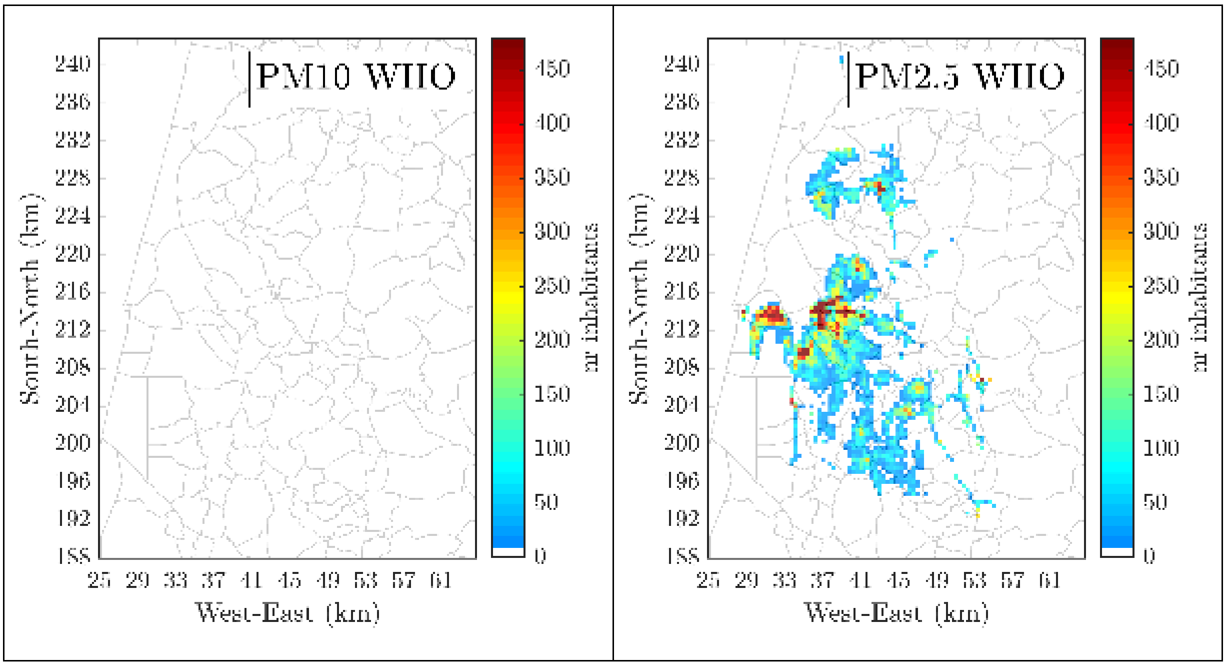


For PM_{10} the ClairCity modelling does not identify any exceedances of PM_{10} concentrations in 2015 (reference year), neither above the EU legal limit, neither above the more stringent guideline concentrations of the World Health Organisation (WHO) (Figure 3-4 a).[18] The ClairCity modelling also indicates that, while Aveiro Region complies with the legal limit

[16] The results of ClairCity modelling do not fully correspond to those of local modelling as a result of different modelling assumptions. A full comparison of ClairCity modelling assumptions with those of all cities was considered to be outside the scope of this project. ClairCity modelling results should therefore be seen as indicative only.
[17] A 'cell' refers to the 200 m x 200m modelling domain that was utilsed by ClairCity
[18] This contradicts actual measurements and is mainly explained by the different approaches to measurements as well as the modelling / simulations, both of which have uncertainties.

values for $PM_{2.5}$ concentrations, it does not comply with the WHO guidelines[19]. Figure 3-4 b) shows 2614 cells exceeding the WHO guideline value, which represents 49% of the population in the Aveiro Region.

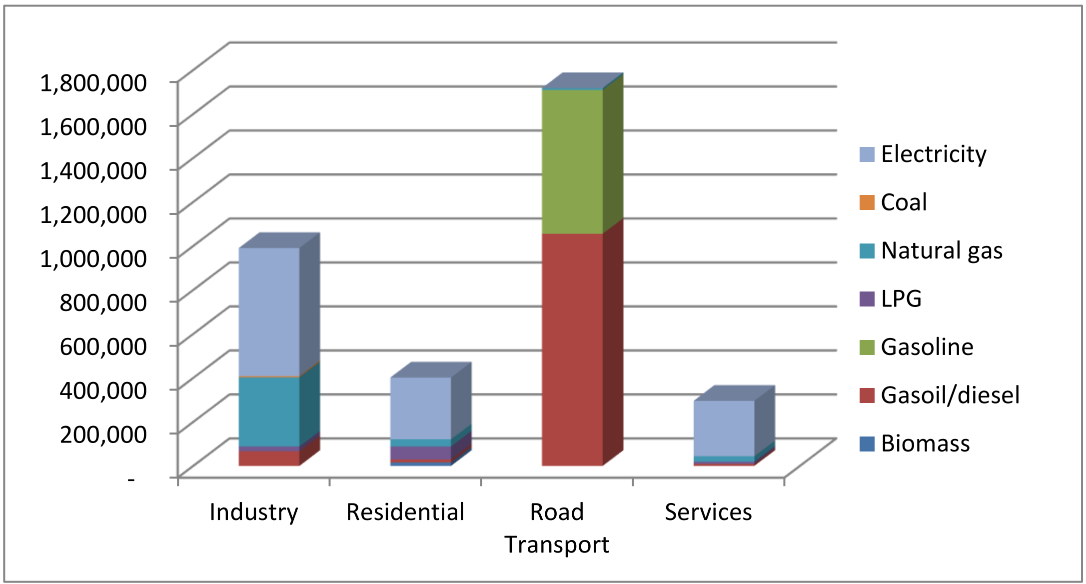
Figure 3-4 Number of inhabitants within the cells exceeding the WHO air quality guideline values: a) of 20 µg.m^{-3} for PM_{10} concentrations, and b) of 10 µg.m^{-3} for $PM_{2.5}$ concentrations.



In Figure 3-4 the Carbon Footprint in 2015 is expressed as tonnes CO_2 equivalent reported by fuel and sector. The indicator takes into consideration the overall life cycle of the energy carrier; this approach includes not only the emissions of the final combustion, but also all emissions of the supply chain; it includes emissions from exploitation, transport and processing (e.g. refinery) steps in addition to the final combustion; this hence includes also emissions that take place outside the location where the fuel is use. The figure shows that the main contribution to the Aveiro Region carbon footprint is road transport followed by industry. In addition, this is followed by emissions in the services and residential sectors.

[19] Based on the latest scientific evidence available, WHO has established limit values for PM_{10} and $PM_{2.5}$ that are substantially below current EU and British legal limit values. These values are 20 µg.m^{-3} for PM_{10} (compared to a legal limit value of 40 µg.m^{-3}) and 10 µg.m^{-3} for $PM_{2.5}$ (legal limit value 25 µg.m^{-3} annual mean). See https://www.who.int/news-room/fact-sheets/detail/ambient-(outdoor)-air-quality-and-health

Figure 3-4: Carbon Footprint in the Aveiro Region expressed as tonnes CO_2-eq on Life Cycle by fuel and sector in 2015 (Source: ClairCuty modelling)



3.2 Existing air quality and carbon policies

EU-prompted national legislation in the areas of industry and transport remain accountable for successes in reducing air pollutants and GHG emissions reduction in the Aveiro Region.

The need to improve the public transport network is currently a priority for the Aveiro Region and local governments. The ambition of the Aveiro Region in the transport area is to achieve 50% modal shift from private cars to active travel and public transport by 2030. With this in mind, in the Aveiro region 150 km of new urban cycle lanes (for commuting, unlike in the past when cycling lanes were purely for leisure) and new cycle parking spaces are planned by 2025 and 50 km of new/renewed pedestrian routes by 2025. Also by 2025, public transport should cater all urban areas and run largely on schedule. A reduction of fares (50% by 2021) and the replacement of 30% of the public transport fleet with zero-emission vehicles (by 2030) are also in the planning. As for private vehicles, bans on the oldest diesel cars and HGVs on urban areas are planned by 2030 (the specifications of this are still to be defined).

There are no regional neither local policies on energy and (domestic) heating in the Aveiro Region. The Municipalities in the Region do not have competences in these areas, which a are regulated by the central government. There is currently no policy in the Aveiro Region to support the replacement of old fireplaces or non-efficient heating systems nor to support the uptake of solar panels.

4 Citizens’ views on cleaner air and carbon policies in the Aveiro Region

The ClairCity citizen engagement process in the Aveiro Region, and in particular the Delphi process, gave insights into the degree that citizens want to change their behaviour in ways that will contribute to cleaner air and lower carbon emissions in the Aveiro Region, as well as into views that citizens have about future policies.

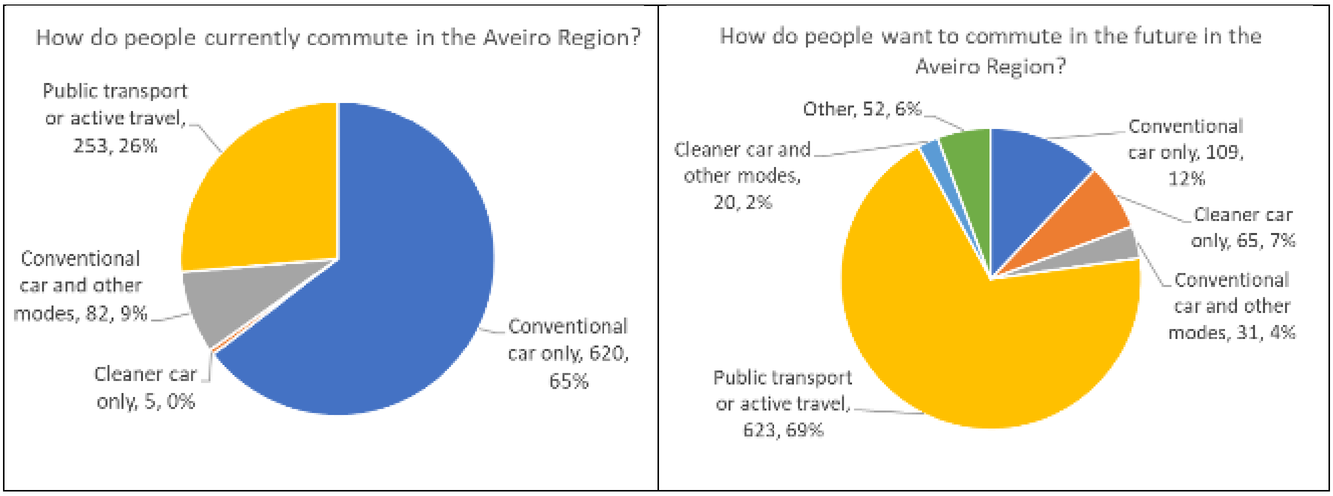
4.1 Views of citizens on their own transport behaviour

In the Delphi process, citizens were asked to what extent they wanted to change their own transport and heating behaviour in the future. Below the results are given of the sample of over 800 people consulted.

4.1.1 Commuting behaviour

Despite the overwhelming reliance on cars in the present (over 65%), 75% of respondents do not want to be using a car in their commute in the future, indicating a very large latent demand for alternatives in the Aveiro region (Figure 4-1).

Figure 4-1: Proportions of present and future car use of commuters in the Aveiro Region



Responses from the sample survey indicate that **there is huge willingness to switch from conventional cars towards both public transport and cycling, with a continued desire for walking (54% of the people surveyed are “looking for positive change”).** Amongst the car drivers, there were also a significant number of people seeking electric cars, hybrids or other “cleaner” cars even though they still think they will travel by car in the future. A large group (33% of the surveyed) is also ‘staying positive’ meaning that they use alternative means next to conventional cars in the present and would like to continue the same way. As such, **current car users who would like to switch to using alternative means, at least some of the time** (our ‘Looking for positive change’ group), **have the potential to be an easy gain for policy-makers seeking to encourage citizens to move to less polluting**

modes. Consequently, this is the group of people we are most interested in understanding. The reason for present behavior (mostly car use) being so different from desired modes of transport for the future (mostly public transport) concern drawbacks of public transport:

"The prices of public transport are very high. It's cheaper to travel with two people by car than pay a bus pass"

"Public transport is lacking, there are no connections or schedules compatible with my needs".

The other arguments for this regarded the (perceived) lack of alternatives and time travel, as illustrated by the quotes below.

"There is no public transport to my workplace"

"Work is about 5 km from my house and there is no adequate public transportation"

"Due to distance and lack of time to complete all activities"

Poor cycling infrastructure in addition was a clear theme, with respondents mentioning unsafe routes (alongside traffic) and a lack of cycle paths for their commuting journeys.

Table 4-1 Matrix of modal change desires for commuting trips in the Aveiro Region[20]

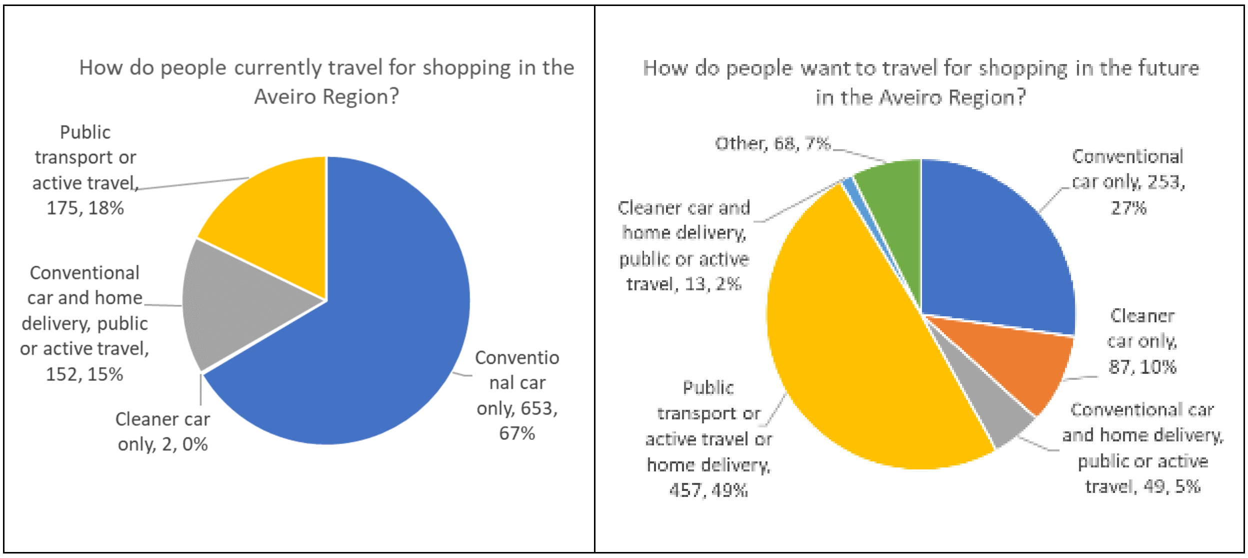
Commuting (total = 856)	High polluting choice in future (conventional car only)	Low polluting choice in future (car and walk; walk and bus, online deliveries, EV etc)
High polluting choice in present (conventional car only)	87 Entrenched	463 Looking for positive change
Low polluting choice in present (car and walk; walk and bus, online deliveries, EV etc)	21 Getting worse	285 Staying positive

Similar to the case of commuting, despite the overwhelming proportion of the citizens that use the car to go shopping currently (67%), a large amount would prefer to be able to do it differently in the future. In fact almost 50% of the population would like to go shopping by public transport, walking/cycling or would opt for shopping being delivered at home. There is also a considerable increase in the amount of people (10%) who would like to use a clean car to go shopping.

[20] **Entrenched:** those who only use a conventional (fossil fuel) car in the present and would like to continue to only use a conventional car in the future. **Looking for positive change:** those who only use a conventional car in the present but would like to use additional means next to or instead of a conventional car (i.e. public transport, active travel, online delivery or electric vehicle) in the future. **Getting worse:** those who use alternative means as well as cars in the present but would like to only use a conventional car in the future. **Staying positive:** those who use alternative means next to conventional cars in the present and would like to continue to use additional means as well as or instead of a conventional car in the future.

4.1.2 Shopping and leisure behaviour

Figure 4-2: Current and future transport choices for shopping in the Aveiro Region



In the matrix below we have divided our shopping respondents into four groups, depending on their use of a conventional car for this transport activity:

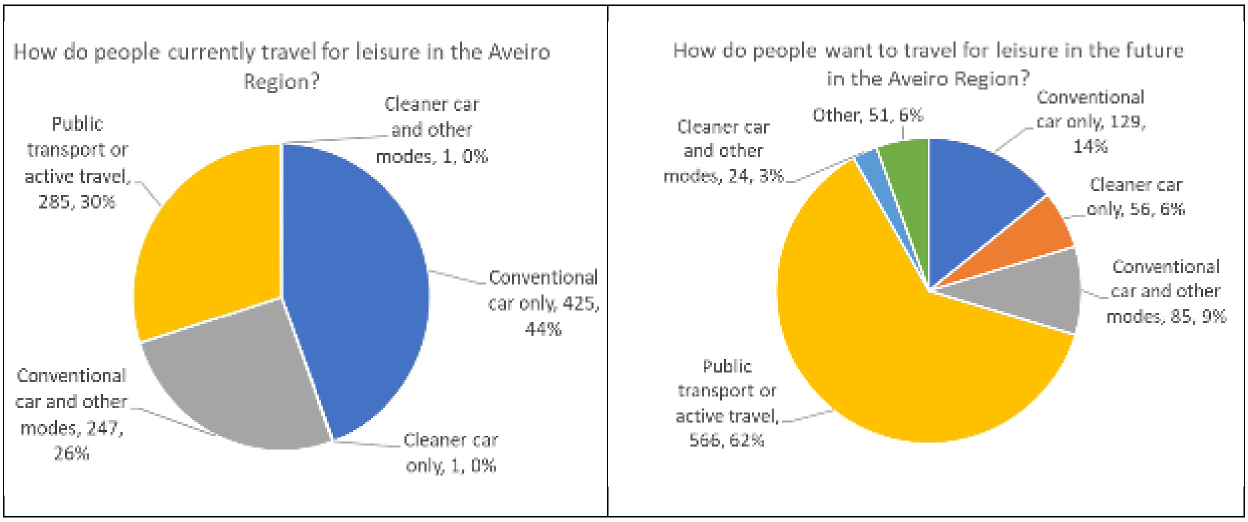
Table 4-2: Matrix of modal change desires for shopping trips in the Aveiro Region

Shopping (total = 883)	High polluting choice in future (conventional car only)	Low polluting choice in future (car and walk; walk and bus, online deliveries, EV etc)
High polluting choice in present (conventional car only)	213 Entrenched	380 Looking for positive change
Low polluting choice in present (car and walk; walk and bus, online deliveries, EV etc)	37 Getting worse	253 Staying positive

The majority of citizens are looking for more environmentally friendly means of mobility and the second largest category corresponds to the group who are already have relatively environmentally friendly modal habits and would like to remain doing the same.

Leisure is the activity for which public transport and active travel are popular in the Aveiro Region citizens currently (30%).The conventional car is however still the primary means of transport for leisure. Similar to the trend for commuting and shopping, also for leisure the majority of citizens would prefer to be able to access leisure through public transport or active travel.

Figure 4-3: Current and future transport choices for leisure in the Aveiro Region



In the matrix below we have divided leisure respondents into four groups, depending on their use of a conventional car for this transport activity:

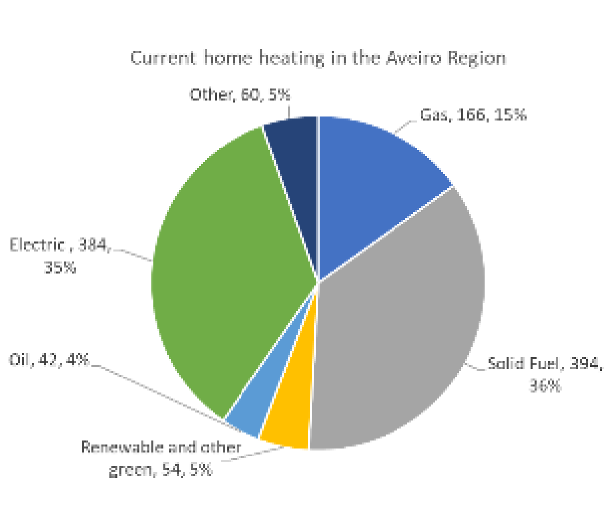
Table 4-3: Matrix of modal change desires for leisure trips in the Aveiro Region

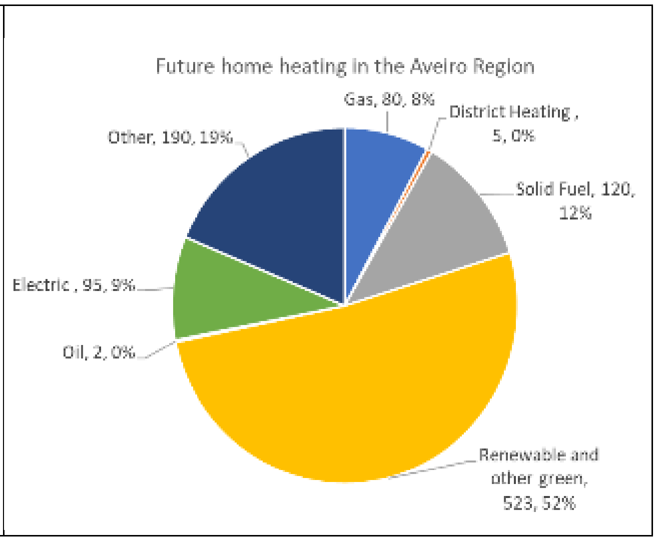
Leisure (total= 861)	High polluting choice in future (conventional car only)	Low polluting choice in future (car and walk; walk and bus, online deliveries, EV etc)
High polluting choice in present (conventional car only)	104 Entrenched	277 Looking for positive change
Low polluting choice in present (car and walk; walk and bus, online deliveries, EV etc)	23 Getting worse	457 Staying positive

4.1.3 Home Heating behaviour

Heating choices in the Aveiro Region are varied, with over a third also using some form of solid fuel e.g. wood burners, open fires (%36), a third relying on electric heating (35%) and gas (15%) as the third largest source. The survey respondents expressed a large shift in their heating-related preferences for the future away from solid fuel and towards renewables. In the future a majority of respondents would like to get their heat from a renewable or "green" source. Around 12% would like to use some form of solid fuel in the future, referring to "fireplace" or "wood" or sometimes "pellets" in their answers.

Figure 4-4 Current and future choices for home heating in the Aveiro Region





We explored the reasons why those who were currently using solid fuel heating systems wanted to change to a less polluting source or felt they could not (or were not interested). Overall for the “entrenched” respondents – who currently used solid fuel and wanted to keep it in the future, **cost was the most significant factor not to change, namely the cost of changing being too high and/or solid fuel being the cheapest way to heat their homes**. It was notable that **ten respondents (12%) of this “entrenched” group mentioned environmental reasons as reasons they did not want to change**.

“Wood burning is ecological, less polluting”

“[it] is sustainable since I only use firewood from sustainable forest management”

It should be noted that although in some circumstances wood or pellets are considered an environmental or renewable heat source, in the context of this project they are identified as polluting due to the air quality issues they generate.

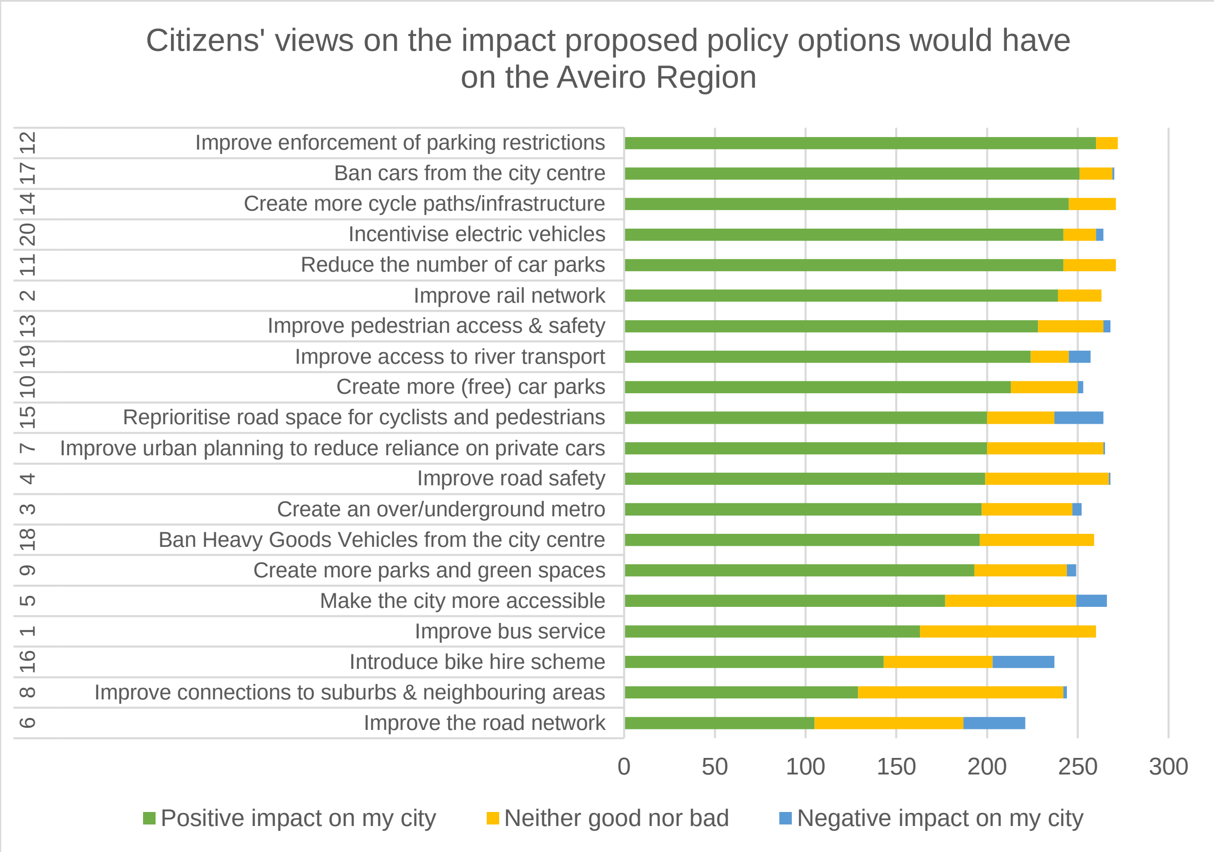
Table 4-4 Matrix of modal change desires for home heating in Bristol

Heating (total= 804)	Solid fuel in the future	Not solid fuel in the future
Solid fuel in the present	86 Entrenched	274 Looking for positive change
Not solid fuel in the present	28 Getting worse	416 Staying positive

4.2 Views of citizens on future policies in the Aveiro Region

In the Aveiro region, the measures that citizens and other stakeholders want to see in place in order to improve the Region consist mainly of discouraging car use and in turn encouraging active travel and public transport (Figure 4-5).

Figure 4-5 Citizens' views on the impact that proposed policy options in Aveiro would have on their city



Considering car use is widely spread in Aveiro, respondents on the survey gave some striking responses. Firstly, 'improving enforcement of parking restrictions' is considered the most positive measure for the city/region by respondents. The second most beneficial policy for the region (cities in the region) is 'banning cars from the city centre'. Encouraging alternative modes, e.g. by 'creating cycle paths and infrastructure', and 'improving pedestrian access' were popular, as was 'improving the rail network' and 'access to river transport'. Citizens see all of this going hand in hand with 'reducing the number of car parking spaces'. 'Electric vehicles' seem an exception, as there is large support for incentivising these. 'Creating more parks and green spaces' was a lot less contentious than transport measures. 'Reprioritising road space', 'introducing a bike hire scheme' and 'improving the road network' had some detractors. Interestingly, 'improving the bus service' was not perceived as particularly beneficial for improving the city/region (albeit when asked differently, namely, "whether an improved bus service would improve citizens' lives", several more people showed enthusiasm for an improved bus service).

4.3 Reflections from the Aveiro Region policy makers

The ten preferred generic policy measures of the Aveiro Region citizens and stakeholders were discussed with six representatives of the Aveiro Region (from the municipalities of Anadia, Estarreja, Ílhavo, Oliveira do Bairro, Ovar and Sever do Vouga). For each of the measures, policymakers were asked to choose between two concrete measures: a specific measure that represented a low ambition level and an specific measure that represented a high ambition level. The ten concrete policy measures chosen by policymakers were put together in a “Final ClairCity Unified Policy Scenario” or “UPS” that has been modelled (see next Chapter).

Policymakers in the Aveiro Region, backed more ‘high ambition’ options than ‘low ambition’ options. **The ambition was highest for virtually all policies directed at facilitating active travel and improving public transport.** Only lowering the fees of public transport and replacing the bus-fleet for cleaner buses were unpopular measures among policymakers. According to policy makers measures such as **‘Promoting working from home’ and ‘Increasing space for pedestrians’ are considered “easy to implement” by policy makers. A barrier to the increased provision and reliability of public transport** (for which the HIGH option was chosen) **is that a private operator has the monopoly of public transport,** which in turn leads to a lack of competitive alternatives and to a lack of inspections on performance. **The way to stimulate the** (also HIGH rated measure) ‘**Creating school and workplace travel plans[21]’ is mainly awareness raising** to change current habits (e.g to increase uptake of active travel and public transport instead of private cars). In addition, the problem with public transport is a chicken-and-egg problem. Transport is unattractive for citizens because it is partly unreliable and not frequent enough and so it is not widely used. **Lowering the fees of public transport and replacing the bus-fleet for cleaner buses are unpopular measures among policy makers primarily for costs reasons.** Further, the reason why bycicle lanes remain outside the urban nexus, suitable for leisure but not for daily commute, is that building bike lanes in urban areas implies greater constraints and costs in the public space when compared to cycle lanes in leisure areas. However**,** external factors such as **the current booming real state situation seems favorable to investments such as an expansion of cycling lanes. Banning diesel cars and HGVs in urban centres is also an unpopular** measure due to te lack of alternatives in some municipalities and because the Aveiro Region considers it difficult to enforce.

Overall, **the standpoint of the region is that air quality and climate policies are expensive both for the city and for citizens, and cities as well as citizens lack funds for implementing such**. Against this backdrop **the Aveiro Region policymakers feel the region is already doing what is at their hands** to improve air quality and reduce carbon emissions. It is interesting to note that **the effectiveness of the measures currently in place is questioned** as illustrated in the quotes below.

> “There are measures being already implemented across all municipalities. However, the effectiveness of some of them is doubtful.” {Aveiro}

> “There is a tendency to follow popular trends (i.e. in one municipality a cycle lane was built and was quite well received by the population; after that everyone is building cycle lanes).” {Aveiro}

[21] ‘Travel plans’ here refer to travel arrangements made by an organisation to have their staff commute together for example in an organised bus. The bus follows a route stopping at a few place in order to pick employees up and carry them to work.

Table 4-5: Aveiro Region's policy makers choice on preferred citizen measures: Final ClairCity Unified Policy Scenario for the Aveiro Region (July 2019 workshop)

#	Policy Area	Chosen ambition	Chosen policy measure	Comments ("Main barriers to be overcome, ways to overcome these barriers = 'implementation plan'")
1	Build segregated urban cycle lanes and create secure cycle storage/parking	High	300 km of new urban cycle lanes and 200 number of new cycle parking spaces by 2035	• Financial effort of cycle lanes in urban areas is greater (greater constraints in the public space) when compared to cycle lanes in leisure areas. • At the moment, external factors such as the real estate situation (real estate sector is coming in Portugal and particularly in Aveiro) seem favorable to stimulate investments. • Bigger accountability required from municipalities.
2	Create school and workplace travel plans to increase uptake of active travel and public transport	High	50% modal shift from private cars to active travel and public transport by 2025	• Cultural problem. • Public transportation is hard to implement and is unpopular. • The region has different characteristics among municipalities. • Raising awareness in schools (to younger people). • There is a school transport service available (for home – school – home transport for children) for decades, financed by the Municipalities (with high cost) but currently it is not used as expected[22]. • A lot of people think that they only have rights and no obligations, and just request and complain. • Younger generations more aware, that can induce the change of behaviour.
3	Reallocate road space to pedestrians and improve safety	High	100 km of new/renewed pedestrian routes by 2025	• Easy to implement from the perspective of urban regeneration. • Work has been done to remove physical barriers from the sidewalks (to make walking more pleasant) but barrier free sidewalks lead to people parking their cars in those areas. • Resistance of the population to the replacement of the typical Portuguese sidewalk by other cheaper, more practical and friendly for pedestrians.
4	Ban diesel cars/HGVs in urban centres	Low	10% ban of diesel cars and 25% HGVs in urban centres by 2025	• Lobby of electric vehicles against diesel vehicles, despite the efforts and investment of the transport industry in the reduction of emissions. • Limited application of the measure in some municipalities due to lack of alternative routes (e.g. Sever do Vouga). • Alternatives are a government responsibility. • Lack of compliance by some heavy-duty drivers. • Requires more inspection.
5	Allow free parking for electric vehicles only	High	Transform 100% of the current parking spaces to free parking for EVs by	• The current policy measure is that '50% of parking spaces should be transformed into to free parking for EVs by 2035', while the LOW ambition level in the citizens scenarios aims only for 25%'. Policy makers unanimously agreed that the scenario should be at least the same as the current policy measure and so opted for the most ambitious option.

[22] The reasons for why this is so have not been studied by the Region. Some personal opinions collected by ClairCity state that the bus-scheme is not fully reliable, that it is easier and more comfortable to take children to school by car, and claim that this is clearly a cultural issue.

#	Policy Area	Chosen ambition	Chosen policy measure	Comments (“Main barriers to be overcome, ways to overcome these barriers = ‘implementation plan’”)
			2035	• Most of the parking spaces are free. The few paid parking sites are usually managed by the private sector. • Municipalities do not have human resources available to carry out the supervision. • This measure seems more suitable for larger cities. Due to the cahracteristics of the CIRA, this measure is difficult to implement.
6	Promote working from home	High	10% commuters work from home 1 day a week by 2030	• It has no big economic costs. • It has mainly costs of adaptation. • It does not apply to certain services in the tertiary sector.
7	Impose stricter regulation on polluting industries	Low	Reduce industrial emissions by 15% by 2030	• Municipalities do not have much intervention room at this level. • Much of what could be done has already been done. • The central administration is the main responsible.
8	Encourage replacement of older public transport fleets	Low	Replace 15% public transport fleets with zero-emission vehicles by 2030	• A private company (Transdev) has currently the monopoly of the public road transport sector in the region. • There are no alternative companies. • The differences between the cities in the region pose difficulties in implementing an intermunicipal service. • Electric buses are very expensive; have autonomy problems; a lot of time is required to charge batteries.
9	Subsidise public transport tickets	Low	Public transport fares reduced by 50% by 2021	• Problems of financial sustainability of the measure after 2021. • Low rate of use. • Problems associated with population density and dispersion in the territories.
10	Increase provision and reliability of public transport services	High	100% public transport journeys on schedule with all urban areas catered for by 2025	• For this measure no HIGH or LOW were presented but only one one option was given namely “100% public transport journeys on schedule with all urban areas catered for by 2025” namely the high option, as at the SDW all citizens groups decided in that ambition level for that measure. Policy makers raised a few issues regarding this policy: • Monopoly of the Transdev company. • Lack of competitive alternatives. • Lack of inspection (municipal responsibility) with scarce human resources. • Data of the transport service are manipulated by the operators, to show that they comply with the schedules. Operators have ownership of the system / program that controls the service provided (there is no independent system or service that monitors the quality of the service) and so are able to change the data regarding their service. Operators can clain that they have adhered to the timetable, when there are complaints of delays. • Permanent justifications for non-compliance with schedules: traffic issues, breakdowns, lack of drivers. • Creating a public mobility company would have serious cost implications, management problems, and increased charges for the end-users.

5 Impacts of implementing citizens' views

This chapter discusses the potential impacts of implementing the citizens' views on future policies on air quality (section 5.1), health (section 5.2), carbon emissions (section 5.3) and costs (section 5.4).

Textbox 5-1 Disclaimer ClairCity modelling versus national modelling

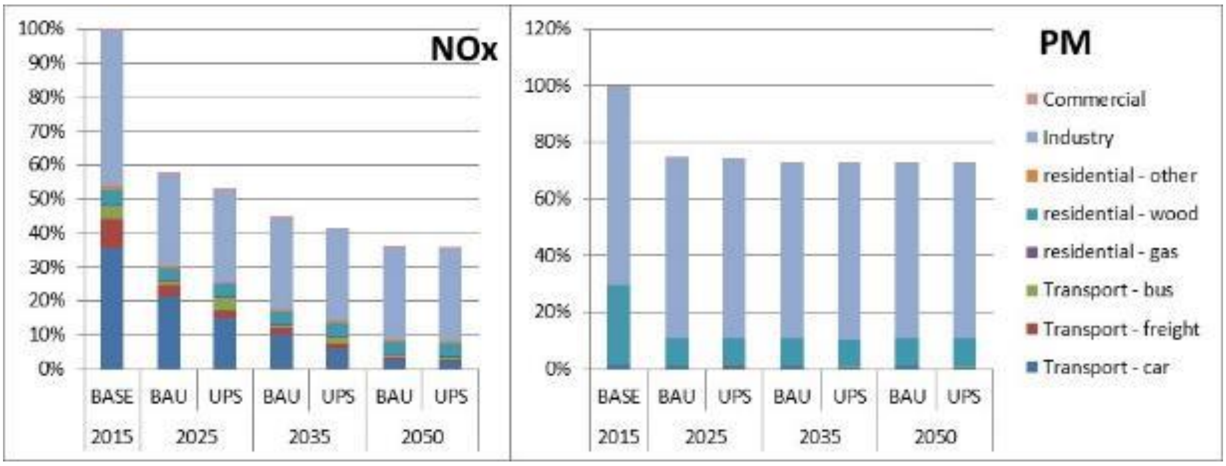
ClairCity modelling differs from regional and national models in Portugal due to the different modelling assumptions and inputs used. Our modeled concentrations can deviate from national and regional models and so should be considered indicative. Although the utmost care has been taken to calibrate the ClairCity models to local conditions, a detailed comparison of ClairCity modelling assumptions to those of local and national models in each ClairCity case study country was outside the scope of this project. Therefore ClairCity modelling outcomes cannot be one-to-one compared with the outcomes of national and local models.

The potential impacts are based on a 'Unified Policy Scenario' (UPS) that was prepared by combining citizen preferences for future policy measures with policy maker reflections and quantifying them where possible. The main assumptions made for preparing the UPS can be found in Annex C. The impacts of the UPS are compared with those of a 'Business-As-Usual' scenario (BAU) that is based on the effect of all city policy measures implemented in the Aveiro Region in the base year 2015 will have.

5.1 Impacts on air quality

Implementing the suggested policy measures of citizens as quantified in the UPS, and thereby enabling alternative behaviours and activities, would result in substantially better air quality and a reduction in the number of premature deaths caused by air pollution in the city as compared to the baseline. The ClairCity UPS scenario results in slight further reduction of NOx. For PM, the UPS does not bring significant further improvements than the BAU as explained in detail below.

Figure 5-1: Trend of PM and NOx emissions in the policy scenario, compared to the business as usual scenario

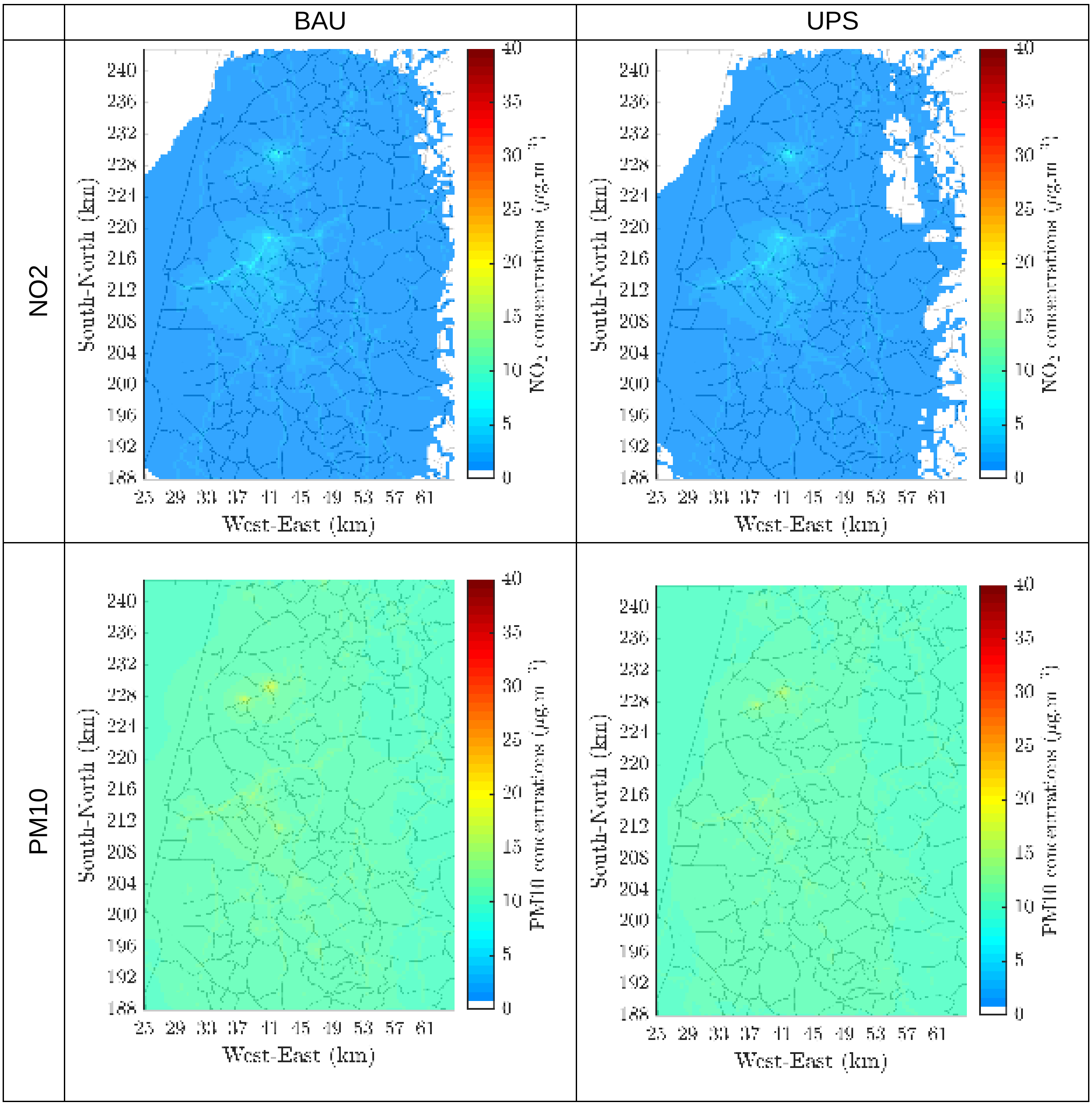


From Figure 5-1, there is a strong trend in improving NOx emission in the BAU and UPS. Reductions in both the BAU and UPS are coming from decreasing transport emissions and industrial emissions. In the UPS, we observe a stronger reduction in emissions from cars and an increase in bus emissions, with a net emission reduction. This is because the UPS encourages a modal choice, getting citizens away from their cars to rather opt for busses. Also, the slightly stronger uptake of EV's in the UPS and accelerated scrappage of older cars leads to some emission savings from cars compared to the BAU. However, in 2050, emission reductions from BAU and UPS are almost the same.

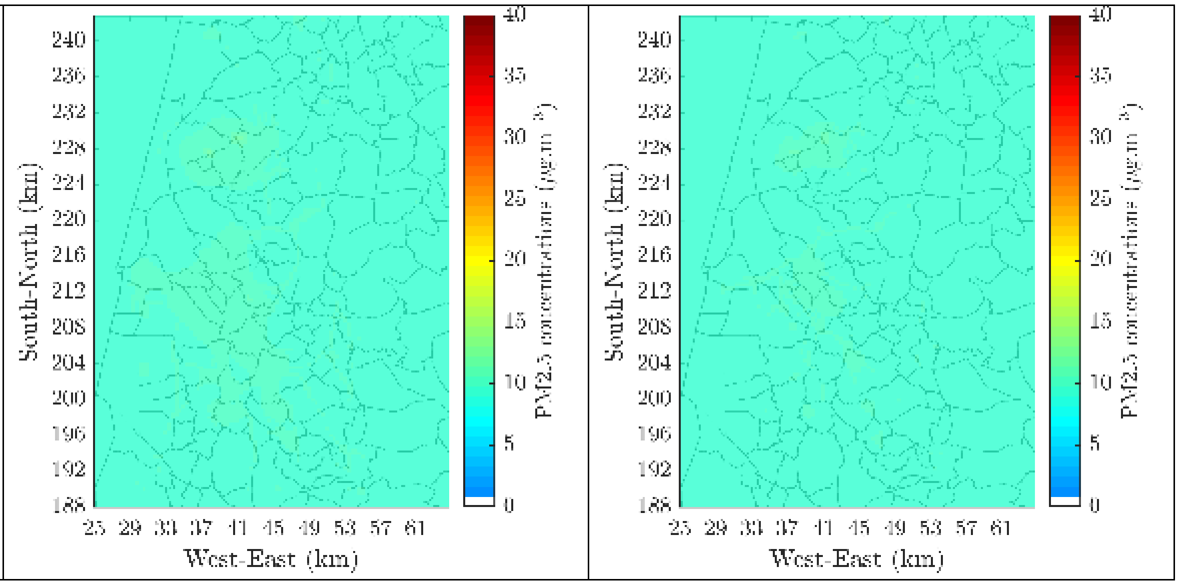
For PM. theemission reductions are limited in the BAU as well as in the UPS. Reductions are mainly observed for residential solid fuel consumption and to a lesser extent in industry. The measures in the UPS have a similar effect to the BAU due to lack of specific measures in the UPS targeting industry and residential heating. Given the low contribution of transport to PM emissions, the emission savings from transport in the UPS compared to BAU are negligible in the overall result.

Figure 5-2 gives an overview of modelled NO_2, PM_{10} and $PM_{2.5}$ concentrations in the BAU and UPS scenario in 2050. More detailed modelling results can be found in Annex B.

Figure 5-2 NO$_2$, PM$_{10}$ and PM$_{2.5}$ concentrations in the BAU and UPS scenario in 2050



PM2.5



The overall analysis of modelling results, comparing UPS and BAU modelling results with legal limit values and WHO guideline values, shows that:

- **Both BAU and UPS scenarios lead to compliance with legal NO_2 limit values in 2025.** In the BAU scenario, the maximum NO_2 concentration will be equal to 33.2 µg.m $^{-3}$ in 2025. In the UPS scenario, in 2025, the maximum NO_2 concentration will be equal to 24.3 µg.m $^{-3}$. The UPS scenario will achieve a reduction in the maximum NO_2 concentrations of 27% by 2025 and of further 7% by 2050, as compared to the BAU scenario.

- **For PM_{10}, the BAU and UPS scenario comply with the EU legal limit values, as well as with the WHO guidelines.** In 2025 the maximum value in the UPS scenario is 16.7 µg.m $^{-3}$ and in 2050, to 14.8 µg.m $^{-3.}$ This equals an 11% reduction of the maximum concentration compared to BAU. Based on the EU limit values and on the WHO guidelines there aren't any exceedances of PM_{10} concentrations. When comparing the UPS scenario with the BAU scenario, the maximum concentrations will be reduced by 0.3 and 11% respectively, in 2025 and 2050.

- **For $PM_{2.5}$, BAU and UPS scenarios comply with EU legal limit values, but even in the UPS scenario there are still significant exceedances of WHO guideline values in 2050.** In 2025 the maximum value in the UPS scenario corresponds to 11.7 µg.m $^{-3}$ and 11.0 µg.m $^{-3}$ in 2050, translating into a 6% reduction of the maximum concentration compared to BAU. Based on the WHO guidelines, 304 grid cells will still show exceedances in the UPS scenario in 2025. By 2050 this number is reduced to 99 cells. When comparing the UPS scenario with the BAU scenario, the maximum concentrations will be reduced by 0.1 and 6% respectively in 2025 and 2050

5.2 Impacts on health

Both UPS and BAU scenarios lead to moderate improvements in human health compared to the current situation when considering exposure to PM concentrations. However, both future scenarios improve substantially human health when considering

exposure to NO_2 concentrations (see Annex C for the methodology on the health impact assessment and results)**.** Table 5-1 shows the comparison between the future scenarios (BAU and UPS) against the baseline scenario, assessing the health impact benefits of the emission levels proposed by the scenarios. The benefit is the same, independently of the health impact indicator.

In 2015 (the baseline year), the number of premature deaths as a result of NO_2, PM_{10} and $PM_{2.5}$ is 63, 154, and 194 respectively. The health benefit from implementing the control measures behind the future emission scenarios (BAU and UPS) is considerable for NO_2 but moderate for particulate matter. **The BAU scenario reduces premature deaths as result of NO_2, PM_{10} and $PM_{2.5}$ by 100%, 5% and 2% in 2050 respectively. The UPS results in slightly larger reductions for PM_{10} (7%), and for $PM_{2.5}$ (3%)** than the BAU scenario but not for NO_2. UPS also reduces NO_2 in 100%, when compared to the current situation.

The health benefits from the emission reduction is in line with the concentration levels reduction predicted for the Aveiro Region for particulate matter. **For NO2, the reduction on the number premature deaths and the numbers of years of life lost is much higher than average concentration levels reduction**. This is explained by the emission reduction measures targeting the more densely populated areas, thus benefiting the population health.

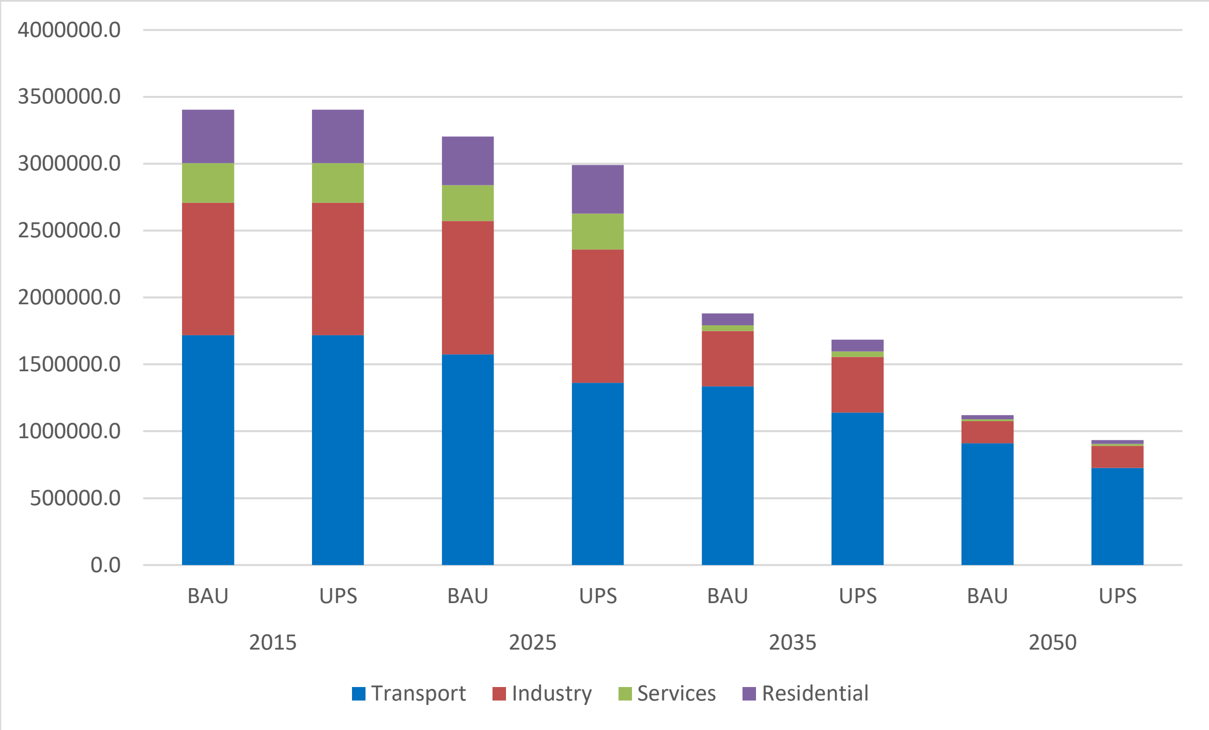
Table 5-1 Benchmarking the UPS emission scenarios in 2025, 2035, and 2050 against the baseline scenario in terms of health indicators (%) related to $PM_{2.5}$, PM_{10} and NO_2 exposure.

Premature deaths		$PM_{2.5}$			PM_{10}			NO_2	
Scenario / Year	2025	2035	2050	2025	2035	2050	2025	2035	2050
BAU	-2	-2	-2	-5	-5	-5	-85	-99	-100
UPS	-2	-3	-3	-5	-7	-7	-95	-100	-100

5.3 Impacts on carbon emissions

Figure 5-3 shows the impacts of UPS measures compared to the BAU scenario in terms of Carbon Footprint. The figure clearly shows that the UPS measures have a moderate impact on Carbon Footprint compared to the BAU. This impact is limited to transport sector emissions reduction as no additional measure is introduced in UPS addressing fossil fuel consumption in the other sectors. The figure shows that the positive effects of policy measures are most obvious in the long run, namely by 2035 and by 2050.

Figure 5-3 Carbon emissions in the UPS compared to BAU scenario (tonnes of CO_2-eq on life cycle)



5.4 Impacts on costs

Table 5-2 gives a qualitative estimate of the cost of the measures in the UPS scenario versus the BAU. We distinghuish between estimated monetary costs to citizens, costs for government / city council[23] and a net total cost to society, summing up both. An exact calculation of benefits and the indirect benefits of health improvement of citizens (saved public health costs) should also be taken into account but it is beyond the scope of the ClairCity modelling.

In total, net monetary cost effects of the 10 UPS measures vary substantially and will sometimes result in additional costs and other times in net benefits for citizens and for government. Exact costs will also depend on how measures are designed in detail. Further detail of the assumptions made is given in annex C. The annex also gives an order-of-magnitude cost estimate of car user costs, car charging revenues and bus subsidies in the UPS compared to the BAU scenario.

However, the overall balance of direct costs of all measures in the citizens' UPS scenario together suggests that a cost effective execution of the UPS for citizens and city council / government is very well possible, as measures with a net direct cost to society can be

[23] No distinction is made between different levels of government.

balanced by measures with net revenues. This balance would be even more positive if also the indirect health benefits of improved health of citizens would be added.

Table 5-2 Estimated cost impacts of citizen measures that are part of the UPS scenario in the Aveiro Region

#	Policy measure	Citizens	Government	Society
1	Build segregated urban cycle lanes and create secure cycle storage/parking	n/a	n/a	n/a
2	Create school and workplace travel plans to increase uptake of active travel and public transport	0	0	0
3	Reallocate road space to pedestrians and improve safety	n/a	n/a	n/a
4	Ban diesel cars/HGVs in urban centres	-	0	-
5	Allow free parking for electric vehicles only	+	-	0
6	Promote working from home	0	0	0
7	Impose stricter regulation on polluting industries	0	0	-
8	Encourage replacement of older public transport fleet	0	-	-
9	Subsidise public transport tickets	+	-	-
10	Increase provision and reliability of public transport services	+	-	-

(+) assumed net positive effect/ benefits for target group; (-) assumed net negative effect / costs for target group; n/a effect of measure cannot be assessed

The assumed cost effects per measure are explained in more detail below:

1. (and 3) are both infrastructure related measures, the cost impact of which cannot be assessed without extra information. When assuming a reallocation of the (fixed) investment fund in infrastructure (i.e. from road for cars to infrastructure for walking and cycling), there is no extra cost. When assuming an aggressive investment strategy in new walking/cycling infrastructure, this measure would come at an (extra) cost to the government. Therefore, we did not consider this measure to have a direct measurable cost effect.
2. **School and workplace travel plans are fully behaviour-related measures which entail no cost**. These measures can be promoted through awareness campaigns whose cost is considered negligible. As such it is concluded that this measure will not incur costs.
4. **Banning polluting cars leads to early scrappage of the existing car fleet, and hence to a loss of capital for private owners** (-). **The measure is assumed to be cost neutral for government** (0), leading to an overal net **negative cost effect on society** (-). This measure only applies to the urban centres in the Aveiro Region.
5. **Free parking for EV's incentivices the use of EV's and comes at the expense of parking ticket revenue for the governement** (-). **This policy will lead to a (limited) benefit for citizens via avoided parking fee's** (+). This results in a **net neutral societal impact.**
6. **Promoting working from home** is expected to have **no cost for citizens and governement**.
7. There is still a cost to be absorbed by the industry if stricter regulation on polluting industries is imposed. Reducing industrial emissions requires investment in exhaust

treatment technology, a cost borne by the industry, with no cost impact on citizen or government. Hence the total negative cost effect on society (-).

8. **Cleaner buses require extra investment at a cost to the government** (-) without a cost effect on citizens (0), leading to an **overall net negative cost effect on society** (-).
9. (and 10) **Cheaper and more reliable public transport requires a higher subsidy for buses to be provided by government** (-). This measure leads to a cost decrease for citizens (lower fares) (+), yet at a greater expense for the government as incremental model shift to public transport is assumed to require a larger subsidy. **The overall societal cost effect is** therefore considered to be **negative** (-).

The most relevant measure in terms of emissions as well as cost impact, is the ban that leads to early scrappage. . That will induce a higher cost for citizens in the early years, when the accelerated scrappage will be the highest. Secondly, the measures that will make public transport more attractive (lower prices, increased reliability, clean busses) will lead to higher governmental expenditure on subsidies.

Further detail of the assumptions made is given in annex B. The annex also gives an order-of-magnitude cost estimate of car user costs, car tax revenues and bus subsidies in the UPS compared to the BAU scenario.

6 The Aveiro Region and other ClairCity cities – Mutual learning for citizen-inclusive policy making

In this chapter, the following are discussed: the main institutional conditions and barriers for implementing citizen policy preferences in the Aveiro Region (section 6.1), the policymaking lessons that the Aveiro Region can offer other cities (section 6.2) and the lessons that the Aveiro Region can learn from the other ClairCity case study cities/regions (section 6.3).

6.1 Institutional conditions and barriers for citizen-inclusive policies in the Aveiro Region

From interviews with stakeholders and policy makers in Aveiro Region and an extensive literature review of Aveiro Region, several specific institutional conditions were identified that appear relevant for a successful implementation of citizen-inclusive policies. Among others, political framing, finance, the existing citizen-engagement culture in city policy making and links with other stakeholders and governance levels were identified as relevant categories of institutional conditions.

Political framing

The Aveiro Region meets its air quality standards and there are no clear local hotspots of poor air quality. As such there is no notable public debate on further improving air quality and hooks such as “health / premature deaths” for attracting public attention and supporting ambitious policies are lacking. Climate change does neither seem a very prowerful frame for policies. While flooding has occurred in recent years, its attribution to climate change is difficult. What is important and very high on the current agenda in the Aveiro Region, however, is mobility.

Financing policies

Overall the standpoint of the region is that air quality and climate policies are expensive both for the city and for citizens, and cities as well as citizens lack funds for implementing such. Against this backdrop financial limitations are the main reason why further – or more stringent - policies are not taken. At the same time, the effectiveness of several policies in place is questioned by policymakers themeselves (for example, it still needs to be assessed if the government tariff reduction support program to encourage the use of public transport has effectively contributed to increasing the number of users or just benefited current users). Currently an exception are investments for cycling lanes, as the current real state situation is favorable to this expansion of cycling lanes.

Citizen and other stakeholder engagement culture

Overall citizen engagement in air quality and climate policies is low in the Aveiro Region. There are a couple of advisory panels for dialogue such as PACOPAR for industry, and the Agency for Sustainability and Competitiveness, with a much broader focus. Further citizen activities are mainly transport based and directed at education (e.g. encouraging cycling). There are no such activities visible in the field of energy.

Governance levels

A hierarchy of four-five levels of policy making determines local policies in the Aveiro Region: the EU, the national government, the Centre of Portugal and the Aveiro Region itself. On an even smaller scale, also the municipalities within the Aveiro Region have their responsibilities. Local authorities, in principle, could set more ambitious air quality or carbon targets than the national level but so far these opportunities have not yet been used in the Aveiro Region. In fact municipalities individually have more room for maneuvre than the Aveiro Region, whose decisions depend on the agreement of all 11 municipalities.

In addition, the central Government in Portugal has widely invested in promoting car use in the past decades, which has gone at the expenses public transport and networks investment. That has caused that overall in Portugal (with some exception in the large metropolitan areas of Lisbon and Porto) public transport services have been degraded and people are attached to their cars. This is a trend that is hard to reverse.

Public transport competence

The responsibility for public transport has only been transferred from the national to the local level in 2015. This is a very short time and therefore its evolution is still to be seen. This recent history makes also that local tendering processes for transport service providers are new for municipalities. Whereas the possibility of awarding the proposals that present more environmental solutions was consideded when evaluating the options, the tender was awarded to the company offering lowest price on offer.[24] There dilemma in this regard is as follows: Transport providers are hindered by the lack of infrastructure and equipment (e.g. electric buses), which have to be purchased abroad due to lack of national market. This makes the most environmental solutions expensive, which if adopted, would require to increase the cost of the service provided.

Capitalising on EU thematic weeks

Since 2000, many of CIRA municipalities have yearly participated in almost every edition of the European Mobility Week (EMW), as well as its predecessor European Day without Cars. The MBW is therefore a popular initiative to raise awareness of sustainable urban mobility. This is not the case in other ClairCity cities.

Air quality information availability and reliability

Although it is outside of the scope of this report to assess the quality of the air quality monitoring network, it should be noted that there are currently only three monitoring stations. This is quite limited in comparison to other ClairCity case studies which have a much wider network of air quality measuring stations measuring pollution in the Aveiro Region: Aveiro (traffic), Estarreja (Industry) and Ílhavo (background). This is quite limited in comparison to other ClairCity case studies which have a much wider network of air quality measuring stations.

6.2 Lessons from the Aveiro Region for other cities

The most exemplary policies that the Aveiro Region can offer the other ClairCity case studies as inspiration concern the promotion of cycling among children and an example of intermunicipal collaboration.

- **Local and regional initiatives centring in particular around kids and schools are helping to create a basis for renewed cycling culture.**
  While only realised at a small scale now, bringing kids to school by bike and teaching them how to repair a bike at school are central elements in reintroducing the bike as a central means of transport in the Aveiro Region. As school children in Portugal are almost always brought to school by car, Ciclaveiro[25] initiated a project called 'Cyclebus' at one primary school in which children and parents cycle together to school in a group. Another successful project carried out by Ciclaveiro was 'Bike buddy' project, in which people who didn't feel safe to bike alone were accompanied by cycling 'buddies'. In a school in the Ílhavo municipality of the Aveiro Region, initiated by a teacher, a workshop to repair bikes was established which has had great success. In their free time kids can repair old bikes and create new ones with old spare parts.

- **Closely working together with nearby municipalities**

[24] Project interviews in Aveiro suggested that.
[25] Ciclaveiro, is a group of citizens who aim to promote cycling, especially on a day-to-day basis, for commuting from home to work / school or to shops.

The Aveiro Region as such exists since a decade. However, the eleven municipalities that compose it have a long tradition of cooperation between them on environmental issues due to the Ria (lagoon). Further the Agency for Sustainability and Competitiveness[26] is a project that aims to help municipalities in the Region of Aveiro to work towards sustainable development goals. The Agency is formed by citizens representing each one of the Aveiro Region municipalities and the Region itself. Their work is structured around 7 themes (Policies for the Green Economy, Energy Efficiency, Water Efficiency, Waste Valorisation, Sustainable Construction, Climate Change Adaptation and Sustainable Mobility and Ecotourism).

- **Closely working with industry**
  PACOPAR[27] in the Estarreja industrial district of the Aveiro Region, is a great example of joint organisation of industries and local community representatives. It is an 'advisory panel' with focus on safety and environmental issues (including air quality). PACOPAR was set up in 2001 as the local implementation of the international 'responsible care' programme of the chemical industry that came in place after major environmental incidents with chemical plants worldwide. It emerged from the need to improve transparency for society. Its goal is to share information about their safety operations with the community and organise open doors days with the aim to promote awareness and transparency. The local community representatives in PACOPAR include: civil protection, health services, Academia (Environment & Planning Department of the Aveiro University) and local NGOs. They also have close ties with the port, where many of the raw materials come from and have good working relationships with the Estarreja Council and with local citizens.

6.3 Lessons from other ClairCity cities for the Aveiro Region

The Aveiro Region could benefit from exchanges with other ClairCity cities that have more developed (district) heating policies, more developed public transport (ticketing systems, train/bus network) and more developed private transport policies such as the introduction of clean air / environmental / pedestrian zones, parking permits and electrical vehicle policies or the stimulation of active transport (cycling and walking).

Environmental zone / clean air zone

A pedestrian zone in a city contributes to a pleasant and green city with clean air and invites active transport such as walking and cycling. Several types of Clean Air Zones and bans of different kinds of vehicles were found in the ClairCity cities. None of the cities had a congestion management or charging system. Evidence from other ClairCity cities suggests that a gradual introduction, some political courage to overcome initial resistance and alternatives for the part of population that do need motorised vehicles (e.g. elderly) could contribute to a successful implementation of a Clean Air Zone in the Aveiro region.

[27] Painel Consultivo Comunitário do Programa Atuação Responsável - Community Advisory Panel for the Responsible Action Program

Textbox 6-1 Relevant experiences from ClairCity for the an Aveiro environmental zone / clear air zone

- In **Amsterdam**, the environmental zone was introduced gradually for different types of vehicles, initially not implementing a ban for private cars. Now that citizens are used to the zones for mopeds, buses, taxis and freight transport and these zones are more or less accepted, also a ban for polluting private cars will be implemented, making the city centre 'emission free' by 2030.
- **Ljubljana** has converted the inner city centre into a pedestrian zone, including a free biking scheme and electrical short-distance taxis. Initial resistance of citizens and business against the pedestrianisation has now turned into massive support as living quality and economic development in the form of tourism have substantially increased over recent years. Ljubljana – pedestrian zone. Initial concerns of local commerce over potential reduced business were proved wrong, as the pedestrian zone has actually contributed to a large increase in tourism and business in recent years. Electric taxis within the zone and a free biking scheme further provide alternative modes of transport within the zone, also for the disabled and elderly.
- **Genoa** wanted to introduce a clean air zone ban of older Vespas. Strong resistance against this ban from Vespa-drivers in the city of origin of the Vespas meant that the proposed ban was withdrawn. Only recently has it been reconsidered.

Encouraging cycling

Virtually all municipalities of the Aveiro Region offer free bicycle municipal systems to citizens but these are not always widely used. Except for the municipalities of Murtosa and Ilhavo, where biking is ingrained in daily life, cycling in the rest of municipalities is mainly for recreational purposes. The experiences in other ClairCity cities suggest that effective modal shift policies towards cycling tend to consist of a combination of education and awareness raising (starting at schools, which the Aveiro Region is already doing) accompanied by large-scale infrastructural adaptations such as the building of bike parkings and increasing road space for cycling to ensure safety and comfort.

Textbox 6-2 Relevant experiences from ClairCity for stimulating active transport

- In **Amsterdam**, cycling is a central part of city transport culture. Cycling traffic lights, bike lanes and paths as well as an integrated train and bike-rent system are already implemented since several years. Providing sufficient bike parkings, reducing car road space in favour of bikes, and spatial planning for short as well as long-distance biking are now central elements in further scaling up of cycling in Amsterdam.
- In **Sosnowiec**, where biking is not a typical mode of transport, a municipal bike-sharing scheme was introduced in April 2018. A first network of bycicle paths was built for its launch.
- In **Bristol**, people that have not cycled for a time can get a one-month bike loan free of charge.

Public transport improvement

The biggest challenge for the Aveiro Region in terms of public transport comes from its geographic / demographic characteristics: it is far more rural and less densely populated than the other ClairCity case study cities. This makes infrastructure investments for a wide transport network and frequent connections costly and less efficient. In turn public transport does not currently offer the comfort the car does. The Aveiro region can learn from the train and bus developments that other cities have recently implemented in order to link less inhabited areas to the main city hubs. In addition a few experiences of the ClairCity case studies show that one ticket for all public transport and integration of the public transport ticket with bike rent can be helpful as a first step to making public transport convenient.

Textbox 6-3 Relevant experiences from ClairCity for stimulating public transport

- **Ljubljana** has integrated its city and regional transport, which can now be travelled with one ticket. According to interviewees, commuting by public transport into the city has been much facilitated in this way.
- **Amsterdam** and the Netherlands have a popular integrated train, bus and bike-rent system that can be travelled with one ticket, which facilitates door-to-door transport.
- **Bristol** has recently implemented large-scale improvements of public transport to connect the city and the metropolitan area: the MetroBus (a bus service for the larger Bristol area which works with 'buy before you board' ticketing to ensure limited stopping, faster boarding and shorter journey times) and MetroWest (project that improves rail connections in the region).

Discouraging private car use

Key for modal shift is that besides making active transport and public transport more attractive (for example by reducing space for cars in the city and making more room for pedestrians, bikes and buses, as previously mentioned), private car use is made less attractive. This can be done by increasing parking tariffs or by reducing the number of residents' parking permits. Parking tariffs do not only discourage car use but, as additional revenue, also can support investments in active mobility and public transport.

Textbox 6-4 Relevant experiences from ClairCity for stimulating active transport

- In **Amsterdam**, through high parking tariffs for the city centre (7 euros an hour) and reducing the number of residents' parking permits, access to the city by car is made less attractive.
- In **Bristol**, limiting access for cars to the historical city centre during working hours is part of the public discussion going on early 2020.

Cleaner private transport

Cleaner cars policies e.g. tax deductions for electric vehicles, are mainly competence of central governments. However ClairCity evidence suggests that cities can also take action in this regard. Facilitating public parking (space, free parking etc) for electrical vehicles can contribute to the attractiveness of electric cars.

Textbox 6-5 Relevant experiences from ClairCity for stimulating cleaner private transport

- In the case of **Amsterdam, where the problem is scarcity of parking,** parking space reserved for electrical car recharging has led to some car owners to switch to an electrical car**.**

Energy measures

There are good practices in ClairCity case studies that can be relevant for the Aveiro Region, given the current lack of heating systems in the majority of homes and buildings. Cities such as Sosnowiec, Ljubljana and Amsterdam have substantial experience with district heating and are also considering expansion of their heating networks. All ClairCity cities are working on expanding energy efficiency of their housing stock. Development of rooftop PV is expanding particularly rapid in Amsterdam. Biomass burning is a policy measure that deserves attention in the future, as it is assumed to be positive for climate change targets but has also negative impacts for air pollution.

Textbox 6-6 Relevant experiences from ClairCity for stimulating energy measures

- **Sosnowiec** and **Ljubljana** show that wood and waste burning – partly from the surroundings (Ljubljana) can have strong detrimental impacts on air quality. This has to be taken into account in particular as wood burning is now often seen as a positive measure from a climate policy point of view.
- **Sosnowiec – public air pollution information**
  In the Polish city of Sosnowiec, winter smog due to air pollution caused in particular by low-quality fuels for home heating is a serious health risk. In order to increase awareness about health risks related to air quality, the city council publishes up-to-date air quality data on public transport information screens.
- **Bristol** is now developing a heat network starting with the inner city centre.

Other measures

Other best practices found in ClairCity case studies that could be insipire the Aveiro Region and contribute to further policy development in the Region regard new ways of providing air quality feedback to citizens, engaging citizens in air quality measurement and specific attention to deprived groups. In addition, ClairCity has found that NGOs are a very important intermediate in engaging citizens not just in Aveiro, but in the other ClairCity case studies as well. Hence, maintaining good relationships with, and support for these NGOs seems to be an important way to stimulate citizen-inclusive policies.

Textbox 6-7 Other relevant experiences from ClairCity for air quality and carbon policies

- **Sosnowiec** provides real-time air quality information to citizens through the electronic transport information system in the city. In this way, awareness of changes in air quality in the city is increased.
- In **Amsterdam**, an active network of citzens measure air quality at home with low-cost equipment. These measurements supplement the official air quality measurements in the city.
- In **Bristol** specific attention is given to deprived groups in air quality and carbon policy making.

7 Innovative citizen-inclusive air quality and carbon policies in the Aveiro Region: Conclusions and recommendations

This chapter outlines the main conclusions of the ClairCity citizen engagement process in the Aveiro Region and the results of the modelling and analysis thereof. Section 7.1 presents the main conclusions; Section 7.2 gives the main recommendations for future policy making in the Aveiro Region.

7.1 Conclusions

In ClairCity, citizen-inclusive policy making was interpreted as to consist of three main activities: analysing the detailed current behaviours of citizens, asking citizens about their preferences for their own future behaviours and enquiring about their preferred city policies for the future. Preferred policies of citizens were discussed with policy makers, quantified and assessed for their impacts in three different ways: regarding emissions and concentrations of air pollutants and CO_2, regarding health and regarding costs. Institutional conditions and barriers for implementing citizen measures were examined and compared with experiences in other ClairCity cities. The main conclusions of all these activities are discussed below.

7.1.1 Current air quality situation and city policies in the Aveiro Region

Air quality in the Aveiro Region is relatively good and compliant with EU limit values. $PM_{2.5}$ is probably the polutant of largest concern. The ClairCity modeling shows that 49% of the population in the Aveiro Region is exposed to $PM_{2.5}$ concentrations above WHO guidelines.

Overall currently air quality and climate policies are not high on the political agenda in the Aveiro Region. Improvement of (public) transport, on the other hand, is a priority and expected to evolve. As such, the main local policies targeted at citizens are on the improvement of public transport and improvement of bike infrastructure. A reduction of fares (50% by 2021) and the replacement of 30% of the public transport fleet with zero-emission vehicles (by 2030) are in the planning, next to bans on the oldest diesel cars and HGVs on urban areas (by 2030). However, it seems unlikely that these measures alone will be able to achieve the very ambitious modal shift[28] envisaged both by citizens and policy makers. In particular, measures to make private car use less attractive are lacking, possibly because these tend to be unpopular. As result, the pace of these improvements is rather slow and no modal shifts towards these transport modes have been observed to date. This is no surprising knowing that Aveiro Region’s public transport infrastructure and service has suffered from the lack of investment of the Portuguese government on public transport (the central government has on the contrary invested generously in policies to support private car use) outside of the main metropolitan areas of Lisbon and Porto.

[28] 50% modal shift from private cars to active travel and public transport by 2030

For CO_2, there are no legal requirements on a local level, and unlike in other ClairCity cities (e.g. Amsterdam, Bristol), there is no climate neutrality ambition.

7.1.2 Current behaviours of citizens

Current behavioural practices of citizens substantially contribute to air pollution and carbon emissions in the city. After industry, car transport is the main contributor to NOx emissions, and it also contributes to a reasonable share of PM_{10} emissions. A very high percentage of citizens use currently 'always' a car for commuting to work (65%), going shopping (67%) or for leisure (44%). Public transport and active travel[29] figures are really small compared to other ClairCity case studies. Leisure is the activity for which public transport and active travel are most popular in the Aveiro Region citizens currently.

Figure 7-1 Percertage of citizens in the Aveiro Region 'always' using a car for commuting to work, shopping or leisure

7.1.3 Behavioural preferences of citizens for the future

There is a mismatch between citizens transport and heating behaviour at present and how citizens would like to behave in the future regarding these. An example of the mismatch is the observed overwhelming car use in the present (particularly for commuting and shopping), while the great majority of citizens indicate that they would wish to reach work, leisure and shopping by public transport or through active travel. This indicates that many citizens would be willing to change their own transport behaviour as a contribution to ambitious air quality and carbon policies if the Aveiro Region facilitates / enables that. For heating, the situation is the same. Citizens currently heat their homes with solid fuels or electricity, while their preference for the future is to do so with renewables instead. Some specific conclusions are given below:

- **There is a huge demand for public transport and active travel in the future provided that current barriers are overcome**
  Despite the overwhelming reliance on cars in the present for commuting to work, shopping and leisure, respectively 75%, 56% and 68% of respondents does not want to be using a car for these activities in the future. This indicates a very large latent demand for alternatives in the Aveiro Region. The main barrier for the use of public

[29] Note that these are a combined category in the survey

transport is the convenience cars offer. Coverage, frequency and travel times of public transport are rather poor at the moment and therefore a disadvantage in comparison to the comfor a car offers. In addition, parking is easy and often free overall in the Aveiro Region. The main barrier for active travel is the fact that cycling infrastructure is not very developed yet.

- **There is interest from citizens for renewables for residential heating**
  ClairCity identified a huge demand for renewables to heat homes in the future (an increase of 50% compared to the current situation). This would go mostly at the expense of solid fuels and electric heating, which several citizens would rather not use in the future. The main barrier for this from the perspective of the citizens is the cost. It should be noted that there are some citizens who are in favour of wood or pellets for they consider these an environmental or renewable heat source. In the context of this project they are identified as polluting due to the air quality issues they generate.

7.1.4 Policy preferences of citizens for the future

In terms of policy priorities, policymakers and citizens are aligned regarding the facilitation of active travel and improving public transport, which is a priority for both. Further specific conclusions are as follows:

- **Citizens favour transport related measures including measures that affect private cars despite their current behaviour says otherwise**
  ClairCity has found a striking preference of Aveiro Region citizens for transport measures (over heating measures). Measures addressing public transport are the most popular, followed by active travel measures and measures to discourage conventional cars and other vehicles. It should be mentioned that this is at odds with current behaviour of citizens. Further, both citizens and policymakers agree making parking free *just* for EVs is a suitable measure to greening the car-fleet.

- **‘Promoting working from home’ and ‘Increasing space for pedestrians’ are relatively low hanging fruits**
  ‘Promoting working from home’ and ‘Increasing space for pedestrians’ are two measures proposed by citizens that policy makers consider “easy to implement”. Promoting working from home requires creating a suitable working environment at home. Provided that it is financed by the private sector (i.e. business) and citizens themselves, this would have no costs for the Aveiro Region. In that sense it is a low-hanging fruit measure that could be put forward relatively easily and quickly. Working from home however does require a main shift in working culture and a good internet infrastructure in place. The measure may be trickier to implement in the public sector, where civil servants need to clock in and out of work. The measure would in this case imply costs for the regional government.

- **Although residential heating is a main source of PM emissions, this is not perceived as an air pollution source by Aveiro Region citizens**
  ClairCity found that the Aveiro Region citizens do not perceive heating / energy as a priority area for action. However home heating is the main source for PM_{10}, and so

tackling this is presumably were most of the gains can be achieved for PM_{10} reductions. Tackling emisions from heating would also climate action i.e. reduction of CO_2 (whose emissions have increased unlike in the other ClairCity case studies) which originates mainly from energy use of buildings, industry and transport. Moreover, citizens showed a huge preference for heating their homes with renewables in the future. The fact that citizens have not come up with one single energy / heating measure is an indication either of lack of knowledge (e.g. on how heating can be a source of polution, on alternatives heating options) or lack of empowerment to ask authorities to do something about it.

7.1.5 Consequences of the policy preferences

If implemented, the measures proposed by citizens (Unified Policy Scenario - UPS) would result in notable health improvements for citizens compared to the situation in the baseline year 2015. According to the ClairCity modelling, policy makers' ambition on citizens measures (i.e. the UPS) would lead to a reduction of 100% premature deaths as consequence of NO_2, 7% reduction in premature deaths as consequence of PM_{10}, and 3% reduction for $PM_{2.5}$.[30] Citizen measures (i.e. the UPS) will also lead to significant carbon emission reductions.

However it should be noted that the additional health benefits of the UPS in comparison to the BAU are rather small. In other words, the ambition that policy makers have chosen for the measures that citizens propose (by 2025, 2035 and 2050) to significantly better results for air quality than the measures already implemented by the region will.[31] By 2050 the UPS only leads to improvements over the BAU for PM_{10}; for NO_2, the UPS and BAU achieve same results by 2050, although the UPS does so quicker (by 2025 and 2035 larger health benefits are observed for the UPS). Carbon emission reductions of citizen measures are also moderately higher than what the BAU (measures currently in place will) would otherwise achieve.

In comparison to the baseline in year 2015, both the UPS and BAU scenarios improve human health substantially when considering exposure to NO_2 concentrations in particular (concerning PM concentrations both scenarios lead to moderate improvements in human health compared to the current situation). The reduction on premature deaths and years of life lost as consequence of NO_2 concentrations is much higher than average concentration levels reduction in both scenarios. This is because NO_2 measures will be implemented in high(er) populated areas.

7.2 Policy recommendations

The following recommendations are tailored to the Aveiro Region (municipalities) based on the analyses of current behavioural practices, preferred future behaviours and preferred

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[30] In 2015 (the baseline year), the number of premature deaths as a result of NO_2, PM_{10} and $PM_{2.5}$ is 56, 156, and 130 respectively.

[31] This may partly also be due to the fact that the quantification of ClairCity measures modelled has not been detailed enough to capture nuances in measures that would lead to more significant differences between the BAU and the UPS.

future policies of citizens, as well as of impact and an institutional context carried out by ClairCity.

7.2.1 Policies to address current behavioural practices and preferred future behaviours

From the detailed analysis of current and preferred future behaviours of citizens we conclude that the following mix of policy measures are worth considering. The measures should be taken alltogether for optimal result.

- **Facilitate cycling through developing an urban bike network and further promote walking**
  It was found in the ClairCity analysis that Aveiro Region citizens want to walk and cycle more. Cycling should be facilitated by infrastructural measures such as urban cycle lanes that reach where citizens want to get on a daily basis, as opposed to the leisure bike routes that currently dominate the Aveiro Region. Fostering intermodality that is, the integration of cycling with public transport, for instance, by offering bike rental options at popular train and bus stations, is also key. In order to make cycling safer, cycling traffic lights and bike parking facilities should be implemented. In addition, municipal bike systems should be widely promoted. The attractiveness of walking can be promoted by awareness campaigns that stress its health benefits. Expanding pedestrian zones and equipping them with electrical mini-taxis for residents in need (elderly, mother with a small kid etc) can be considered.

- **Public transport development and constant improvement needs to go along with other measures to discourage car use and collect revenues for financing public transport**
  The efforts in recent years to develop public transport are a positive sign but public transport problems seem to persist (coverage, frequency, travel time). To make public transport more feasible and therefore appealing, continued and further improvement of public transport is needed. This can be done by linking municipalities and by offering more frequent and wider (more lines) services. What is key is that improvements in public transport go hand in hand with discouraging car use. Examples of this are expanding car-free, pedestrian zones; limiting parking spaces in the city centre of the Aveiro Region municipalities; and most importantly, making parking more expensive (higher fees where parking is already paid and starting to charge where parking is still free). Extra fees are excellent government revenue to fund further measures. A policy that could work to stimulate EVs would be paid to make parking free only for these type of vehicles (and high fees for the rest).

- **Promote alternatives to private car use and make public transport more attractive**
  A city transport plan and communications campaign that shows that a private car is not the only feasible way to get to work, shops or leisure is needed in the Aveiro Region. Next to financially punishing car use, promoting public transport is necessary to change well-rooted habits and address the status symbol that cars currently have in the Aveiro Region. Campaigns should be directed to promoting the alternatives to private car use, communicating widely about public transport services available, and about any improvements made in that regard. Promoting cycling not only for leisure, but also as an

efficient and healthy way for commuting should be part of the campaign. The communications messages could also make reference to the cycling culture that the Aveiro Region had in the past. Such a campaign should also serve to tackle issues such as the fact that the school transport network in the Aveiro Region (financed by the Municipalities with high cost) is not widely used in practice.

- **Intensify cooperation with employers, schools, destinations of leisure and shopping to minimise car travel.**
  ClairCity found that the great majority of citizens in the Aveiro Region would rather use public transport or active travel for communting, leisure and shopping. Particularly for commuting, the difference between the current situation (65% go always by car) and the desifdred situation (75% would like to go to work by public transport, active travel or other ways that a private car) is striking. The barriers that citizens encounter for changing their behaviour, such as current limitations of public and active transport infrastructure (public transport and bike lanes that do not reach these facilites), should be addressed as mentioned on the points above. In addition, the promotion of active travel and public transport requires intensified cooperation with big employers as well as destinations of leisure and shopping (e.g. retailers, shopping malls, sports clubs, theaters or cinemas). Options for bus stops and bike parking next to these destinations, together with biking infrastructure to get there should be considered. Engagement of schools is also essential. These could take the societal role of encouraging children and parents to avoid travelling by car, for example by distributing a survey to parents enquiring why they do not use the free bus available to all kids. School and workplace travel plans are mostly behaviour-related measures which entail no cost for the Aveiro Region government when these are promoted through awareness raising campaigns (the cost of campaigns is considered negligible) and when ultimately employers and schools are responsible for executing such. In addition, working from home is a measure citizens would be keen to see implemented. This has no cost neither for citizens nor for the regional / local governement when private business are financing the shift. It can however be more complicated when trying to implement it for public authorities. Further, city planning should consider encouraging more jobs, leisure and shopping options close by to where people live.

- **Air quality should be integrated in the current educational offer and further promoted by NGOs**
  Air quality related education could be integrated as part of the sustainability education, already introduced in the local schools curricula. However, educational options are limited and largely voluntary. Giving sustainability education - and in turn air quality education - a more prominent place in the curriculum, is essential to raise awareness of the youngest generations and their parents. Air quality education should address directly the activities / sources of polution that citizens can relate to, which are also the most important local emission sources i.e. private cars and domestic heating. Addressing why it is important to go to school by public transport or active travel, should be part of sustainability education. These classes should also address the issues around biomass and raise awareness around the fact that home heating is currently the main source for PM_{10}. In addition, maintaining good relationships with environmental NGOs, as intermediates between authorities and citizens, is important, and so is liasing with them for educating children and society is considered useful.

- **Promoting energy efficient renovation of buildings, support local PV implementation and raised awareness on the negative health effects of biomass burning**
  Providing the existing building stock with thermal insulation would help bring down energy demand and reduce domestic heating bills at the same time. Setting standards for domestic heating fuels and devices would bring down local emissions as well and provide direct feedback on behaviour. However, this would probably have to be initiated at the national level. The ClairCity engagement process showed that many citizens want to change to renewables for home heating in the future. Dedicated spatial planning, promoting the expansion of national support for rooftop solar PV, increasing rooftop solar on public buildings and supporting local citizen cooperatives for renewables generation could be measures to achieve this. In addition, the dilemma of biomass burning (positive for climate, bad for air quality and thus health) should be seriously considered and communicated to citizens. Portuguese national law includes forest biomass residues burining as a renewable source for the achievement of renewables tagets. This can cause confusion among citizens, who are often not aware of the negative effects of biomass burning particularly in urban areas where people live close to each other.

- **Make citizen support for current and planned policies more explicit and accelerate policy implementation**
  The ClairCity analysis revealed that many citizens support not only the air quality and carbon policies that will bring direct benefits for them (e.g. improved public transport), but also support already happening / planned policies that will affect their lives (e.g. free parking only for EVs, reallocation of road space to pedestrians and improve safety). For public transport policies citizens demand more ambition and speed in their implementation. Against this backdrop, communication of the citizen support for existing policies should be used to generate a wider acceptability of policies. Implementation can be facilitated by a detailed year-by-year implementation plan of long-term policy ambitions, as this could help identify where implementation can be accelerated.

7.2.2 Addressing institutional barriers and mutual learning

- **'Improving transport options' rather than 'improving air quality' or 'improving health' is the best hook for framing air quality and carbon policies**
  Considering that neither awareness nor interest on air quality are high, and that air pollution is not accute in the Aveiro Region, other hooks (messages that resonate with citizens) need to be sought. Mobility, is in this case a suitable hook. Improvement of transport in the Aveiro Region municipalities and between them is a top priority and something citizens really look forward to. At the same time mobility tighly related to air quality.

- **Using public procurement and independent monitoring of the system to improve environmental performance and service of overall public transport**
  The opportunity that Aveiro Region has since 2015 to manage its public transport is a good opportunity for the region to set strict rules in tendering. In the free market where different companies compete in tendering, the Aveiro Region can require strict environmental performance (how clean the busses network has to be) and quality of transport (service provided in terms of coverage, frequency and travel times) from

providers. In addition, an independent party or system to monitor the quality of the public transport service should be considered to shift from the current situation were the provider mornitors its own performance (and so distruct exists on whether they report true numbers).

- **Compensate costs of required infrastructural measures by revenue generating local financial instruments and communicate the need for such instruments.**
  Finance is a key institutional condition that determines the possibilities for implementing citizen-inclusive policies. Wide public transport improvements for instance are costly and compensating its costs by generating local funding through for example parking fees and permits, congestion levies or workplace parking levies, could mitigate this hurdle. Such financial burden tends to be less popular with citizens, hence the to properly communicate the need for it. Also, authorities should consider possibilities to reward behavioural change (e.g. bike parkings and rentals offering discounts at local shops). Next to that, whether current funds are being used in the most efficient way needs to be questioned (for example, if the government tariff reduction support program to encourage the use of public transport has effectively contributed to increasing the number of users or just benefited current users).

- **Continue with low-barrier, long-term relationships with other cities to encourage experimenting and mutual learning.**
  ClairCity shows many EU cities struggle with similar implementation issues for citizen-inclusive air quality and carbon policies. It is therefore recommended to maintain a regular and long-term exchange with other cities, both in the Region, in Portugal and in Europe. Particularly interesting for the Aveiro Region are cities that are trying to overcome / have overcome a long tradition of car use to transition towards a wide use of public transport and an increased use of active travel. Since cooperations are often dependent on project funding, in particular low-cost and little-effort opportunities for regular exchange beyond such funding (e.g. video-conferencing, informal networks) should be examined.

Annex A. The ClairCity process in detail

This annex explains in more detail the ClairCity process and the positioning of this policy package report.

The ClairCity project consists of three phases and seven work packages (Figure A-1):

Phase 1: Establish the Baseline Evidence

The primary aim of Phase 1 is to understand and quantify the baseline status of air quality, carbon emissions and related public health in our cities. Phase 1 is achieved with the following main activities:

1. **Benchmarking behaviour**: Understanding the local demographic data and establishing the citizen practice-activity data to feed into the air quality models.
2. **Quantify the baseline**: Quantification of the baseline air quality emissions and concentrations, carbon emissions and public health impacts in a city.
3. **Assessment of Policy**: Collation and analysis of current policies (local, regional, national and EU) that influence the city.

Phase 2: Citizen and Stakeholder Engagement & Co-creation of Scenarios

Phase 2 has three key aims: (1) understand citizens' current behaviours, practices and activities, (2) enable citizens and stakeholder to co-create and visualise their low carbon, clean air, future city and (3) raise awareness of the environmental challenges and their solutions. Phase 2 utilised evidence from Phase 1 to help frame and inform the engagement activities. Phase 2 is achieved with the following main activities:

Citizen and stakeholder engagement & co-creation

1. The ClairCity Delphi method uses citizens as local experts to generated qualitative evidence of their entrenched behaviours and what enabling interventions would allow them to act and behave differently in future (WP4).
2. The Mutual Learning Workshop brings citizens and stakeholders together to debate the challenges facing the city and co-create policy interventions for cleaner, healthier futures (WP4).
3. The ClairCity Skylines Game 'crowd-sources' the public perceptions and public acceptability of difference policy interventions (WP4)
4. Citizens and stakeholders come together in a Stakeholder Dialogue Workshop to review and debate the Delphi, Mutual Learning Workshop and ClairCity Skylines evidence and co-create scenarios for a low carbon, clean air, health futures (WP4 and WP7).
5. The scenarios generated in the Stakeholder Dialogue Workshop go through a rapid quantification step (WP5) and are then returned to the local citizens/stakeholders to discuss in a Policy Workshop (WP6) and to agree a single Unified Policy Scenario (WP7).

Public Engagement & Awareness: Additional awareness raising activities are also implemented across the project in each city (WP4). These include:

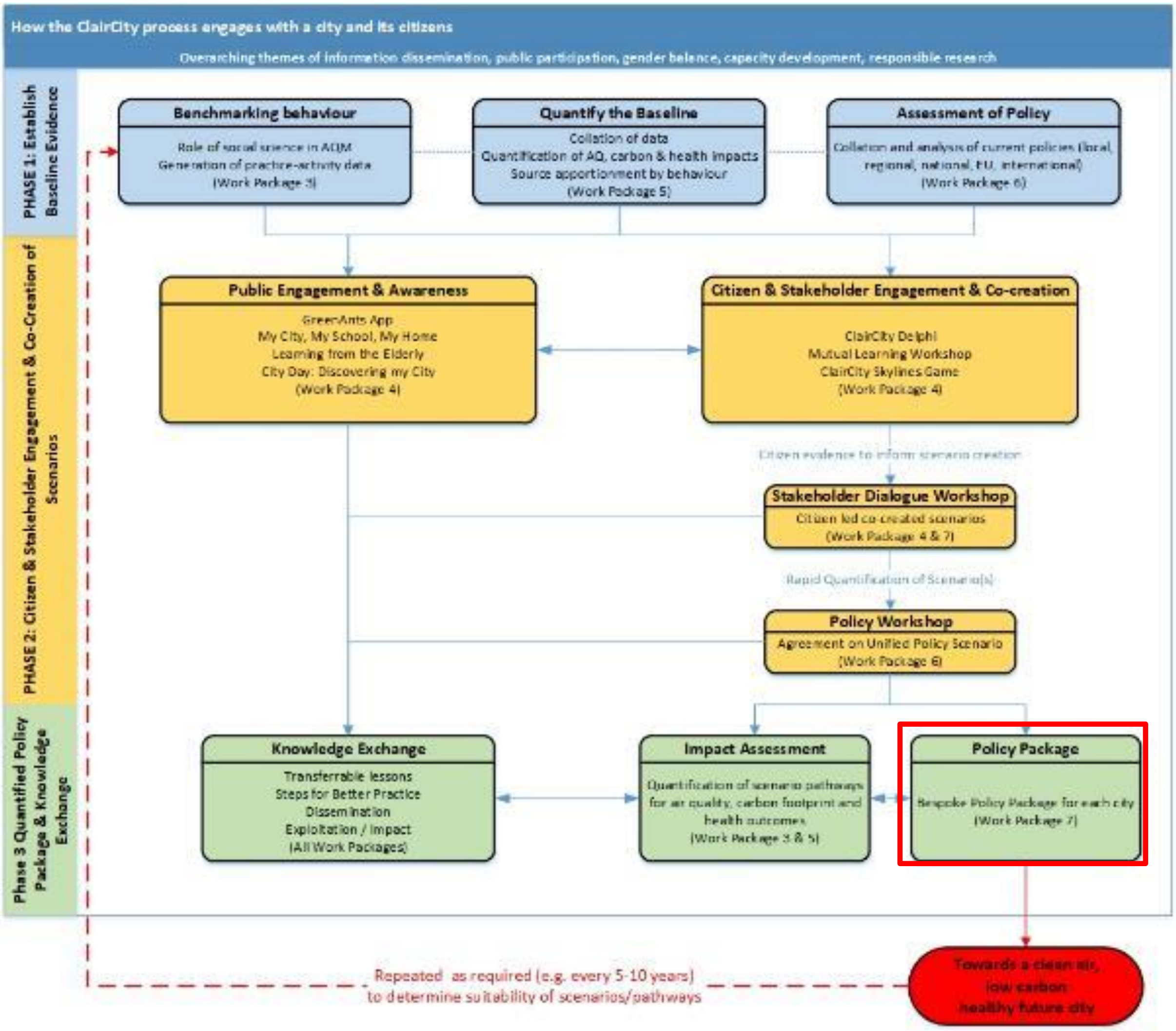
6. The GreenAnt App which allows citizens to become a citizen scientist and monitoring their transport activities, emission generation and exposure using mobile GPS data.
7. The School Competition: My City, My School, My Home engages young people in the air quality, carbon and public health debate utilising an online platform for the students to select the interventions that influence their housing, transport and use of resources in order to be able to design tools for change towards smart consumption, reduced emissions and healthy lifestyles.
8. Learning from the elderly filming activity engages the older, potentially vulnerable, community to talk about the changes in their city, their personal mobility and the steps they take to minimise their exposure to air pollution.
9. The City Day: Discovering my City helps disseminate the final project results and provide healthy and smart tips to promote non-motorised mobility of citizens by highlighting availability and benefits of walking and cycling routes in the city.

Phase 3: Quantified Policy Package & Knowledge Exchange

The primary aim of the final Phase 3 is to collate the evidence and lessons learned from Phase1 and Phase 2 to generate a quantified, bespoke, citizen-led and citizen-inclusive policy package for each city. Phase 3 is achieved with the following main activities:

1. **Knowledge Exchange**: Collation of transferrable lessons and steps for better practice based on the experiences of the ClairCity project to inform other environmental and public health practitioners (WP3, WP4, WP5, WP7).
2. **Impact Assessment**: Rapid quantification of the scenarios generated in the Stakeholder Dialogue Workshop (WP4) and detailed impact assessment of the final Unified Policy Scenario generated in the Policy Workshop (WP6). This quantification includes an assessment of the source apportionment by behaviour or purpose; air quality emissions and concentrations, carbon emissions, air pollution related health impact and interventions cost analysis (WP5).
3. **Policy Package**: Development of a bespoke Policy Package for each city drawing together the findings from across the whole project (WP7).

Figure A-0-1 The ClairCity project and position of the Policy Package report in detail



Annex B. The ClairCity citizen engagement process

The citizen engagement process developed by ClairCity consisted of policy focused activities and of awareness raising directed activities. In annex A-1 the former are discussed in some more detail, in annex A-2 the latter. For an even more comprehensive overview and analysis in addition the more detailed ClairCity reports on each activity can be consulted.

B.1 Policy focused engagement activities

Three main engagement activities directly informed the policy workshop and the policy recommendations: the Mutual Learning Workshop, the Delphi process and the Skylines game.

Mutual Learning Workshop (MLW)

The Aveiro Region Mutual Learning Workshop (MLW) engaged with a variety of stakeholders from different sectors and organisations (Table B-1).

Table B-1 Participants in the Aveiro Mutual Learning Workshop (excluding ClairCity team)

Stakeholder group	Number of participants	Organisations
Industry	2 (15%)	PACOPAR, AIDA
Harbour	1 (8%)	APA,S.A.
Science/Academia	1 (8%)	DEM-UA
Civil/Civic Society (including NGOs/Partnerships and Networks)	5 (38%)	Ciclaveiro, UAU Bike, GAFE BIKE LAB, Quercus, Cegonha/Estarreja
Policy Makers (including councilors and public servants)	1 (8%)	CCDR-Centro
Business sector	1 (8%)	Transdev Mobilidade
Health sector	1 (8%)	ARS Centro
Education	1 (8%)	DGESTE/DSR Centro

Participants had to think on their visions and strategies for the future (2020 and 2050), set goals to achieve such by 2050, present and discuss them within the group. For 2020 the main visions and ideas for the Aveiro Region discussed were related to:

- the need of awareness for teachers (to engage children and parents), politicians, citizens;
- the use of social media platforms for alerts on air quality;
- improve the air quality monitoring network;
- the promotion of strategies for environment and health protection, namely promote the use of bicycles / bike paths, less cars, electric public transportations, create green corridors / forests, to guarantee emission reduction and energy and resources efficiency.

For 2050, participants were more ambitious and envisioned:

- citizenship / commitment / behaviour / values;
- increased enforcement / inspection;
- city maps of air quality / environmental awareness pf citizens;

- more efficient housing / fireplace certification;
- better public transport network combined with parking outside city center, car sharing, ban car traffic in cities, create free public transport network throughout the region; infrastructure for cycling.

Figure B-1: Mutual Learning Workshop in Aveiro

Participants also discussed the main challenges and barriers identified and concluded these were as follows:

- Need to change mentality (away from individualism, egocentrism) and increase awareness raising to combat ignorance;
- Promote participation and opinion of citizens;
- Fight against car lobby and energy;
- lack of good environmental leadership/ inadaptability of policies / functioning of local policy systems;
- lack of incentives for cleaner behavior and public participation / tax incentives.

Delphi process

The Delphi process consisted of two broad survey rounds of Aveiro Region citizens, a workshop with citizens and concluded with a ‘Stakeholder Dialogue Workshop’ (SDW). The surveys and events resulted in the following participation:

- 1031 responses to Round 1 survey which included a mix of open and closed questions presented online and face-to-face by interviewers and in self-completed forms

- 285 responses to Round 2 survey which included a mix of open and closed questions including measures (generated based on Round 1 responses, to be rated by citizens in this second round)

- 2 face-to-face workshops with 33 citizens (Reported in ClairCity Deliverables D4.2, D4.3 and D4.4) intended to work out in more detail the citizens' measures, enablers and constraints before handing them to policy makers.
- At the SDW 12 attendees discussed priority policy measures derived from the questionnaires in the Delphi process and created various scenarios (Table B-2).

Table B-2 Policy measures discussed in Stakeholder Dialogue Workshop and proposed LOW and HIGH ambitions for each policy

	Measure	Proposed scenario LOW	Proposed scenario HIGH
1	Build segregated urban cycle lanes and create secure cycle storage/parking	150 km of new urban cycle lanes and 100 number of new cycle parking spaces by 2025	300 km of new urban cycle lanes and 200 number of new cycle parking spaces by 2035
2	Create school and workplace travel plans to increase uptake of active travel and public transport	50% modal shift from private cars to active travel and public transport by 2025	50% modal shift from private cars to active travel and public transport by 2025
3	Reallocate road space to pedestrians and improve safety	50 km of new/renewed pedestrian routes by 2025	100 km of new/renewed pedestrian routes by 2025
4	Ban diesel cars/HGVs in urban centres	10% ban on diesel cars and 25% HGVs in urban centres by 2025	100% ban on diesel cars and HGVs in urban centres by 2030
5	Allow free parking for electric vehicles only	Switch 25% parking spaces into free parking for EVs only by 2035	Switch 100% parking spaces into free parking for EVs only by 2035
6	Promote working from home	5% commuters work from home 1 day a week by 2030	10% commuters work from home 1 day a week by 2030
7	Impose stricter regulation on polluting industries	Reduce industrial emissions by 15% by 2030	Reduce industrial emissions by 45% by 2030
8	Encourage replacement of older public transport fleet	Replace 15% public transport fleet with zero-emission vehicles by 2030	Replace 60% public transport fleet with zero-emission vehicles by 2030
9	Subsidise public transport tickets	Public transport fares reduced by 50% by 2021	Public transport fares reduced by 75% by 2025
10	Increase provision and reliability of public transport services	100% public transport journeys on schedule with all urban areas catered for by 2025	100% public transport journeys on schedule with all urban areas catered for by 2025

Skylines Game

ClairCity Skylines is a 'serious game', designed to capture citizen decision making about issues in their city, where players travel between areas representing a city's environment, economy and its citizen's health & satisfaction, collecting ideas for policies to enact to achieve a low carbon, clean air, healthy future before 2050 (Figures B-2 and B-3).

Figure B-2: Google Play Store listing

Figure B-3: Six playable cities completed

In the Aveiro Region ClairCity Skylines was launched in January 2019 with primary data capture closing at the end of March 2019. The game includes English, Dutch, Slovenian, Polish, Italian and Portuguese localisations for game text, UI and the policy database.

B.2 Awareness related engagement activities

At the time of writing this report, three ClairCity awareness related engagement activities had been implemented: a school competition, the film activity for the elderly, the city day and the GreenAnts app. The reason for the focus on young people and the elderly is that ClairCity builds on the WHO Policy Framework and the European Commission's Clean Air Policy Package that promote public health by paying special attention to more vulnerable groups, such as children and senior citizens. The aim is to empower these citizens to better understand the specific challenges and opportunities that their city currently offers and to engage them into moving towards reduced air pollutant emissions and carbon footprints. The project has therefore collected their perceptions and ideas on sustainable lifestyles and a *'better quality of life'* within their city in the future.

Schools activity

Between March and December 2019 UAVR ClairCity colleagues gave workshops in several schools across the Aveiro Region. The goal of this activity was to engage school children to act towards good environment, low carbon emission, healthy city, health promoting school and healthy home environment. The UAVR team did a spectacular job in engaging hundreds of children between the ages of 6 and 18. A participation diploma has been given to all participants, namely students and teachers. The following schools were engaged:

- Colégio Nossa Senhora da Assunção, Anadia
- Escola Secundária da Gafanha da Nazaré, Ílhavo
- Escola Secundária de Estarreja, Estarreja
- Colégio do Calvão, Ílhavo

- Escola Básica e Secundária Soares Basto, Oliveira de Azeméis
- Escola Básica 2, 3 do Loureiro, Oliveira de Azeméis
- 1º CEB do Agrupamento de Escolas de Estarreja, Estarreja
- Escola Básica 2, 3 João Afonso, Aveiro

Besides workshops at those schools, the Aveiro team gave a presentation on "Mobility, air quality and citizenship" for an auditorium of 400 students from 3 different schools at the 'Mix and Move' event during the EU Mobility Week.

Elderly film activity

ClairCity activities with the elderly focused on promoting non-motorised mobility of citizens in the Aveiro Region to show the health, environmental and social benefit of active travel. The activity invited local older citizens to tell about their experiences in short films. In the Aveiro Region the participants in the video competition were:

- "Associação Humanitária de Salreu" (Association of Elderly People);
- "Centro Social de Oiã" (Association of Elderly People);
- "Os Maiores de Idade" (Association of Elderly People) in collaboration with the municipality of Ílhavo;
- Municipality of Albergaria-a-Velha; and
- Manuel Ramos (individual citizen).

Some common themes among the range of thoughts and ideas shared in the videos by the participants are as follows:

- Older people in the Aveiro Region walk and cycle as efficient modes of transportation;
- Walking and cycling improves the participant's quality of life and health. Even the elderly with some mobility limitations can benefit from walking or cycling (quote from one of the videos: *"It does not matter if you move fast or slow, as long as you keep moving on..."*);
- Walking and cycling can be an enjoyable experience, being an opportunity to socialize;
- Walking and cycling allows people to connect to their surroundings and nature;
- Participants' acknowledge that walking and cycling have benefits for the whole community, like reducing road traffic pollution and congestion;
- In the Aveiro Region there are several pleasant leisure options for walking and cycling;
- In the Aveiro Region there are many beautiful landscapes that deserve to be appreciated;
- In the Aveiro Region there are bicycle-sharing systems that the elderly can use.

The Aveiro ClairCity videos can be found here:
https://www.youtube.com/playlist?list=PLMjeme8vWNJcAS_Pvo6aNFOkUBGEmZ14b

Region Day

The Aveiro Region Day took place on 17 October 2019, as part of a larger event canemly the Aveiro Region Congress 2019. The theme chosen for the Region Day was "Public Transport - Integration, Sharing, Sustainability, Urban environment" and the presentations given by the ClairCity Aveiro team touched upon sustainable, flexible and shared mobility. The event attracted a total of 230 people. These indluded citizens, municipal policy makers and workers, intermunicipal communities, associations and NGO’s, infrastructures entities, education entities, mobility and transport entities, companies, energy and health entities.

Some recommendations formulated by participants were as follows:

- Optimize the region's public transport service and the intercity mobility network.
- Promote active mobility - with emphasis on citizens with reduced mobility.
- Build cycling routes.
- Reduce the number of free car parks.
- Promote telework.
- Implement energy efficiency measures in the residential sector.
- Improve residential heating systems.
- Implement measures to control and reduce agriculture burning.
- Optimize the articulation of policies at different levels - EU, national, regional and local.
- Explore the co-benefits between air quality, climate, energy and health.
- Integration of various forms of transport services into a single, easy-to-use service / platform is necessary.
- Implement holistic solutions to reduce the need of people to move around (e.g. work close to home; video conferencing).
- Promote nautical mobility - important in this region that has a vast area of water (Ria de Aveiro Lagoon).
- Simplify the information given to citizens and placed them in strategic locations.
- Promote public transport to reduce road traffic in cities.
- Look for flexible mobility solutions, which can be adapted through time.
- Take better care of degraded floors in urban centers and other public spaces outside urban centers to enhance walking.

Other comments and suggestions on the matter were as follows:

- Transport and mobility are as essential as the air we breathe.
- Citizens' freedom is linked to their mobility.
- Micromobility (buses / trains / electric / soft modes) is more sustainable and allows a better quality of life. Micromobility - The challenge lies in educating users to comply with the rules.
- Bicycle - Important Mode for Intermodality.
- Behaviour change is necessary towards sharing modes of travel.
- There is lack of regulation for pedestrian protection.
- There is a need of economic incentives to implement electric buses in the public transport.

GreenAnts App

GreenAnt provides insight into people’s daily travel habits and their reaction to changes. It visualizes how people’s everyday travel impact air quality and what people can do to reduce negative impact.

The GreenAnt system consists of:

1. a website for creating a user profile and accessing data
2. a smartphone application for Android and iOS devices for data collection.

To use the system, it is necessary to register zones on the web tool named ANTS, where you want to collect data about how people travel. Users can assign themselves to the zone by downloading the GreenAnt smartphone app. When the user is within the zone, route and transportation data will be collected and later stored on the server.

In the Aveiro Region the GreenAnt app was intensively tested in November 2019 by a group of 19 people. The feedback received shows that the app is not yet ready for public use in the Aveiro Region. There were issues of user friendliness and usefulness and a few privacy concerns that need to be sorted out first. The GreenAnt system is now evaluated to satisfy TRL6 and is moving towards TRL7.

Annex C. The Aveiro Region citizen engagement impacts: scenarios and modelling

C.1 Modelling impacts of the citizen scenarios

To understand the impact of the policies the citizens put forward, we assessed the impact of policies on emissions, air quality, health and costs in three steps:

1. Step 1: Reproduce the air quality situation as it is currently, in a modelling environment (“baseline”):
    a. First, estimate total emissions from different sources, in line with statistics (by sector, by time of day, link with behavior)
    b. Secondly, model the air quality and validate the modeling ouput with with observations
    c. Finally: assess exposure and health impact with common indicators
2. Step 2: Estimate future emissions in a scenario with existing policy measures and model the resulting air quality. This business-as-usual (“BAU”) scenario aims to capture the changes in air quality if no further measures are taken, only accounting for changes in the emissions due to policy measures made in the past and expected technological and/or behavioral changes.
3. Step 3: Estimate future emissions in a scenario with **additional** policy measures as aimed for by the Aveiro Region citizens. We follow the same suite, from estimating the impact of the measures on emissions, to air quality and health impact.

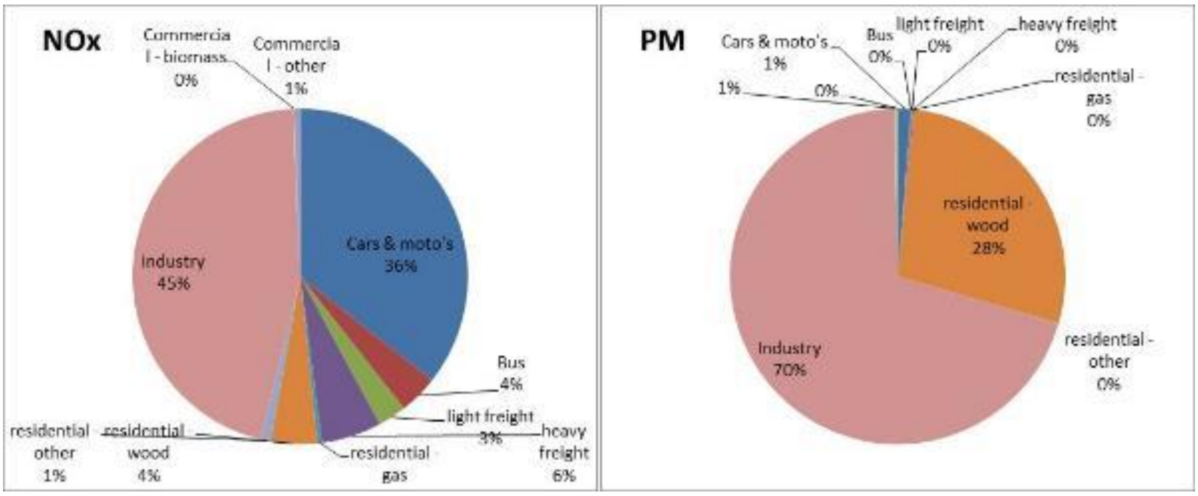
The results of the modelling exercise therefore consists of three parts:

1. Results for the situation as it is (baseline)
2. Expected future without future action (BAU)
3. Future with additional policy action (UPS)

C.1.1 Air quality for the baseline

Figure C-1 shows the emissions by source in the baseline situation (year 2015), for 2 key pollutants: NOx and $PM_{2.5}$.

Figure C-1 relative importance of different sectors for NOx and PM emissions



The figure shows that for NOx, the industrial sector is the most important source of emissions, accounting for about 45% of total emissions. When we exclude Industrial emissions, transport as a whole is the dominant sector accounting for about 90% of the remaining emissions. This is due to NOx-emissions from mostly diesel cars, busses and freight vehicles.

For PM, residential wood burning and industry are the dominant sources, combined accounting for more then 95% of the of total emissions. When excluding the industrial emissions residential wood combustion in fact accounts for almost all PM emissions. Transport emissions are of lesser importance.

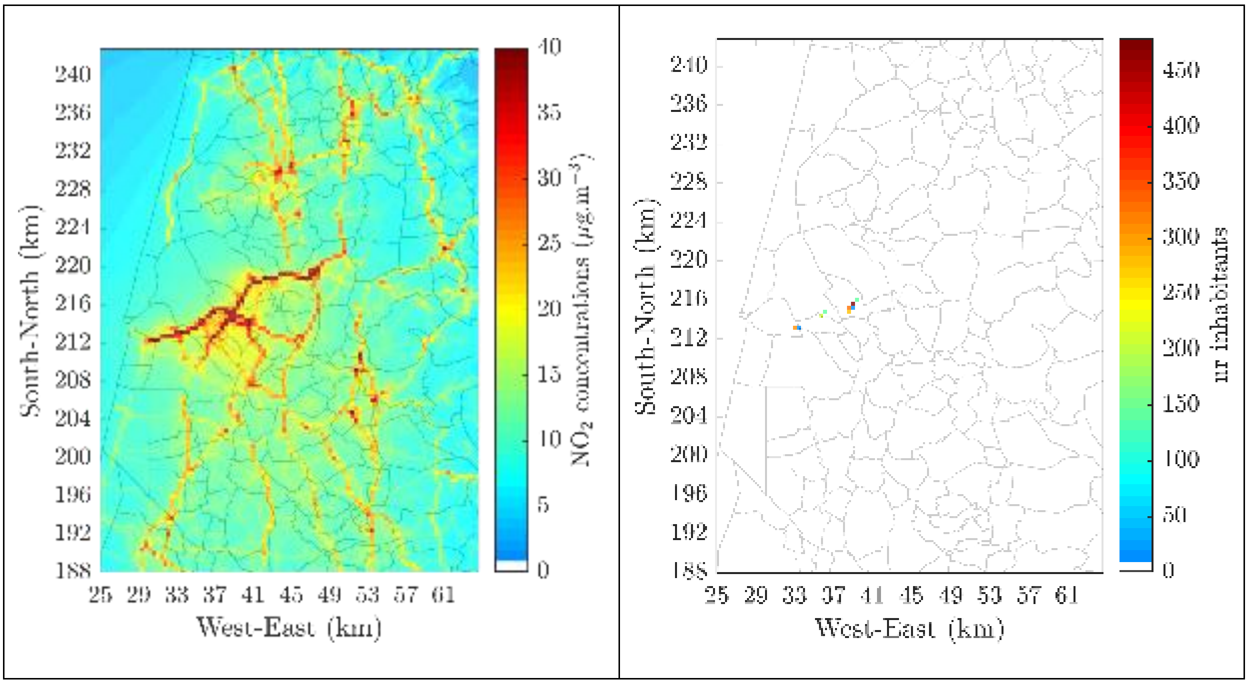
The second-generation Gaussian model URBAIR was setup and run at an urban scale for the computational domain over the Aveiro Region. The baseline simulations were performed for the full-year using the meteorological vertical profiles from the WRF-CAMx system and the emissions available on the ClairCity emissions database. Background concentrations were added to the URBAIR model results. For that purpose, it was established a single value to apply to each grid cell. This value is the average concentration from the transboundary transport obtained from the WRF-CAMx results using the source apportionment tool. In addition, the simulation results together with the added background concentrations were calibrated against the measurements[32] through the adjustment procedure. For NO_2 concentrations, a slope of 2.2 obtained from the linear regression is applied as a correction factor over all the domain. In case of particulate matter, PM_{10} and $PM_{2.5}$ concentrations the

[32] The NO_2 observations available for 2015 include measurements from 3 continuous measurements for 2015, from the Portuguese monitoring network: 1 road traffic site, 1 suburban background site, and 1 industrial site. The PM10 observations available include measurements from the same 3 continuous sites. PM2.5 observations are only available for the industrial site.

slope obtained from the linear regression is equal to 1.4 for PM_{10} and 0.5 for $PM_{2.5}$ concentrations.

Figure C-2 a) shows the resulting NO_2 annual average concentrations. Figure C-2 b) points out the population potentially exposed to NO_2 concentrations above the EU legal limit value of 40 µg.m^{-3}.

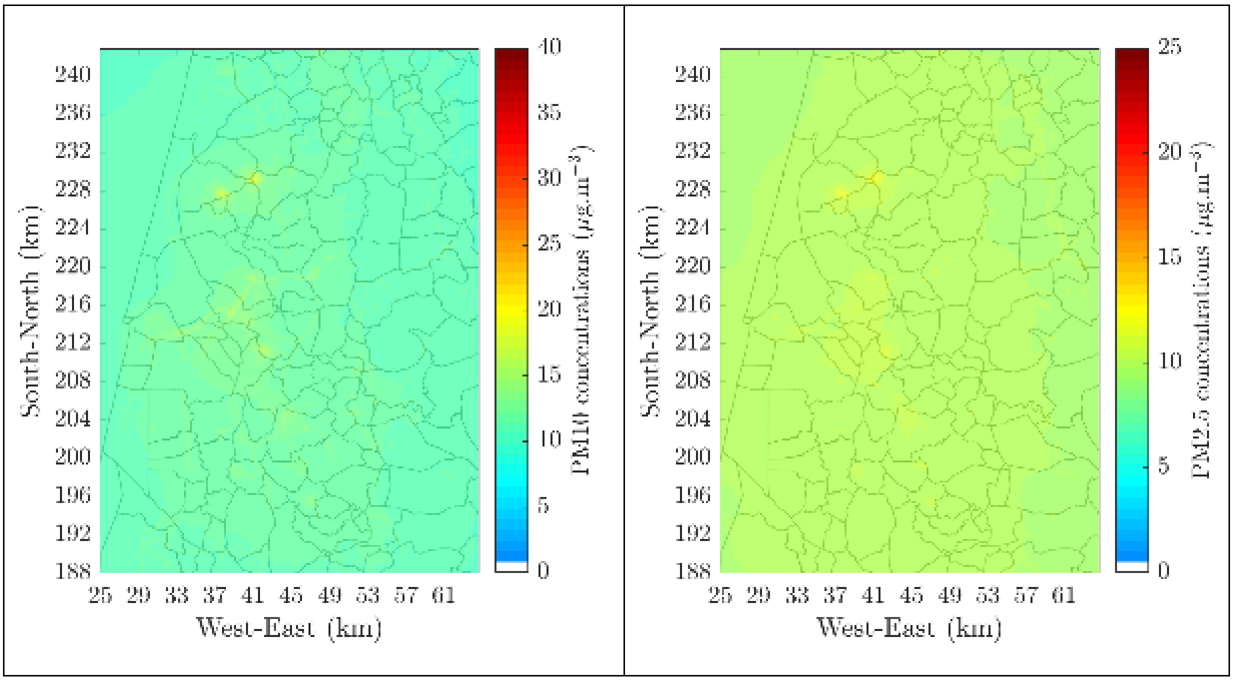
Figure C-2 NO_2 contour maps: a) annual average of NO_2 concentrations and b) number of inhabitants within the cells exceeding the EU annual limit value of 40 µg.m^{-3} in 2015



The simulation results indicate a maximum concentration of 57.7 µg.m^{-3} within the urban area of Aveiro municipality, with an hot-spot over the highway A25 link. The EU annual legal limit value for NO_2 annual concentrations is exceeded in 15 cells corresponding to less than 1% (0.6%) of the total population within the Region potentially exposed to those concentrations.

Figure C-3 presents the PM_{10} annual average concentrations (Figure C-3 a)) and the $PM_{2.5}$ annual average concentrations (Figure C-3 b)).

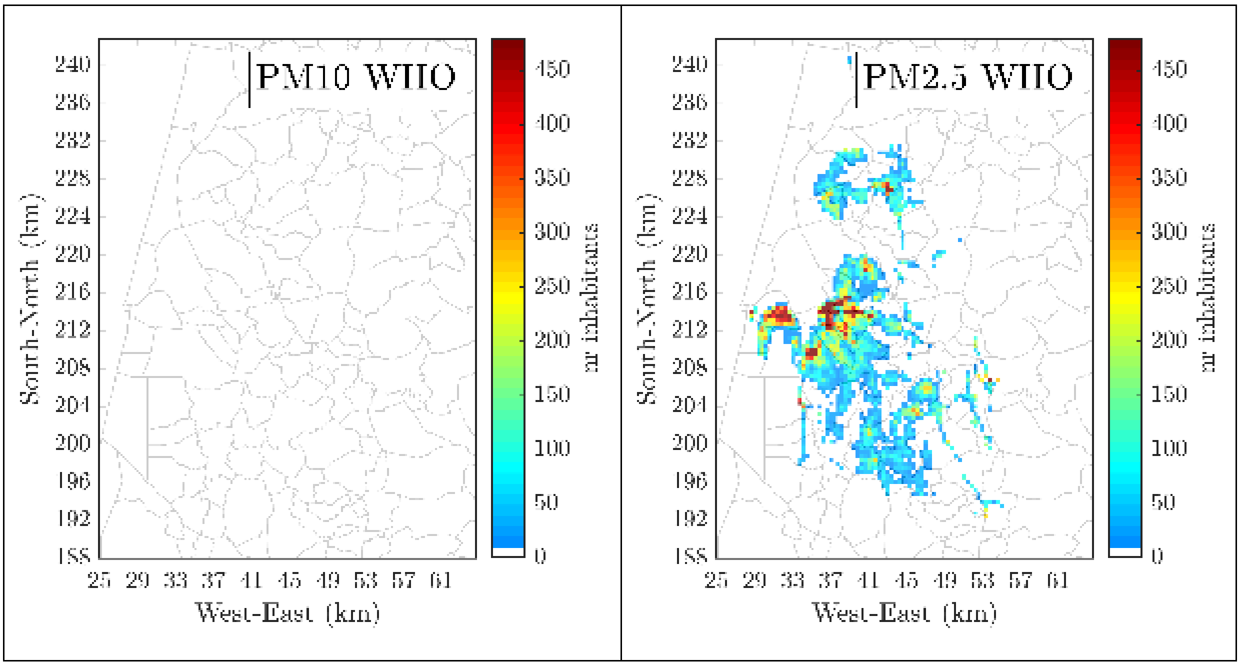
Figure C-3 (a) PM_{10} annual average concentrations and (b) $PM_{2.5}$ annual average concentrations in 2015



The maximum value of PM_{10} concentrations is equal to 17.6 µg.m $^{-3}$, which is simulated over the industrial area in Estarreja, while the simulated maximum concentration of $PM_{2.5}$ is equal to 12.1 µg.m $^{-3}$. The PM concentration contour maps point out no exceedances to the EU legal limit values for PM_{10} and $PM_{2.5}$, equal to 40 µg.m $^{-3}$ and 25 µg.m $^{-3}$. PM_{10} contour map indicates also no exceedances to the WHO guideline concentrations value of 20 µg.m $^{-3}$.

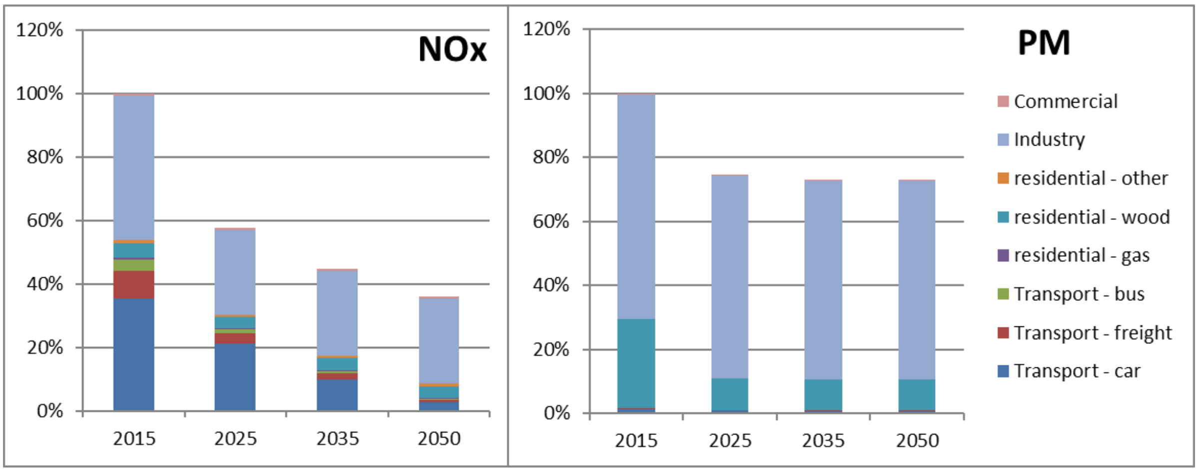
However, despite the compliance of the EU legal limit values for $PM_{2.5}$ concentrations, the annual concentrations indicate exceedances of the WHO guideline values. Figure C-4 b) shows 2614 cells exceeding the WHO guideline value, which represents 49% of the population within the simulation area potentially affected by $PM_{2.5}$ concentrations above the recommended value.

Figure C-4 Number of inhabitants within the cells exceeding the WHO air quality guideline values: a) of 20 µg.m-3 for PM10 concentrations, and b) of 10 µg.m-3 for PM2.5 concentrations in 2015



C.1.2 BAU

Figure C-5 trend of PM and NOx emissions in a business as usual scenario



BAU impacts on air quality

The substantial reductions of the NOx emissions in the BAU scenario will lead to significant reductions of the NO_2 concentrations. Figure C-6 presents as example the NO_2 annual average concentrations considering the impacts of BAU scenarios for 2025 and 2050. The maximum NO_2 concentration will be equal to 33.2 µg.m^{-3} in 2025 and to 9.8 µg.m^{-3} in 2050, corresponding to an overall reduction of the maximum concentration of 71% (from 2025 to

2050). In the BAU scenario, the NO_2 concentrations will not exceed the EU limits and WHO guidelines already by 2025.

Figure C-6 NO_2 annual average concentrations for the BAU scenarios: a) 2025 and b) 2050.

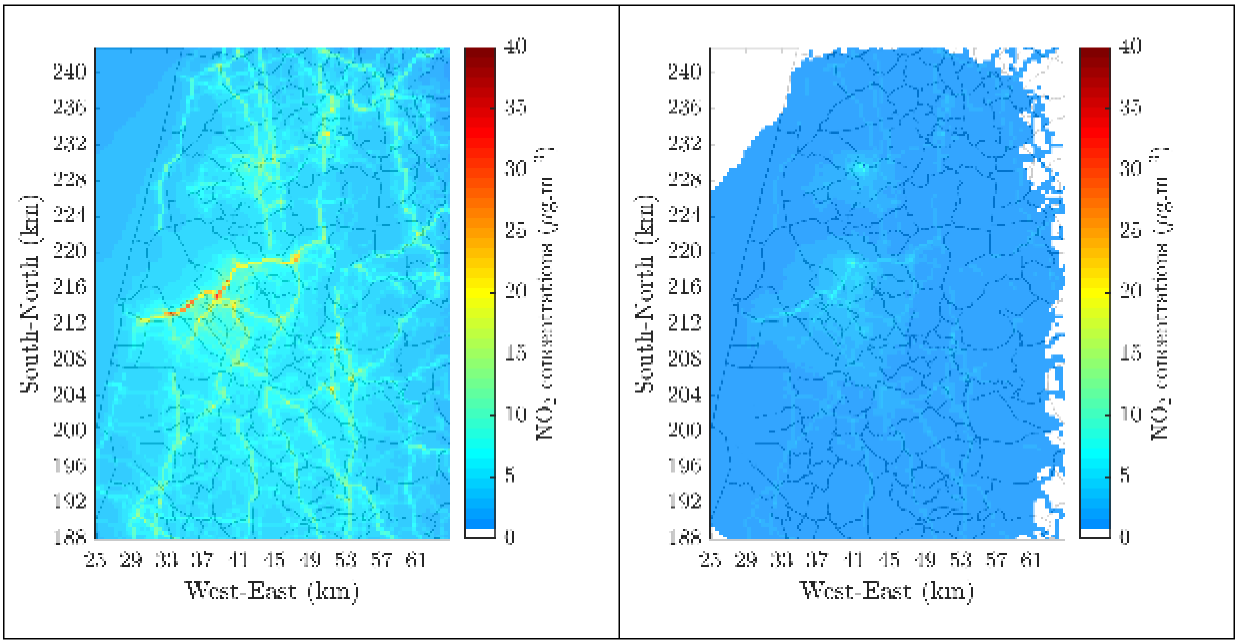
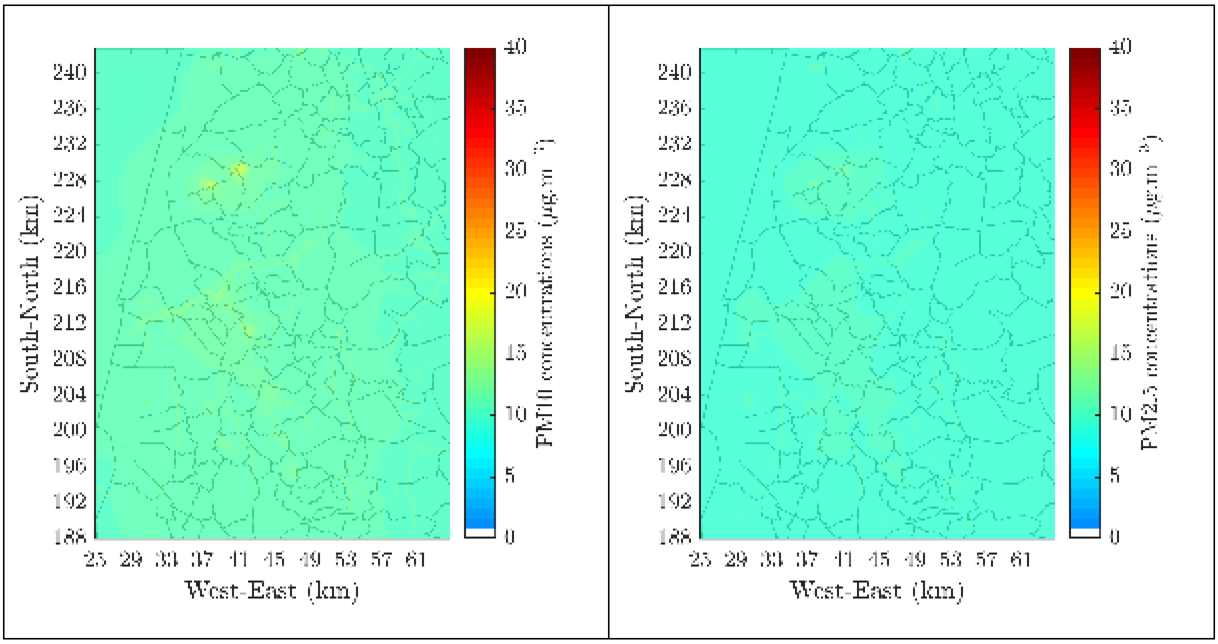


Figure C-7 (a) presents the PM_{10} annual average concentrations for 2050 and (b) the $PM_{2.5}$ annual average concentrations for the same year. The simulated maximum values of PM_{10} concentrations range from 16.7 to 16.6 µg.m^{-3} between 2025 and 2050, while the simulated maximum concentration of $PM_{2.5}$ slightly vary from 11.7 to 11.6 µg.m^{-3}. Therefore, the BAU scenarios will lead to the reduction of PM_{10} concentrations showing compliance with EU limit values and with the WHO guideline values already in 2025. The BAU scenarios will lead to the reduction of $PM_{2.5}$ concentrations showing compliance with EU limit values in 2025. However, for the WHO guideline values there are still 346 cells exceeding this limit in 2050.

Figure C-7 Particulate matter annual average concentrations for the BAU scenario in 2050. a) PM_{10} and b) $PM_{2.5}$ concentrations.

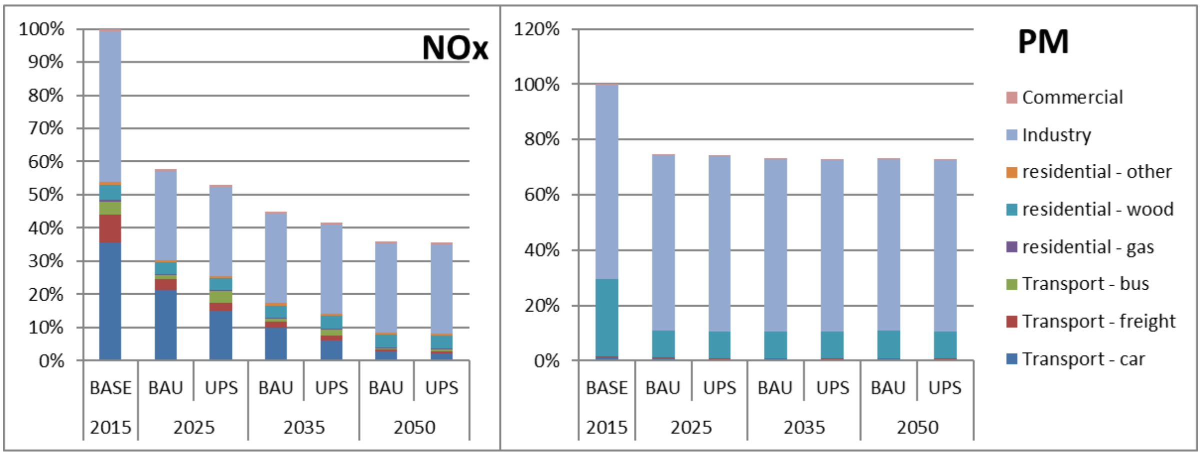


BAU impacts on health

The results for the BAU scenario indicate there has been 9, 146, 190 premature deaths and 118, 1 868, 2 184 years of life lost atributed to NO_2, PM_{10} and $PM_{2.5}$ polution levels in Aveiro Region in 2025 respectively. Estimations for 2035 indicate that 1, 146,190 premature deaths and 8, 1 863, 2 184 years of life lost atributed to NO_2, PM_{10} and $PM_{2.5}$ polution levels,respectively , and 0, 147, and 190 premature deaths and 0, 1 870, 2 184 years of life lost atributed to NO_2, PM_{10} and $PM_{2.5}$ polution levels in 2050.

C.1.3 UPS

Figure C-8 trend of PM and NOx emissions in the UPS, compared to the business as usual scenario



UPS impacts on air quality

The significant reductions of the NOx emissions in the UPS scenario comparing with the BAU scenarios will lead to even more significant reductions of the NO_2 concentrations. Figure C-9 shows for example the NO_2 annual average concentrations considering the impacts of UPS scenarios for 2025 and 2050. In 2025 the maximum NO_2 concentration will be equal to 24.3 µg.m^{-3} and in 2050 equal to 9.1 µg.m^{-3}, showing no exceedances of the legal limit value already in 2025 (with no differences between BAU and UPS scenarios in terms of exceedancas). Comparing UPS and BAU scenario in 2050, the maximum concentrations will be at 83 and 84% compared to 2015.

Figure C-9 NO_2 annual average concentrations for the UPS scenarios: a) 2025 and b) 2050.

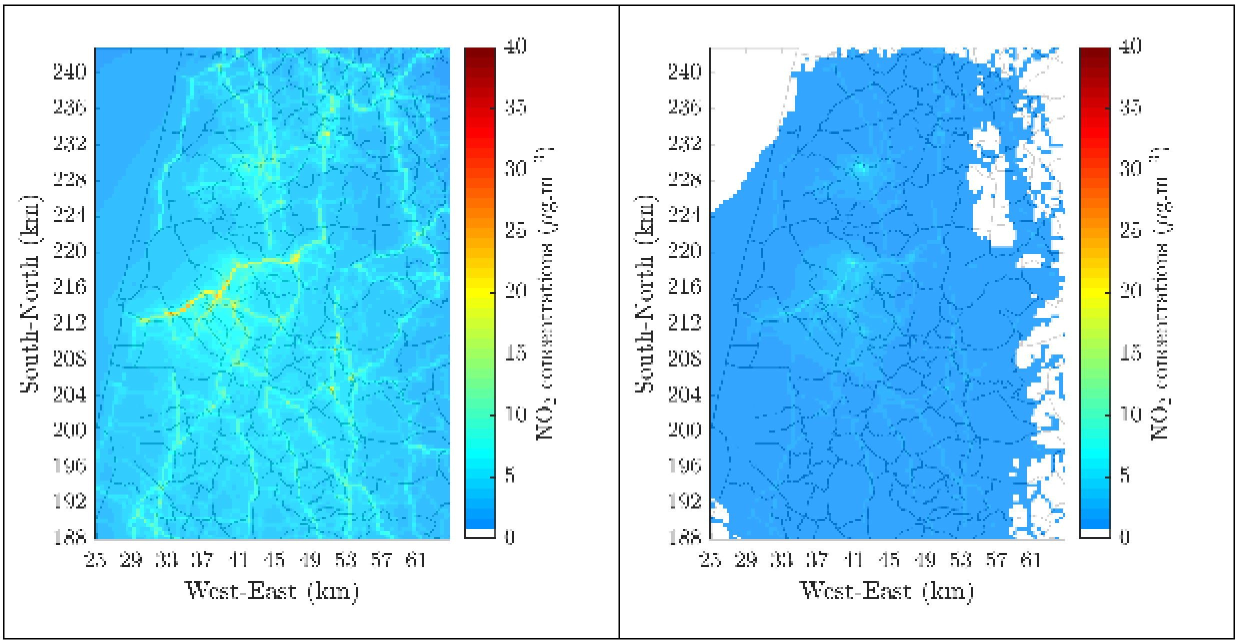


Figure C-10 presents the UPS PM_{10} annual average concentrations (a) in 2025 and (b) in 2050. For PM_{10}, in 2025 the maximum value corresponds to 16.6 µg.m^{-3} and 14.8 µg.m^{-3} in 2050. This means that there are any exceedances, neither to the EU limit values, nor to the WHO guideline contentrations. Compared to the BAU scenario, the UPS scenario will reduce the maximum concentrations by a further 0.3% and 11% in 2025 and 2050.

Figure C-10 PM_{10} annual average concentrations for the UPS scenario: a) in 2025 and b) in 2050.

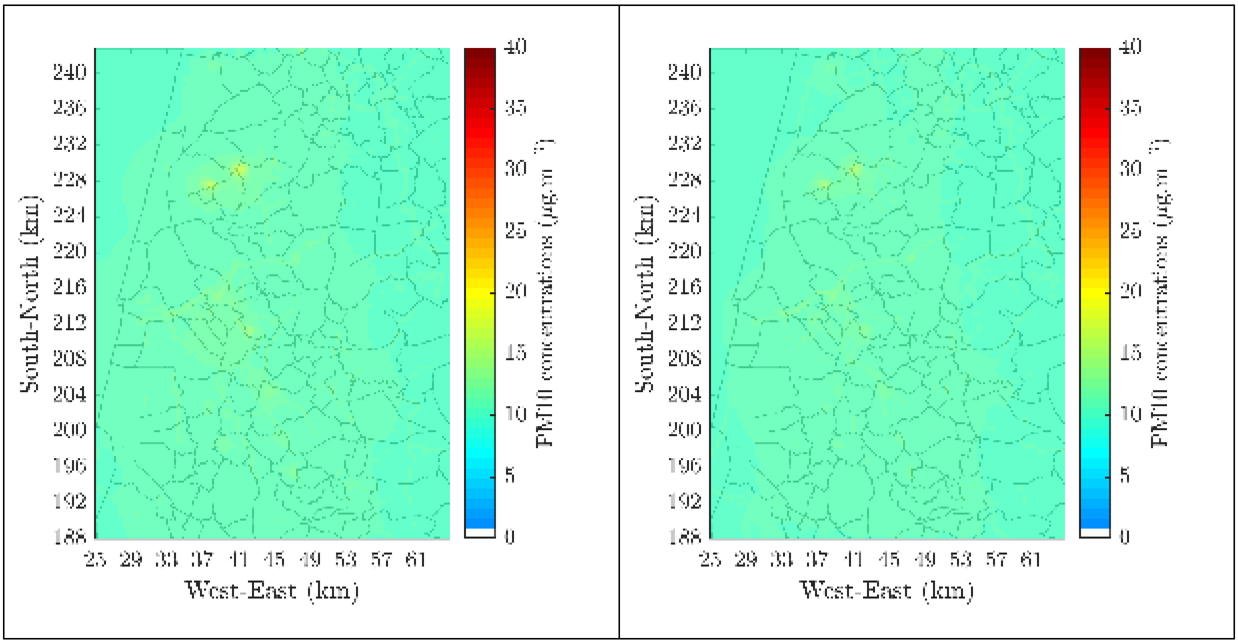
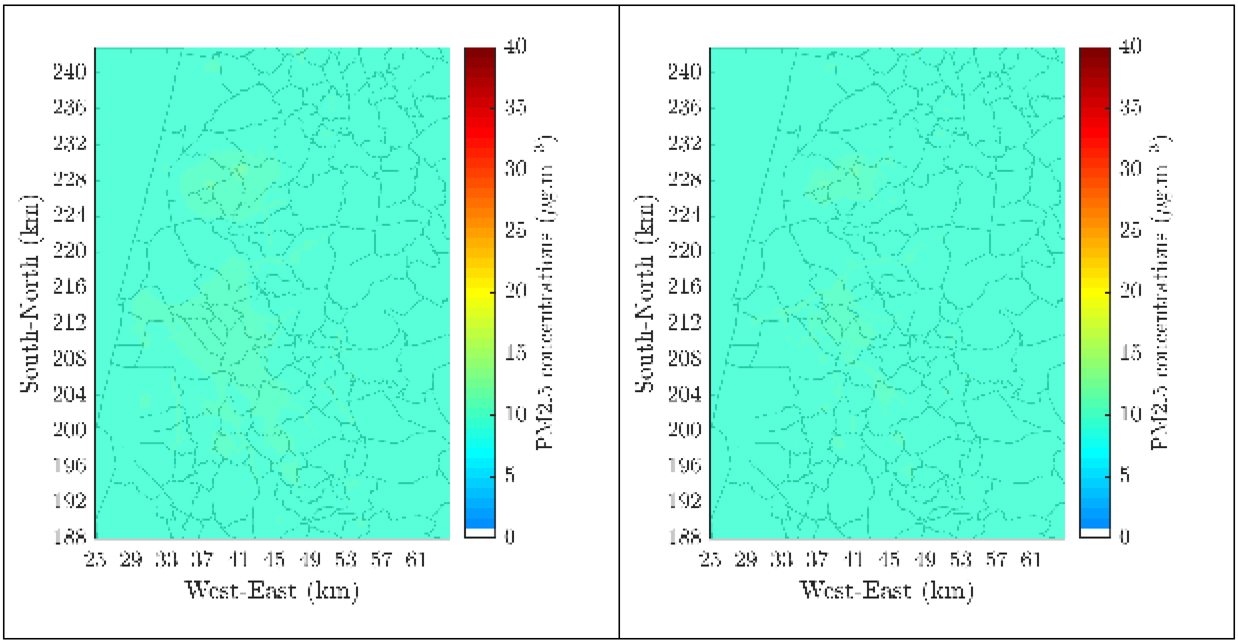


Figure C-11 presents the $PM_{2.5}$ annual average concentrations in the UPS scenario (a) in 2025 and (b) in 2050. For $PM_{2.5}$, in 2025 the maximum value corresponds to 11.7 µg.m^{-3} and 11.0 µg.m^{-3} in 2050, translating into a further 6% reduction of the maximum concentration compared to BAU. Based on the WHO guidelines in 2025, 304 cells show exceedences, and by 2050 this number is reduced to 99 cells. The UPS will reduce the maximum concentrations by a further 0.1 and 6% in 2025 and 2050 as compared to BAU.

Figure C-11 $PM_{2.5}$ annual average concentrations for the UPS scenario: a) in 2025 and b) in 2050.



UPS impacts on health

The results for low, high and final UPS scenarios for 2025, 2035 and 2050 are presented in Table C-1 for premature deaths, and Table C-2 for years of life lost.

Table C-1 Number of remature deaths related to $PM_{2.5}$, PM_{10} and NO_2 exposure for the UPS, low and high emission scenarios in 2025, 2035, and 2050.

	$PM_{2.5}$			PM_{10}			NO_2		
Scenario	**2025**	**2035**	**2050**	**2025**	**2035**	**2050**	**2025**	**2035**	**2050**
UPS	190	188	188	146	143	143	3	0	0
High	190	188	188	145	142	143	1	0	0
Low	190	189	189	146	145	145	3	0	0

Table C-2 Number of years of life lost related to $PM_{2.5}$, PM_{10} and NO_2 exposure for the UPS, low and high emission scenarios in 2025, 2035, and 2050.

	$PM_{2.5}$			PM_{10}			NO_2		
Scenario	**2025**	**2035**	**2050**	**2025**	**2035**	**2050**	**2025**	**2035**	**2050**
UPS	2180	2162	2164	1856	1819	1826	41	0	0
High	2180	2162	2164	1856	1817	1823	15	0	0
Low	2180	2174	2176	1856	1844	1850	41	1	0

UPS impacts on costs

The assessment os costs carried out is indicative. For a more accurate calculation of benefits, the indirect benefits of health improvement of citizens (saved public health costs) would have to be taken into account. This was beyond the scope of the ClairCity modelling. Exact costs will also depend on the design of measures, which has not been defined to such detailed as to be able to model that.

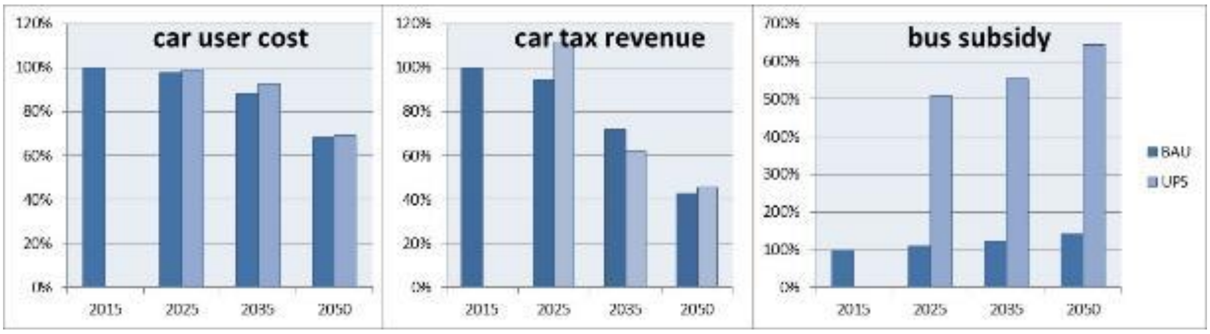
For the assessment of costs, we used 3 indicators:

1. The car user cost: to what extend does the cost to drive a car changes relatively over time in the BAU as well as under influence of the scenario's
2. The government tax revenue from car transport, combing fuel excises, registration taxes as well as any levy's (e.g. cordon charge)
3. The government expenditure on public transport, i.e. bus subsidies

The indicators on tax revenue or subsidy expenditure do not distinguish between different types of government (local, regional, national).

With these indicators, we assessed qualitatively the likely costs of measures for citizens, government and society at large. Costs for society were assumed to be the net sum of citizen and government costs. The cost estimations must be order-of-magnitude estimations only, as the real costs until 2050 will depend on many variables that were not included in the ClairCity modelling. Figure C-12 gives an overview of these order of magnitude costs of the UPS scenario compared to the BAU scenario.

Figure C-12 trends of user cost (left), government tax revenue (mid) and bus subsidy (right) in all scenario's



Car user cost

The car private user cost is expected to decrease over time in the BAU. The cost decrease over time, in the BAU, is due to the combination of the cost benefit of more fuel efficient cars (fuel savings offset the higher purchase cost) as well as the uptake of electric vehicles (EVs) that are becoming ever cheaper in the future, reflected in the stronger decrease of user cost in 2050 due to stronger uptake of EVs. The cost decrease particularly manifests from 2035 onwards.

This changes in the UPS under impulse of the accelerated scrappage of older cars due to the ban on old and polluting cars. This is causing an increase in car user cost which diminishes over time as the impact of the accelerated scrappage levels out and organic fleet renewal takes over. The cost increase is in total related to the loss of capital of old, yet still functioning cars which loose all (remaining) capital value as they are scrapped. Although replaced by (slightly) cheaper new cars with a lower user cost over the entire lifetime, the loss of capital outweighs that benefit.

Car tax revenues

The tax revenue decreases in the BAU. This decrease follows the lower tax revenue from electric vehicles as the fleet gradually electrifies. Under current assumptions, the taxation of EV’s is limited and as EV’s enter the fleet, government revenue from taxing cars on average will shrink. Clearly. The loss of tax revenue typically is a concern for central governments and not so much for local governments as the bulk of the revenue is collected at national level (fuel excise, registration/circulation taxes,…).

In the UPS, we observe a remarkable effect of an initial increase of tax revenue in 2025 compared to the BAU, followed by a lower revenue in 2035 compared to the BAU to then end up with a marginally higher tax revenue in 2050. All these effects can be linked to the impact of the accelerated scrappage due to the ban of polluting cars. At first, more sales of new cars are expected, increasing the revenue of registration tax; in 2035, there is a backlash as the wave of newly bought cars in 2025 is still too young to be replaced, causing a decrease in sales and thus tax revenue. In 2050, the remaining effect is marginal.

Bus subsidies

Bus subsidy follow increasing demand in the BAU. The increase is modest of 10% in 2025, 22% in 2035 and 42% in 2050. However, due to several measures to promote PT in the UPS, will lead to higher subsidy levels in the UPS. The massive modal shift in the UPS leads to a threefold increase of users. Lower ticket prices mean to lower cost coverage and thus lead to huge increase in bus subsidy costs. We estimate that up to factor 5.5 in 2035 and 6.5 in 2050 subsidy compared to BAU would be needed for public transport to satisfy increased demand at the lower ticket cost, which is likely unsustainable from a public spending perspective.

ClairCity: Citizen-led air pollution reduction in cities

D7.5 Final City Policy Package – Liguria Region / Genoa

June 2020

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Description	This report provides policy recommendations to the Liguria Region based on the overall ClairCity project. It also summarises the main results of the project regarding citizens behaviour, citizens preferred policies and policymakers' views on those policies.

Version History

Version	Updated By	Date	Changes / Comments
V1	Irati Artola	January 2020	First draft
V2.0	Irati Artola	January – February 2020	Included modelling inputs from UAVR, TML, Techne, NILU and behaviour data from UWE. Further drafting.
V2.1	Irati Artola	April 2020	First full draft
V3	Carlo Trozzi	April 2020	Contributions, clarifications, review
V4	Irati Artola	April 2020	Review by Stephan Slingerland
V5	Irati Artola	May 2020	Review by Patrizia Costi
V5.1	Irati Artola	May 2020	Review of modelling sections from Kris Vanherle (TML), Joana Soares (NILU) and Vera Rodrigues (UAVR)
V6	Irati Artola	May - June 2020	Review after discussions with Regione Liguria and in consultation with the modelling team.

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Project internal comments	Carlo Trozzi (Techne)

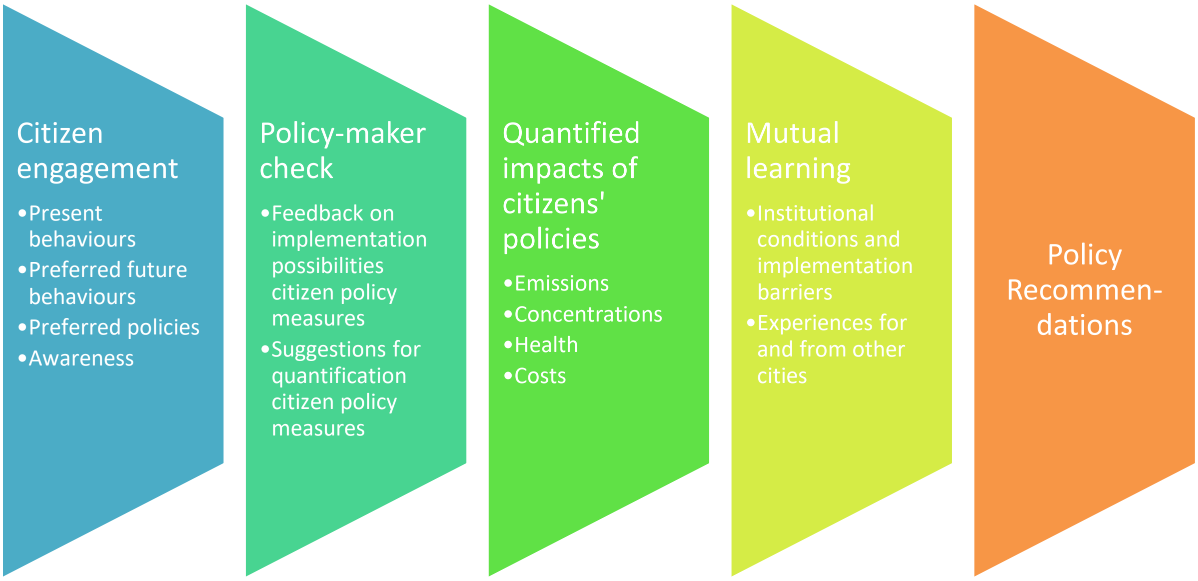
Contents

Executive Summary

ClairCity project and method

The ClairCity Horizon 2020 project aims to contribute to citizen-inclusive air quality and carbon policy making in middle-sized European cities. It does so by investigating citizens' current behaviours as well as their preferred future behaviours and policy measures in six European cities[1] through an extensive citizen and stakeholder engagement process. The project also models the possible future impacts of citizens' policy preferences and examines implementation possibilities for these measures in the light of the existing institutional contexts in each city (Figure 0-1). **This report summarises the main policy results for the Liguria Region with Genoa area as main focus.**

Figure 0-1: The ClairCity method in brief



The methodological understanding as developed in the ClairCity project of what citizen-inclusive policymaking is, and what it should and should not comprise, is given in Textbox 0-1.

Textbox 0-1 Citizen-inclusive policy-making according to ClairCity

- Tailor local policies based on detailed knowledge of behavioural practices of citizens;
- Engage with citizens via a diversity of methods, paying particular attention to hearing the voice of 'hard-to-reach' groups;
- Ask citizens for their preferred future behaviours and barriers to behavioural changes. Address the perceived barriers of citizens by concrete measures or initiate dialogue with citizens about misconceptions concerning air quality and climate change;

[1] Bristol, Amsterdam, Sosnowiec, Ljubljana,Aveiro/CIRA region, Genoa/Liguria region

- Ask citizens for their preferred future policies for the city, examine potential impacts of these policies and discuss with stakeholders and policy makers their implementation possibilities;
- Examine and address potential implementation barriers for preferred citizen policy measures beyond citizen perceptions;
- Experiment, and exchange experiences with other cities that are also aiming to implement citizen-inclusive policies;
- Do not confuse citizen-inclusive policies with populist policies. Take full responsibility for democratically implementing popular or unpopular measures considered appropriate, after having been extensively informed about citizens' views and behaviours.

In total, during the period 2017-2019, over 1 400 stakeholders, primarily citizens, were reached by the various ClairCity citizen engagement methods in the Liguria Region (Table 0-1). While this sample is not fully representative of the Liguria Region population as a whole, it gives an indication of support for policy measures and intentions for behavioural change that can be used by policy makers to inform future policies.

Table 0-1: Number of participants in ClairCity citizen engagement methods in the Liguria Region

Citizen engagement activity	Participants engaged
Delphi Process (Round 1 & Round 2 surveys + Delphi workshop)	1 127
Skylines Game	66
Mutual Learning Workshop	28
Stakeholder Dialogue Workshop	10
Schools activity	23 teams (123 students in total) 4 teacher teams (12 teachers)
Film competition	5[2]
Policy Workshop	20

Regarding modelling in the ClairCity project, the following limitation applies:

ClairCity modelling differs from regional and national models in the Liguria Region due to the different modelling assumptions and inputs used. The concentrations therefore can deviate from national and regional models and should therefore be considered as indicative. Although the utmost care has been taken to calibrate the ClairCity models to local conditions, a detailed comparison of ClairCity modelling assumptions to those of local and national models in each ClairCity case study country was outside the scope of this project.

[2] Five people submitted videos but in the process of recruiting videos tens of people were engaged. Also, the promotion of the videos through social media reached hundreds of people potentially.

Conclusions and recommendations for the Liguria Region

The main conclusions and recommendations from the ClairCity project for citizen-inclusive policy making in the Liguria Region are:

Current air quality and carbon situation in the Liguria Region

Air pollution has decreased in the past decades in Liguria as result of transport and industry policies. Also GHG emissions have gone down mainly due to a reduction in emissions from industry. Currently in the Liguria Region NO_2 is the most critical pollutant. Mainly caused by road transport, its EU limit values are not met. The Liguria Region does comply with PM_{10} EU limit values although the number of exceedances of daily limit values across several stations make it a concerning pollutant as well. O_3, is also a problem.

The Liguria Region has a wide regional, multi-modal network of local public transport. Large railway works are underway to develop the 'Genoese node' with the aim to separate the traffic flows of the metropolitan and local railway system, from those of medium-long distance. Also the Terzo Valico railway network will offer the port of Genoa an alternative route for the transfer of goods to the Po Valley area and northern Italy, substituting road transport. Regarding buses, the renewal of the fleet from old diesel buses to Euro 6 is underway. The link-road Gronda project will allow road traffic to flow from one side of Genoa to the other without going through the city centre. Electric mobility is being facilitated through subsidies, an increasing number of charging points, tax exemption, parking discounts and allowed access to the areas of limited traffic (ZTL). A public e-bikes sharing system, a privately operated e-scooters, and a free-of-cost charging point for electric scooters have been introduced in Genoa as well. Further there are plans to revive the municipal bike sharing scheme.

There are regional funds for energy efficiency which are promoted through ESCOs as well as measures on energy efficiency and renewables financed by the European Regional Development Fund (ERDF). Liguria is behind with renewables implementation compared to other regions in Italy. Renewable energy for heating purposes in the Liguria region consists mainly of biomass burning - mostly outside the major urban centres. Several port initiatives are ongoing concerning the electrification of docks and future use of LNG for ships.

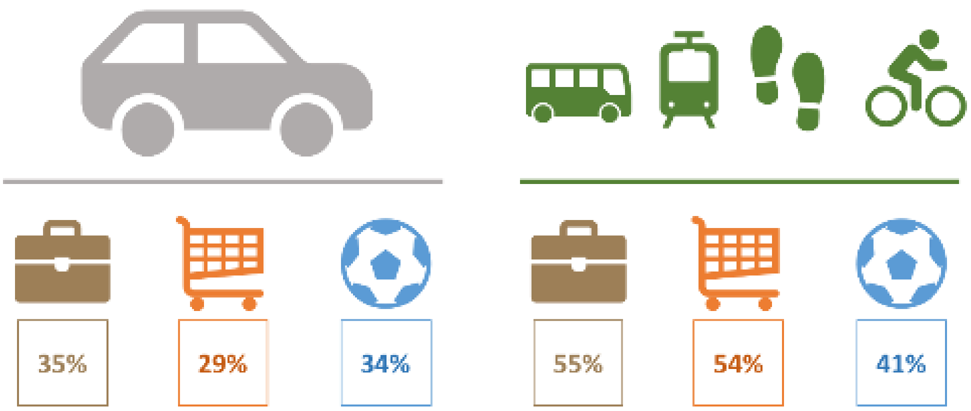
Figure 0-2: Main features of the current Liguria Region air quality and carbon situation

NO_2	PM_{10}	O_3	BaP	SO_2	GHG
• Main pollutant of concern • EU limit values are not met • The Genoa Agglomeration has the highest concentrations • Main source: transport	• Pollutant of concern • Concentrations decreased in the last years but remain high • Main sources: Industry, transport	• Exceedances in most of the Liguria Region • Exceedances in urban, suburban and rural stations • Exceedances above the alarm threshold in 2016	• Situation has worsened recently • Main source: Industry, wood burning	• Not a problem pollutant • Main sources: Industry, harbour	• Significant CH4, N2O and CO2 emission reductions in 2005-2011 • CO2 (95% of total GHG) has also decreased • Reductions mainly from industry emissions

Current behaviours of the Liguria Region citizens

Current behavioural practices of citizens substantially contribute to air pollution and carbon emissions in the city, mainly through car transport, which is the main contributor to NO_2 emissions. A 35% of the consulted citizens always use their car or motorbike/scooter for commuting to work; 29% do so when going shopping and 34% for leisure activities. More than half of the consulted citizens on the contrary always go to work and shopping by public transport or through active travel.

Figure 0-3 Percentage of citizens in Genoa 'always' using a car for commuting to work, shopping or leisure (left) vs those 'always' using public transport, walking or cycling (right)



Citizens also account by far for the highest contribution to the Liguria Region's carbon footprint through residential heating (compared to road transport, industry and services) which currently is powered primarily by natural gas.

Preferred future behaviours of Liguria Region citizens for the future

There is a mismatch between citizens transport and heating behaviour at present and how citizens would like to behave in the future regarding these. From the current car users, an important share would wish to reach work, leisure and shopping by public transport or through active travel. This suggests that many citizens would be willing to change their own transport behaviour as a contribution to ambitious air quality and carbon policies if the

Liguria Region facilitates / enables that. For heating, the situation is even more obvious. Citizens currently heat their homes with natural gas, while there is a massive preference for using renewables in the future.

- **There is a large demand for public transport and active travel in the future provided that current barriers are overcome**
  A considerable number of those citizens relying on cars at present for commuting to work, shopping and leisure, does not want to be using a car at all for these activities in the future. 73%, 75% and 67% in total, would rather walk or take public transport to travel to these activities. There is also a considerable latent demand of citizens who would like to cycle to work in the future. This indicates a latent demand for active travel and public transport in the Liguria Region that could be fulfilled in the future. The main barriers for the use of public transport are mainly related to travel time, timetabling, reliability and the availability (coverage) of public transport.

Figure 0-4: Proportions of present and future car use of commuters in the Liguria Region

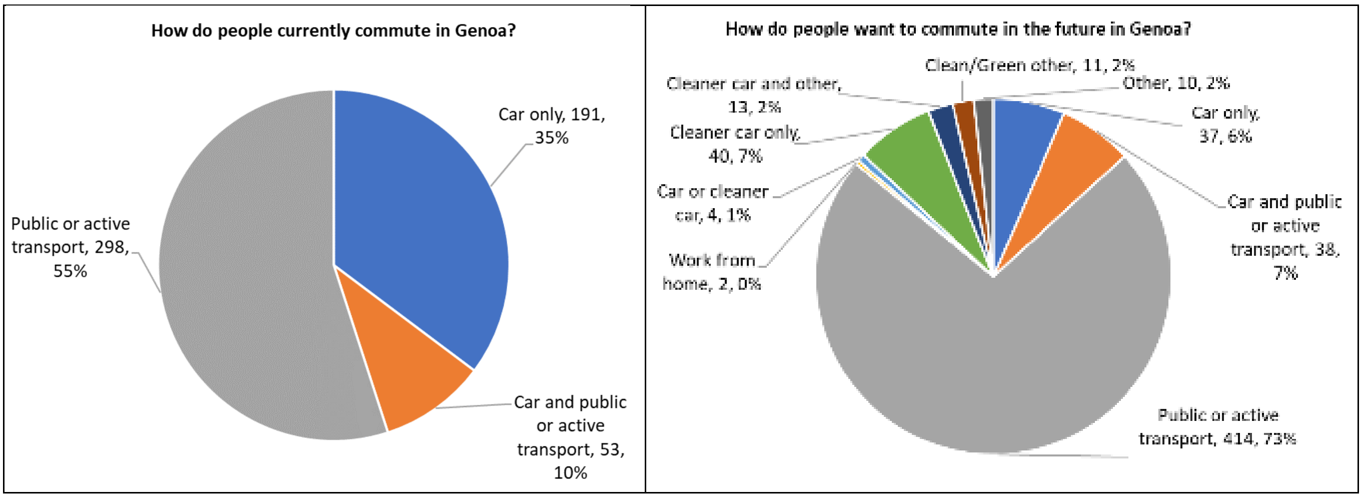


Figure 0-5: Current and future transport choices for shopping in the Liguria Region

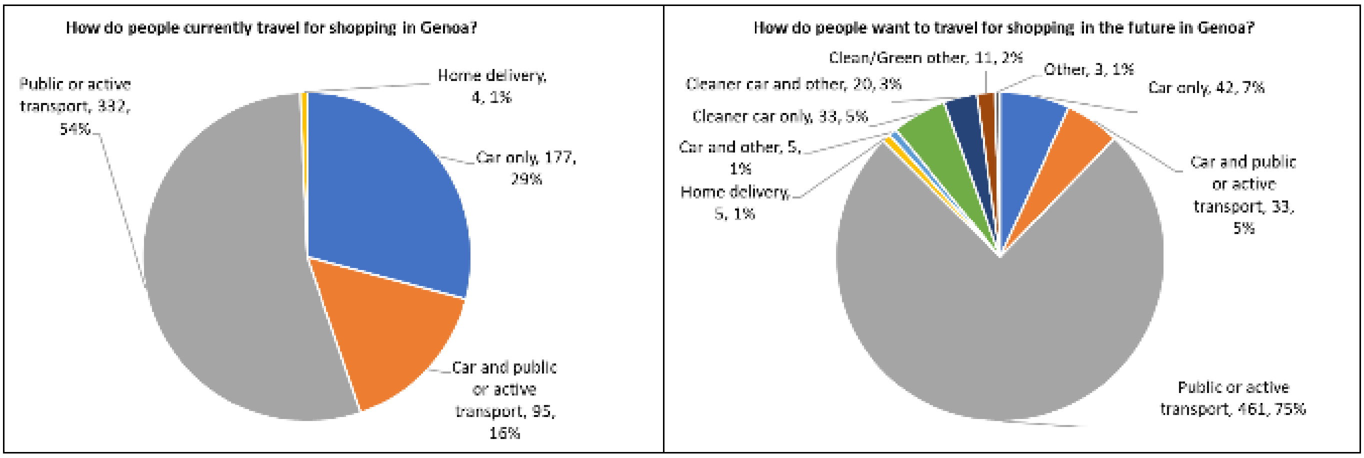
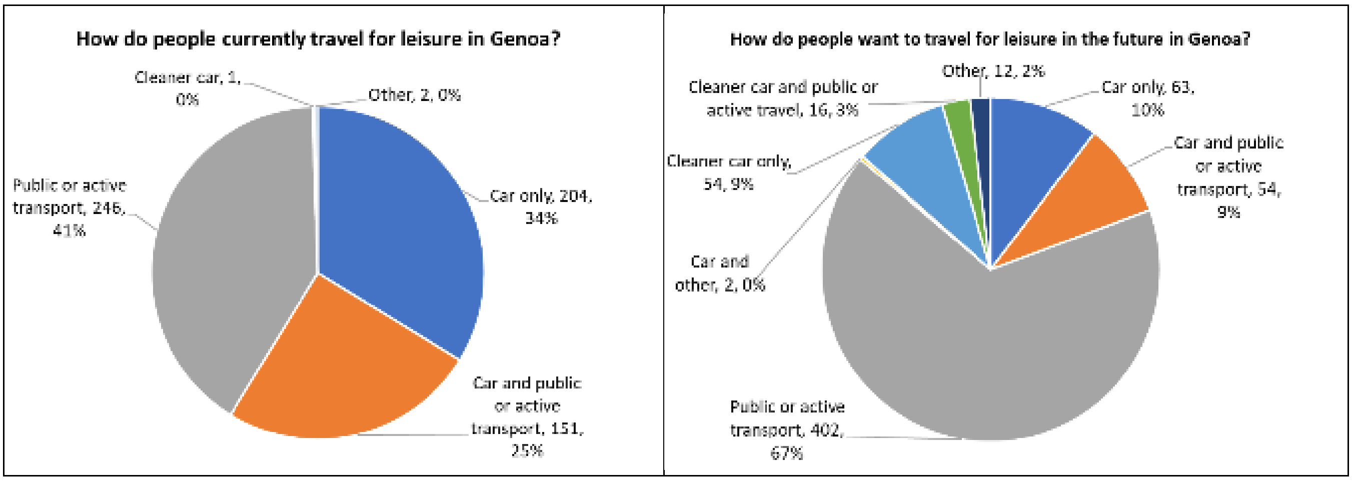


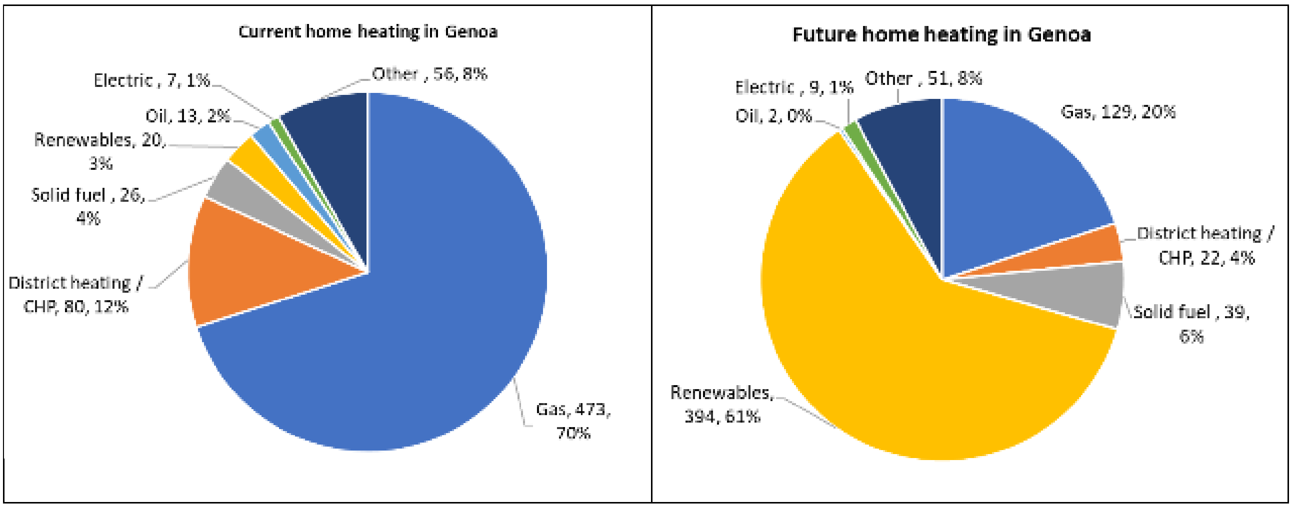
Figure 0-6: Current and future transport choices for leisure in the Liguria Region



- **There is interest from citizens for renewables for residential heating**
  ClairCity identified a very latent demand for renewables to heat homes in the future, as 20 times more people than currently said they would like to heat their homes with

renewables in the future. This would go mostly at the expense of natural gas and to a less extent district heating. The reason not to opt for renewables ‘now’ seems to revolve around ownership of homes and costs of switching.

Figure 0-7 Current and future choices for home heating in the Liguria Region



Preferred future policies of Liguria Region citizens and reflections by policy makers

The consulted citizens in the Liguria Region favour transport and energy related measures including measures that would affect their behaviours.

- When talking about improving air quality in their city/region, citizens the Liguria Region are most keen on transport measures. The transport measures proposed by citizens concern private cars (banning of oldest diesel cars and promotion of electric vehicles), public transport (improvement of railway, metro, bus), active travel (promotion of walking and cycling), and heavy-duty vehicles (decreasing their share by deviating traffic via rail).
- Concerning energy, citizens would like to see measures in place for the reduction of residential energy consumption (and of the service sector)

In terms of policy priorities, **policymakers and citizens are aligned regarding the improvement of public transport and the integration of public transport with private transport; promotion of vehicle sharing; boosting electric mobility and promoting active travel.**

- For increasing public transport use and reducing private car use the main barrier according to policymakers is changing transport habits. For expanding cycle paths and sidewalks / pedestrian areas the main barrier is space, as these modes compete with other uses of roads (parking, car lanes). For energy systems replacement, the cost, both for the Region and the citizens is a main barrier.

Table 0-2 Liguria Region citizen and policymakers combined measures

#	Policy area defined by citizens	Detailed policy measure for modelling (policymakers’ choice)
1	Improve local public transport and vehicle-sharing	Increase integrated local public transport network use (including shared vehicles), from 25.4% to 31.5% by 2029, and from 31.5 in 2029 to 45% by 2050

2	Improve integration between public transport and private transport	Increase integrated local public transport network use (including shared vehicles), from 25.4% to 31.5% by 2029, and from 31.5 in 2029 to 45% by 2050
3	Ban diesel vehicles and the most polluting motorcycles in the city	Ban diesel cars and light vehicles less than or equal to the EURO 5 category by 2025 in urban areas
4	Encourage electric mobility	Install an adequate number of charging stations for 50% of the circulating electric vehicles (including car sharing) and replace 50% of vehicles circulating in urban areas with electric cars and motorcycles by 2050
5	Encourage active travel	Increase private trips by bicycle or on foot in the metropolitan area from 23.2% in 2029 to 35% in 2050
6	Transfer part of the goods traffic from road transport to rail transport	Reduction of heavy vehicle traffic by 30% by 2035 and by 50% by 2050
7	Reduction of energy consumption in housing and buildings	Reduction of residential consumption by 10%, and consumption in the service sector by 16% in 2030

Concerning the priority policy areas defined by citizens, policymakers in Liguria were ambitious for measures in favour of improving the options for public transport, collective transport and active travel as well as for facilitating a shift to 'electric mobility'. Policymakers on the other hand were not too ambitious regarding the ban of polluting vehicles nor about measures to reduce energy consumption in housing and buildings. buildings.

Table 0-3 Main reflections of policy makers regarding citizen measures

Policy area	Main reflections of policy makers
Public transport	- A change in behaviour of citizens (i.e. shift from private cars to public transport) difficult to achieve - Public transport not optimal (travel time, cost, unavailability in some areas e.g. hilly parts of the city). - Lack of space to expand public transport further - Improving public transport involves high costs - introducing specific requirements in public transport management service contracts - Reduced rates to encourage people make the switch from private cars to public transport
Active transport	- Lack of space where cycle paths and sidewalks / pedestrian areas compete with other uses of roads (parking, car lanes) - Need to create an adequate network of bicycle lanes / bike parking / bike sharing systems - Communication and awareness towards more active lifestyles, starting from the younger generations - Increase space dedicated to pedestrians and offer more safety.
Private car	- Resistance to change expected from citizens if a ban of polluting vehicles is imposed - Encouraging 'shared' mobility initiatives (bikes, cars, vans, motorcycles) is necessary - Awareness raising essential to facilitate the switch to other modes - Shifting to electric mobility is a high priority particularly for scooters and motorbikes - Subsidies and charging points are necessary to boost electric mobility
Energy	- Very costly to switch to more sustainable systems both for the region as well as for citizens - Awareness raising essential to encourage the switch

Modelled impacts of the combined citizen and policy maker measures

ClairCity modelling indicates that **the 'Unified Policy Scenario' (UPS)[3] will lead to compliance with legal NO_2 EU limit values widely in the Liguria Region by 2050[4]. The**

[3] The 'Unified Policy Scenario' (UPS) consist of policy measures prepared by combining citizen preferences for future policy measures with policy maker reflections.

[4] Local modelling suggests that compliance will be achieved by 2025. In the context of the project, it was not possible to identify what is the exact reason for the difference in modelling outcomes. One possible explanation is that the BAU scenario applied by ClairCity only includes policy measures implemented or specified in the base year 2015 and that the UPS scenario only differs slightly from the BAU scenario in the Genoa/Liguria case.

UPS will comply with the EU legal limit values for PM_{10} everywhere in the Liguria Region, but not with the WHO guidelines in 2050. The estimate is that in 2050, still 55% of the population could be potentially exposed to PM_{10} concentrations above WHO guideline values[5]..

- According to the ClairCity modelling, **the UPS would lead to a significant decrease of NOx emissions over time** due to reductions across various sectors, with a particular strong decrease from NOx-emission from road transport and industry. **The trend for PM emissions is also downward**, mainly result of a decrease in residential emissions linked to heating. UPS measures also have a moderate impact on Carbon Footprint compared to the 'Business As Usual' (BAU) scenario**[6]** This impact is limited to transport sector emissions reduction as no additional measure has been introduced in UPS addressing fossil fuel consumption in the other sectors.

The ClairCity UPS scenario results in limited additional reductions compared to the BAU. This is partly explained by the fact that policymakers chose in various cases to keep the current ambition level for transport and energy measures instead of opting for more ambitious measures proposed by Genoa area citizens. The additional reduction of NOx that the UPS generates beyond the BAU is negligible, as **the decrease in NOx from passenger cars is offset by a rebound of NOx emissions from buses**. **The UPS does lead to a slight additional reduction of PM emissions than the BAU.**

If implemented, the measures proposed by citizens (the UPS) would result by 2050 in notable health improvements for citizens compared to the situation in the base year (2015). **The ClairCity modelling estimates that the UPS would reduce the number of premature deaths from air pollution by 79% for NO_2, 11% for PM_{10}, and 6% for $PM_{2.5}$. The UPS barely leads to further reductions than the BAU** for the reason explained above, which is an indication that more stringent measures may be needed.[7]

The reduction in premature deaths and the number of years of life lost expected in the UPS is lower than the average concentration levels reduction.

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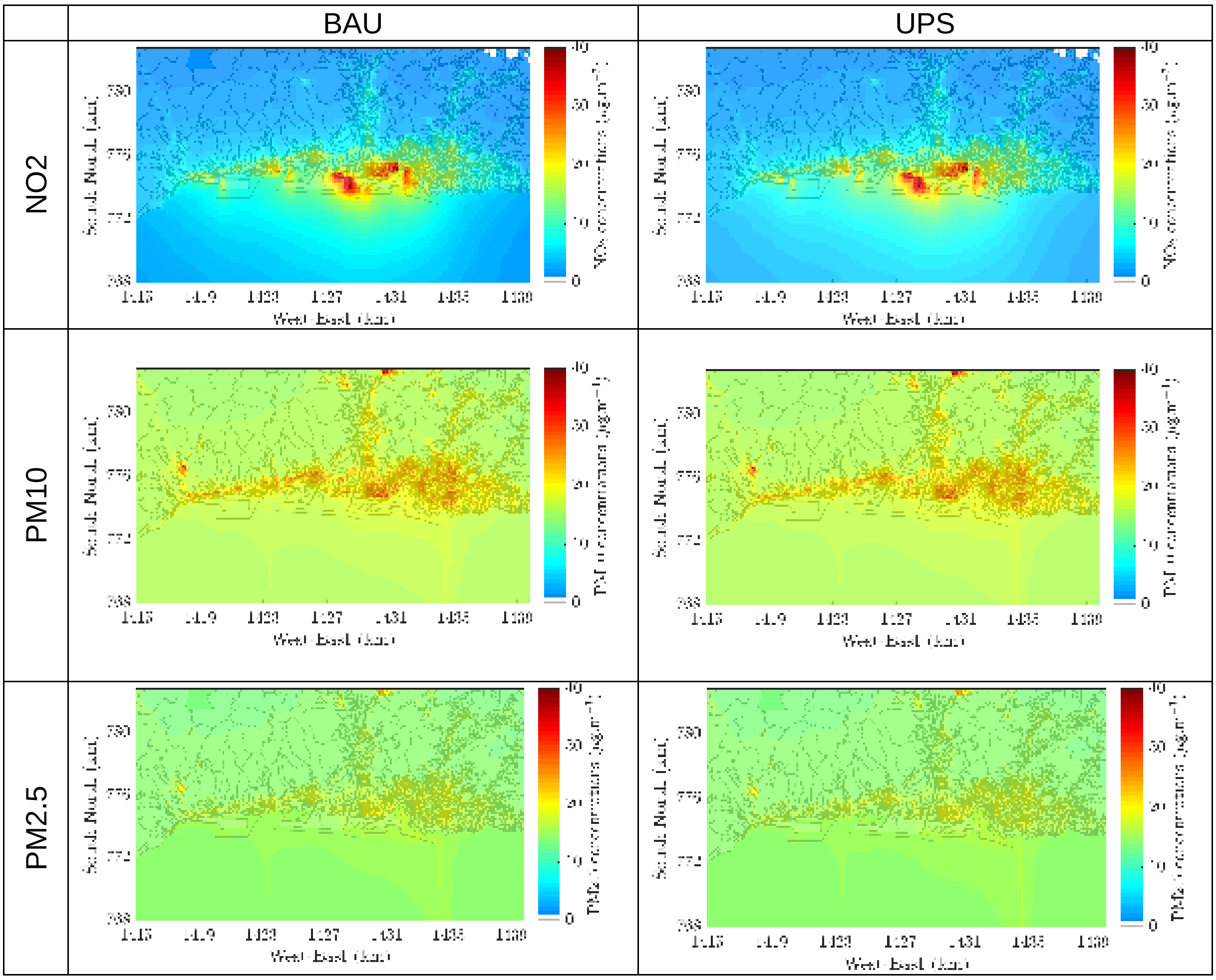
[6] The Business-As-Usual' scenario (BAU) concerns the set of strategies/policy measures which are already formally and politically agreed upon at European, national or regional level but may yet be implemented in the baseline year 2015 and thus only have an effect on emissions in the future.".

[7] It should be noted that the measures in the ClairCity Liguria UPS have mostly focused on solving NO_2 issues related to transport rather than PM. Considering the constant downward trend of the average annual PM_{10} concentrations in the Liguria Region, presumably, PM_{10} concentrations in reality will be by 2050 lower than those modelled by the UPS of ClairCity.

Figure 0-8 NO_2, PM_{10} and $PM_{2.5}$ concentrations in the Liguria Region in the BAU and UPS scenario in 2050[8]



Mutual learning for implementing citizen-inclusive policies in the Liguria Region

The Liguria Region can serve the other ClairCity case studies as inspiration concerning its Areas of Limited Traffic (ZTL) policies and incentives for electric transport and past experiences of citizen opposition.

- Several municipalities in the Liguria Region have an Areas of Limited Traffic (ZTL) with a different design. In these ZTL, access may be allowed only to vehicles owned by residents in the area; to electric cars, motorcycles and mopeds; or to authorised cars. In addition in the Liguria Region, electric cars enjoy also an exemption from the regional car tax as well as discounts on parking and often access to the areas of limited traffic (ZTL). The Liguria Region and more specifically Genoa provide also an example of how municipal policy cannot differ radically from the willingness of citizens. When the difference between a proposed measure and citizens' will is very

[8] ClairCity modelling results cannot be directly compared to the regional models in Liguria due to different modelling approaches. Also, within the ClairCity approach gradients between concentrations within and outside the city borders result from the overlay of different models. Only concentrations within the city borders should be regarded. See also the statement on ClairCity modelling in chapter 5.

different, the measure will clash against massive opposition as illustrated by the 'Vespa' ban attempt in 2016 described above.

Other ClairCity case studies can serve as inspiration for Liguria in the areas of public transport, discouraging private car use, encouraging cycling, energy measures, and engagement across municipalities.

- In the area of public transport other ClairCity case studies could inspire Liguria concerning one-ticketing systems; integrated train, bus and bike-rent systems; and city and metropolitan areas connection examples. ClairCity case studies also provide examples to discourage (conventional) car use, ranging from high parking tariffs in the city centre, reducing the number of residents' parking permits, reserved parking spots for electric vehicles. Exemplary cases to encourage cycling (through wide cycling networks, integrated train and bike-rent system, bike loans, and NGO and schools initiatives) can also inspire (e-)cycling developments in Liguria. Further some other ClairCity case studies provide examples of more advanced district heating networks. Lastly, ClairCity has gathered real examples of coordination between municipalities in a region with regards to air quality related issues.

The ClairCity Action Plan for the Liguria Region

For citizen-inclusive city air quality and carbon policies.

- **Constant public transport improvement needs to go along with other measures to discourage car use and collect revenues for financing public transport**
  ClairCity concluded that there are several conventional car users currently who would like to switch to using alternative means, at least some of the time. This has the potential to be an easy gain for policymakers if adequate measures are taken. To encourage modal change away from cars, first and foremost public transport needs to be become more convenient and attractive through continued improvement of its coverage, frequency, travel time. A transport card / ticketing system which works for all modes of transport would also facilitate public intermodal transportation. What is key is that improvements in public transport go hand in hand with discouraging car use. Examples of measures to discourage car use are expanding car-free, pedestrian zones; limiting parking spaces in the city centre of the Liguria Region municipalities; and most importantly, making parking more expensive (higher fees where parking is already paid and starting to charge where parking is still free). Traffic restriction policies, although unpopular, can be seen as an opportunity that can help establish new transport habits. Extra fees are excellent government revenue to fund further measures. Communication campaigns should be considered for informing citizens about public transport services available, about any improvements made in that regard and for defending any policies affecting cars.

- **Developing an urban bike network to facilitate (electric) cycling, integrate (e-) cycling with public transport and further facilitate walking through interventions in the urban space.**
  Liguria Region citizens want to walk and cycle more. (Electric) cycling should be facilitated by infrastructural measures such as urban cycle lanes (and lifts) that reach where citizens want to get on a daily basis, as opposed to the leisure bike routes that currently dominate the Liguria Region. Fostering intermodality that is, the integration of (e-)cycling with public transport, for instance, by allowing (e-)bikes in public transport

as well as offering bike rental options at popular train and bus stations, is also key. In order to make cycling safer, cycling traffic lights and bike parking facilities should be implemented. Walking can be boosted through increasing the space for pedestrians and expansion of pedestrian-only zones. Equipping pedestrian zones with electrical mini-taxis for citizens who may need motorised travel (elderly, mother with a small kid etc) can be considered. Public transport and constant improvements of (e-)bike infrastructure (including municipal biking/scooter sharing systems) will require effective promotion from the local government (for example through an awareness raising campaign), in order to inform citizens and encourage them to opt for those modes. Promotion of (e-)cycling should stress that cycling is not only an activity for leisure, but also an excellent, efficient and healthy way for commuting. The attractiveness of walking can also be promoted by awareness campaigns that stress its health benefits.

- **Provide incentives for electric vehicles.**

  Considering citizens' support for continued private vehicle use, and their wish to drive in cleaner vehicles, Genoa and the Liguria Region should continue to incentivise electric vehicles through subsidies, tax exemptions, offering ease for parking or access to restricted areas, and by ensuring that there are enough charging points. Continuing to reward EV drivers with free parking (while charging high parking fees for conventional cars) seems also important to encourage the switch particularly considering that 'more and free parking' is seen as important by citizens in Genoa. It should be noted though that electric vehicles do not solve the problem of scarcity of space (where it is necessary to make room for public transport and active travel) therefore electric mobility should not become an alternative to public transport and active travel.

- **Intensify cooperation with employers, schools, destinations of leisure and shopping to minimise car travel.**

  ClairCity found that the great majority of citizens in the Liguria Region would rather use public transport or active travel for commuting and shopping. The barriers that citizens encounter for changing their behaviour, such as current limitations of public and active transport infrastructure (public transport and bike lanes that do not reach these facilities), should be addressed as mentioned on the points above. In addition, the promotion of active travel and public transport requires intensified cooperation with big employers as well as destinations of leisure and shopping (e.g. retailers, shopping malls, sports clubs, theatres or cinemas). Options for bus stops and bike parking next to these destinations, together with biking infrastructure to get there should be considered. Workplace travel plans are mostly behaviour-related measures which entail no cost for the Liguria Region government when these are promoted through awareness raising campaigns (the cost of campaigns is considered negligible) and when ultimately employers and schools are responsible for executing such. In addition, working from home can be considered. This has no cost neither for citizens nor for the regional / local government when private business are financing the shift. It can however be more complicated when trying to implement it for public authorities. Further, city planning should consider encouraging more jobs, shopping and leisure options close by to where people live.

- **Air quality and sustainable development in general should be integrated in the current educational offer**

  Giving sustainability education - and in turn air quality education - a more prominent place in the curriculum, is essential to raise awareness of the youngest generations and their parents. The success of the ClairCity schools activity in Liguria also suggests that there is interest for air quality education to be integrated in the local schools curricula. Air quality education should address directly the activities / sources of pollution that citizens can relate to, which are also the most important local emission sources i.e. private cars and domestic heating. Addressing why it is important to go to school by public transport or active travel, should be part of sustainability education. These classes should also address biomass combustion as source for PM_{10} and other pollutants.

- **Work closely together with NGOs to create citizen sustainability (air quality / climate) awareness in the Liguria Region.** Citizen interest in air quality and carbon emissions in the Liguria Region is relatively low and limits possibilities for policy action. This might be related to a lack of knowledge. For instance, many citizens may not realise of the health dangers of transport emissions (cars and motorbikes). Education and awareness raising are important enablers identified in by Liguria Region policymakers to motivate and engage with citizens to shift to sustainable mobility and heating modes. If policy measures affecting citizens' lives are to be implemented, citizens need to be aware and understand why those measures are important or even necessary, and how they can affect their lives for the better (e.g. beneficial for health, pleasant environment). Against this backdrop, NGOs, as intermediates between authorities and citizens as well as citizen groups (e.g. Vespisti), can play an important role in educating the public and creating public awareness around air quality.

- **Promote renewable energy and district heating with renewables.**
The ClairCity engagement process showed that there is massive willingness from citizens for change regarding heating behaviour towards renewable energy. Considering residential heating is the primary source of carbon emissions in the city, action in this area is needed. Supporting rooftop solar PV, increasing rooftop solar on public buildings and supporting local citizen cooperatives for renewables generation could be measures that the government should consider to facilitate this. District heating, which is not popular in Genoa, can also provide a sustainable energy alternative if powered through renewables. Tackling this issue may also involve measures that may not be well received by all citizens at first (e.g. because they involve costs). Providing information and awareness raising is therefore essential to increase acceptance of policy measures. In addition, the dangers of biomass burning for air quality and health should be further communicated to citizens as often biomass is considered as a sustainable fuel.

- **Make a long-term vision for air quality related policies and make citizen support for current and planned policies more explicit**
ClairCity found that no long-term targets and policy plans exist for air pollution or climate change on either a regional or local level. Also, the last available air quality plan for the Liguria Region dates from 2006. As such, updating the Regional air quality plan and developing a long-term vision for air quality and climate related policy measures should be considered. Implementation can be facilitated by a detailed year-by-year implementation plan of long-term policy ambitions and a few milestones. The ClairCity analysis revealed that many citizens support not only the air quality and carbon policies that will bring direct benefits for them (e.g. improved public transport, subsidies for shifting transport/heating modes), but also support already happening / planned policies that will affect their lives (e.g. banning of diesel cars from city centres). Against this backdrop, communication of the citizen support for existing policies should be used to generate a wider acceptability of policies.

- **Reallocate costs or compensate costs of required transport measures through revenue generating local financial instruments and communicate the need for such instruments.**

  Finance is a key institutional condition that determines the possibilities for implementing policies in the areas of transport and energy. Subsidising heating systems, modes and/or fuel change, as well as public transport improvements are all costly. These costs can be compensated by generating local funding through for example parking fees and permits, congestion levies or workplace parking levies. Such financial instruments tend to be unpopular with citizens, hence the need to properly communicate such measures. Authorities should consider possibilities to reward behavioural change (e.g. discounts at local shops rewarding bike use/rental). Costs can be additional to current investments or simply a reallocation of existing investment funds. The costs of new walking/cycling infrastructure (e.g. expanding the cycling network) for instance, can be (partly) offset by reallocating funds currently dedicated to road infrastructure for cars, to infrastructure for walking and cycling.

- **'Improving quality of life' and 'preserving Ligurian environment' as hooks to defend transport and heating policies**

  Considering that neither awareness nor interest on air quality are high, other kinds of 'hooks' should be used to defend transport or heating policies that affect citizens. For example, messages around better quality of life or preservation of the Ligurian environment', which is so beloved by the locals. Given that Ligurian citizens appreciate walking, stressing the side benefits to overall quality of city life resulting from larger pedestrian zones and less cars could be more concrete messages to use in communications. In addition, with 'climate change' gaining traction at both the political and citizen levels, 'climate' can also be used as hook for putting policies forward. Considering the 'seasonal' aspect of O_3 (in hot summer days), it is probably worth implementing transport measures affecting cars/ motorbikes/ scooters and focusing any awareness campaigns in the summer months, when the problem is most visible.

1 Introduction to this report

This chapter provides the context for the ClairCity project (section 1.1), introduces the project objectives and process (section 1.2) and provides a reading guide for this report (section 1.3).

1.1 Context

In 2015, the Paris climate agreement set the goal to reduce global greenhouse gas emissions to keep global temperature rise this century to well below 2 degrees Celsius above pre-industrial levels[9]. A similar binding agreement for global air quality is lacking, but in 2005 the World Health Organisation formulated guidelines for ambient air quality aiming to improve health and reduce premature death caused by air pollution throughout the world. In 2016, 91% of the world population was living in places where the WHO air quality guidelines levels were not met.[10] Numerous countries and the European Union have set air quality targets that are often not as ambitious as the WHO guideline values, yet provide a legally binding framework for emission and concentration reductions of air pollutants.

Cities are the main contributors to the emissions of greenhouse gases and air pollutants, and many have set stricter local goals for emission reductions of greenhouse gases and air pollutants than the national or EU targets. Improving air quality and reducing carbon emissions as a contribution to the global, national and local targets and ambitions therefore will be a huge challenge for cities all over the world in the years to come.

Citizens living in these cities do not only cause an important part of these emissions through their daily behaviours, they can also play a key role in solving these issues. This can be via a change in behaviour and through providing democratic support for policy measures to be implemented that will affect their daily lives. ‘Citizen-inclusive policy making’ is therefore a crucial prerequisite for future air quality and carbon policies in cities to be successful in reducing emissions and reaching targets set on the local, national and global scales.

[9] https://unfccc.int/process-and-meetings/the-paris-agreement/the-paris-agreement
[10] https://www.who.int/en/news-room/fact-sheets/detail/ambient-(outdoor)-air-quality-and-health

1.2 The ClairCity Project

The **ClairCity Project**[11] puts citizens' behaviours and views central in city air quality and carbon policies. It addresses citizens' daily activities in cities, and their impacts on carbon emissions, air pollution and health. It also investigates what views citizens have on future air quality and carbon policies in their city.

'Citizen-inclusive policy making' in the ClairCity project is defined as:

1. Tailoring city air quality and carbon policy measures based on a detailed knowledge of current behavioural practices of citizens;
2. Asking citizens for their preferences regarding own future behavioural changes and taking these preferences into account in policy making;
3. Asking citizens for their preferences regarding future air quality and carbon policy measures in their city and also taking these into account in policy making.

In ClairCity, the views of citizens on future air quality and carbon policies in their city are investigated through an innovative suite of citizen engagement activities in six European cities[12]. As a result of the project, policymakers in each city receive a calibrated and quantified[13] set of preferred policies suggested by citizens. The project also identifies for each city separately the behaviours that citizens would be willing to change in order to contribute to such policies. Furthermore, overarching lessons from the six pilot cities for other cities aiming for citizen-inclusive air quality and carbon policies are presented in a final report and conference.

Figure 2-1 shows the **five-step process** in which the policy recommendations for city policymakers in the Liguria Region were prepared.

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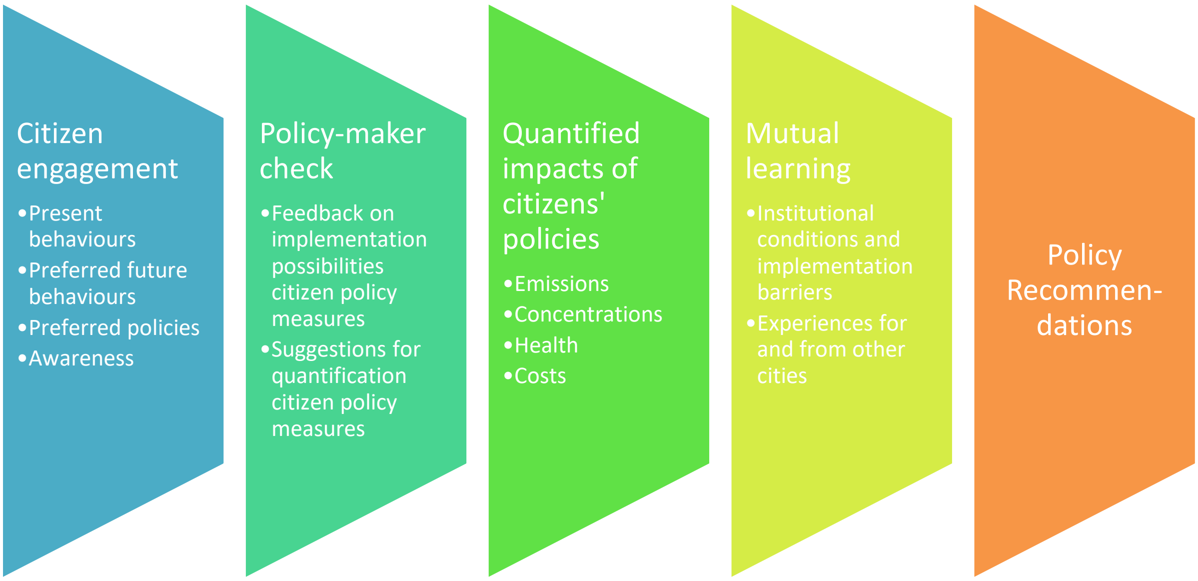
[11] The ClairCity project ('Citizen Led Air pollution Reduction in the City') is funded under the EU Horizon2020 programme, grant agreement nr 689289. It started in May 2016 and runs until May 2020. ClairCity website: www.claircity.eu.
[12] Amsterdam (Netherlands), Bristol (UK), Ljubljana (Slovenia), Sosnowiec (Poland), Aveiro / CIRA Region (Portugal) and Genua/ Liguria Region (Italy).
[13] Including views of other stakeholders and preliminary modelled data to give an outline of possible impacts on air quality and carbon emissions

Figure 1-1: ClairCity process including key phases and activities and chain of evidence leading to ClairCity policy recommendations



First, in the ClairCity engagement process citizens were consulted in order to examine their present behavioural practices, their preferences for future behaviours and their preferences for future policies. The process by itself contributed to citizen awareness of air quality and carbon issues and policies in the city and also included some activities specifically directed at awareness building.

Second, feedback was obtained on implementation possibilities of the citizen policy preferences through a workshop with local and regional policymakers involved in air quality and carbon related policies. In the workshop, the policy measures that evolved from the engagement process were further developed and partly quantified.

Third, from the more detailed citizen policy measures a ‘Unified Policy Scenario’ was constructed. In this scenario the impacts were modelled regarding emissions and concentrations of air pollutants and greenhouse gases, health impacts and costs to citizens and city. These impacts were compared to a business-as-usual scenario with city policy measures implemented and specified in the base year 2015.

Fourth, the specific institutional conditions and barriers for implementation of the citizen measures in the Liguria Region were examined. These consisted of political framing, financial conditions, multilevel policies and other conditions. These were compared with the experiences in the other ClairCity cities to examine what lessons could be learned from and for the Liguria Region regarding promising ways for implementation of the citizen measures.

The detailed policy recommendations for the Liguria Region were prepared taking the four aforementioned steps into account.

1.3 This report

This report is the ClairCity "**Final Policy Package Report**" for the Liguria Region[14]. It provides a summary of the lessons learned for local air quality and carbon policy making in the Liguria Region. The focus has been placed on the Genoa area, since this is where exceedances of the regulatory limits for air quality in the Liguria Region happen. The primary target group of this report are therefore the Liguria Region policymakers and politicians. The report can be further of interest to politicians and policymakers in other cities, to national and regional policymakers, to EU policymakers, and not least to stakeholders and citizens in the Liguria Region and elsewhere engaged or interested in improving air quality and reducing carbon emissions in their city.

Chapter 2 of this report discusses the ClairCity citizen engagement methods that were applied and tested in the Liguria Region, which focused on Genoa area. Chapter 3 analyses the current air quality and carbon situation in the Liguria Region and looks into current behaviours of citizens that contribute to air pollution and carbon emissions. Chapter 4 examines what behavioural changes Liguria Region citizens envisage for themselves in the future and what preferences they have for policy measures. It also shows what reflections Liguria Region policymakers have on the views of citizens. Chapter 5 quantifies potential consequences of the citizens' preferences in terms of emissions and concentrations of air pollutants and of carbon dioxide, in terms of health and in terms of costs of measures. Chapter 6 discusses specific institutional conditions and barriers for citizen-inclusive policies found in the Liguria Region as well as mutual learning possibilities in order to remove these barriers. Chapter 7 finally gives the main conclusions and policy recommendations that follow from the ClairCity citizen engagement and analysis in the Liguria Region.

[14] In the ClairCity project, this report is part of deliverable D7.5 ClairCity Policy Package – Last City, where also the Policy Packages for Amsterdam, Bristol, Sosnowiec, Ljubljana and the Aveiro Region are encompassed.

2 ClairCity engagement in the Liguria Region

The ClairCity project developed a suite of citizen engagement methods aiming to involve a broad cross-section of the population. This mix of proven policy related engagement methods includes a three-step ‘Citizen Delphi Process’ consisting of proven methods such as online surveys and workshops to engage citizens, and other stakeholders such as experts. Also, an innovative game for mobile phones was developed (ClairCity Skylines) that allows citizens to state their policy preferences for the city in a creative context.

Figure 2-1: ClairCity ‘Skylines’ Game launch via social media in the Liguria Region

Further, a schools activity and a filming activity were designed and implemented in order to improve the awareness of young and elderly people respectively. An overview of citizen engagement methods designed and applied in ClairCity is given in Table 2-1.

Table 2-1: ClairCity’s citizen engagement activities in the Liguria Region

Objective	Method	Citizens, general	Specific citizen groups[1)]	Stake-holders[3)]	Policymakers
Policy related	Online surveys	X			
	Street interviews	X			
	Workshops	X		X	X
	Serious gaming	X			
	Schools activity		X[1)]		

Awareness related	Film competition		X[2)]		

1) Pupils secondary school
2) Elderly
3) NGOs, business

In total, during the period 2017 – 2019 around 1 400 stakeholders, primarily citizens, were reached in the Liguria Region. Such an engagement was done through various methods (Table 2-2). It should be noted that most of the activities were rolled out in the Genoa area and not across the whole of the Liguria Region. While this sample is not fully representative of Genoa and the Liguria Region population as a whole[15], it gives an indication of support for policy measures and intentions for behavioural change that can be used by policymakers to inform future policies.

Table 2-2: Number of participants in ClairCity stakeholder engagement methods in Genoa area (Liguria Region)

Citizen engagement activity	Participants engaged
Delphi Process (Round 1 & Round 2 surveys + Delphi workshop)	1 127
Skylines Game	66
Mutual Learning Workshop	28
Stakeholder Dialogue Workshop	10
Schools activity	23 teams (123 students in total) 4 teacher teams (12 teachers)
Film competition	5[16]
Policy Workshop	20

[15] We received 646 responses to our Round 1 survey in Genoa, out of a municipal population of 580,097. The majority of respondents (59%) were female. Over 65s were under-represented, with a disproportionate number of younger respondents. Only 11% of the respondents are over 65, compared to a municipal proportion of 29%. Our respondents were disproportionately educated, with 28% holding a degree equivalent or higher, compared to the municipal average of 11%. 25% of the region has received either no education or only up to primary school, compared to less than 1% of our respondents.

[16] Five people submitted videos but in the process of recruiting videos tens of people were engaged. Also, the promotion of the videos through social media reached hundreds of people potentially.

3 Current air quality and carbon situation in the Liguria Region

In the ClairCity project, the existing air quality and carbon status and policies in the Liguria Region were identified in order to establish a baseline against which the impacts of citizen desires for the future of their city could be compared and contextualised.

3.1 Current concentrations and emissions

As noted in the ClairCity Policy Baseline report for Liguria (March 2018)[17] an overall decrease in air pollution is observed in the past decades. The main policies that have contributed to this trend are the standards relating to sulphur content in marine fuels, the standards for diesel cars and the (progressive) decommissioning of some industry plants (e.g. the integrated ILVA steel plant, the ENEL thermoelectric power plant in Genoa)[18]. Nonetheless exceedances are observed, mainly for NO_2, PM_{10}, and O_3[19].

NO_2 concentrations – NO_2 is the most critical pollutant as EU limit values are not met in the Liguria Region. The highest values are found in traffic stations with exceedances of the average annual concentration limit value (40 µg/m3) in several traffic monitoring stations in the Genoa agglomerate and in one traffic station in La Spezia. The overall measures adopted in recent years addressing emissions from industry, energy, transport, and maritime activities have helped bring down NO_2 concentrations, albeit not enough to comply with the EU limit values at all the Liguria traffic stations. For this reason, the agglomeration of Genoa is one of those zones affected by the aforementioned infringement procedure No. 2015/2043.

PM_{10} concentrations – The overall measures adopted in recent years addressing emissions from industry, energy, transport, and maritime activities have helped bring down PM_{10} concentrations in Liguria to the limit values required by the EU. PM_{10} remains however a pollutant to be monitored closely, given the high values and number of exceedances of daily limit values (50 µg/m^3 not to be exceeded more than 35 times/year) in several industrial, traffic, and background stations. Genoa exceeded PM_{10} day-mean limit values in one station in 2015 for the first time in the period 2010-2016, however all locations complied with the annual mean (40 µg/m^3).

O_3 concentrations – Exceedances in O_3 concentrations persist in most of the Liguria Region. In 2016, the EU's maximum daily 8-hour mean limit value (120 µg/m3 as the maximum daily average of 8 hours, not to be exceeded for more than 25 times/year, and as an average of the last 3 years) was exceeded in the two zones where O3 is

[17] Please refer to D6.2 Policy Baseline Report – Last City which contains a whole detailed chapter on the Liguria Region. Available on www.claircity.eu

[18] Liguria Region (2016), Emissioni regionali per uno o più Inquinanti (Dettaglio socioeconomico: Macrosettore); Liguria Region (2015) Sintesi risultati delle Proiezione delle emissioni Scenario di riferimento.

[19] Since O_3 is a photochemical secondary pollutant, the levels are determined by the meteorological characteristics and precursor emissions such as NO2 and volatile organic compounds.

measured. Exceedances have been registered in urban, suburban and rural stations. In 2016, and for the first time since 2007, two days were registered in which the hourly average was above the alarm threshold (240 µg/m^3 for 3 consecutive hours), in the Genoa agglomeration zone.

BaP concentrations – The situation regarding Benzo (a) pyrene (BaP) has worsened and the average annual limit value (1.0 ng / m^3) is since recently no longer met as seen in monitoring stations located in the inland Bormida industrial area.

SO_2 concentrations – SO_2 does not present critical issues in any area of Liguria. EU limit values (both daily and hourly ones) are met although there are still a few exceedances in the Sarissola-Busalla industrial monitoring station. The highest concentrations are recorded in stations affected by industrial and port activities.

CO emissions - CO is not a problematic pollutant in Liguria, however occasionally, some stations register high values. In 2016 (latest year for which data was available at the time of writing the report) this was the case for the traffic stations Corso Europa and Via Buozzi in the Genoa agglomerate. The highest values are recorded in stations aimed at monitoring vehicle traffic.

As also noted in the ClairCity Policy Baseline report for Liguria[20] in the period 2005-2011 a significant GHG emissions reduction (for all CH_4, N_2O and CO_2) has taken place in Liguria. The most important GHG namely CO_2 emissions (accounting for over 95% of total emissions in Liguria) has decreased in this period, mainly due to a reduction in emissions from industry.

Figure 3-1 Main features of the current the Liguria Region air quality and carbon situation

NO_2	PM_{10}	O_3	BaP	SO_2	GHG
• Main pollutant of concern • EU limit values are not met • The Genoa Agglomeration has the highest concentrations • Main source: transport	• Pollutant of concern • Concentrations decreased in the last years but remain high • Main sources: Industry, transport	• Exceedances in most of the Liguria Region • Exceedances in urban, suburban and rural stations • Exceedances above the alarm threshold in 2016	• Situation has worsened recently • Main source: Industry, wood burning	• Not a problem pollutant • Main sources: Industry, harbour	• Significant CH4, N2O and CO2 emission reductions in 2005-2011 • CO2 (95% of total GHG) has also decreased • Reductions mainly from industry emissions

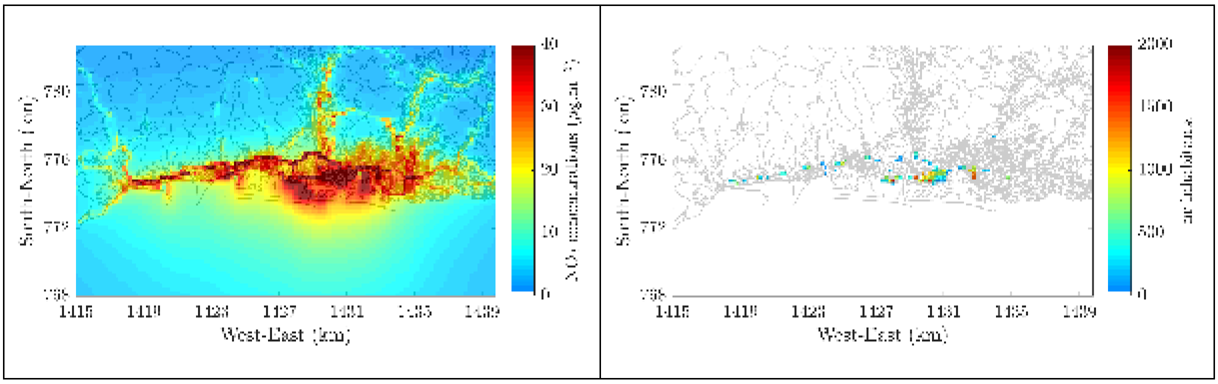
The ClairCity modelling corroborates these facts. ClairCity has modelled concentrations of air pollutants for the base year 2015 in order to compare them to business-as-usual policies as

[20] Please refer to D6.2 Policy Baseline Report – Last City which contains a whole detailed chapter on the Liguria Region. Available on www.claircity.eu

known in 2015 as well as to the measures jointly suggested by citizens and policymakers. Annex C gives more information of the ClairCity modelling assumptions[21].

Figure 3-3 a) indicates that there are high exceedances of the EU annual legal limit value for NO_2 (EU annual legal limit value for NO_2 concentrations is 40 µg.m^{-3}) in the baseline year (2015) as modelled by ClairCity. The figure shows a correlation between concentrations and the road traffic pattern, as well as around the port area. The simulation results indicate an annual maximum concentration of around 85 µg.m^{-3} NO_2 within the urban area of Genoa. According to the modelling, this value is exceeded in 123 grid cells[22] (out of 10 000 grid cells), although 97 of those grid cells have population living in there (Figure 1-1 b). that the ClairCity model estimates that **around 8% of the total population within the entire Region are potentially exposed to NO_2 concentrations above the EU annual legal limit value.**

Figure 3-2 NO_2 contour maps for Liguria Region in current situation (reference year 2015): a) annual average of NO_2 concentrations and b) number of inhabitants within the cells exceeding the EU annual limit value of 40 µg.m^{-3}.



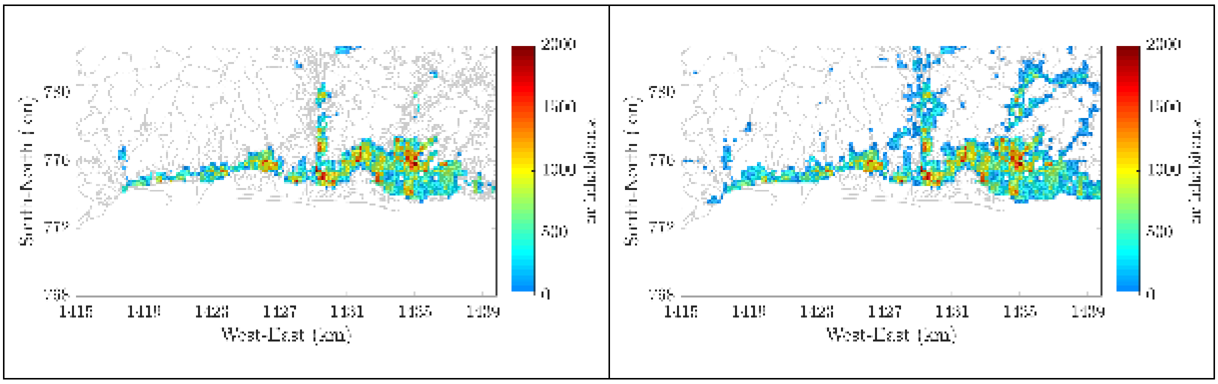
The PM_{10} concentrations contour map (Figure 3-3 a) indicates only a few grid cells exceed the EU legal limit value in 2015 (reference year), with just 3 grid cells showing values above the annual EU limit value. However, the results indicate several exceedances to the World

[21] The results of ClairCity modelling do not fully correspond to those of local modelling as a result of different modelling assumptions. A full comparison of ClairCity modelling assumptions with those of all cities was considered to be outside the scope of this project. ClairCity modelling results should therefore be seen as indicative only.
[22] A 'cell' refers to the 200 m x 200m modelling domain that was utilsed by ClairCity

Health Organisation (WHO) guidelines, which are stricter (albeit voluntary). The Figure shows 924 cells where people live exceed the WHO annual guideline value for PM_{10} in 2015, which is equivalent to approximately **77% of the population within the simulation area** being **potentially exposed to PM_{10} concentrations above the WHO guidelines**.

In a similar vein, with regards to $PM_{2.5}$ concentrations (Figure 3-3 b), the ClairCity modelling indicates that only 5 grid cells where people live exceede the EU legal limit value. Similar as with PM_{10}, the Liguria Region does not comply with the guidelines of the WHO though[23]. The Figure shows that 2637 inhabited cells exceed the WHO guideline value for $PM_{2.5}$, which implies that **the entire population within the simulation area are potentially exposed to $PM_{2.5}$ concentrations above the WHO guideline**.

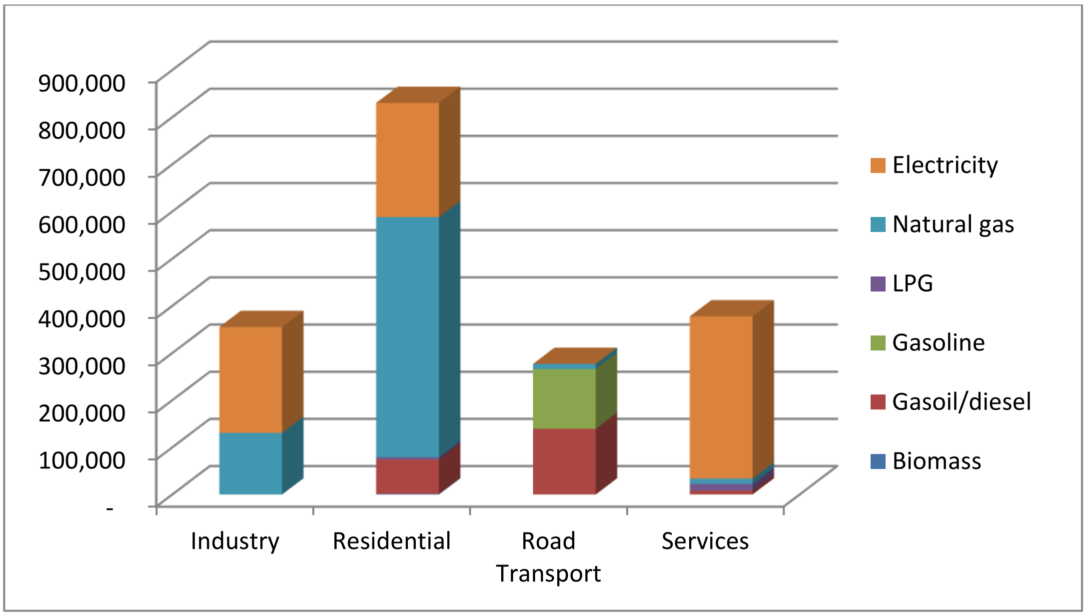
Figure 3-3 Number of inhabitants within the cells exceeding the WHO air quality guideline values: a) of 20 µg.m^{-3} for PM_{10} concentrations, and b) of 10 µg.m^{-3} for $PM_{2.5}$ concentrations.



In Figure 3-4 the Carbon Footprint in 2015 is expressed as tonnes CO_2 equivalent reported by fuel and sector. The indicator takes into consideration the overall life cycle of the energy carrier. This approach includes not only the emissions of the final combustion, but also all emissions of the supply chain, namely the emissions of exploitation, transport and processing (e.g. refinery). Emissions that take place outside the location where the fuel is use are therefore included. The figure shows that residential heating is the main contributor to the carbon footprint of the Liguria Region, with CO_2 originating mainly from natural gas. The carbon footprint from industry and services is about half of that each. CO_2 in these cases is mainly result of electricity, particularly in the services sector.

[23] Based on the latest scientific evidence available, WHO has established limit values for PM_{10} and $PM_{2.5}$ that are substantially below current EU legal limit values. These values are 20 µg.m^{-3} for PM_{10} (compared to a legal limit value of 40 µg.m^{-3}) and 10 µg.m^{-3} for $PM_{2.5}$ (legal limit value 25 µg.m^{-3} annual mean). See https://www.who.int/news-room/fact-sheets/detail/ambient-(outdoor)-air-quality-and-health

Figure 3-4: Carbon Footprint in the Liguria Region expressed as tonnes CO_2-eq on Life Cycle by fuel and sector in 2015 (Source: ClairCity modelling)



3.2 Existing air quality and carbon policies

The Liguria Region ClairCity Policy Baseline report (2018)[24] studied the policies in place in the Liguria Region in the areas of transport and energy mainly. This section synthesises the findings in the report, complementing such with some more recent information were updates have taken place.

The Liguria Region has a **wide regional network of local public transport** consisting of urban and suburban buses (mainly diesel-powered), trains, a metro, maritime transport and a funicular and lifts. Large railway works are underway to **develop the 'Genoese node'** with the aim to separate the traffic flows of the metropolitan and local railway system, from those of medium-long distance (for travellers and goods), in particular along the coastal axis of the city. Also the development of the **Terzo Valico railway network** which will allow the rapid connection between Genoa and the main railway lines of northern Italy, is ongoing (expected to be finalised by 2022). This will offer the port of Genoa an alternative route for the transfer of goods to the Po Valley area and northern Italy, to substitute road transport. In addition the **buses fleet is undergoing continuous renewal,** with 96 new Euro 6 vehicles and 11 hybrid vehicles entering service in 2019.[25]

On road transport, the link-road **Gronda project** is underway to upgrade the current Genoese highway infrastructure, which is inadequate to deal with urban and extra-urban traffic. The interventions planned have been designed to allow traffic to cross from one side

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[24] Please refer to D6.2 Policy Baseline Report – Last City which contains a whole detailed chapter on the Liguria Region. Available on www.claircity.eu

[25] AMT Genova (2019) Carta della mobilità 19-20

of Genoa to the other without going through the city centre. To encourage sustainable mobility **financial incentives** are being granted **for the purchase of electric vehicles** and charging points in Genoa (financed by the Ministry of Infrastructure and Transport as part of the national infrastructure plan for the recharging of vehicles powered by electricity - PNire). Electric mobility is also incentivised by the Region and Municipality of Genoa through measures such as the exemption from the regional car tax and with discounts on parking and access to the areas of limited traffic (ZTL). Since recently, a public e-bikes sharing system and privately operated e-scooters[26] have been introduced in Genoa. Also a free-of-cost charging point for electric scooters is in place[27]. A municipal bike sharing scheme has been in place since 2009 years although this is barely used. The city is applying for a national funding call in order to revive the system.[28]

Concrete energy targets, strategies and measures aiming for energy efficiency and the increased production of renewable energy sources are laid out in the Regional Environmental Energy Plan 2014-2020 (PEAR)[29]. There is regional funding for energy efficiency which are promoted through ESCOs and measures which will be implemented through The Thematic Objective 4 of the Regional Operation Programme for Liguria (POR Liguria) funded by the European Regional Development Fund (ERDF). Measures on renewable energy will also be implemented through POR funding and regional rural development funding (PSR) alongside regulatory measures. Liguria is behind with renewables implementation compared to other regions in Italy. Renewable energy for heating purposes consists mainly of biomass burning - mostly outside the major urban centres.

As part of their Triennial Operational Plan of the Port of Genoa 2017-2019 port authorities launched a significant set of measures for the port of Genoa and Savona aimed at the **electrification of docks in ships repair area and future use of LNG** for ships. These works were finalised in 2018 after a few delays. There are more electrification projects underway for the port of Pra' (to be finalised by 2021) and for a cruise and ferry area (to be implemented by 2025)[30].

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[26] https://mimoto.it/
[27] Telenord (2020) Genoa, 60 free recharging stations for scooters and electric bikes
[28] Genova24 (2020) Guasti continui e utenti in fuga, bike sharing al minimo storico: l'ultima chance è un bando Mise
[29] Regione Liguria (2017) Piano Energetico Ambientale Regionale (PEAR 2014-2020)
[30] Port of Genoa (2019) L'elettrificazione delle banchine dei porti del Mar Ligure Occidentale

4 Citizens' views on cleaner air and carbon policies in the Liguria Region

The ClairCity citizen engagement process in the Liguria Region, and in particular the Delphi process, gave insights into the degree that citizens want to change their behaviour in ways that will contribute to cleaner air and lower carbon emissions in the Liguria Region, as well as into views that citizens have about future policies.

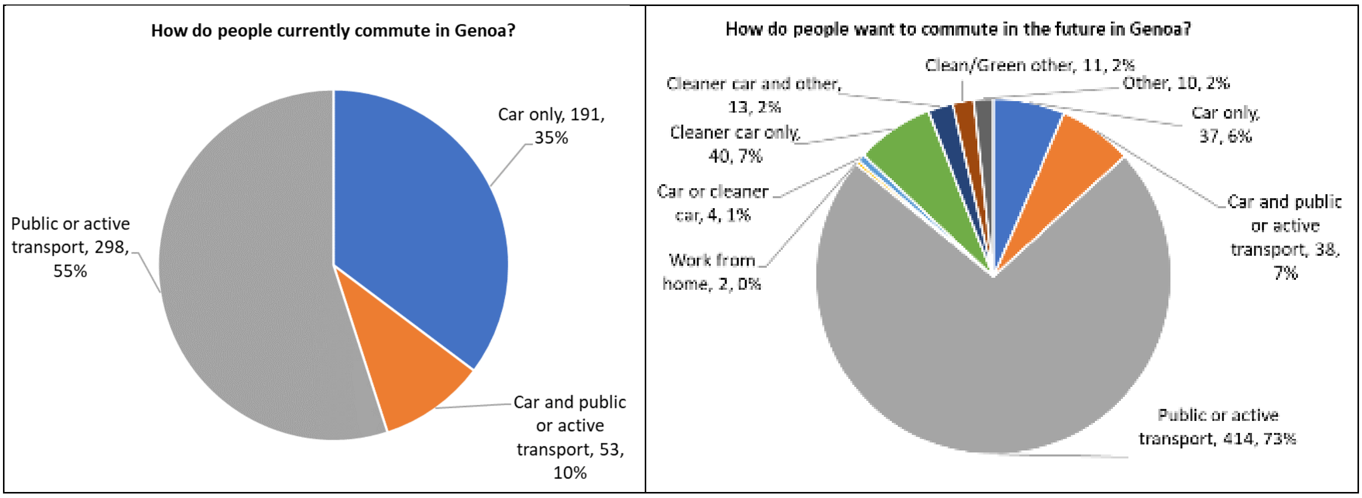
4.1 Views of citizens on their own transport behaviour

In the Delphi process, citizens in Genoa area were asked about their preferences in terms of transport and heating behaviour for the future. Below the results are given of the sample of over 500 people consulted.

4.1.1 Commuting behaviour

As seen in Figure 4-1, 35% of the Genoa citizens in our sample 'always' use a private vehicle for their commute in Liguria. In most of the cases (21% out of 35%) this was a scooter or motorbike. 55% of respondents 'never' used a private motorised transport to commute to work and instead commuted 'always' by public transport (28%) or active travel (27%). The predominant non-car mode overall was public transport (50% would use it at least sometimes), with more respondents using this mode than using cars. 22% of the respondents walked to work and only 5% of respondents cycled.[31]

Figure 4-1: Proportions of present and future car use of commuters in Genoa[32]



[31] A more specific split please is however presented in D4.4 Delphi Evaluation available in the ClairCity website: http://www.claircity.eu/reports/

[32] By 'car only' we mean 'private motorised transport only' so it also includes scooters.

In contrast, in the future, 73% of the people in Genoa area would prefer not to commute to work by private motorised transport. Instead, public transport is the preferred option (60% of respondents would like to use it at least sometimes). 16% of the people would like to walk and **the number of people wanting to cycle to work is 4 times larger (21%) than currently.**

Table 4-1 Matrix of modal change desires for commuting trips in Genoa[33]

Commuting (total = 519)	High polluting choice in future (conventional car only)	Low polluting choice in future (car and walk; walk and bus, online deliveries, EV etc)
High polluting choice in present (conventional car only)	22 Entrenched	158 Looking for positive change
Low polluting choice in present (car and walk; walk and bus, online deliveries, EV etc)	11 Getting worse	328 Staying positive

Responses from the sample survey indicated that **several people are 'looking for positive change'. There is a large willingness primarily to switch from conventional cars towards both public transport and active travel, but also to change conventional cars for green cars** (e.g. electric). Note that this number may be disproportional due to a sampling bias in our survey[34].

ClairCity examined the reasons why conventional car users and scooters users who would like to switch to "public or active travel" (including public transport, walking or cycling), at least some of the time (our 'Looking for positive change' group), do not do so. The reasons are mainly related to slowness (time it takes to travel) and timetabling.

"The metropolitan network of our city is ridiculous and to make the same journey home / work using public transport would take much longer."

"The scooter offers comfort and public transport is inefficient"

Also the reliability or the availability of public transport, were highly criticised.

"*The subway does not reach my home and my destinations*" and "*high prices in public transport that are often late in dirty and badly served."*

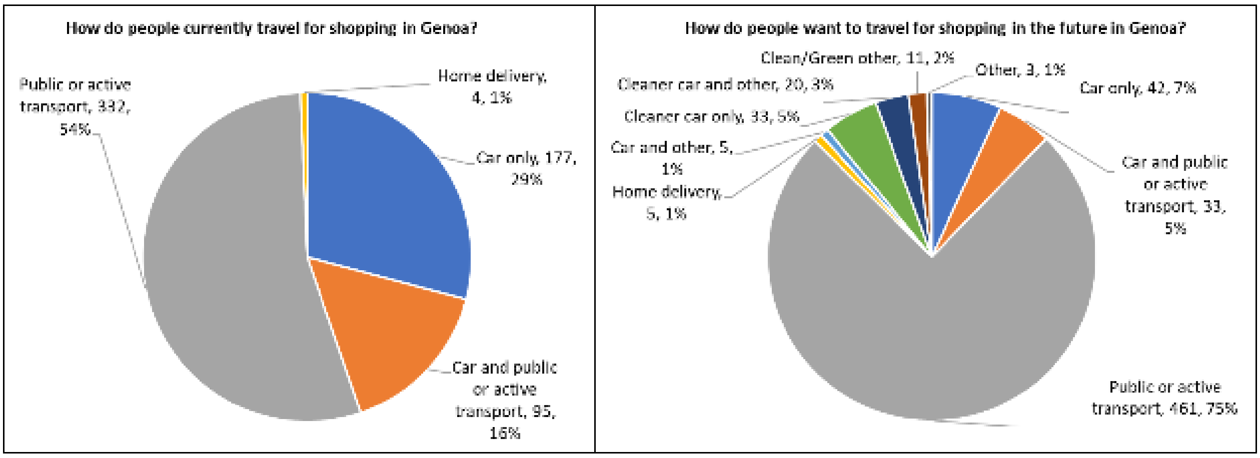
[33] **Entrenched:** those who only use a conventional (fossil fuel) car in the present and would like to continue to only use a conventional car in the future. **Looking for positive change:** those who only use a conventional car in the present but would like to use additional means next to or instead of a conventional car (i.e. public transport, active travel, online delivery or electric vehicle) in the future. **Getting worse:** those who use alternative means as well as cars in the present but would like to only use a conventional car in the future. **Staying positive:** those who use alternative means next to conventional cars in the present and would like to continue to use additional means as well as or instead of a conventional car in the future.

[34] That people who responded were more likely to be environmentally minded, or that when giving answers people were more likely to give what they thought was the "right" answer that the survey was looking for.

4.1.2 Shopping behaviour

Almost 30% of the respondents are dependent on their cars in order to do shopping and over 50% always access the shops either by public transport or active travel. **When asked about the future, there is a huge preference for accessing shops by public transport or through active travel** (by 75% of the respondents). Clean cars are the exception, which 5% more people would like to use in the future in order to go shopping.

Figure 4-2: Current and future transport choices for shopping in Genoa



In the matrix below we have divided our shopping respondents into four groups, depending on their use of a conventional car for this transport activity:

Table 4-2: Matrix of modal change desires for shopping trips in Genoa

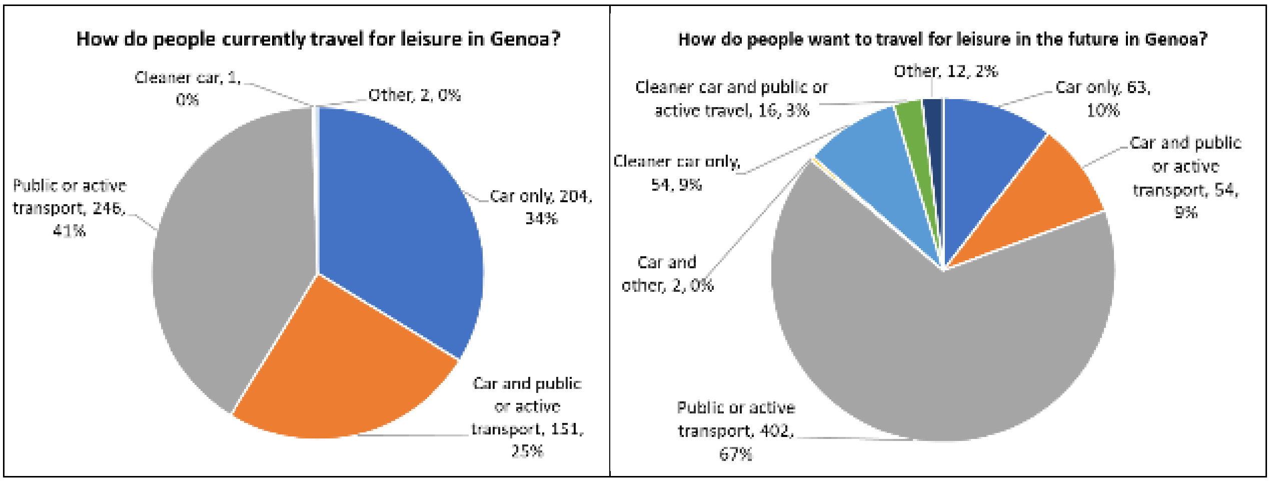
Shopping (total = 641)	High polluting choice in future (conventional car only)	Low polluting choice in future (car and walk; walk and bus, online deliveries, EV etc)
High polluting choice in present (conventional car only)	30 Entrenched	140 Looking for positive change
Low polluting choice in present (car and walk; walk and bus, online deliveries, EV etc)	12 Getting worse	459 Staying positive

It is observed that there is willingness among respondents for positive change towards (more) sustainable transport behaviour. The great majority of citizens (over 70%) are 'staying positive', that is, would like to continue using public transport or active travel. A large share (around 22%) of respondents are 'looking for positive change' (that is shifting from car to other modes at least partly, or to a cleaner car).

4.1.3 Leisure behaviour

Leisure is the activity for which 'car' transport is most popular in Genoa area, with approximately 60% of the respondents using a conventional car either always (34%) or partially, in combination with public transport or active travel (25%). 41% of the respondents 'always' access leisure in a non-motorised way, either by public transport or through active travel. In the future, the share respondents wanting to access leisure with a conventional car decrease, as more people would like to be able to access leisure just by public transport or active travel (67%). There is also a quite prominent increase (9%) in the share of people who would opt for a cleaner car.

Figure 4-3: Current and future transport choices for leisure in Genoa



In the matrix below we have divided leisure respondents into four groups, depending on their use of a conventional car for this transport activity:

Table 4-3: Matrix of modal change desires for leisure trips in Genoa

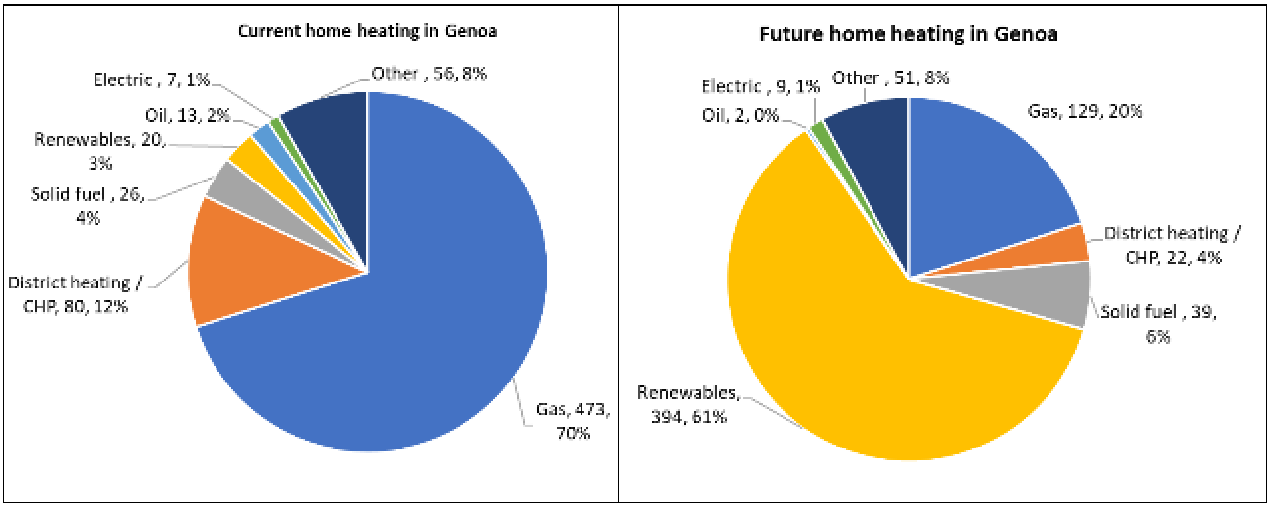
Leisure (total= 581)	High polluting choice in future (conventional car only)	Low polluting choice in future (car and walk; walk and bus, online deliveries, EV etc)
High polluting choice in present (conventional car only)	49 Entrenched	146 Looking for positive change
Low polluting choice in present (car and walk; walk and bus, online deliveries, EV etc)	17 Getting worse	369 Staying positive

We observe that there is willingness for sustainable modes and positive change, as the number of those 'getting worse' and 'entrenched' and notably lower that the share of people 'looking for positive change' and 'staying positive'. This means that over 60% of the respondents would like to continue accessing leisure either by public transport or through active travel ('staying positive') and 25% additional (who currently use a car at least partly) would like to do so in the future.

4.1.4 Home Heating behaviour

At the time of being surveyed, 70% of respondents used gas in their homes, with 12% on district heating (**Error! Reference source not found.**). For the future, however, there was a **clear d esire to shift away from gas towards renewables** (the demand for renewables is 20 times bigger than current use), with district heating also reducing its share.

Figure 4-4 Current and future choices for home heating in Genoa



We explored the reasons why those who were currently using solid fuel[35] heating systems wanted to change to a less polluting source or felt they could not (or were not interested).

Table 4-4 Matrix of modal change desires for home heating in Genoa

Heating (total= 619)	Solid fuel in the future	Not solid fuel in the future
Solid fuel in the present	9 Entrenched	17 Looking for positive change[36]
Not solid fuel in the present	30 Getting worse	563 Staying positive

The "getting worse" group in Genoa was larger than those who were "looking for positive change", with 30 people wanting to start using solid fuel heat sources. They were mostly using gas in the present, with 10% using district heating. no alternative"). Although ClairCity lacks an elaborate explanation of what motivated people to want to use solid fuel instead of gas or district heating, the main reasons given were '*I do not own my flat/house'*, *'I have no alternative'* and *'cost'.* All of those 'looking for positive change' wanted to switch to renewables or other green

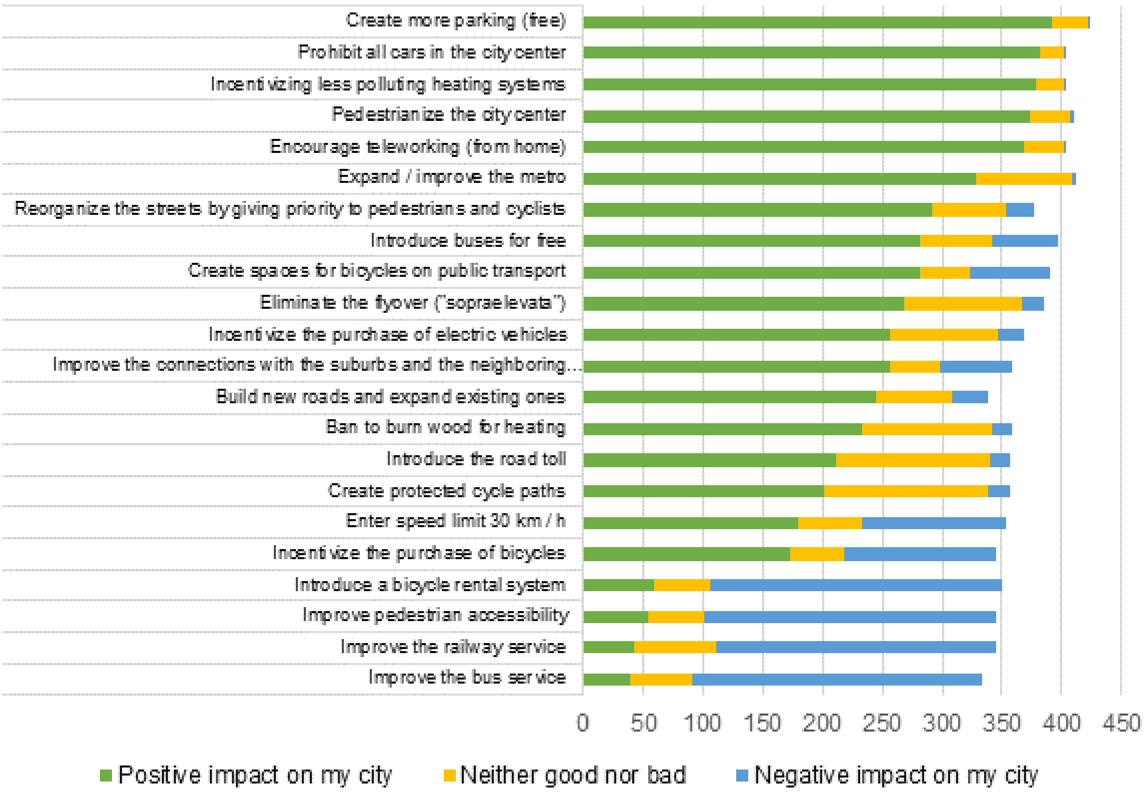
[35] "Solid fuel" includes wood, pellets, biomass or coal (although coal is already banned in the city). These fuel types have been grouped together as they all have a negative impact on local air pollution, despite the fact that they have different carbon footprints.
[36] From an emissions perspective, solid fuel burning is the only 'negative' choice, hence 'looking for positive change' applies to those who are moving from solid fuel to any other fuel type. However, if they are already using other modes other than solid fuel, then they are 'staying positive'. Solid fuel use in the present is pretty low in Genoa so hence the 'looking for positive change group' is relatively small.

sources. Their reasons for not being able to change were largely financial, with 70% of this group mentioning cost as a problem.

4.2 Views of citizens on future policies in the Liguria Region

Based on citizens views in the Genoa area, the measures that citizens and other stakeholders believe would in improve the Liguria Region most are mixed (Figure 4-5).

Figure 4-5 Citizens' views on the impact that proposed policy options in Genoa area would have on their city



Although 'creating more (free) parking' was seen as the top priority by citizens, respondents appeared to recognise that 'banning cars' and 'pedestrianizing the city centre' would be beneficial for Genoa. Ironically, 'improving pedestrian accessibility' was seen as a negative impact. 'Encouraging teleworking', thereby reducing the need to commute, was popular for individuals and for the city/region. While there is quite a lot of support for 'expanding/improving the metro', interestingly enough, this is not the case for other modes like buses or railway. Reducing the space for cars in order to 'reprioritise pedestrians and cyclists' is also supported by several respondents. In the area of energy, 'incentivising less polluting heating systems' was a high priority for the city/region but banning wood burning was a lot lower in the priorities list. This suggests that respondents may not be aware of 'wood burning' being a polluting form of heating.

4.3 Reflections from the Liguria Region policymakers

The seven preferred generic policy measures of the Genoa area citizens and other stakeholders in the Liguria Region were discussed in a workshop with policymakers. Besides the ClairCity team in Liguria (colleagues from Techne as well as the Regione Liguria), other 10 stakeholders participated: policy officers from Regione Liguria (environment, infrastructure and health departments), IRE delegates (company which deals with infrastructure, building renovation and energy in the Liguria Region), ARPAL (the Environment Agency of the Liguria Region), the Western Ligurian Sea Port Authority, and representatives from Genoa Municipality and AMIU (Multiservice and urban hygiene company).

The seven measures related to the political areas considered by ClairCity namely road transport and domestic heating. For each of the measures, policymakers were asked to choose between two concrete measures: a specific measure that represented the 'current' ambition level (existing / planned policy) and a specific measure that represented a 'high' ambition level. The seven concrete policy measures chosen by policymakers were put together in a "Final ClairCity Unified Policy Scenario" or "UPS" that has been modelled (see next Chapter).

Policymakers in Liguria were ambitious for measures in favour of improving the options for public transport, collective transport and active travel. A change in behaviour of citizens (i.e. shift from private cars to public transport) was seen as difficult to achieve, partly due to public transport not being optimal (travel time, cost, unavailability in some areas e.g. hilly parts of the city). Policymakers also perceive lack of space and the costs required to improving the network as important barriers to the development public transport further. The recent collapse of the highway viaduct (Morandi bridge) in the city of Genoa was perceived to bring opportunities in terms of new investments for the modernization of public transport and providing an opening to the development of new transport habits and ways of organising city. Policymakers in Liguria also thought that introducing specific requirements in public transport management service contracts as well as reduced rates could help encourage people make the switch from private cars to public transport modes. Encouraging shared mobility initiatives (bikes, cars, vans, motorcycles), alongside the use of public transport is also believed to be necessary.

Policymakers agreed that the current policy to progressively ban diesel vehicles and the most polluting motorcycles in the city' is sufficient and decided not to opt for a more ambitious option. Policymakers expect high resistance from citizens which could be overcome by raising awareness on air quality and carbon emission issues as well as by implementing policies that discourage private car / scooter / motorbike use (and that way encouraging public transport use). Shifting to 'electric mobility' was on the other hand considered a high priority for public and private vehicles, although acknowledging that going electric for private vehicles does not solve lack of space and traffic issues. Going electric is particularly a priority for scooters and motorcycles, which account for the biggest share of private trips in Genoa. Policymakers believe that high investments to subsidise the purchase of electric vehicles would be needed for this next to charging stations.

Policymakers were neither too ambitious the 'reduction of energy consumption in housing and buildings' due to the costs this implies for both citizens as well as the region. Awareness raising is also seen as essential for encouraging sustainable heating.

Overall, the standpoint of policymakers in the Liguria Region is that **current policy is not enough to achieve air quality and climate goals in the region**, as evidenced by the non-compliance of average annual NO_2 concentration and O_3 exceedances. A new action plan for air quality was adopted in November 2018 (deliberation n.941 del 16 novembre 2018) and its effects are monitored. An update of the regional plan for air quality and greenhouse gases is also necessary.

To finance such policy measures, both national and European funds are needed. **Investing in mitigation policies would allow to reduce the investments necessary to manage emergencies in the long run.**

In terms of citizens support, policymakers in the Liguria Region believe that **citizens back air quality and climate goals overall but are not too keen on changing of behaviour** from their side.

"Road mobility and home energy measures, which require initial investment costs, are not sufficiently supported by citizens."

Table 4-5: Liguria Region's policymakers choice on preferred citizen measures: Final ClairCity Unified Policy Scenario for the Liguria Region (July 2019 workshop)

#	Policy Area	Chosen ambition	Current policy measure	Comments regarding implementation (Barriers, opportunities)
1 - 2	Improve local public transport and vehicle-sharing Improve integration between public transport and private transport	High	Increase integrated local public transport network use (including shared vehicles), from 25.4% to 31.5% by 2029, and from 31.5 in 2029 to 45% by 2050	• Barriers: - costs, travel time related to public transport; - connections to the hill districts; - narrow roads, lack of space for differentiated lanes and road congestion which slows down public transport; - difficulty in changing transport habits. • Opportunities could be (not necessarily planned yet): - High share of the people already use local public transport in Genoa; - Investments for the purchase of electric vehicles in general and for the modernization of the bus fleet thanks to the emergency resources due to the collapse of the highway viaduct (Morandi bridge). - Establishing new transport habits and organizing city / smart working schedules following the collapse of the highway viaduct. - Building of important works such as Genoa railway junction and metro extension. • Ways to overcome barriers: - Introducing obligations / specific actions to be realised in the service contracts for the management of public transport services could be a way to overcome current barriers. - Implementation of Actions included in the Urban Plan for Sustainable Mobility. - Encourage shared mobility initiatives (bikes, cars, vans, motorcycles), alongside the use of public transport. - Reduced rates, integrated bus-train-extra-urban lines, electronic payment systems. - 5 new large Park & Ride areas are being built (large parking lots with capacity up to 1000 parking spaces) located at the motorway exits where it is possible to leave the private vehicle and continue with the urban collective vehicle (buses, metro, tram, etc.).
3	Ban diesel vehicles and the most polluting motorcycles in the city	Current	Ban diesel cars and light vehicles less than or equal to the EURO 5 category by 2025 in urban areas	• Barriers: - Hard for citizens to renounce to private vehicles due to necessity and habit. - Difficult to enforce (hard to run controls in the borders of the area with this restriction) • Opportunities - Traffic restriction policies can help establish new transport habits - The growing sensitivity to the problem of climate change. • Ways to overcome barriers: - Adequate communication towards and awareness raising of citizens is necessary.
4	Encourage electric mobility	High	Install an adequate number of charging stations for 50% of the circulating electric vehicles (including car sharing) and replace 50% of vehicles circulating in urban areas with electric cars and motorcycles by 2050	• Focus on encouraging electric mobility particularly for 2 wheels-vehicles, given the high use of the motorcycles for private trips in Genoa; • Shared electric vehicles should be given priority. • Threat: electric does not solve the problems of congestion and safety on the streets of Genoa; • Ways to overcome barriers: - Information for citizens regarding the technologies and benefits of electric vehicles will be necessary; - Charging - stations are needed;

5	Encourage active travel	High	Increase private trips by bicycle or on foot in the metropolitan area from 23.2% in 2029 to 35% in 2050	• Barriers: Narrow roads, lack of space. Cycle paths and sidewalks / pedestrian areas compete with other uses of roads (parking, car lanes) • Opportunity: Recent development of electric bike technologies. • Ways to overcome barriers: - Need to create an adequate network of bicycle lanes / bike parking / bike sharing systems - Adapt public transport to allow transport of bikes - Communication and awareness raising towards more active lifestyles to stimulate a change of habits among citizens starting from the younger generations - Increase space dedicated to pedestrians and offer more safety
6	Transfer part of the goods traffic from road transport to rail transport	Current policy	Reduction of heavy vehicle traffic by 30% by 2035 and by 50% by 2050	• Barriers: - Old and limited railway lines. - Port traffic, whose trend is to increase. - The goal depends on strategies and policies beyond the region. • Opportunity: using the noise argument as the project to upgrade the railway link includes works that include noise noise reduction. • Ways to overcome barriers: - Construction of rail infrastructure and connections that link to harbours. - Improve logistics of port goods.
7	Reduction of energy consumption in housing and buildings	Current policy	Reduction of residential consumption by 10%, and consumption in the service sector by 16% in 2030	• Future policies will have to consider the forecasts that energy consumption for winter heating will decrease and that electricity consumption for summer cooling will increase; • Barriers: - High initial investment costs, low consumer awareness of the potential benefits of energy savings. - Rather expensive incentive mechanisms for the Region. - Difficulties in concealing renewable energy production objectives with environmental objectives (safeguarding biodiversity, landscape constraints, dust emissions) • Ways to overcome barriers: - Adaptation of regional policies to the new national strategy (SEN and PNIEC) - Innovation and competitiveness in the sectors of renewable sources production and energy efficiency - Communication and public awareness

5 Impacts of implementing citizens' views

This chapter discusses the potential impacts of implementing the citizens' views on future policies on air quality (section 5.1), health (section 5.2), carbon emissions (section 5.3) and costs (section 5.4).

Textbox 5-1 Disclaimer ClairCity modelling versus national modelling

> ClairCity modelling differs from regional and national models in the Liguria Region due to the different modelling assumptions and inputs used. Our modelled concentrations can deviate from national and regional models and so should be considered indicative. Although the utmost care has been taken to calibrate the ClairCity models to local conditions, a detailed comparison of ClairCity modelling assumptions to those of local and national models in each ClairCity case study country was outside the scope of this project. Therefore ClairCity modelling outcomes cannot be one-to-one compared with the outcomes of national and local models.

The potential impacts are based on a 'Unified Policy Scenario' (UPS) that was prepared by combining citizen preferences for future policy measures with policy maker reflections. The main assumptions made for preparing the UPS can be found in Annex C. The impacts of the UPS are compared with those of a 'Business-As-Usual' scenario (BAU) which consists of the set of all policy measures adopted or projected in the base year 2015.

5.1 Impacts on air quality

Implementing the policy measures that resulted from the combination of citizen preferences with policy maker reflections (UPS), and thereby enabling alternative behaviours and activities, would result in better air quality and a reduction in the number of premature deaths caused by air pollution in the Liguria Region as compared to the baseline situation. The simulated ClairCity UPS scenario results in limited additional reductions compared to the BAU for PM. This is partly explained by the fact that policymakers chose for the 'current' ambition option (business as usual) instead of the 'high' ambition that citizens put forward (as seen on Table 4-5 from the previous chapter). The additional reduction of NOx that the UPS generates beyond the BAU is negligible.

Figure 5-1: Trend of PM and NOx emissions in the UPS, compared to the BAU scenario

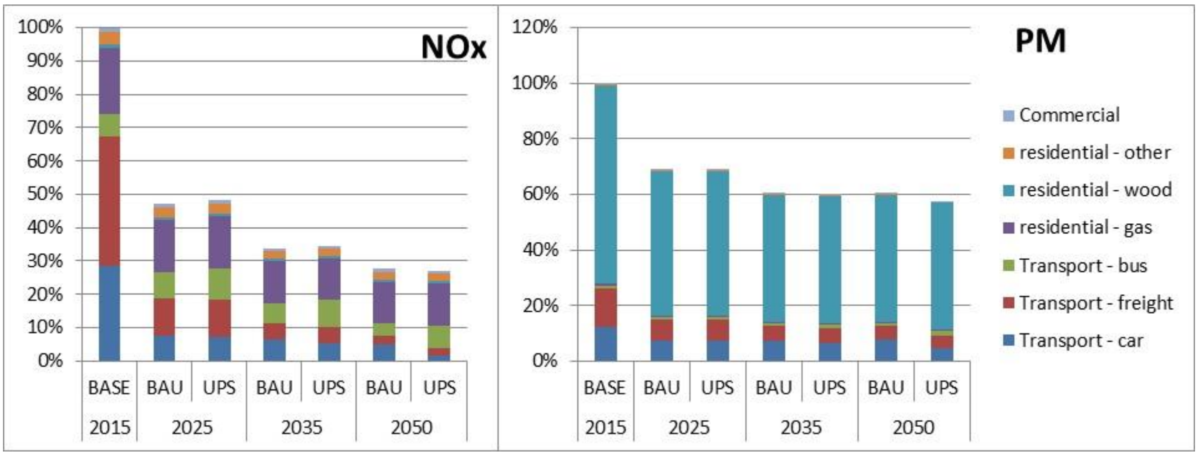
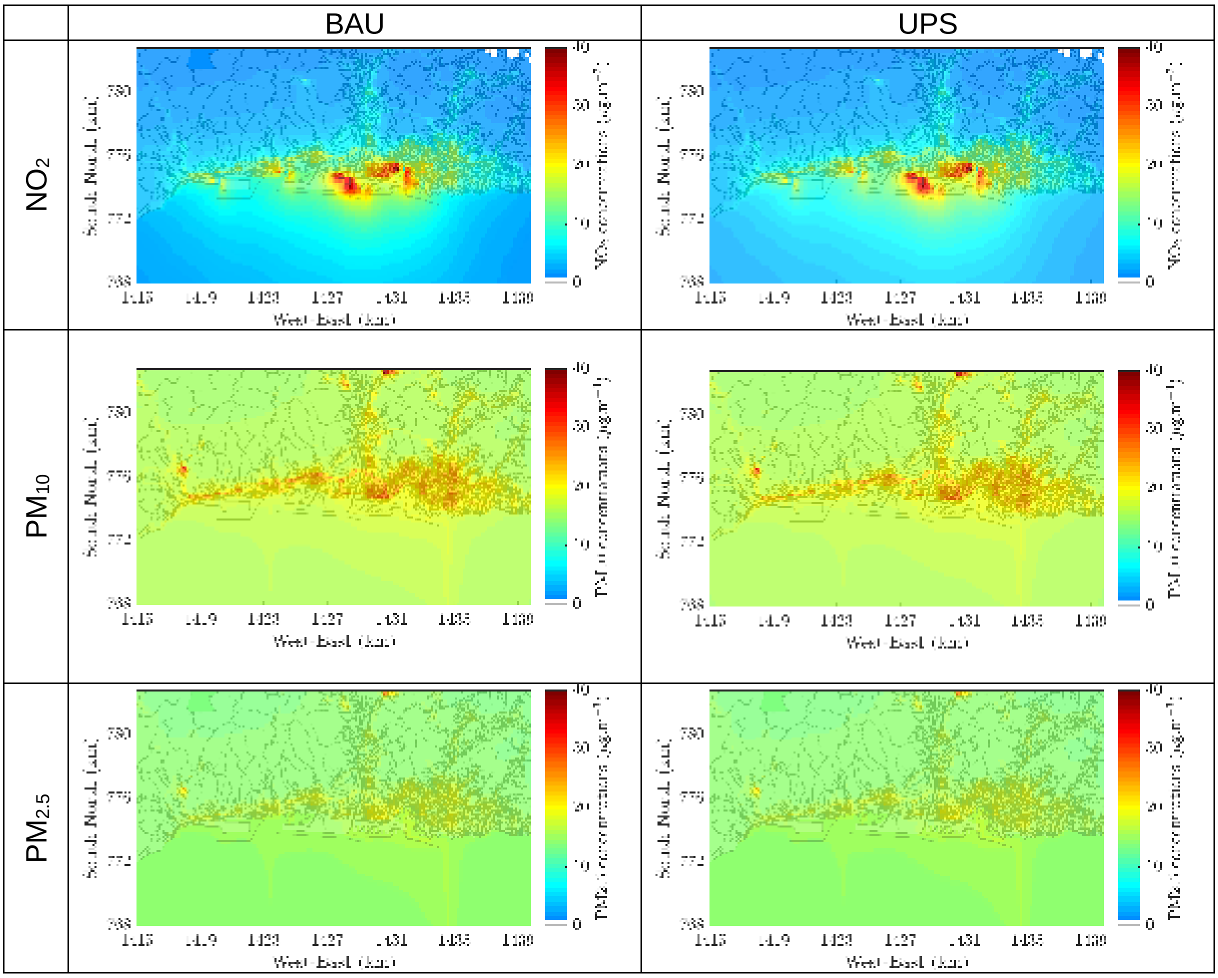


Figure 5-1 shows that there is a clear trend in reducing NOx emissions already in the BAU by 2025 with a particular strong decrease from NOx-emission from road transport. **The UPS scenario leads to a limited decrease in emissions beyond the reductions already in the BAU for most sectors**. Passenger cars further reduce NOx-emissions as consequence of a reduced demand (due to the modal shift to public transport and walking/cycling) and a stronger EV-uptake. **However, the decrease is offset by a rebound of NOx emissions from buses.** This is because UPS measures increase the use of buses by citizens (e.g. increase in kilometres driven by buses). **With increased use and no measures concerning the improvement of NOx emissions of public transport (and more concretely buses) in the UPS, emissions from buses are expected to increase**. The rebound is very small and subject to assumptions made in terms of what public transport mode is used (ClairCity modelling did not consider additional measures to reduce bus emissions, such as electrified lines for buses). In 2050, the total emissions in the BAU scenario and the UPS are almost the same (with the UPS leading to an additional %0.3 reduction).

We observe a similar trend for PM emissions, without the rebound from bus emissions. This decrease in PM emissions is mainly result of a decrease in residential emissions linked to heating. **The UPS does lead to a slight additional reduction of PM emissions compared to the BAU (2.6%). This difference originates from a reduction in transport emissions, due to a decrease in the number of cars as compared to the BAU. Given the low contribution of transport to PM emissions, however, the emission savings from transport in the UPS compared to BAU are very small.**

Figure 5-2 gives an overview of modelled NO_2, PM_{10} and $PM_{2.5}$ concentrations in the BAU and UPS scenario in 2050. More detailed modelling results can be found in Annex C.

Figure 5-2 NO_2, PM_{10} and $PM_{2.5}$ concentrations in the BAU and UPS scenario in 2050



The overall analysis of these modelling results, comparing UPS and BAU with the legal EU limit values and WHO guideline values, shows that:

– **Both the BAU scenario and the UPS will lead to compliance with legal NO_2 EU limit values[37] widely in the Liguria Region in 2050. EU limit values will be exceeded only in two grid cells where people live.** The modelling exercise shows exceedances of EU limit values in only two grid cells (hotspots) where hardly any citizens live. These hotspots may be caused by the inherent uncertainty of the ClairCity modelling / emission sources / emission scenarios formulated and are not in line with all other cells or other data. Further research on emissions / location of sources / modelling and/or monitoring) could help to better understand the relevance of these two exceedances the distribution of concentrations at the detailed resolution chosen for ClairCity. In the BAU scenario, the maximum NO_2 concentrations modelled by ClairCity will be around 62µg.m^{-3} and 59 µg.m^{-3} in 2025 and 2050 respectively. The UPS scenario will only offer a slightly lower maximum NO_2 concentrations in 2025 (associated to an increase in road traffic emissions projections in the UPS when compared to BAU), as compared to the BAU scenario. The

[37] 40 µg/m3 (annual mean)

UPS (and the BAU scenario, since reductions will be exactly the same) will lead to a reduction of 27% and 30% of the maximum NO_2 concentrations by 2025 and 2050 respectively.

- **The BAU scenario and the UPS will both comply with the EU legal limit values for PM_{10}, but not with the stricter (albeit voluntary) WHO guidelines in 2050.** The maximum PM_{10} concentrations in the UPS as modelled by ClairCity will be roughly 40 $\mu g.m^{-3}$ in 2025 and 37 $\mu g.m^{-3}$ in 2050. This means that the UPS will lead to a reduction in the maximum concentrations of approximately 19% by 2025, and of 25% by 2050, compared to 2015, the reference year. Still, several exceedances of the WHO guideline value[38] are expected: 553 grid cells where people live are exceeding this guideline value, which implies that **55% of the population could potentially exposed to PM_{10} concentrations above WHO guideline values in the UPS scenario in 2050. The UPS does not lead to further reductions than the BAU scenario** neither by 2025 nor by 2050.[39]

- **Both the BAU scenario and the UPS scenario will comply with EU legal limit values for $PM_{2.5}$, in 2050. Nonetheless, in 2050, the entire population could potentially be exposed to $PM_{2.5}$ concentrations above WHO guideline values.** The maximum $PM_{2.5}$ concentrations in the BAU scenario and the UPS are the same, 27 $\mu g.m^{-3}$ in 2025 and 25 $\mu g.m^{-3}$ in 2050. Based on the WHO guidelines, all grid cells with allocated population will still show exceedances in the UPS scenario in 2050. When comparing the UPS and BAU scenario with the reference year (2015), the maximum concentrations will be reduced by 15% and 20% respectively in 2025 and 2050.

5.2 Impacts on health

Table 5.1 shows the comparison between the future scenarios (BAU and UPS) against the baseline scenario, assessing the health impact benefits of the emission levels proposed by the scenarios.

Table 5-1 Benchmarking the UPS emission scenarios in 2025, 2035, and 2050 against the baseline scenario in terms of health indicators (%) related to $PM_{2.5}$, PM_{10} and NO_2 exposure.

Premature deaths	$PM_{2.5}$			PM_{10}			NO_2		
Scenario / Year	**2025**	**2035**	**2050**	**2025**	**2035**	**2050**	**2025**	**2035**	**2050**
BAU	-5	-6	-6	-8	-11	-10	-59	-73	-79
UPS	-5	-6	-6	-8	-11	-11	-57	-72	-79

This comparison shows that:

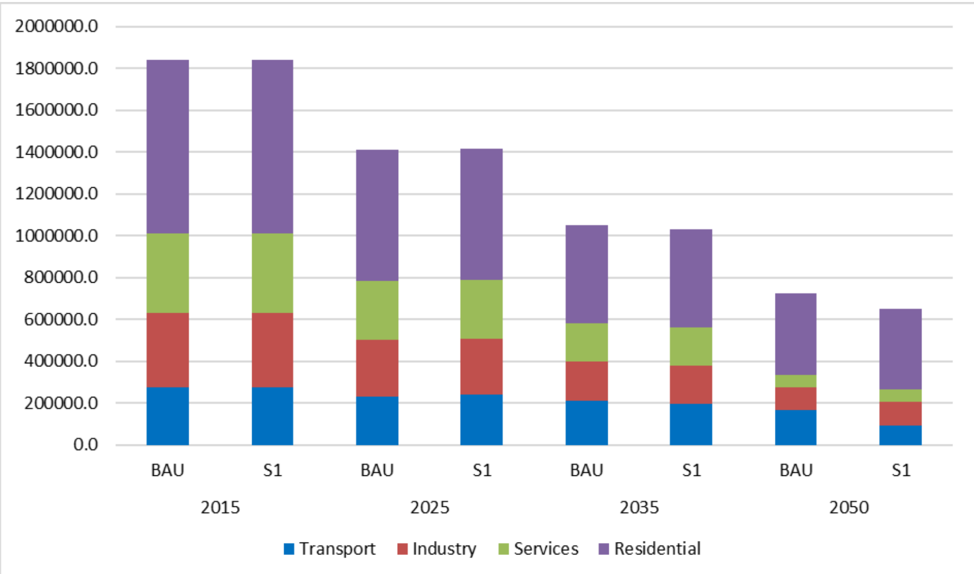
[38] 20 µg/m3 (annual mean)
[39] It should be noted that the measures in the ClairCity Liguria UPS have mostly focused on solving NO_2 issues related to transport rather than PM. Considering the constant downward trend of the average annual PM_{10} concentrations in the Liguria Region, presumably, PM_{10} concentrations in reality will be by 2050 lower than those modelled by the UPS of ClairCity.

- **The BAU scenario and UPS lead to moderate improvements in human health compared to the reference year when considering exposure to PM concentrations. However, the UPS and BAU improve substantially human health when considering exposure to NO_2 concentrations** (see Annex C for the methodology on the health impact assessment and results). The health benefit from implementing the control measures behind the future emission scenarios (BAU and UPS) is considerable for NO_2 but not as significant for neither PM_{10} nor $PM_{2.5}$. In 2015 (reference year), the number of premature deaths as a result of NO_2, PM_{10} and $PM_{2.5}$ were 418, 506, and 590 respectively.
- **The positive impact on human health prompted by the UPS and the BAU scenario are virtually the same**. By 2050, the BAU scenario reduces these premature deaths by 79%, 10%, and 6%, respectively; the UPS reduces them by 79% for NO_2, 11% for PM_{10}, and 6% for $PM_{2.5}$. The UPS does therefore not lead to further reductions than the BAU, except for PM_{10}, for which the additional reduction is also minimal.
- **The health benefits from the emissions reduction in terms of the number of premature deaths and the number of years of life lost is lower than average concentration levels reduction**.

5.3 Impacts on carbon emissions

As part of the ClairCity project, a methodology for estimating the carbon footprint was tested. Figure 5-3 shows the impacts of UPS measures in terms of Carbon Footprint, compared to the impacts of measures in the BAU scenario. The figure shows that the UPS measures have a moderate impact on Carbon Footprint compared to the BAU. This impact is limited to transport sector emissions reduction as no additional measure is introduced in UPS addressing fossil fuel consumption in the other sectors. The figure shows that the positive effects of policy measures are most obvious in the long run, namely by 2035 and by 2050.

Figure 5-3 Carbon emissions in the UPS compared to BAU scenario (tonnes of CO_2-eq on life cycle)



5.4 Impacts on costs

Table 5-2 gives a qualitative estimate of the cost of the measures in the UPS scenario versus the BAU. We distinguish between estimated monetary costs to citizens, costs for government / city council[40] and a net total cost to society, summing up both. An exact calculation of benefits and the indirect benefits of health improvement of citizens (saved public health costs) should also be taken into account but it is beyond the scope of the ClairCity modelling.

In total, net monetary cost effects of the 8 UPS measures vary substantially and will sometimes result in additional costs and other times in net benefits for citizens and for government. Exact costs will also depend on how measures are designed in detail. Further detail of the assumptions made is given in annex C. The annex also gives an order-of-magnitude cost estimate of car user costs, car charging revenues and bus subsidies in the UPS compared to the BAU scenario.

However, the overall balance of direct costs of all measures in the citizens' UPS scenario together suggests that a cost effective execution of the UPS for citizens and city council / government is possible, as measures with a net direct cost to society can be balanced by measures with net revenues. This balance would be even more positive if also the indirect health benefits of improved health of citizens would be added.

Table 5-2 Estimated cost impacts of citizen measures that are part of the UPS scenario in Liguria

#	Policy measure	Citizens	Governement	Society
1	Improve the local public transport service (including sharing)	+	-	-
2	Improve integration of local public transport service and private transport with new interchange parking lots	0	-	-
3	Ban on most polluting diesel and motorcycle vehicles in the city center	-	0	-
4	Promote electric mobility	+/-	+/-	+/-
5	Promote active mobility (walking, cycling)	n/a	n/a	n/a
6	Transfer part of the road freight traffic to railway	n/a	n/a	n/a
7	Reduction of energy consumption in the residential, commercial and institutional sector	+/-	+/-	+/-
8	Cold ironing in port	n/a	0	-

(+) assumed net positive effect/ benefits for target group; (-) assumed net negative effect / costs for target group; n/a effect of measure cannot be assessed

The assumed cost effects per measure are explained in more detail below:

1. **The measure 'Improving public transport'** is not sufficiently specified to allow for a clear-cut cost assessment**.** On the one hand it **is expected to require large subsidies for buses by the government to improve services (-).** On the other hand, this measure could lead to a cost decrease for citizens, if lower fares are introduced (+). The large

[40] No distinction is made between different levels of government.

subsidies required by incremental model shifts **together with the fact that the government income from other alternatives (i.e. cars) will decrease** will not be offset by the lower fares for citizens. The overall societal cost effect is therefore considered to be negative (-).

2. I**mproved integration of local public transport services and private transport** with new interchange parking lots **will require extra investment at a cost to the government (-)** without a cost effect on citizens (0), leading to an overall net negative cost effect on society (-). The net benefit to the citizen are time gains of a smooth public transport interconnection, yet these are not monetary, so not considered in this analysis.
3. **Banning polluting cars leads to early scrappage of the existing car fleet,** and hence to a loss of capital for citizens i.e. private car owners (-). The measure **is assumed to be cost neutral for government (0),** leading to an overall net negative cost effect on society (-).
4. **Incentivising/promoting the use of electrical vehicles (EVs)** is not clearly specified. This **can be achieved with a subsidy for electric vehicles at as cost for the government (-),** leading to lower prices for EVs, a benefit for citizens (+). **It can also be promoted through a mandatory target at no cost for the government** and a cost or a benefit to the citizen, depending on the timing of the mandate (at a time when EVs are more expensive than conventional cars over a lifetime[41], this will be a cost for citizens). The overall societal effect depends on the cost differential between conventional cars and electric cars. Currently, EVs are still more expensive, so an incentive scheme leads to a net negative societal effect (-). This will change in the future, thus resulting in a mixed message of a likely net negative impact on short term and net positive societal impact in the long term.
5. Measures 5-8 are insufficiently specified to make any assessment in terms of cost impact. Modal shift ambitions (measures 5 and 6) can be achieved in various ways (pricing, infrastructure investment, nudging/cultural changes, etc.). The reduction of energy consumption can lead to a net cost benefit if energy prices are high and the reduction is achieved with gradual efficiency improvements. Finally, more stringent environmental standards for industrial processes (measure 8) typically lead to cost increases.

Measures are not detailed enough to be able to produce a definite assessment of the cost impacts. Several measures can be achieved in different ways. For example, the cost of incentivizing EV's can depend on the instrument used (e.g. legislation, subsidy, taxation of non-EV) and on the timing of the measure. The same goes for infrastructure investments which can be additional to current investments (higher cost) or simply a reallocation of existing investment funds. While difficult to assess, we can make a rough assessment of the relative cost of measures compared to each other. For example, making public transport cheaper would come at high cost for the government, while banning the oldest cars, although likely to be unpopular, would entail limited additional cost for the government.

[41] EV's will still be more expensive in purchase, but cheaper in use (when electricity is cheaper than diesel/petrol)

6 The Liguria Region and other ClairCity cities – Mutual learning for citizen-inclusive policy making

In this chapter, the main institutional conditions and barriers for implementing citizen policy preferences in the Liguria Region are discussed (section 6.1), followed by the (policy making) lessons that the Liguria Region can offer other cities (section 6.2) and the lessons that the Liguria Region can learn from the other ClairCity case study cities/regions (section 6.3).

6.1 Institutional conditions and barriers for citizen-inclusive policies in the Liguria Region

From the extensive literature review and interviews carried out with stakeholders and policymakers[42], several specific institutional conditions have been identified that appear relevant for a successful implementation of citizen-inclusive policies.

Economy and demographics

- In Liguria services (particularly tourism) account for about 80% of total employment, and 20% industry.
- Liguria has the largest share of harbour activity in the country (industrial and recreational i.e. cruise-ships) and it is second when it comes to naval ship-building and ship fleet.
- Per capita GDP in the Liguria Region is above the Italian and European averages. Liguria has a high percentage of elderly.

Political framing of air quality and climate

- In the Liguria Region in general air quality is not considered a ‘major’ problem because: 1) with its large forest area, the air in the Liguria Region is cleaner than in other parts of Italy; 2) other problems (e.g. floods, droughts, heat waves, waste, forest fires, water quality) are generally perceived as more pressing; and 3) the air is cleaner than in the past, due to industrial policy and industrial activity decrease among others.
- This drives attention away from hotspots / urbanised areas like Genoa where air pollution IS a problem. Genoa is highly congested, with both the highway node and the rail network (which supports regional and long-distance passenger as well as freight traffic) converging in the city. Industry, the large port, traffic and housing are all close together. The sources of pollutants in Genoa are therefore very close to where citizens live, affecting exposure.
- Air quality is neither a top priority for NGOs nor citizens, for the same reason i.e. perception that other problems are more pressing.

Governance levels

[42] Please reer to D6.2 Policy Baseline Report – Last City for further details.

- A hierarchy of four-five levels of policy making determines local policies in the Liguria Region: the EU, the national government, the Liguria Region and Genoa municipality.
- The overall standpoint of policymakers in the Liguria Region is that current policy was not enough to achieve air quality and climate goals everywhere in the region, as evidenced by the non-compliance of average annual NO_2 concentration and O_3 exceedances.
- The use of public transport is being fostered by the region through its continuous efforts to improve and expand public transport. However at the local level (in Genoa) certain policies are at odds with this e.g. more scooter parking, cheaper car parking.
- Local policymakers have been in the past been unwilling to implement unpopular measures affecting car/scooter use in Genoa fearing reaction from citizens.

Box 6-1 Example of citizens movement against scooters' ban[43]

Mayor of Genoa at the time, Marco Doria, issued a Decree in December 2016 to ban motorcycles built before 1999 (Euro 0) in an attempt to reduce air pollution in Genoa. This was part of a nationwide campaign weeks of unusual warm weather in which smog reached alarming levels, particularly in Rome, Naples, and Milan. The ban was due to come into force on February 1st, 2017 but was postponed until April 1st, 2017 under public pressure. The ban would affect 20,000 Vespa community ('Vespisti') who were against the Council's Decree. This generated the social media reaction under the hashtag #lamiavespanonsitocca ("Don't touch my Vespa"). This, along with other reactions from citizens and associations of motorcyclists, managed to block the ban.

- More recently in September 2019 the Mayor in Genoa has introduced a limitation to the circulation of vehicles in a relatively large area of the city centre[44] The ban applies to the oldest vehicles and for a certain timeslot (from 7.00 to 19.00) on weekdays. Historic vehicles listed in the special register (8% of all vehicles in 2011[45]) are exempt.

Figure 6-1 Traffic sign illustrating vehicles ban[46]

[43] Please refer to D6.2 Policy Baseline Report – Last City which contains a whole detailed chapter on the Liguria Region. Available on www.claircity.eu
[44] Comune di Genova (2019) ORDINANZA DEL SINDACO N. ORD-2019-311 DATA 25/09/2019
[45] ACI (2011) CAPITOLO 3 ANALISI DELL'ANZIANITA' DEL PARCO VEICOLI NELLE PROVINCE CAPOLUOGO DI REGIONE AL 31/12/2011
[46] Genova24 (2020) Ordinanza anti-smog, da oggi è realtà: la mappa delle vie interessate e di quelle escluse

Financing of policy measures

- The Liguria Region relies on national as well as European funds in order to finance its air quality and climate related policies (e.g. on transport, energy etc).
- Public transport improvement investments compete in local and regional budgets with social care. Until recently, local public transport improvements were slowed down as result of the cuts in state resources.
- The collapse of the Morandi bridge of Genoa in August 2018 led to a complete restructuring of traffic flows in the city. In 30 September 2018, a Decree Law was issued that dedicates substantial funds to local public transport and city planning.
- Several financial schemes are at the disposal of the public and public authorities to finance the energy transition.

Citizen engagement culture

- Citizens in Liguria are generally not actively involved in the air quality and climate discussion.
- Several citizens (mainly owners of the Vespa) in fact demonstrated a few years ago against a planned ban on most polluting motorbikes leading to the withdrawal of the plan. The citizens lobby of history vehicles is strong but they are relatively few. Citizens did protest to demand cleaner, energy efficient harbour policies.
- Environmental activism comes principally from NGOs, but air quality is not high up on their priority list. Cleaner transport and energy topics are on their agenda, motivated by climate mitigation needs, not by air pollution.

Other air quality related aspects

- The Liguria Region has a wide air quality monitoring network divided in zones according to emission characteristics, climate, topography and geography.
- The latest air quality plan of the Liguria Region dates from 2006. The new air pollutants emissions inventory is currently being defined and the air quality monitoring network has been restructured and a pollution action plan has been approved but the procedures for updating the air quality plan has not yet been started.

6.2 Lessons from the Liguria Region for other cities

The policies in the Liguria Region that can serve the other ClairCity case studies as inspiration concern the environmental zones, called Areas of Limited Traffic (ZTL) in the Liguria Region and incentives for electric cars.

- Several municipalities in the Liguria Region have an Areas of Limited Traffic (ZTL). In the Genoa ZTL, access is allowed only to vehicles (i.e. cars, vehicles for the transport of goods; mopeds and motorcycles) owned by residents in the area, who pay a fee for that.

Electric cars, motorcycles and mopeds can access the ZTL at all times without any fee[47]. In La Spezia, cars are not allowed (unless authorised) in the ZTL, but mopeds and motorcycles are. Residents in the ZTL area, owners of a parking space within the ZTL, vehicles for the transport of goods, and vehicles of craftsmen are also allowed[48]. In Savona only citizens resident in the ZTL area, commercial operators (according to the allowed time slots), and owners of a parking space within the ZTL are allowed[49]

- Cleaner cars policies, which make electric cars for instance more attractive, tend to be mainly competence of central governments. However ClairCity evidence shows that cities or regions can also take action in this regard. In the Liguria Region, electric cars enjoy an exemption from the regional car tax as well as discounts on parking and access to the areas of limited traffic (ZTL).
- The Liguria Region and more specifically Genoa provide also an example of how municipal policy cannot differ radically from the willingness of citizens. When the difference between a proposed measure and citizens' will is very different, the measure will clash against massive opposition as illustrated by the 'Vespa' ban attempt in 2016 described above.

6.3 Lessons from other ClairCity cities for the Liguria Region

The Liguria Region could benefit from exchanges with other ClairCity cities concerning public transport / active travel encouragement, private transport policies and ways to engage with citizens and stakeholders, including various municipalities.

Public transport improvement

The Liguria Region already has an established network of public transport consisting of various modes but could learn from experiences of the other ClairCity case studies. The Liguria Region can learn from the train and bus developments that other cities have recently implemented in order to link less inhabited areas to the main city hubs. In addition, ClairCity found that one ticket for all public transport and integration of the public transport ticket with bike rent are helpful in stimulating public transport due to the convenience they offer.

Textbox 6-1 Relevant experiences from ClairCity for stimulating public transport

- **Ljubljana** has integrated its city and regional transport, which can now be travelled with one ticket. According to interviewees, commuting by public transport into the city has been much facilitated in this way.
- **Amsterdam** and the Netherlands have a popular integrated train, bus and bike-rent system that can be travelled with one ticket, which facilitates door-to-door transport.
- **Bristol** has recently implemented large-scale improvements of public transport to connect the city and the metropolitan area: the MetroBus (a bus service for the larger Bristol area which works with 'buy before you board' ticketing to ensure limited stopping, faster boarding and shorter journey times) and MetroWest (project that improves rail connections in the region).

Discouraging private car use

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47 Comune di Genova, Disciplina dell'accesso alle zone a traffico limitato
48 Citta de La Spezia, ZTL e zone interdette
49 Comune di Savona, Richiesta autorizzazione accesso ZTL

Key for modal shift is that improvements in public transport, go hand in hand with measures that make private car use is made less attractive. This can be done for example by reducing space for cars in the city and making more room for pedestrians, bikes and buses, as well as by reducing the number of residents' parking permits (e.g. in new housing developments) or by increasing parking tariffs. Parking tariffs are beneficial in two ways: they do not only discourage car use but, as additional revenue, can also support investments in active mobility and public transport.

Textbox 6-2 Relevant experiences from ClairCity for stimulating active transport

- In **Amsterdam**, through high parking tariffs for the city centre (7 euros an hour) and reducing the number of residents' parking permits, access to the city by car is made less attractive. Electric vehicles enjoy reserved parking spots, used to enjoy free parking a few years ago, when electric vehicles were rare; and will enjoy a lower tariff that regular vehicles from 2021 onwards.
- In **Bristol**, limiting access for cars to the historical city centre during working hours is part of the public discussion going on early 2020.

Encouraging cycling

Cycling in Liguria is mostly a recreational activity. Urban cycling is negligible in Genoa (partly because of its hilly geography, partly because of insufficient infrastructure) and slightly more common in other smaller, flatter cities with better cycling infrastructure. The municipal bike sharing system in place is barely used. Local policies creating more scooter parking and cheaper car park, and the lack of cycling infrastructure make motorised road transport more convenient. The experiences in other ClairCity cities suggest that effective modal shift policies towards cycling tend to consist of a combination of education and awareness raising (e.g. at schools) accompanied by large-scale infrastructural enablers such as sufficient bike parking spots and increasing road space for cycling to ensure safety and comfort. In the case of Genoa, these learnings could be applied to the new schemes for e-bikes and e-scooters that have been introduced in the city.

Textbox 6-3 Relevant experiences from ClairCity for stimulating active transport

- In **Amsterdam**, cycling is a central part of city transport culture. Cycling traffic lights, bike lanes and paths as well as an integrated train and bike-rent system are already implemented since several years. Providing sufficient bike parking facilities, reducing car road space in favour of bikes, and spatial planning for short as well as long-distance biking are now central elements in further scaling up of cycling in Amsterdam.
- In **Sosnowiec**, where biking is not a typical mode of transport, a municipal bike-sharing scheme was introduced in April 2018 with great success. A first network of bicycle paths was built for its launch.
- In **Bristol**, people that have not cycled for a time can get a one-month bike loan free of charge.
- In the **Aveiro Region** a couple of small-scale initiatives are aiming to revive the cycling culture of the past by targeting the youngest groups. As school children in Portugal are almost always brought to school by car, a local NGO initiated a group for children and parents to cycle together to school. The same NGO initiated a 'Bike buddy' project, in which people who did not feel safe to bike alone were accompanied by cycling 'buddies'. In addition, a school a teacher set up a workshop to repair bikes where kids can repair old bikes and create new ones with old spare parts.

Energy measures

There are good practices in ClairCity case studies that can be relevant for the Liguria Region, given the current lack of heating systems in the majority of homes and buildings. Cities such as Sosnowiec, Ljubljana and Amsterdam have substantial experience with district heating and are also considering expansion of their heating networks. All ClairCity cities are working on expanding energy efficiency of their housing stock. Development of rooftop PV is expanding particularly rapid in Amsterdam. Biomass burning is a policy measure that deserves attention in the future, as it is assumed to be positive for climate change targets but has also negative impacts for air pollution.

Textbox 6-4 Relevant experiences from ClairCity for stimulating energy measures

- **Sosnowiec** and **Ljubljana** show that wood and waste burning – partly from the surroundings (Ljubljana) can have strong detrimental impacts on air quality. This has to be taken into account in particular as wood burning is now often seen as a positive measure from a climate policy point of view.
- **Bristol** is now developing a heat network starting with the inner-city centre.
- **Amsterdam –** Promotes district heating as an important element of the degasification of the built environment in the city.

Engaging with citizens, stakeholder groups and other municipalities

ClairCity case studies have provided good examples for local governments of collaboration with citizens and other stakeholders as well as of cooperation among different municipalities in a region. Overall ClairCity found that NGOs are a very important intermediate in engaging citizens in environmental issues. Maintaining good relationships with NGOs could be beneficial for raising the profile of air quality among citizens, raising awareness and justifying (unpopular) transport and heating policies. The other Region in ClairCity, namely the Aveiro Region in Portugal, could also server as inspiration for collaboration between municipalities, which is important for a common effort to improve regional air quality.

Textbox 6-5 Other relevant experiences from ClairCity for air quality and carbon policies

- In the **Aveiro Region** an NGO is driving change with regards to cycling and the engagement of kids and parents in this (see Textbox 6-1).
- In **Amsterdam**, an active network of citizens measure air quality at home with low-cost equipment. These measurements supplement the official air quality measurements in the city.
- The **Aveiro Region** (which as such exists only since a decade) has a long tradition of close cooperation between the eleven municipalities that compose it. In addition, the Region has a so-called Agency for Sustainability and Competitiveness formed by citizens representing each one of the Aveiro Region municipalities and the Region itself. This group works around 7 themes (Policies for the Green Economy, Energy Efficiency, Water Efficiency, Waste Valorisation, Sustainable Construction, Climate Change Adaptation and Sustainable Mobility and Ecotourism).

7 Innovative citizen-inclusive air quality and carbon policies in the Liguria Region: Conclusions and recommendations

This chapter outlines the main conclusions (Section 7.1) and recommendations (Section 7.2) of the ClairCity citizen engagement process in the Liguria Region and the results of the modelling and analysis thereof.

7.1 Conclusions

In ClairCity, citizen-inclusive policy making was interpreted as to consist of three main activities: analysing the detailed current behaviours of citizens, asking citizens about their preferences for their own future behaviours and enquiring about their preferred city policies for the future. Preferred policies of citizens were discussed with policymakers, quantified and assessed for their impacts in three different ways: regarding emissions and concentrations of air pollutants and CO_2, regarding health and regarding costs. Institutional conditions and barriers for implementing citizen measures were examined and compared with experiences in other ClairCity cities. The main conclusions of all these activities are discussed below.

7.1.1 Current air quality situation and city policies in the Liguria Region

Air pollution has decreased in the past decades in Liguria as result of transport and industry policies. Also GHG emissions have gone down mainly due to a reduction in emissions from industry. Currently in the Liguria Region NO_2 is the most critical pollutant. Mainly caused by road transport, its EU limit values are not met. The Liguria Region does comply with PM_{10} EU limit values although the number of exceedances of daily limit values across several stations make it a concerning pollutant as well. O_3, is also a problem.

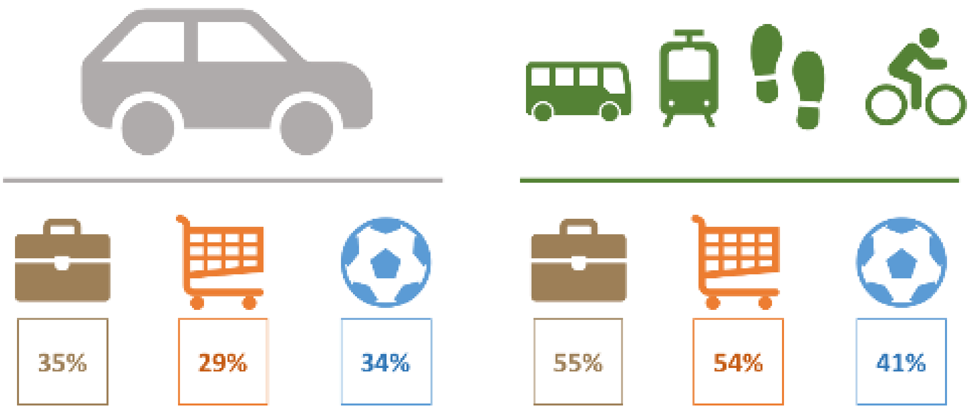
The Liguria Region has a wide regional, multi-modal network of local public transport. Large railway works are underway to develop the 'Genoese node' with the aim to separate the traffic flows of the metropolitan and local railway system, from those of medium-long distance. Also the Terzo Valico railway network will offer the port of Genoa an alternative route for the transfer of goods to the Po Valley area and northern Italy, substituting road transport. Regarding buses, the renewal of the fleet from old diesel buses to Euro 6 is underway. The link-road Gronda project will allow road traffic to flow from one side of Genoa to the other without going through the city centre. Electric mobility is being facilitated through subsidies, an increasing number of charging points, tax exemption, parking discounts and allowed access to the areas of limited traffic (ZTL). Recently, a public e-bikes sharing system and privately operated e-scooters have been introduced in Genoa. Also a free-of-cost charging point for electric scooters is in place. A municipal bike sharing system has been in place since a few years although this is not widely used as there is not yet sufficient cycling infrastructure to support urban cycling. Further there are plans to revive the municipal bike sharing scheme.

There is regional funding for energy efficiency which are promoted through ESCOs as well as measures on energy efficiency and renewables financed by the European Regional Development Fund (ERDF). Liguria is behind with renewables implementation compared to other regions in Italy. Renewable energy for heating purposes in the Liguria region consists mainly of biomass burning - mostly outside the major urban centres. Several port initiatives are ongoing concerning the electrification of docks and future use of LNG for ships.

7.1.2 Current behaviours of citizens

Current behavioural practices of citizens substantially contribute to air pollution and carbon emissions in the city, mainly through car transport, which is the main contributor to NO_2 emissions. A 35% of the consulted citizens always use their car or motorbike/scooter for commuting to work; 29% do so when going shopping and 34% for leisure activities. Public transport and active travel[50] figures are higher with more than half of the consulted citizens going always to work and shopping by public transport or through active travel.

Figure 7-1 Percentage of citizens in Genoa 'always' using a car for commuting to work, shopping or leisure (left) vs those 'always' using public transport, walking or cycling (right)



Citizens also account by far for the highest contribution to the Liguria Region's carbon footprint through residential heating (compared to road transport, industry and services).

7.1.3 Behavioural preferences of citizens for the future

There is a mismatch between citizens transport and heating behaviour at present and how citizens would like to behave in the future regarding these. From the current car users, an important share would wish to reach work, leisure and shopping by public transport or through active travel. This suggests that many citizens would be willing to change their own transport behaviour as a contribution to ambitious air quality and carbon policies if the Liguria Region facilitates / enables that. For heating, the situation is even more obvious.

[50] Note that these are a combined category in the survey

Citizens currently heat their homes with natural gas, while there is a massive preference for using renewables in the future.

- **There is a large demand for public transport and active travel in the future provided that current barriers are overcome**
  A considerable number of those citizens relying on cars at present for commuting to work, shopping and leisure, does not want to be using a car at all for these activities in the future. 73%, 75% and 67% in total, would rather walk or take public transport to travel to these activities. There is also a considerable latent demand of citizens who would like to cycle to work in the future. This indicates a latent demand for active travel and public transport in the Liguria Region that could be fulfilled in the future. The main barriers for the use of public transport are mainly related to travel time, timetabling, reliability and the availability (coverage) of public transport.

- **There is interest from citizens for renewables for residential heating**
  ClairCity identified a very latent demand for renewables to heat homes in the future, as 20 times more people than currently said they would like to heat their homes with renewables in the future. This would go mostly at the expense of natural gas and to a less extent district heating. The reason not to opt for renewables ‘now’ seems to revolve around ownership of homes and costs of switching.

7.1.4 Policy preferences of citizens for the future

The consulted citizens in the Liguria Region favour transport and energy related measures including measures that would affect their behaviours.

- When talking about improving air quality in their city/region, citizens the Liguria Region are most keen on transport measures. The transport measures proposed by citizens concern private cars (banning of oldest diesel cars and promotion of electric vehicles), public transport (improvement of railway, metro, bus), active travel (promotion of walking and cycling), and heavy-duty vehicles (decreasing their share by deviating traffic via rail).
- Concerning energy, citizens would like to see measures in place for the reduction of residential energy consumption (and of the service sector)

In terms of policy priorities, **policymakers and citizens are aligned regarding the improvement of public transport and the integration of public transport with private transport; promotion of vehicle sharing; boosting electric mobility and promoting active travel.**

- For increasing public transport use and reducing private car use the main barrier according to policymakers is changing transport habits. For expanding cycle paths and sidewalks / pedestrian areas the main barrier is space, as these modes compete with other uses of roads (parking, car lanes). For energy systems replacement, the cost, both for the Region and the citizens is a main barrier.

7.1.5 Impacts of the policy preferences

ClairCity modelling has concluded that **the 'Unified Policy Scenario' i.e. UPS[51] will lead to compliance with legal NO_2 EU limit values[52] widely in the Liguria Region by 2050. The UPS will comply with the EU legal limit values for PM_{10} everywhere in the Liguria Region, but not with the WHO guidelines in 2050**. The estimate is that in 2050, still 55% of the population could be potentially exposed to PM_{10} concentrations above WHO guideline values.

- According to the ClairCity modelling, **the UPS would lead to a significant decrease of NOx emissions over time** due to reductions across various sectors, with a particular strong decrease from NOx-emission from road transport and industry. **The trend for PM emissions is also downward**, mainly result of a decrease in residential emissions linked to heating. UPS measures also have a moderate impact on Carbon Footprint compared to the BAU. This impact is limited to transport sector emissions reduction as no additional measure is introduced in UPS addressing fossil fuel consumption in the other sectors.

The ClairCity UPS scenario results in limited additional reductions than the BAU will[53]. This is partly explained by the fact that policymakers chose in various cases to keep the current ambition level for transport and energy measures instead of opting for more ambitious measures proposed by Genoa area citizens. The additional reduction of NOx that the UPS generated beyond the BAU is negligible, as **the decrease in NOx from passenger cars is offset by a rebound of NOx emissions from buses**. **The UPS does lead to a slight additional reduction of PM emissions than the BAU.**

If implemented, the measures proposed by citizens (the UPS) would result by 2050 in notable health improvements for citizens compared to the situation in the baseline year (2015). **The ClairCity modelling estimates that the UPS would reduce the number of premature deaths from air pollution by 79% for NO_2, 11% for PM_{10}, and 6% for $PM_{2.5}$. The UPS barely leads to further reductions than the BAU** which is an indication that more stringent measures may be needed.

The reduction in premature deaths and the number of years of life lost expected in the UPS is lower than the average concentration levels reduction.

7.2 Policy recommendations

The following recommendations are tailored to the Liguria Region based on the analyses of current behavioural practices, preferred future behaviours and preferred future policies of

[51] The 'Unified Policy Scenario' (UPS) consist of policy measures prepared by combining citizen preferences for future policy measures with policy maker reflections.
[52] 40 µg/m3 (annual mean)
[53] The Business-As-Usual' scenario (BAU) concern the policy measures implemented in the Liguria Region in the base year 2015.

citizens, as well as of the study of the impact and an institutional context carried out by ClairCity.

7.2.1 Policies to address current behavioural practices and preferred future behaviours

From the detailed analysis of current and preferred future behaviours of citizens we conclude that the following mix of policy measures are worth considering. The measures should be taken altogether for optimal result.

- **Constant public transport improvement needs to go along with other measures to discourage car use and collect revenues for financing public transport**
  ClairCity concluded that there are several conventional car users currently who would like to switch to using alternative means, at least some of the time. This has the potential to be an easy gain for policymakers if adequate measures are taken. To encourage modal change away from cars, first and foremost public transport needs to be become more convenient and attractive through continued improvement of its coverage, frequency, travel time. A transport card / ticketing system which works for all modes of transport would also facilitate public intermodal transportation. What is key is that improvements in public transport go hand in hand with discouraging car use. Examples of measures to discourage car use are expanding car-free, pedestrian zones; limiting parking spaces in the city centre of the Liguria Region municipalities; and most importantly, making parking more expensive (higher fees where parking is already paid and starting to charge where parking is still free). Traffic restriction policies, although unpopular, can be seen as an opportunity that can help establish new transport habits. Extra fees are excellent government revenue to fund further measures. Communication campaigns should be considered for informing citizens about public transport services available, about any improvements made in that regard and for defending any policies affecting cars.

- **Developing an urban bike network to facilitate (electric) cycling, integrate (e-) cycling with public transport and further facilitate walking through interventions in the urban space.**
  Liguria Region citizens want to walk and cycle more. (Electric) cycling should be facilitated by infrastructural measures such as urban cycle lanes (and lifts) that reach where citizens want to get on a daily basis, as opposed to the leisure bike routes that currently dominate the Liguria Region. Fostering intermodality that is, the integration of (e-)cycling with public transport, for instance, by allowing (e-)bikes in public transport as well as offering bike rental options at popular train and bus stations, is also key. In order to make cycling safer, cycling traffic lights and bike parking facilities should be implemented. Walking can be boosted through increasing the space for pedestrians and expansion of pedestrian-only zones. Equipping pedestrian zones with electrical mini-taxis for citizens who may need motorised travel (elderly, mother with a small kid etc) can be considered. Public transport and constant improvements of (e-)bike infrastructure (including municipal biking/scooter sharing systems) will require effective promotion from the local government (for example through an awareness raising campaign), in order to inform citizens and encourage them to opt for those modes. Promotion of (e-)cycling should stress that cycling is not only an activity for leisure, but also an excellent, efficient

and healthy way for commuting. The attractiveness of walking can also be promoted by awareness campaigns that stress its health benefits.

- **Provide incentives for electric vehicles.**
  Considering citizens' support for continued private vehicle use, and their wish to drive in cleaner vehicles, Genoa and the Liguria Region should continue to incentivise electric vehicles through subsidies, tax exemptions, offering ease for parking or access to restricted areas, and by ensuring that there are enough charging points. Continuing to reward EV drivers with free parking (while charging high parking fees for conventional cars) seems also important to encourage the switch particularly considering that 'more and free parking' is seen as important by citizens in Genoa. It should be noted though that electric vehicles do not solve the problem of scarcity of space (where it is necessary to make room for public transport and active travel) therefore electric mobility should not become an alternative to public transport and active travel.

- **Intensify cooperation with employers, schools, destinations of leisure and shopping to minimise car travel.**
  ClairCity found that the great majority of citizens in the Liguria Region would rather use public transport or active travel for commuting and shopping. The barriers that citizens encounter for changing their behaviour, such as current limitations of public and active transport infrastructure (public transport and bike lanes that do not reach these facilities), should be addressed as mentioned on the points above. In addition, the promotion of active travel and public transport requires intensified cooperation with big employers as well as destinations of leisure and shopping (e.g. retailers, shopping malls, sports clubs, theatres or cinemas). Options for bus stops and bike parking next to these destinations, together with biking infrastructure to get there should be considered. Workplace travel plans are mostly behaviour-related measures which entail no cost for the Liguria Region government when these are promoted through awareness raising campaigns (the cost of campaigns is considered negligible) and when ultimately employers and schools are responsible for executing such. In addition, working from home can be considered. This has no cost neither for citizens nor for the regional / local government when private business are financing the shift. It can however be more complicated when trying to implement it for public authorities. Further, city planning should consider encouraging more jobs, shopping and leisure options close by to where people live.

- **Air quality and sustainable development in general should be integrated in the current educational offer**
  Giving sustainability education - and in turn air quality education - a more prominent place in the curriculum, is essential to raise awareness of the youngest generations and their parents. The success of the ClairCity schools activity in Liguria also suggests that there is interest for air quality education to be integrated in the local schools curricula. Air quality education should address directly the activities / sources of pollution that citizens can relate to, which are also the most important local emission sources i.e. private cars and domestic heating. Addressing why it is important to go to school by public transport or active travel, should be part of sustainability education. These classes should also

address the issues around biomass and raise awareness around the fact that residential biomass as source for PM_{10} and other pollutants.

- **Work closely together with NGOs to create citizen sustainability (air quality / climate) awareness in the Liguria Region.** Citizen interest in air quality and carbon emissions in the Liguria Region is relatively low and limits possibilities for policy action. This might be related to a lack of knowledge. For instance, many citizens may not realise of the health dangers of transport emissions (cars and motorbikes). Education and awareness raising are important enablers identified in by Liguria Region policymakers to motivate and engage with citizens to shift to sustainable mobility and heating modes. If policy measures affecting citizens' lives are to be implemented, citizens need to be aware and understand why those measures are important or even necessary, and how they can affect their lives for the better (e.g. beneficial for health, pleasant environment). Against this backdrop, NGOs, as intermediates between authorities and citizens as well as citizen groups (e.g. Vespisti), can play an important role in educating the public and creating public awareness around air quality.

- **Promote renewable energy and district heating with renewables.**
  The ClairCity engagement process showed that there is massive willingness from citizens for change regarding heating behaviour towards renewable energy. Considering residential heating is the primary source of carbon emissions in the city, action in this area is needed. Supporting rooftop solar PV, increasing rooftop solar on public buildings and supporting local citizen cooperatives for renewables generation could be measures that the government should consider to facilitate this. District heating, which is not popular in Genoa, can also provide a sustainable energy alternative if powered through renewables. Tackling this issue may also involve measures that may not be well received by all citizens at first (e.g. because they involve costs). Providing information and awareness raising is therefore essential to increase acceptance of policy measures. In addition, the dangers of biomass burning for air quality and health should be further communicated to citizens as often biomass is considered as a sustainable fuel.

7.2.2 Addressing institutional barriers and mutual learning

- **Make a long-term vision for air quality related policies and make citizen support for current and planned policies more explicit**
  ClairCity found that no long-term targets and policy plans exist for air pollution or climate change on either a regional or local level. Also, the last available air quality plan for the Liguria Region dates from 2006. As such, updating the Regional air quality plan and developing a long-term vision for air quality and climate related policy measures should be considered**.** Implementation can be facilitated by a detailed year-by-year implementation plan of long-term policy ambitions and a few milestones. The ClairCity analysis revealed that many citizens support not only the air quality and carbon policies that will bring direct benefits for them (e.g. improved public transport, subsidies for shifting transport/heating modes), but also support already happening / planned policies that will affect their lives (e.g. banning of diesel cars from city centres). Against this backdrop, communication of the citizen support for existing policies should be used to generate a wider acceptability of policies.

- **Reallocate costs or compensate costs of required transport measures through revenue generating local financial instruments and communicate the need for such instruments.**
  Finance is a key institutional condition that determines the possibilities for implementing policies in the areas of transport and energy. Subsidising heating systems, modes and/or fuel change, as well as public transport improvements are all costly. These costs can be compensated by generating local funding through for example parking fees and permits, congestion levies or workplace parking levies. Such financial instruments tend to be unpopular with citizens, hence the need to properly communicate such measures. Authorities should consider possibilities to reward behavioural change (e.g. discounts at local shops rewarding bike use/rental). Costs can be additional to current investments or simply a reallocation of existing investment funds. The costs of new walking/cycling infrastructure (e.g. expanding the cycling network) for instance, can be (partly) offset by reallocating funds currently dedicated to road infrastructure for cars, to infrastructure for walking and cycling.

- **'Improving quality of life' and 'preserving Ligurian environment' as hooks to defend transport and heating policies**
  Considering that neither awareness nor interest on air quality are high, other kinds of 'hooks' should be used to defend transport or heating policies that affect citizens. For example, messages around better quality of life or preservation of the Ligurian environment', which is so beloved by the locals. Given that Ligurian citizens appreciate walking, stressing the side benefits to overall quality of city life resulting from larger pedestrian zones and less cars could be more concrete messages to use in communications. In addition, with 'climate change' gaining traction at both the political and citizen levels, 'climate' can also be used as hook for putting policies forward. Considering the 'seasonal' aspect of O_3 (in hot summer days), it is probably worth implementing transport measures affecting cars/ motorbikes/ scooters and focusing any awareness campaigns in the summer months, when the problem is most visible.

Annex A. The ClairCity process in detail

This annex explains in more detail the ClairCity process and the positioning of this policy package report.

The ClairCity project consists of three phases and seven work packages (Figure A-1):

Phase 1: Establish the Baseline Evidence

The primary aim of Phase 1 is to understand and quantify the baseline status of air quality, carbon emissions and related public health in our cities. Phase 1 is achieved with the following main activities:

1. **Benchmarking behaviour**: Understanding the local demographic data and establishing the citizen practice-activity data to feed into the air quality models.
2. **Quantify the baseline**: Quantification of the baseline air quality emissions and concentrations, carbon emissions and public health impacts in a city.
3. **Assessment of Policy**: Collation and analysis of current policies (local, regional, national and EU) that influence the city.

Phase 2: Citizen and Stakeholder Engagement & Co-creation of Scenarios

Phase 2 has three key aims: (1) understand citizens' current behaviours, practices and activities, (2) enable citizens and stakeholder to co-create and visualise their low carbon, clean air, future city and (3) raise awareness of the environmental challenges and their solutions. Phase 2 utilised evidence from Phase 1 to help frame and inform the engagement activities. Phase 2 is achieved with the following main activities:

Citizen and stakeholder engagement & co-creation

1. The ClairCity Delphi method uses citizens as local experts to generated qualitative evidence of their entrenched behaviours and what enabling interventions would allow them to act and behave differently in future (WP4).
2. The Mutual Learning Workshop brings citizens and stakeholders together to debate the challenges facing the city and co-create policy interventions for cleaner, healthier futures (WP4).
3. The ClairCity Skylines Game 'crowd-sources' the public perceptions and public acceptability of difference policy interventions (WP4)
4. Citizens and stakeholders come together in a Stakeholder Dialogue Workshop to review and debate the Delphi, Mutual Learning Workshop and ClairCity Skylines evidence and co-create scenarios for a low carbon, clean air, health futures (WP4 and WP7).
5. The scenarios generated in the Stakeholder Dialogue Workshop go through a rapid quantification step (WP5) and are then returned to the local citizens/stakeholders to discuss in a Policy Workshop (WP6) and to agree a single Unified Policy Scenario (WP7).

Public Engagement & Awareness: Additional awareness raising activities are also implemented across the project in each city (WP4). These include:

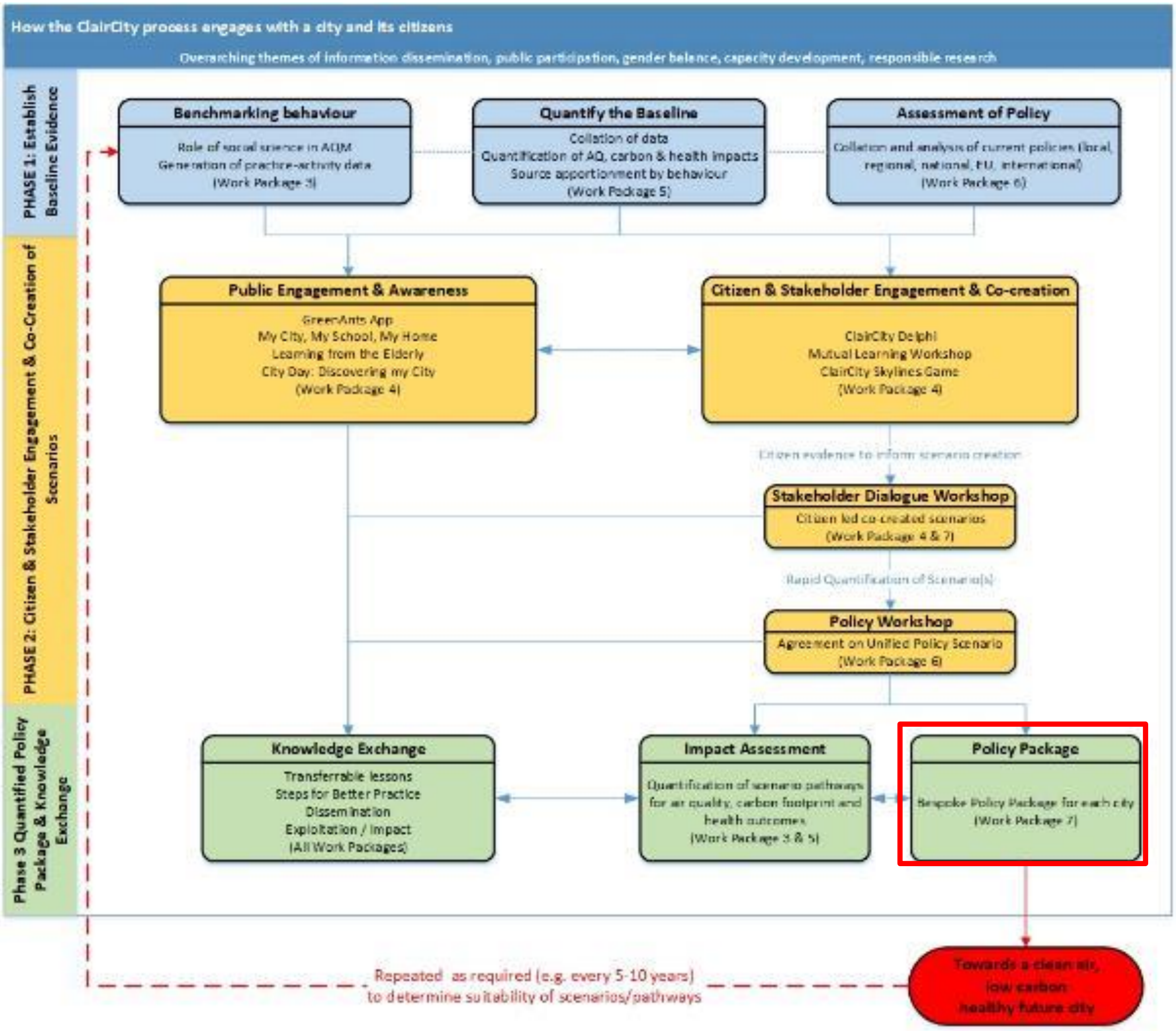
6. The GreenAnt App which allows citizens to become a citizen scientist and monitoring their transport activities, emission generation and exposure using mobile GPS data.
7. The School Competition: My City, My School, My Home engages young people in the air quality, carbon and public health debate utilising an online platform for the students to select the interventions that influence their housing, transport and use of resources in order to be able to design tools for change towards smart consumption, reduced emissions and healthy lifestyles.
8. Learning from the elderly filming activity engages the older, potentially vulnerable, community to talk about the changes in their city, their personal mobility and the steps they take to minimise their exposure to air pollution.
9. The City Day: Discovering my City helps disseminate the final project results and provide healthy and smart tips to promote non-motorised mobility of citizens by highlighting availability and benefits of walking and cycling routes in the city.

Phase 3: Quantified Policy Package & Knowledge Exchange

The primary aim of the final Phase 3 is to collate the evidence and lessons learned from Phase1 and Phase 2 to generate a quantified, bespoke, citizen-led and citizen-inclusive policy package for each city. Phase 3 is achieved with the following main activities:

1. **Knowledge Exchange**: Collation of transferrable lessons and steps for better practice based on the experiences of the ClairCity project to inform other environmental and public health practitioners (WP3, WP4, WP5, WP7).
2. **Impact Assessment**: Rapid quantification of the scenarios generated in the Stakeholder Dialogue Workshop (WP4) and detailed impact assessment of the final Unified Policy Scenario generated in the Policy Workshop (WP6). This quantification includes an assessment of the source apportionment by behaviour or purpose; air quality emissions and concentrations, carbon emissions, air pollution related health impact and interventions cost analysis (WP5).
3. **Policy Package**: Development of a bespoke Policy Package for each city drawing together the findings from across the whole project (WP7).

Figure A-0-1 The ClairCity project and position of the Policy Package report in detail



Annex B. The ClairCity citizen engagement process

The citizen engagement process developed by ClairCity consisted of policy focused activities and of awareness raising directed activities. In annex B-1 the former are discussed in some more detail, in annex B-2 the latter. For an even more comprehensive overview and analysis in addition the more detailed ClairCity reports on each activity can be consulted.

B.1 Policy focused engagement activities

Three main engagement activities directly informed the policy workshop and the policy recommendations: the Mutual Learning Workshop, the Delphi process and the Skylines game.

Mutual Learning Workshop (MLW)

The Liguria Region Mutual Learning Workshop (MLW) engaged with a variety of stakeholders from different sectors and organisations (Table B-1).

Table B-1 Participants in the Genoa Mutual Learning Workshop (excluding ClairCity team)

Stakeholder group	Number of participants	Organisations
Harbour	1 (3% of the total)	Port authority
NGOs	1 (3% of the total)	Associazione Amici di Ponte Carrera
Policymakers	19 (66% of the total)	Various departments of the Region (health, energy, transport), of the City of Genoa (health, transport) and of its territorial structures (municipalities)
Business sector / private companies	2 (7% of the total)	Gemacht srl, ERG spa
Public agencies	5 (17% of the total)	Regional Energy Agency, Regional Environmental Agency, Epidemiological services, Local health agencies
Other (if applicable): **specify**	1 (3% of the total)	Universities

The MLW in Liguria consisted of several presentations by experts (e.g. relevant authorities). The presentations addressed several topics such as air quality situation and policies in the Liguria Region; the Regional Environmental Energy Plan 2014-2020, and the local context with the Covenant of Mayors for Climate and Energy; Transport infrastructure and sustainable mobility; ongoing and planned port initiatives such as electrification projects.

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Participants had to think on their visions and strategies for the future (2020 and 2050), set goals to achieve such by 2050, present and discuss them within the group. For 2020 the main visions and ideas for the Liguria Region discussed were related

In the MLW, a few main challenges or barriers that hinder the achievement of future visions with clean air and low carbon emissions were identified. The challenges and barriers identified were political; environmental, social, business/market; housing; citizen challenges; cultural; inter-generational. Some specific challenges names are as follows:

- The need for several stakeholders to work together;
- Behaviour change need;
- The lack of awareness and knowledge on environmental issues among citizens (which in turn is reflected on individual behaviour).
- Political short-termism;
- Difficulties of visualising desired futures workshops and pathways to get there.

Delphi process

The Delphi process[54] consisted of two broad survey rounds of Liguria Region citizens, a workshop with citizens and concluded with a 'Stakeholder Dialogue Workshop' (SDW). The surveys and events resulted in the following participation:

- 646 responses to Round 1 survey which included a mix of open and closed questions presented online and face-to-face by interviewers and in self-completed forms

- 462 responses to Round 2 survey which included a mix of open and closed questions including measures (generated based on Round 1 responses, to be rated by citizens in this second round)

- 1 face-to-face workshop with 19 citizens intended to work out in more detail the citizens' measures, enablers and constraints.

[54] Results from the Delphi Process have been reported on Reported in D4.2 DELPHI Workshops Complete – First City, D4.3 DELPHI Workshops Complete – Last City, ClairCity Deliverables D4.4 Pilot Cities DELPHI Evaluation Report, D4.5 Stakeholder Dialogue Workshop - First City and D4.6 Stakeholder Dialogue Workshop – Last City.

- At the SDW 14 attendees discussed priority policy measures derived from the questionnaires in the Delphi process and created various scenarios (Table B-2).

Table B-2 Policy measures discussed in Stakeholder Dialogue Workshop and proposed HIGH ambition scenario for each policy

	Measure	Proposed scenario HIGH
1	Improve the local public transport (including sharing); increase the number of metro stops, electrified lines in most polluted areas; reduced pricing with integrated ticket. One ticket one travel.	Increase number of travels on the integrated local public transport system, including vehicles sharing, from 25% to 31% by 2029 and from 31% in 2029 to 45% by 2050
2	Build new parking lots for transfer from private cars to public transport	5 new big interchange parking lots
3	Ban most polluting diesel and motorcycle vehicles in the city centre.	Replace 50% of vehicles circulating in urban areas with electric cars and motorcycles by 2050
4	Encourage the purchase of electric vehicles, the use of shared electric vehicles and increase infrastructure for charging	Install an adequate number of charging stations for 50% circulating electric vehicles (including sharing)
5	Create new separate cycle paths and related infrastructure (safe bicycle storage / parking areas, security); adapt public transport (trains, buses / trolleybuses) to bike transport; increase the safety of pedestrian traffic	Increase active travel from 22% to 23% by 2029 and from 23% by 2029 to 35% by 2050.
6	Provide infrastructure to facilitate transfer of freight from road to rail.	50% reduction in heavy traffic at 2035 and 70% at 2050
7	Reduction of energy consumption in the civil sector	Reduction of residential consumption by 10% and consumption in the service sector by 16% in 2030

Skylines Game

ClairCity Skylines is a ‘serious game’, designed to capture citizen decision making about issues in their city. Players travel between areas representing a city’s environment, economy and its citizen’s health & satisfaction, collecting ideas for policies to enact to achieve a low carbon, clean air, healthy future before 2050 (Figures B-2 and B-3). The game includes visuals with Ligurian landmarks.

Figure B-2: Google Play Store listing

Figure B-3: Six playable cities completed

In the Liguria Region ClairCity Skylines was launched in January 2019 with primary data capture closing at the end of March 2019. The game includes English, Dutch, Slovenian, Polish, Italian and Portuguese localisations for game text, UI and the policy database.

B.2 Awareness related engagement activities

At the time of writing this report, three ClairCity awareness related engagement activities had been implemented: a school competition, the film activity for the elderly, the city day and the GreenAnts app. The reason for the focus on young people and the elderly is that ClairCity builds on the WHO Policy Framework and the European Commission's Clean Air Policy Package that promote public health by paying special attention to more vulnerable groups, such as children and senior citizens. The aim is to empower these citizens to better understand the specific challenges and opportunities that their city currently offers and to engage them into moving towards reduced air pollutant emissions and carbon footprints. The project has therefore collected their perceptions and ideas on sustainable lifestyles and a *'better quality of life'* within their city in the future.

Schools activity

The schools activity in Genoa was run between February and March 2019. The activity consisted of a competition between school kids aimed at learning about air quality and climate issues. 23 teams of schools kids aged 13-16 years took part in the competition. The participating schools were four: Primo Levi (Ronco Scrivia), Lafranconi, Marsano (Molassana) and Colombo (however 35 schools received the materials prepared by ClairCity).

The competition was run using the online tool developed by ClairCity specifically for this activity. The tool, which has been translated to Italian, presented a set of questions around air quality, health, energy, transport and the like for students to answer. It also allowed students to select policies that they would like to see implemented. As preparation for the competition, teachers in these schools gave lessons about air pollution and climate change pior to the competition.

All school teams supported the increase of green spaces and virtually all teams supported the accelerated uptake of vehicles running on alternative fuels, and the expansion and modernisation of district heating networks. Kids were not very supportive of several measures directed at private cars though. For example, the great majority of teams did neither support the increase in price of fossil fuels (gasoline, diesel), nor the increase in road tolls to encourage people to drive less, nor the reduction of the road capacity, nor the reduction of the speed limit to 30 km/h in residential areas. This reluctancy to implement policies affecting cars may indicate a lack of knowledge among kids (of the impacts of road traffic in air pollution and climate change). It may also show that motorised traffic is engrained in Ligurian transport behaviour, and that kids ‘inherit’ that from their parents.

The winning team was awarded a price at the City Day celebrated in autumn 2019 in Genoa. Given the success booked for this activity, the ClairCity team in Liguria is planning to run the school competition again, this time countrywide.

Elderly video activity

ClairCity activities with the elderly aimed to promote non-motorised mobility of citizens in the Liguria Region to show the health, environmental and social benefit of active travel. The activity invited local older citizens to tell about their experiences in short videos. In the Liguria a total of five videos were collected.

Local residents participating in the ClairCity videos project shared a range of thoughts and ideas which included the following highlights:

- People using cycling and walking in their free time;
- People going to work by train and walking;
- Road traffic in the city is a problem; and
- Appreciation for the beauty of the landscape without vehicles.

Several stakeholders from the Genoa Municipality, University of Genoa, Third Age University of Genoa and organisations (environmental, leisure, cycling, voluntary, cultural and migrant associations) were contacted on order to spread the word about the videos.

The best three films were selected based on who gets the most ‘likes’ on YouTube. One of the videos had 600 views and 183 “Likes” at the time of closing the process.

Feedback from participants suggests that it has been technically difficult for them to generate the videos and upload them onto YouTube. Although only five videos were generated, the process reached several stakeholders, helping make some noise around awareness of air pollution and non-motorized mobility.

The Liguria ClairCity videos can be found here:
https://www.youtube.com/channel/UC5QW07j4NKD_0gzFb-FX17w

Genoa City Day

The Genoa City Day took place on 25th October 2019 at the Transparency Hall of Regione Liguria, in De Ferrari Square, in Genoa. The City Day, which was held as part of the 'Genoa Science Festival', aimed to present the ClairCity project to the public. Special attention was given to two specific activities, namely the schools competition and the videos competition with the elderly, with a ceremony award for the winners.

The ClairCity Liguria Team worked closely with the Genoa Science Festival to co-organise and co-promote the ClairCity City Day. The Festival is a major event for science communication and dissemination in the region and therefore provides a great opportunity for engaging researchers, science enthusiasts, schools and families. The City Day was publicised on the Genoa Science Festival Website:
http://festival2019.festivalscienza.it/site/home/programma-2019/genova-city-day.html?fbclid=IwAR3pc8_g6PssHNPhjEkG0hlu8Cepdqye43DwqVB4G4YzvlGBE-5E7lA2S5Y

Over 80 people (excluding the Liguria ClairCity Team from Techne and Regione Liguria) participated. This included students and teachers of the local schools which participated in the schools competition as well as the elderly who submitted videos about non-motorised mobility.

All participants of the videos and school competition initiatives were given a certificate for their participation and a Liguria 'goodie' bag which included: a geologic map; a DVD on the sea and the coast; an informative book on the parks; a guide of the nature walks; two leaflets on biodiversity; and a book on animals. The winners also received a ticket for two people to visit up to four museums.

GreenAnts App

GreenAnt provides insight into people's daily travel habits and their reaction to changes. It visualizes how people's everyday travel impact air quality and what people can do to reduce negative impact. The GreenAnt system consists of:

1. a website for creating a user profile and accessing data
2. a smartphone application for Android and iOS devices for data collection.

To use the system, it is necessary to register zones on the web tool named ANTS, where you want to collect data about how people travel. Users can assign themselves to the zone by downloading the GreenAnt smartphone app. When the user is within the zone, route and transportation data will be collected and later stored on the server.

In the Liguria Region the GreenAnt app was tested in November 2019. The feedback received shows that the app is not yet ready for public use in the Liguria Region. Issues of accuracy (when providing information to the user) and functioning (technical issues) were raised next to privacy concerns. The GreenAnt system is now evaluated to satisfy TRL6 and move towards TRL7.

Annex C. The Liguria Region citizen engagement impacts: scenarios and modelling

C.1 Modelling impacts of the citizen scenarios

To understand the impact of the policies the citizens put forward, we assessed the impact of policies on emissions, air quality, health and costs in three steps:

1. Step 1: Reproduce the air quality situation as it is currently, in a modelling environment ("baseline"):
    a. First, estimate total emissions from different sources, in line with statistics (by sector, by time of day, link with behavior)
    b. Secondly, model the air quality and validate the modelling output with observations
    c. Finally: assess exposure and health impact with common indicators
2. Step 2: Estimate future emissions in a scenario with existing policy measures and model the resulting air quality. This business-as-usual ("BAU") scenario aims to capture the changes in air quality if no further measures are taken, only accounting for changes in the emissions due to policy measures made in the past and expected technological and/or behavioral changes.
3. Step 3: Estimate future emissions in a scenario with **additional** policy measures in the area of road transport and domestic heating as aimed for by the Liguria Region citizens. We follow the same suite, from estimating the impact of the measures on emissions, to air quality and health impact.

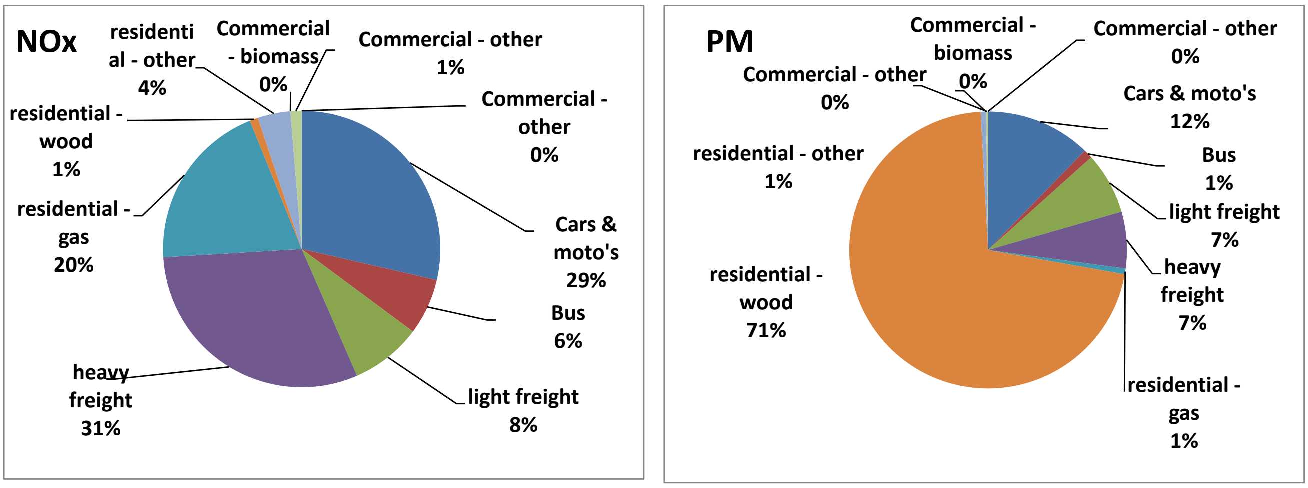
Therefore, the results of the modelling exercise consist of three parts:

1. Results for the situation as it is (baseline)
2. Expected future without future action (BAU)
3. Future with additional policy action (UPS)

C.1.1 Air quality for the baseline

Figure C-1 shows emissions calculated by ClairCity, by source of interest for the project (road transport and residential) in the baseline situation (year 2015), for 2 key pollutants: NOx and $PM_{2.5}$.

Figure C-1 relative importance of different sectors for NOx and PM emissions



The figure shows that for NOx, the road transport sector is the most important source of emissions, accounting for about 49% of total emissions. This is due to NOx-emissions from mostly diesel cars, buses and freight vehicles. Other sources of NOx-emissions are mostly industrial sources (33%). For PM, the share of transport is smaller (25%) while the dominant source is residential heating accounting for about two thirds of total emissions (67%). The dominance of the residential sector for PM emissions is striking. This estimate of emissions from wood combustion is affected by a strong uncertainty linked to emission factors and technologies which led to an overestimation.

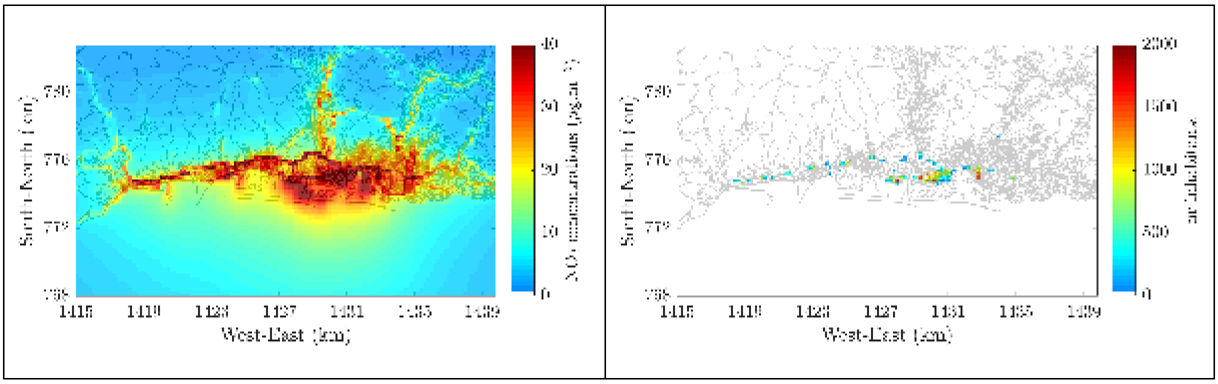
The second-generation Gaussian model URBAIR was setup and run at an urban scale for the computational domain over the Liguria Region. The baseline simulations were performed for the full-year using the meteorological vertical profiles from the WRF-CAMx system and the emissions available on the ClairCity emissions database. Background concentrations were added to the URBAIR model results. For that purpose, it was established a single value to apply to each grid cell. This value is the average concentration from the transboundary transport obtained from the WRF-CAMx results using the source apportionment tool. In addition, the simulation results together with the added background concentrations were calibrated against the measurements[55] through the adjustment procedure. For NO_2 concentrations, a distinct slope obtained from the linear regression is applied as a correction factor, depending on the classification of the air quality station. The slope obtained from the linear regression considering the air quality stations classified as background stations, or as

[55] The NO_2 observations available for 2015 include measurements from 7 continuous measurements for 2015, from the Liguria monitoring network: 3 road traffic sites, 3 urban background sites, and 1 urban industrial site. The PM10 observations available include measurements from 4 continuous sites: 1 road traffic site, 2 urban background sites, and 1 urban industrial site. PM2.5 observations are only available for one urban background site and one road traffic site.

road-traffic stations, or industrial stations is equal to 1.9, 1.6 and 1.9. The slope obtained with the background stations was applied to the concentrations simulated with the emissions from the residential and commercial sector; the slope obtained with the industrial stations was applied to the concentrations obtained from the simulations of the industrial emission sector: the slope obtained with the traffic stations was applied to the concentrations obtained from the simulations of the on-road transport sector. In case of particulate matter, PM_{10} and $PM_{2.5}$ concentrations an unique slope with no distinction of the air quality station type was obtained from the linear regression equal to 3 for PM_{10} and 1.6 for $PM_{2.5}$ concentrations.

Figure C-2 a) shows the resulting NO_2 annual average concentrations. Figure C-2 b) points out the population potentially exposed to NO_2 concentrations above the EU legal limit value of 40 µg.m^{-3}.

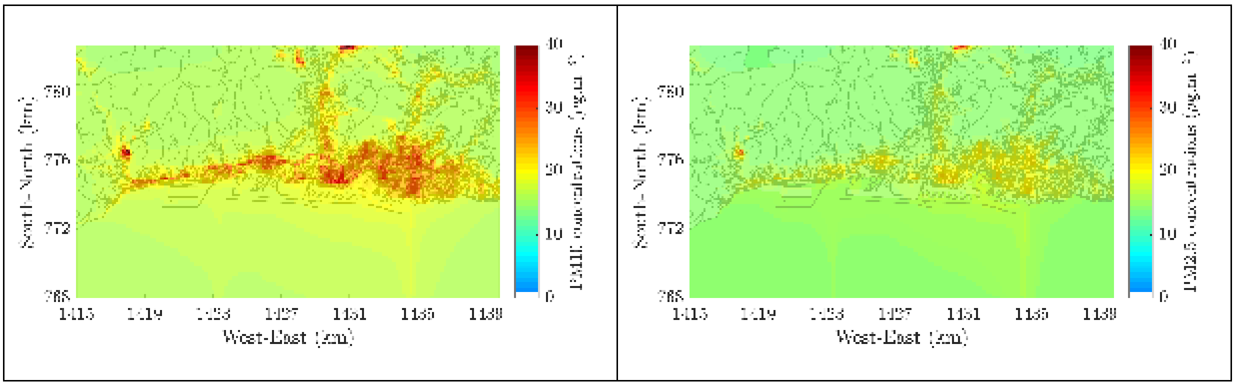
Figure C-2 NO_2 contour maps: a) annual average of NO_2 concentrations and b) number of inhabitants within the cells exceeding the EU annual limit value of 40 µg.m^{-3} in 2015



The simulation results indicate a maximum concentration of 84.9 µg.m^{-3} within the urban area of Liguria municipality. The EU annual legal limit value for NO_2 annual concentrations is exceeded in 123 cells corresponding to 8% of the total population within the Region potentially exposed to those concentrations.

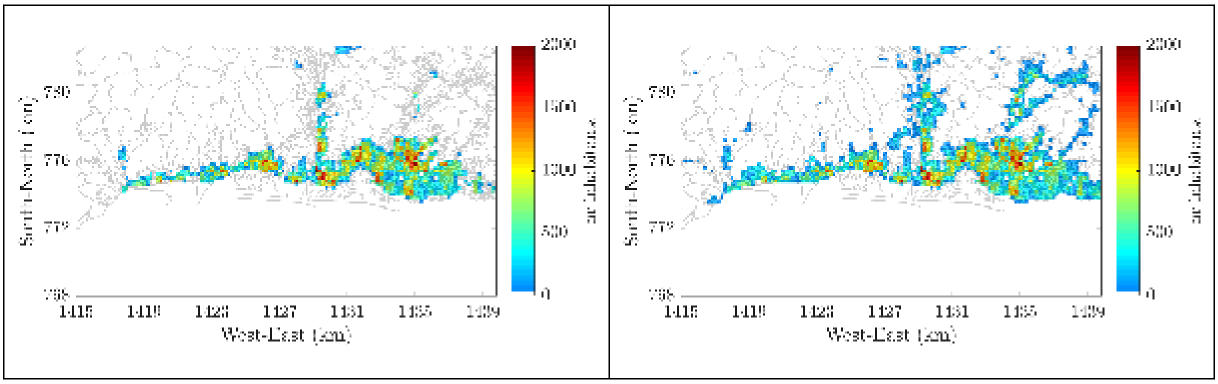
Figure C-3 presents the PM_{10} annual average concentrations (Figure C-3 a)) and the $PM_{2.5}$ annual average concentrations (Figure C-3 b)).

Figure C-3 (a) PM_{10} annual average concentrations and (b) $PM_{2.5}$ annual average concentrations in 2015



The maximum value of PM_{10} concentrations is equal to 50.2 µg.m $^{-3}$, which is mainly simulated over the residential areas of Genoa, while the simulated maximum concentration of $PM_{2.5}$ is equal to 32.5 µg.m $^{-3}$. The PM concentration contour maps point out only a few exceedances to the annual EU legal limit values for PM_{10} and $PM_{2.5}$, equal to 40 µg.m $^{-3}$ and 25 µg.m $^{-3}$. However, despite the nearly compliance of the EU legal limit values for PM_{10} and $PM_{2.5}$ concentrations, the annual concentrations indicate significant exceedances of the WHO guideline values. Figure B-3 shows 999 and 9375 cells exceeding the WHO guideline value for PM_{10} and $PM_{2.5}$ concentrations, respectively, which represents 78% (PM10)and 100% (PM2.5) of the population within the simulation area potentially affected by those concentrations above the recommended value.

Figure C-4 Number of inhabitants within the cells exceeding the WHO air quality guideline values: a) of 20 µg.m-3 for PM_{10} concentrations, and b) of 10 µg.m-3 for $PM_{2.5}$ concentrations in 2015



Assessment of health impacts for the baseline

The health benefits related to air pollution were illustrated by calculating health impact indicators for different air pollutants (NO2, PM10, and PM2.5): the number of premature deaths and years of life lost (YLL). Premature mortality is a standard measure of the burden of the population's health, as it is expected that most deaths are preventable before a person reaches an expected age. YLL is defined as the years of potential life lost due to premature deaths. Since YLL takes into account the age at which deaths occur, relative to life expectancy, higher weight is given to deaths at a younger age than at an older age. Mortality indicators are not the only indicators available for the burden of disease related to air quality but are certainly the ones with higher external costs to society.

The burden of disease associated with ambient air pollution is estimated by relating air concentrations to health outcomes. Gridded annual averages were used as input to quantify the relative risk in a population, based on concentration-response functions (CRF). CRFs reflect the effect of a pollutant on a health outcome, e.g. NO_2 on mortality from cardiopulmonary diseases, typically expressed as the increase in incidence or prevalence per unit increase in concentration. Table *B-1* describes the risk ratios, the mortality causes, age interval, and concentration threshold consider when calculating the health outcomes for each air pollutant. The threshold concentration is the concentration level below which no health effects are expected.

Table C-1: Risk ratios (RR) for mortality

Pollutant	Value [per 10 μg/m3]	Type	Reference
$PM_{2.5}$	RR 1.062 (95 % CI 1.040-1.083) No threshold	All-cause (natural) mortality in ages above 30 (ICD-10 codes A00-R99).	WHO 2013a
PM_{10}	RR 1.04 (95% CI, 1-1.09) No threshold		Beelen et al., 2014
NO_2	RR 1.055 (95 % CI 1.031-1.08%) Threshold: 10 μg/m^3		WHO 2013a

Premature deaths can be estimated at the grid-cell level by multiplying the population attributable fraction (PAF), the crude death rate (CDR), and the total population for every cell. PAF is defined as the reduction in population mortality if exposure to a risk factor was reduced to an ideal exposure scenario (e.g., concentrations equal to zero). PAF can be calculated from the relative risk, assuming an exponential behaviour. CDRs were calculated based on natural all-cause mortality in 2015 and country level population, broken down by age and sex. Here it is assumed that CDR is constant across the country's population. YLL is calculated at the grid cell level by multiplying premature deaths with life expectancy by age and sex. Life expectancy data is based on data published by the UN. The expected burden of disease attributable to air pollution in a specific area can finally be estimated by summing over all grid cells in the area of interest for the indicator of interest.

The results for the baseline scenario indicate there has been 418, 506, and 590 premature deaths attributed to NO_2, PM_{10} and $PM_{2.5}$ pollution levels in the Liguria Region in 2015, respectively. For the same pollutants, 3549, 4294, and 5014 years of potential life lost were estimated for the Liguria Region in 2015.

It should be noted that every single step of the process to assess health risks due to air pollution exposure is associated with uncertainties. These uncertainties are partly linked to the uncertainties of the input data used (e.g. concentrations, population, demographic and health data)

- The estimated ambient air concentration levels are very important for the outcome of the health risk assessment. The uncertainties around concentration levels are related to the uncertainty on each step of the modelling chain from emission to air quality modelling.

- Population and demographic data has been collected by WHO, UN and Eurostat. The data have uncertainties inherent to statistical products and processes, and data completeness depending on the availability of raw data transmitted by the National Statistical Offices (ESS, 2012). Some level of inconsistency between the datasets may be expected, as there may be different methodologies to collect and treat the data.

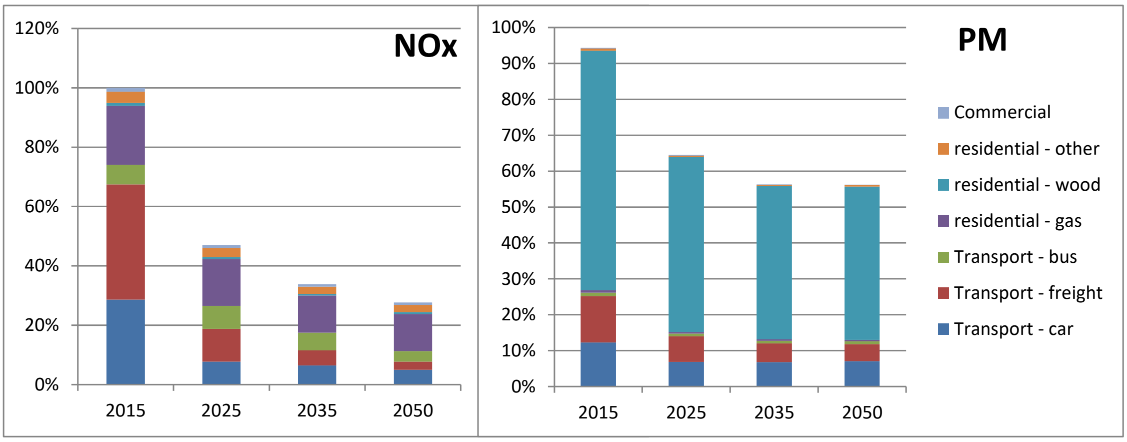
There are also uncertainties related to the concentration-response functions (CRF) used to calculate the population's exposure relative risk.

- Epidemiological studies provide the concentration-response functions (CRF) to calculate the population's exposure relative risk. In this study the CRF chosen are the ones recommended by the World Health Organisation. The CRFs chosen have associated confidence intervals quantifying the error and the variability associated with the epidemiological study and are representative of the population represented in the studies. The choice of CRF and its generalisation to other regions than the ones where the epidemiological study was done is an important source of uncertainty.

- The estimated ambient air concentration levels are very important for the outcome of the health risk assessment. The uncertainties around concentration levels are related to the uncertainty on each step of the modelling chain from emission to air quality modelling. Currently, the quantification of health risks is done individually for each air pollutant, but they exhibit some degree of correlation, positive or negative. WHO (2013) warns against adding the health risks estimated for different air pollutants without adjusting the used CRFs. For example, adding the risks of $PM_{2.5}$ and NO_2 to estimate a total health risk may lead to a significant double counting. Conversely, only assessing health risks due to exposure to an air pollutant at the time does not reflect the impact of the mixture of pollutants that coexist in ambient air.

C.1.2 BAU

Figure C-5 trend of PM and NOx emissions in a business as usual scenario



BAU impacts on air quality

The reductions of the NOx emissions in the BAU scenario will lead to relevant reductions of the NO_2 concentrations. Figure C-6 presents as example the NO_2 annual average concentrations considering the impacts of BAU scenarios for 2025 and 2050. The maximum NO_2 concentration will be equal to 62.2 $\mu g.m^{-3}$ in 2025 and to 59.5 $\mu g.m^{-3}$ in 2050. In the BAU scenario, the NO_2 concentrations will still exceed the EU limits and WHO guidelines in 2050 in 6 grid cells (0.04% of the population exposed).

Figure C-6 NO_2 annual average concentrations for the BAU scenarios: a) 2025 and b) 2050.

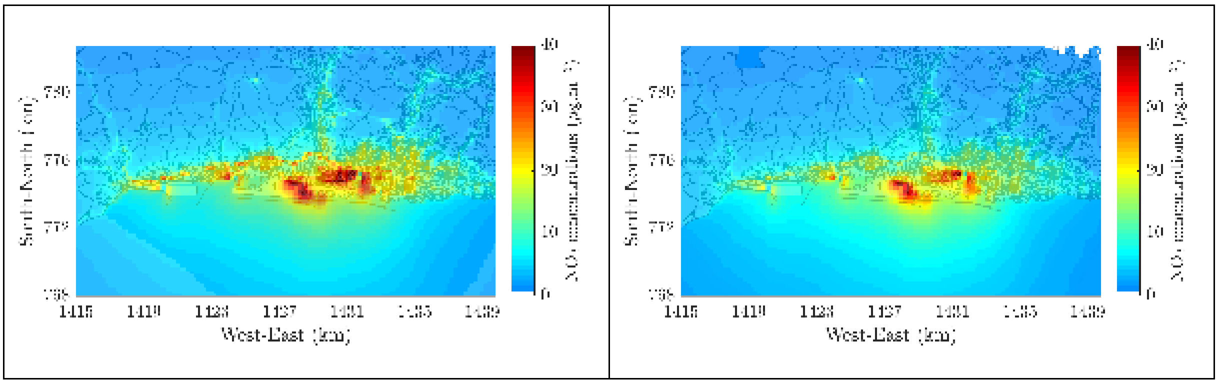
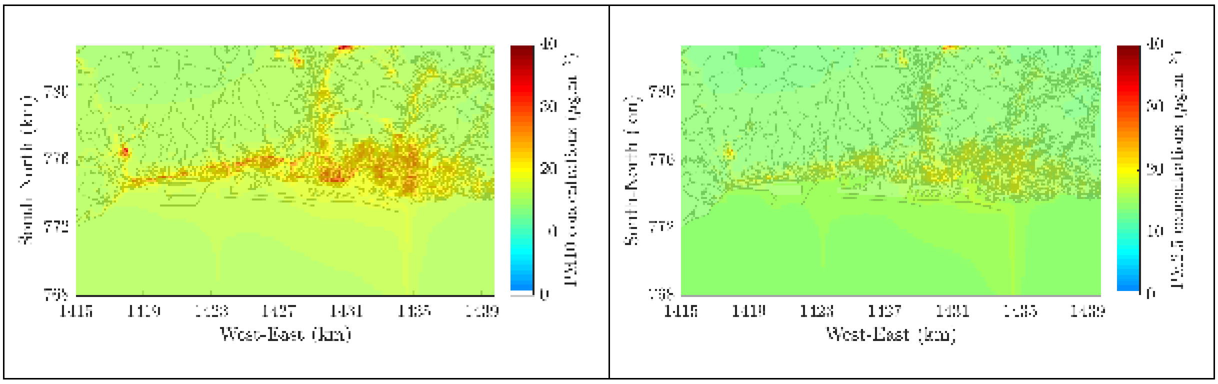


Figure C-7 (a) presents the PM_{10} annual average concentrations for 2050 and (b) the $PM_{2.5}$ annual average concentrations for the same year. The simulated maximum values of PM_{10} concentrations range from 40.7 to 37.6 µg.m $^{-3}$ between 2025 and 2050, while the simulated maximum concentration of $PM_{2.5}$ slightly vary from 27.4 to 25.7 µg.m $^{-3}$. Therefore, the BAU scenarios will lead to the reduction of PM_{10} concentrations showing compliance with EU limit values (only one cell exceeding the limit in 2025, and no exceedances in 2050). However, Liguria region does not comply with the stricter guideline values of the WHO, showing 682 grid cells exceeding the value in 2025, and 574 in 2050, corresponding to 63.5% and 55.3% of the population within the simulation area potentially exposed to those concentrations. The BAU scenarios will lead to the reduction of $PM_{2.5}$ concentrations showing compliance with EU limit values in 2025 (only 3 grid cells with exceedances, in 2025; and only 1 in 2050. However, for the WHO guideline values there are still exceedances to this limit in 2050 (9375 cells with exceedances, corresponding to 100% of the population potentially exposed).

Figure C-7 Particulate matter annual average concentrations for the BAU scenario in 2050. a) PM_{10} and b) $PM_{2.5}$ concentrations.



BAU impacts on health

The results the BAU scenario for 2025, 2035 and 2050 are presented in Table C-2 for premature deaths, and Table C-3 for years of life lost.

The results for the BAU scenario indicate that from the base year (2015) there could potentially be 173, 465 and 564 premature deaths and 1469, 3947, 4786 years of life lost attributed to NO_2, PM_{10} and $PM_{2.5}$ pollution levels in Liguria Region in 2025 respectively.

Estimations for 2035 indicate that 113, 452 and 554 premature deaths and 959, 3 841 and 4 702 years of life lost attributed to NO_2, PM_{10} and $PM_{2.5}$ pollution levels respectively. By 2050, the BAU scenario would lead to 88, 454, and 554 premature deaths and 750, 3 851 and 4 707 years of life lost as result of exposure to NO_2, PM_{10} and $PM_{2.5}$.

It should be noted that given this is a scenario exercise, there is a level of uncertainty associated with these results. Further discrepancies arise from the differences between the concentrations modelled by ClairCity and the concentrations recorded by the monitoring stations in the liguria Region (particularly for PM_{10} and $PM_{2.5,}$ differences in this regard are high, with monitoring stations in Liguria reporting considerably lower figures).

Table C-2 Number of premature deaths related to $PM_{2.5}$, PM_{10} and NO_2 exposure for the BAU scenario in 2025, 2035, and 2050.

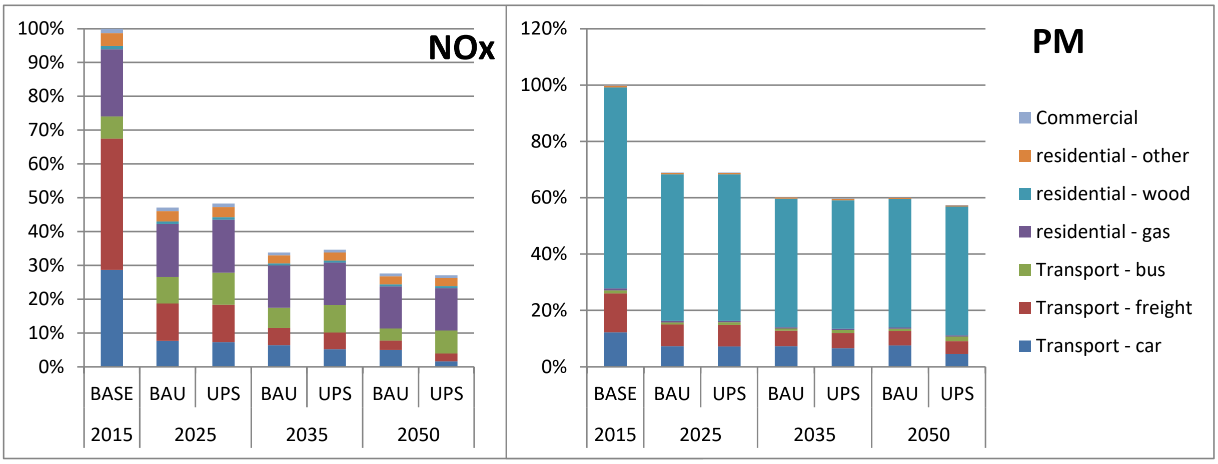
	$PM_{2.5}$			PM_{10}			NO_2		
Scenario	**2025**	**2035**	**2050**	**2025**	**2035**	**2050**	**2025**	**2035**	**2050**
BAU	564	554	554	465	452	454	173	113	88

Table C-3 Number of years of life lost related to $PM_{2.5}$, PM_{10} and NO_2 exposure for the BAU scenario scenarios in 2025, 2035, and 2050.

	$PM_{2.5}$			PM_{10}			NO_2		
Scenario	**2025**	**2035**	**2050**	**2025**	**2035**	**2050**	**2025**	**2035**	**2050**
BAU	4786	4702	4707	3947	3841	3851	1469	959	750

C.1.3 UPS

Figure C-8 trend of PM and NOx emissions in the UPS, compared to the business as usual scenario



UPS impacts on air quality

Since there are no reductions in NOx emissions in the UPS scenario comparing with the BAU scenario, no reductions of the NO_2 concentrations are expected in the UPS. Figure C-9 shows for example the NO_2 annual average concentrations considering the impacts of UPS scenarios for 2025 and 2050. In 2025 the maximum NO_2 concentration will be equal to 62.4 µg.m^{-3}[56] and in 2050 equal to 59.5 µg.m^{-3}, showing 12 and 6 grid cells exceeding the legal limit value already in 2025 and 2050, respectively. Comparing the UPS and the BAU scenario in 2050, the maximum concentrations will be at 30% compared to 2015.

Figure C-9 NO_2 annual average concentrations for the UPS scenarios: a) 2025 and b) 2050.

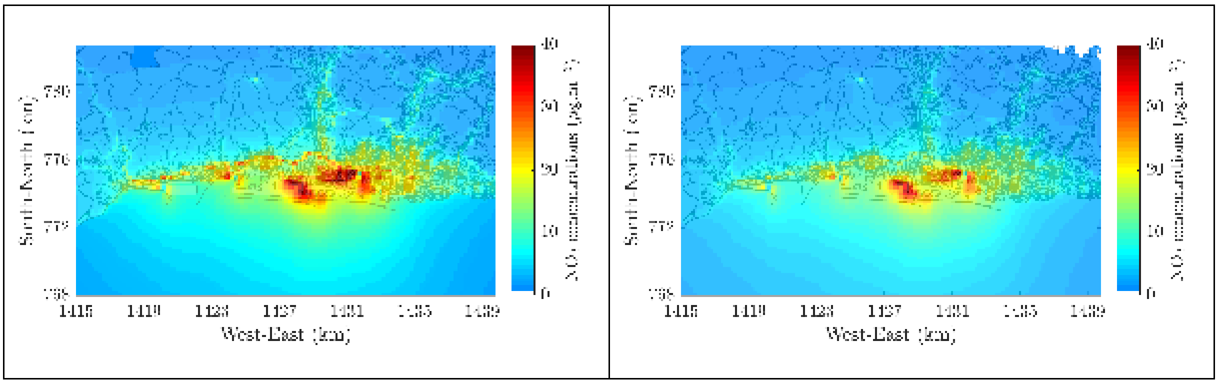


Figure C-10 presents the UPS PM_{10} annual average concentrations (a) in 2025 and (b) in 2050. For PM_{10}, in 2025 the maximum value corresponds to 40.7 µg.m^{-3} and 37.5 µg.m^{-3} in 2050. This means that there are still a few exceedances to the EU limit value in 2025 (one grid cell). Based on the WHO guidelines in 2050, 531 grid cells will still show exceedances to the guideline value, corresponding to 52.5% of the population within the simulation area potentially exposed to PM_{10} concentrations. Compared to the reference year, the UPS scenario will reduce the maximum concentrations by 18.9% and 25.1% in 2025 and 2050.

Figure C-10 PM_{10} annual average concentrations for the UPS scenario: a) in 2025 and b) in 2050.

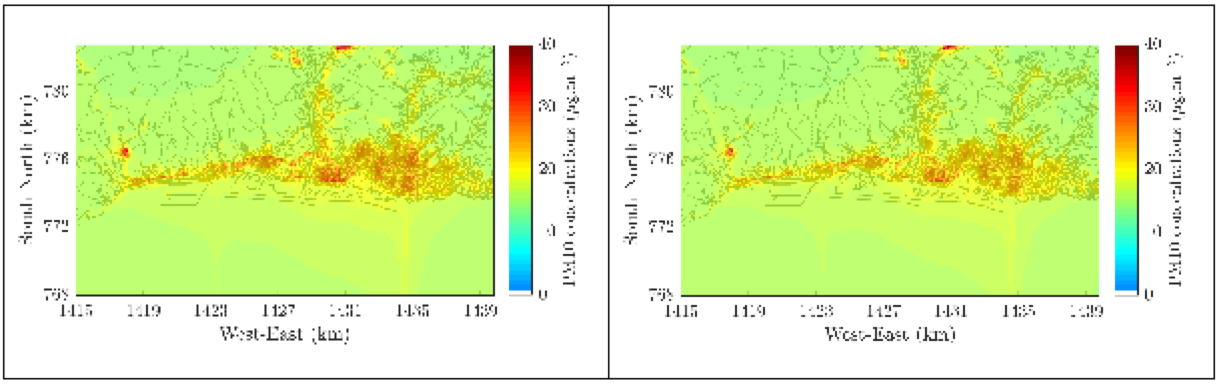
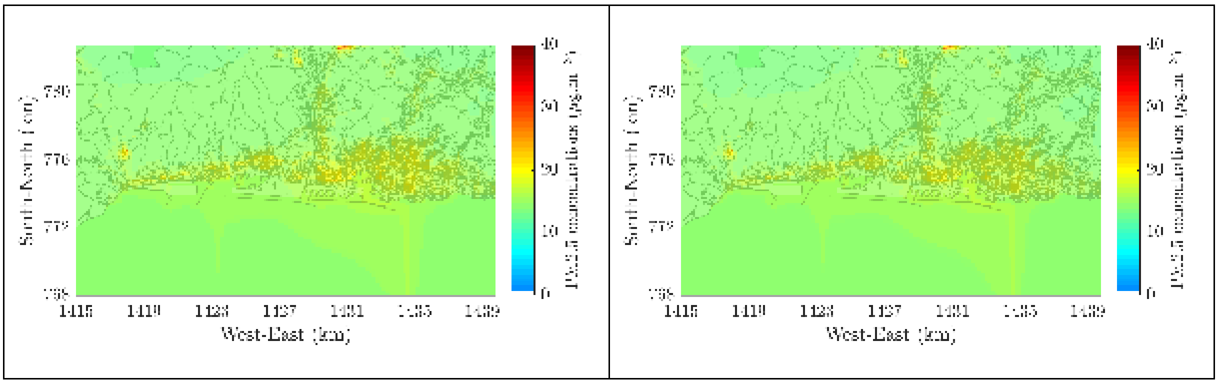


Figure C-11 presents the $PM_{2.5}$ annual average concentrations in the UPS scenario (a) in 2025 and (b) in 2050. For $PM_{2.5}$, in 2025 the maximum value corresponds to 27.4 µg.m^{-3} and 25.7 µg.m^{-3} in 2050, translating into further reductions of 15.6% and 20.8% of the maximum

[56] By 2025 there is therefore a slight increase of concentrations in the UPS (62.4 µg.m-3), when compared to BAU (62.2 µg.m-3), which is a direct consequence of the emissions projections for road traffic emissions.

concentration compared to the reference year. Based on the WHO guidelines in 2050, 9375 cells show exceedances. The UPS will not reduce the concentrations as compared to BAU.

Figure C-11 $PM_{2.5}$ annual average concentrations for the UPS scenario: a) in 2025 and b) in 2050.



UPS impacts on health

The results the UPS scenario for 2025, 2035 and 2050 are presented in Table C-4 for premature deaths, and Table C-5 for years of life lost.

Table C-4 Number of premature deaths related to $PM_{2.5}$, PM_{10} and NO_2 exposure for the UPS emission scenario in 2025, 2035, and 2050.

	$PM_{2.5}$			PM_{10}			NO_2		
Scenario	**2025**	**2035**	**2050**	**2025**	**2035**	**2050**	**2025**	**2035**	**2050**
UPS	564	553	552	465	452	450	178	117	88

Table C-5 Number of years of life lost related to $PM_{2.5}$, PM_{10} and NO_2 exposure for the UPS emission scenario in 2025, 2035, and 2050.

	$PM_{2.5}$			PM_{10}			NO_2		
Scenario	**2025**	**2035**	**2050**	**2025**	**2035**	**2050**	**2025**	**2035**	**2050**
UPS	4787	4699	4689	3949	3835	3818	1515	992	748

UPS impacts on costs

The assessment of costs carried out is indicative. For a more accurate calculation of benefits, the indirect benefits of health improvement of citizens (saved public health costs) would have to be taken into account. This was beyond the scope of the ClairCity modelling. Exact costs will also depend on the design of measures, which has not been defined to such detailed as to be able to model that.

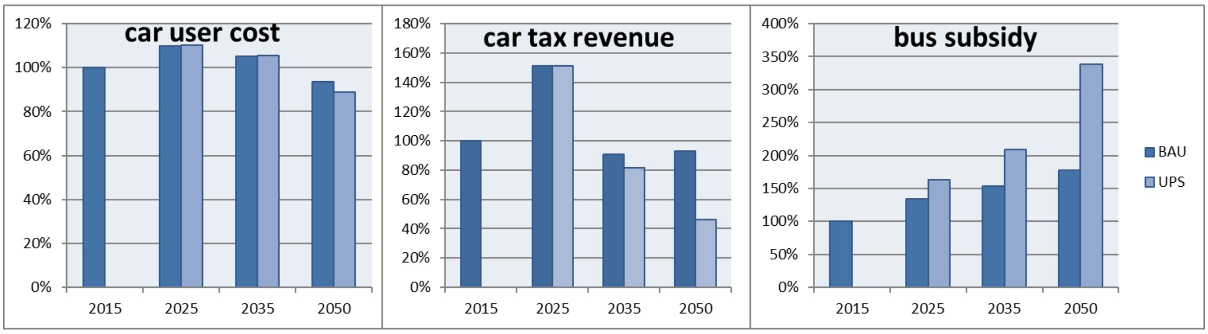
For the assessment of costs, we used 3 indicators:

1. The car user cost: to what extend does the cost to drive a car changes relatively over time in the BAU as well as under influence of the scenario's;
2. The government tax revenue from car transport, combing fuel excises, registration taxes as well as any levy's (e.g. cordon charge)
3. The government expenditure on public transport, i.e. bus subsidies.

The indicators on tax revenue or subsidy expenditure do not distinguish between different types of government (local, regional, national).

With these indicators, we assessed qualitatively the likely costs of measures for citizens, government and society at large. Costs for society were assumed to be the net sum of citizen and government costs. The cost estimations must be order-of-magnitude estimations only, as the real costs until 2050 will depend on many variables that were not included in the ClairCity modelling. Figure C-12 gives an overview of these order of magnitude costs of the UPS scenario compared to the BAU scenario.

Figure C-12 trends of user cost (left), government tax revenue (mid) and bus subsidy (right) in all scenario's



Car user cost
In the BAU, the car private user cost is expected to increase slightly and then decrease. The gradual uptake of EV's is likely to be the main driver. These cars have a higher upfront cost, but lower running cost to ultimately have a similar total cost over the lifetime, depending on the time-window. Currently, EV's are still more expensive over the lifetime, compared to conventional cars, but this is expected to reverse in about 2025.

The private car user cost in the UPS somewhat increases to the BAU scenario in 2035, to drop further in 2050. This is in full linked to the stronger EV-uptake scenario in the UPS compared to the BAU. An earlier higher EV-share will reflect a (fleet-average) higher cost in UPS vs. BAU. In any case, car user costs differ only slightly between the UPS and the BAU.

Car tax revenues
In the BAU, after an initial increase, tax revenue decreases. It is not fully clear what is driving the surge in tax revenue in 2025. One possibility is a large fleet renewal "backlog" of the aging fleet in Italy, leading to a surge in sales tax. The effect is visible both in equal levels in BAU and UPS.

Tax revenue further decreases in 2035 and 2050. This trend is stronger in the UPS than in the BAU scenario. There are two effects that play a role there. First, the gradual replacement of conventional cars by electric cars. Under current assumptions, the taxation of EV's is limited and as EV's enter the fleet, government revenue from taxing cars on average will shrink. This is not sustainable and it is expected to change as the decreasing tax revenue of excise duties on diesel and petrol will become apparent to public authorities. However, in our simulation, we have kept the taxation levels constant. Also, the UPS scenario includes a strong modal shift to public transport and walking/cycling, thus reducing car transport demand and consequently also tax revenue from car transport.

Bus subsidies

There is an increasing demand for bus subsidies in both the BAU and the UPS. The demand in the UPS is higher due to the (arbitrary) model shift measures in the UPS. Assuming no other changes to the level of cost coverage, this leads to a triplication of the bus subsidies in the UPS by 2050.