Industry Residential/Commercial & Other services business as usual and scenario projections

(WP5 Task 5.2.4)

Work realized under the project CLAiR-CITY - Citizen Led Air Pollution Reduction in Cities

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1 FINALITY OF THE REPORT

This document reports about the WP5 Task 5.2.4 Design & development of Industry Residential/Commercial & Other services module activities related to BAU and scenarios definition.

The module integrates in the overall model the industrial, residential, commercial and institutional emissions sources.

Another report[1] describes methodology and results for:

- Develop a specific tool to evaluate emissions using existing industrial emissions data (EMEP, E-PRTR, others) and EMEP/EEA Emission inventory Guidebook;
- Develop a specific tool to estimate emissions from small combustion in residential, commercial and institutional sector;
- Evaluate emissions for year 2015, based on available data.

In this report methodology and results are reported for:

- ***Business as Usual (BAU)***: future situation without any policy interventions beyond what is decided upon at this point with three-time horizons: 2025, 2035 and 2050;
- ***Scenario***: added policy interventions to the BAU, same time horizon as results from Stakeholder Dialogue Workshop;
- ***Unified Policy Scenario***: final scenario as a result of Policy Workshop.

The current edition contains all the results for BAU and scenarios in all the city/regions included in the project and Unified Policy Scenario for Amsterdam and Bristol, future editions/ revision will include the Unified Policy Scenario results for all the others city/regions.

2 FUTURE EMISSIONS PROJECTIONS

2.1 Future emissions modelling tool set

Emissions projection is evaluated for the different kind of sources: area and point.

Area emissions for future year (k) in a single territorial unit (e. g. LSOA, Buurt, …) (u) related to a specific activity (i) are estimated starting from the base year (0) emissions and using specific projections factors (drivers) of activity level (a_{ikn}) due to activity measures n, specific drivers for emission factors (f_{ijkm}) due to emissions control measures m for a selected pollutant (j), specific projections factors (drivers) of activity level related to a selected territorial units (a^{d}_{ikun}) due to activity measures n and specific drivers for emission factors

[1] Techne Consulting, Design & development of Industry Residential/Commercial & Other services module (WP5 Task 5.2.4), ECH.MA.15 RF1 Ed. 5 – March 2019

(f^{d}_{ijkum}) due to emissions control measures m and, if any, additional emissions foreseen for a selected new activity in a selected territorial units u (E^{new}_{ijku}):

$$E^{d}_{ijuk} = E^{d}_{iju0}\ \Pi_m\Pi_n\ a_{ikn} f_{ijkm}\ a^{d}_{iukn} f^{d}_{ijukm} + E^{new}_{ijku}$$

Point source emissions for future year (k) for a selected production unit of a selected plant (u), related to activity (i) are estimated starting from the base year (0) emissions and using specific drivers of activity level (a_{ik}) due to activity measures n, specific drivers for emission factors (f_{ijkm}) due to emissions control measures m for a selected pollutant (j), specific drivers (a^{p}_{jkun}) for activities i, related to selected production unit of a selected plant u, due to activity measures n, specific drivers for emission factors related to a selected pollutant (j) related to a selected line (f^{l}_{ijkum}) due to emissions control measures m, and, if any, additional emissions foreseen for a new plant u (E^{l}_{ijkn}):

$$E^{l}_{ijuk} = E^{l}_{iju0}\ \Pi_m\Pi_n\ a_{ikn} f_{ijkm}\ a^{l}_{iukn} f^{l}_{ijukm} + E^{new}_{ijku}$$

Drivers for activity levels and for emission factors can be related to multiple activities, plants and lines; for example, the “population” driver can be used to forecast emissions coming from glue or paint applications in household as well as drivers related to fuel consumptions in residential sector, and sulphur content of distillate oil can be used for the projections of emission factors for sulphur dioxides in the industry and service sectors. Besides, an abatement system for particulate matter can be applied to a single activity (e.g. power plants with output higher than 300 MWth) and to one or more production units related to another activity (e.g. aluminum production).

New additional emissions for point, line and area sources are used to simulate planned plants, planned units of a plant, and planned roads and so on.
It is possible to manage the following groups of drivers:

- Drivers for activity levels related to single activities, territorial units, lines, production units of industrial plants.
- Drivers for emission factors related to single activities, territorial units, lines, production units of industrial plants.
- Additional emissions related to single territorial units, lines, production units of industrial plants.

2.2 The regulatory framework at European Union and national level

In order to define the scenarios for reducing emissions at the local level, it is first necessary to consider the national measures that the member state has already introduced and defined and that are also relevant at city level.

These measures are essentially due to the adoption at European Commission level of the so-called NEC Directive (NECD)[2]. The NECD establishes the emission reduction commitments for the Member States' anthropogenic atmospheric emissions of sulphur dioxide (SO_2),

[2] Directive (EU) 2016/2284 of the European Parliament and of the Council of 14 December 2016 on the reduction of national emissions of certain atmospheric pollutants, amending Directive 2003/35/EC and repealing Directive 2001/81/EC, Official Journal of the European Union L 344/1, 17.12.2016

nitrogen oxides (NO_x), non-methane volatile organic compounds (NMVOC), ammonia (NH_3) and fine particulate matter ($PM_{2,5}$) and requires that national air pollution control programmes be drawn up, adopted and implemented and that emissions of those pollutants, as well as their impacts, be monitored and reported.

Projection of emissions under NECD are reported and updated by member states and collected by EEA[3].

Following the NECD' Annex IV, Member States shall prepare national emission projections, such as national emission inventories, using the methodologies adopted by Parties to the LRTAP Convention (EMEP Reporting Guidelines), and are requested to use the EMEP/EEA air pollutant emission inventory Guidebook (EMEP/EEA Guidebook). In addition, supplementary information, in particular the activity data, needed for the assessment of the national emission inventories and projections shall be prepared in accordance with the same guidelines.

Projections of emissions shall be estimated and aggregated to relevant source sectors. Member States shall provide a 'with measures' (adopted measures) projection and, where relevant, a 'with additional measures' (planned measures) projection for each pollutant in accordance with the guidance established in the EMEP/EEA Guidebook.

Over 2030, where projections of NO_x and $PM_{2.5}$ do not exist, gross estimates are made taking as a reference the CO_2 reductions envisaged by the EU 2050 low-carbon economy strategy (LCES)[4].

EU low-carbon economy roadmap[5] suggests that:

- By 2050, the EU should cut greenhouse gas emissions to 80% below 1990 levels;
- Milestones to achieve this are 40% emissions cuts by 2030 and 60% by 2040.

In Table 1, Greenhouses Gases reductions by sector compared to 1990 are reported[6].

Table 1 – Greenhouses Gases reductions by sector compared to 1990

	2005	2030	2050
Power (CO_2)	-7%	-54 to -68%	-93 to -99%
Industry (CO_2)	-20%	-34 to -40%	-83 to -87%
Transport (incl. CO2 aviation, excl. maritime)	+30%	+20 to -9%	-54 to -67%
Residential and services (CO_2)	-12%	-37 to -53%	-88 to-91%
Agriculture (non-CO_2)	-20%	-36 to -37%	-42 to -49%
Other non-CO_2 emissions	-30%	-72 to -73%	-70 to -78%
Total	**-7%**	**-40 to -44%**	**-79 to -82%**

[3] EEA Eionet, Reporting Obligations Database (ROD), Deliveries for National Emission Ceiling Directive (NECD) - Projected emissions by aggregated NFR sectors
[4] EU 2050 low-carbon economy
[5] Total greenhouse gas emission trends and projections, 24 Nov 2017
[6] European Commission, A Roadmap for moving to a competitive low carbon economy in 2050, COM(2011) 112 final

We assume that in the period from 2030 to 2050 NO_x and $PM_{2,5}$ industry and residential emissions follow the same trend as CO_2 assuming reductions produced essentially from fossil fuels energy saving.

Emissions projections at city level for ClairCity must take into consideration national emissions measures and supplementary city level emissions measures.

We adopted the NECD definition and introduce:

- ***Baseline***: the current situation (i.e. 2015 data), based on emission inventories and available data[7];
- ***BAU*** "business as usual": future situation without any policy interventions beyond what is decided upon at this point with three-time horizons: 2025, 2035 and 2050; this future projection include:
    - the national measures defined in the 'with measures' (adopted measures) projection in the frame of NECD or in energy/GHG strategies;
    - all the other measures *already adopted* at city level by local planning actions;
- ***Scenario***: added policy interventions to the BAU, same time horizon; this future projection includes:
    - the national measures defined in the 'with additional measures' (planned measures) projection in the frame of NECD where available;
    - all the other planned measures defined at city level by local planning actions.

2.3 Projections model territorial domains

The air pollutant Emissions projections, as the 2015 emissions, are evaluated in the city domains defined as follow for the territorial units' classes reported in Table 2.

Table 2 – Territorial domains

City/region partner	Lower level subdivision
Bristol	LSOA
Amsterdam	Buurt
Ljubljana	Naselje
Sosnowiec	Obreby
Genoa	Census Sections
Aveiro	Freguesia

The Bristol modelling domain (red box) is reported in Figure 1, with boundary of LSOA belonging to the domain (yellow areas), Amsterdam modelling domain (red box) is reported in Figure 2, with boundary of Buurt belonging to the domain (yellow areas), Ljubljana modelling domain (red box) is reported in Figure 3 with boundary of Občine belonging to the domain (yellow areas), Sosnowiece modelling domain (red box) is reported in Figure 4 with boundary of Gminas belonging to the domain (yellow areas) while Liguria Region (Genoa area) modelling domain (red box) is reported in Figure 5 with boundary of Census Sections

[7] At national level the emissions reported to the National emissions reported to the Convention on Long-range Transboundary Air Pollution (LRTAP Convention)

subdivision belonging to the domain (yellow areas), Liguria Region (Genoa area) modelling domain (red box) is reported in Figure 5 with boundary of Census Sections subdivision belonging to the domain (yellow areas) while modelling domain (red box) is reported in Figure 6 with boundary of Freguesia subdivision belonging to the domain (yellow areas).

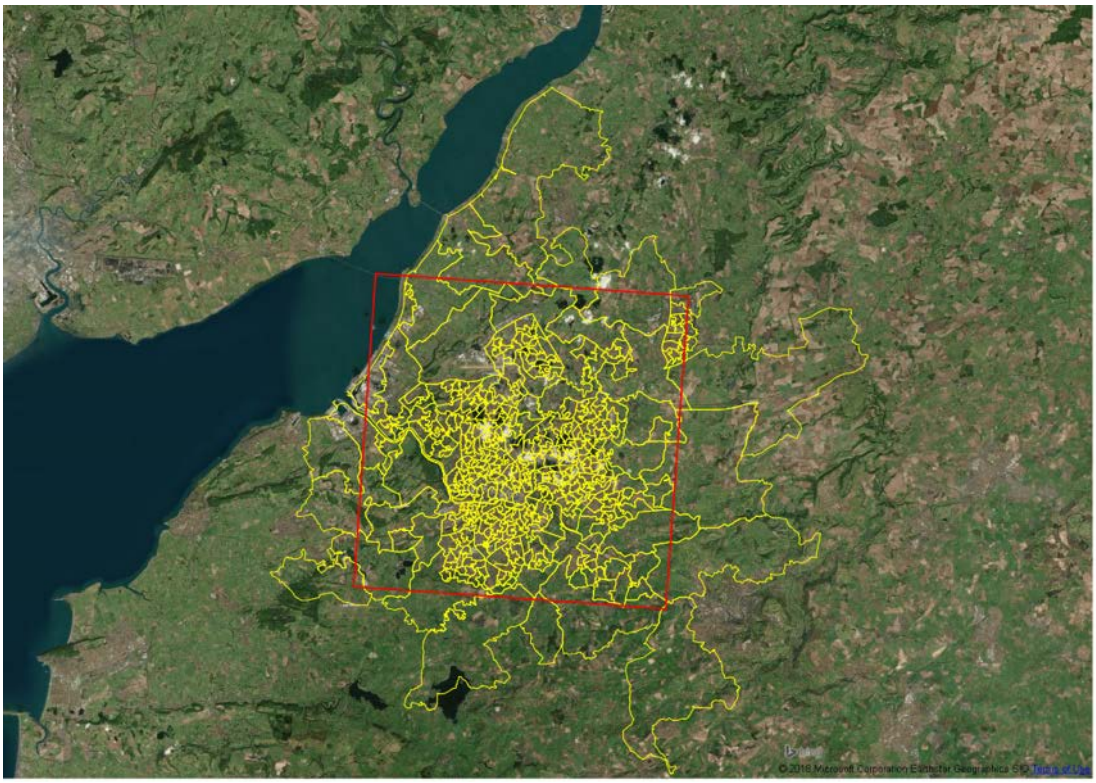

Figure 1 – Bristol domain with LSOA subdivision

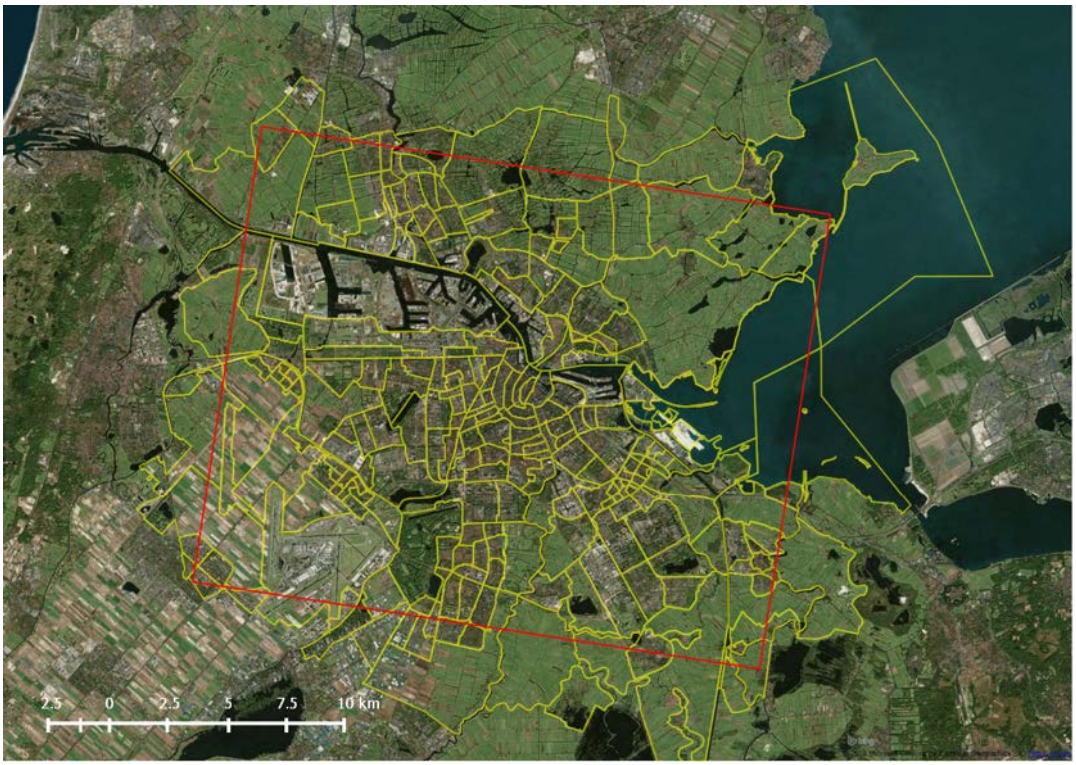

Figure 2 – Amsterdam domain with Buurt subdivision

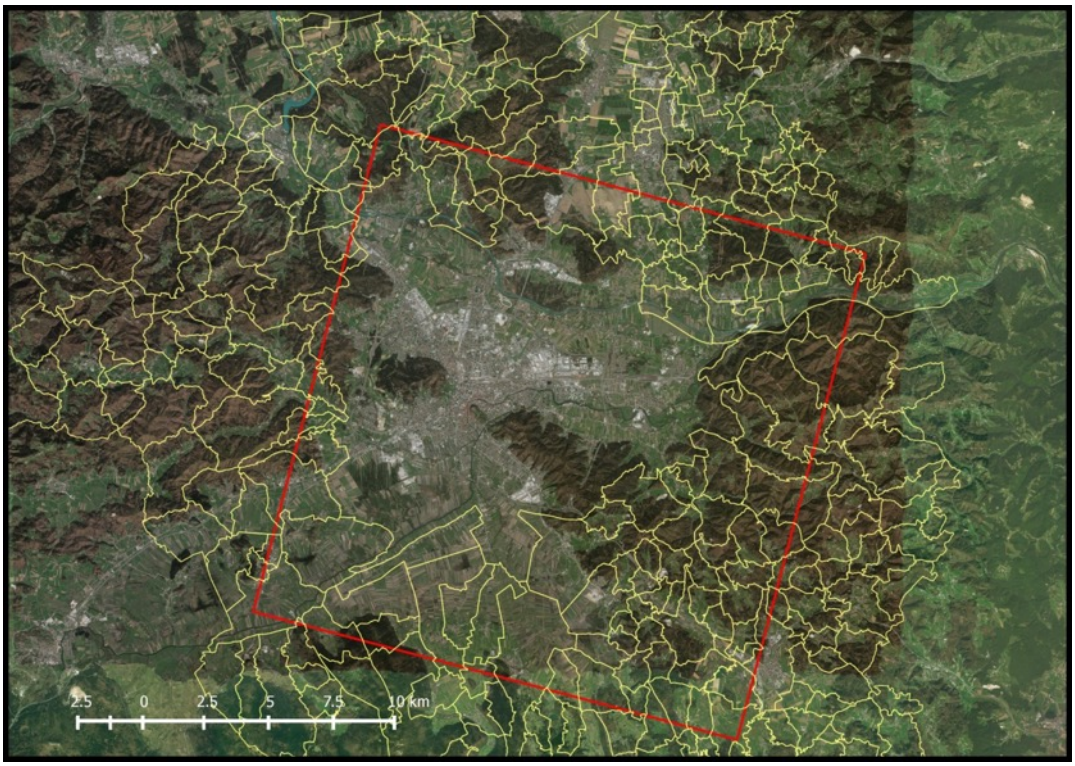

Figure 3 – Ljubljana domain with Naselje subdivision

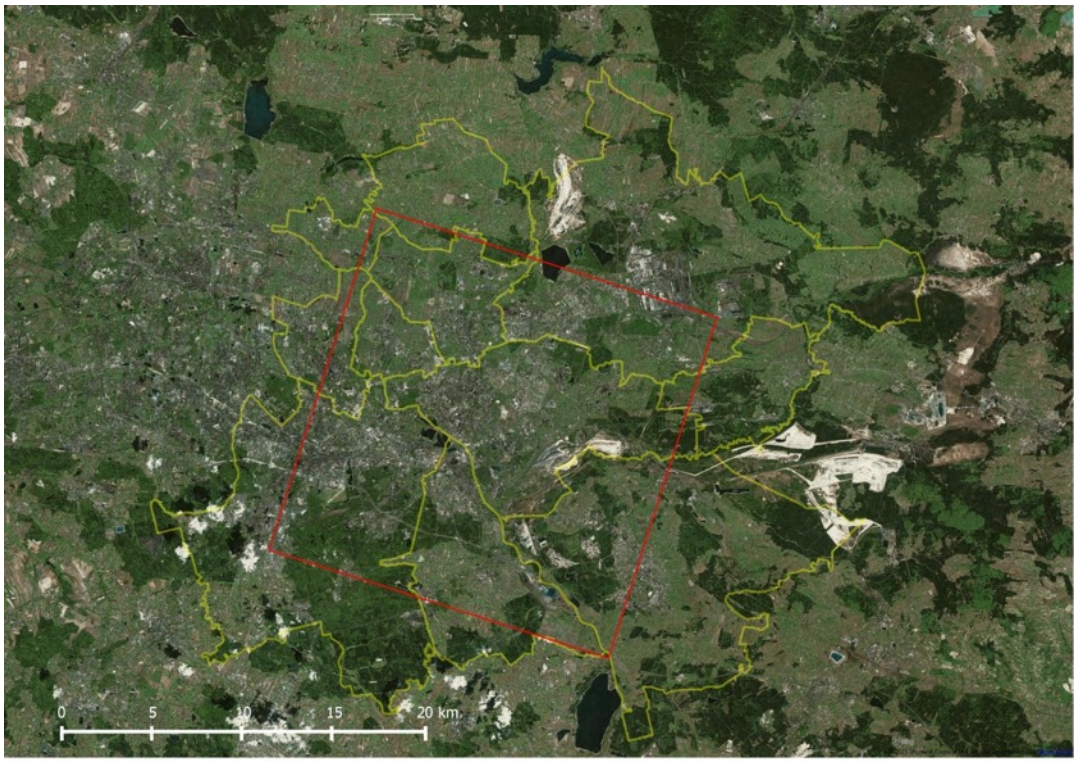

Figure 4 – Sosnowiec domain with Gminas subdivision

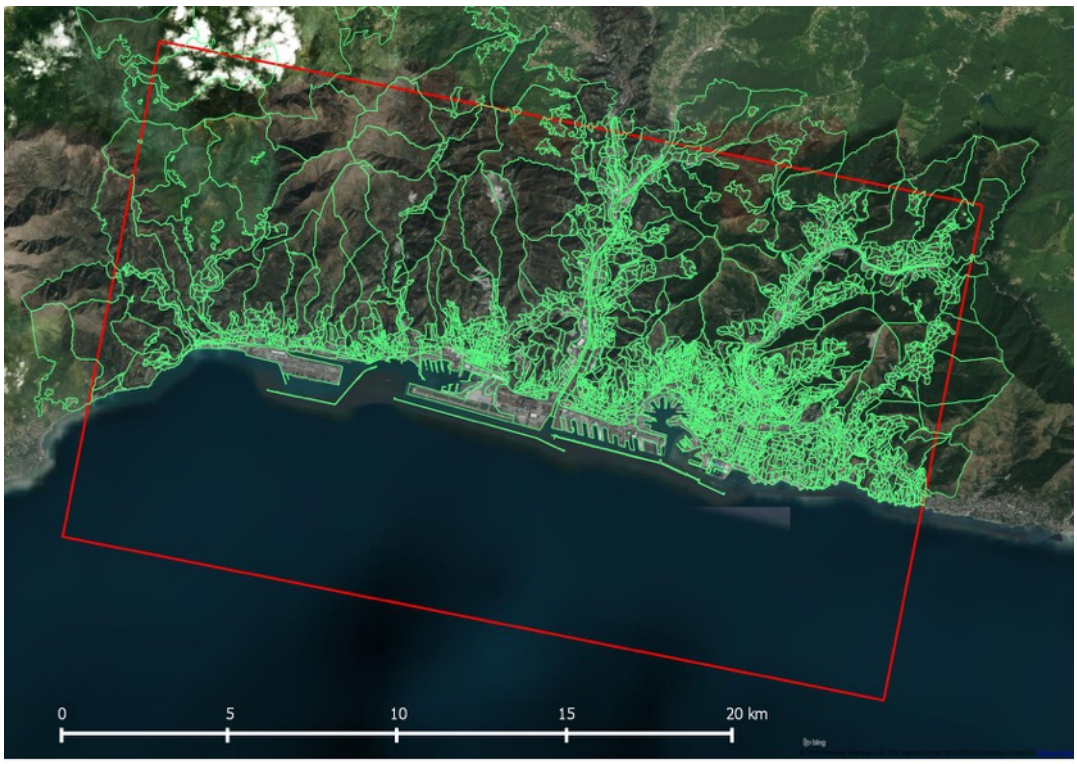

Figure 5 – Liguria Region (Genoa area) domain with Census $_{\text{Section+s}}$ subdivision

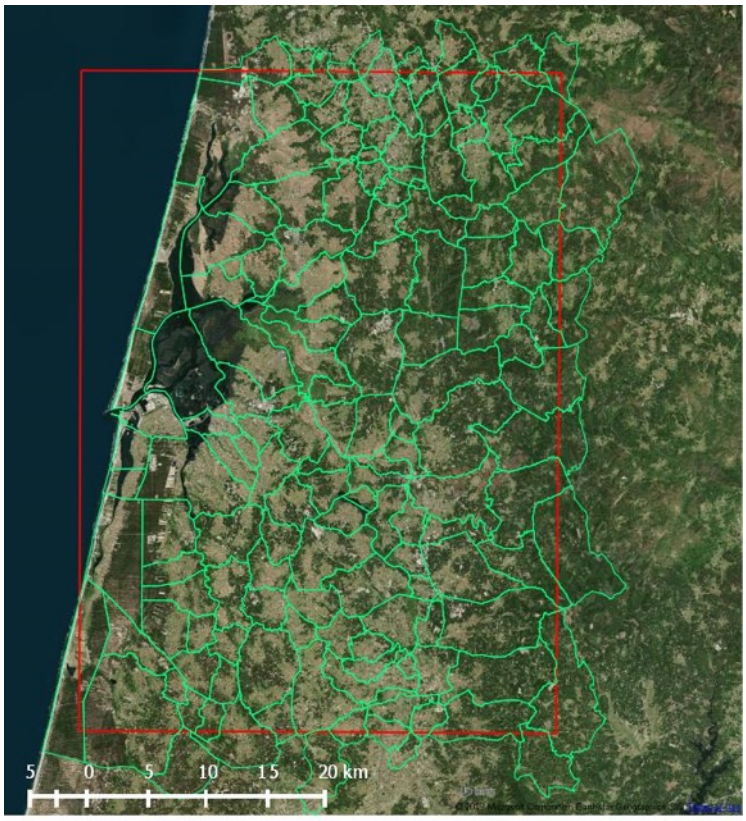

Figure 6 – (red box) with Freguesia subdivision

3 BRISTOL

3.1 Business As Usual projections

Business as Usual (BAU) scenario takes into consideration national and city level measures already defined/decided.

3.1.1 Modelling

3.1.1.1 National BAU Projections

National BAU scenario evaluates national emission reduction starting from UK official projections.

The scenario was built in two steps using:

- the projections of greenhouse gas emissions and energy demand from 2016 to 2035 from UK Department for Business, Energy & Industrial Strategy (BEIS)[8];

[8] UK Department for Business, Energy & Industrial Strategy Updated Energy and Emissions Projections 2017, January 2018

- the national measures defined in the 'with measures' (adopted measures) projection in the frame of NECD[9]

In the first step the fuel consumption was varied following the energy demand projection with socioeconomic drivers, in the second step the emissions were varied to meet the NECD emissions considering technological drivers.

The projections of greenhouse gas emissions and of energy demand are based on central estimates of economic growth and fossil fuel prices in the original *Reference scenario*. It contains all agreed policies where decisions on policy design are sufficiently advanced to allow robust estimates of impact (i.e. including "planned" policies).

3.1.1.2 Bristol BAU projections

The Bristol BAU projections consider:

- *Demographic evolution [DVEL].*
  The city will grow10 with time (5% by 2020, and 20% by 2036 on 2015 levels). 33,500 new dwellings are foresee by 2036, land at bath road Brislington, green belt Thornbury/ Buckover and Nailsea/Backwell. Regarding new houses, there is a programme to increase housing supply in Bristol11. There were 30,600 homes envisaged to be delivered in the city between 2006 and 2026, with a minimum target of 26,400 set out in the adopted Local Plan. Between 2006 and 2015, 16,300 homes have been built in the city.

- *Bristol Council Framework for Climate and Energy Security*[12].
  The Bristol Council Framework for Climate and Energy Security translates existing 2050 CO_2 reduction target of 80% into key milestones of 50% reduction by 2025 and 60% by 2035. In BAU, only already delivered initiatives are considered, and particularly:
  - *Warmer Homes*
    Will bring improvements to certain types of council homes, including numbers of low-rise flats, houses and bungalows, and blocks of high-rise flats. Over a nine to 10-year period it's planned to:
    - repair and improve 30 blocks of flats;
    - repair and improve 3,200 homes which were built using the *No-fines* and *Easiform* construction methods;

    Cabinet approval has been given for up to £45m of external wall insulation for low rise homes and up to £60.5m for tower block external wall insulation projects, both subject to the capacity of the Housing Delivery Business Plan.
  - *Warm Up Bristol*
    Delivers energy efficiency improvements to privately owned homes, through assessing home energy performance, identification of improvements, provision

[9] EEA Eionet, Reporting Obligations Database (ROD), Deliveries for National Emission Ceiling Directive (NECD) - Projected emissions by aggregated NFR sectors
[10] Bristol City Council, The Population of Bristol, July 2018
[11] Bristol's Housing Strategy, 2016 – 2020
[12] Bristol Council Our Resilient Future: A Framework for Climate and Energy Security

of options and advice for grant funding and manages the installations. £40m of capital investment and circa £11m of ECO funding to support this investment.

- *Heat Networks: City Centre, Redcliffe & Temple Quarter Enterprise Zone*
  The first sections of the Redcliffe & Temple Heat Network were installed in Summer 2015 (as part of a General-Purpose Service Trench that also included Superfast broad band ducting); this first section included Heat mains on the new Arena Island bridge to enable the Arena development to be connected; construction has also been started on the first Energy Centre to supply the network incorporating a 1MW biomass boiler to supply zero Carbon heat; in addition to Redcliffe & Temple, BCC is also planning a City Centre network (in association with the University of Bristol and University Hospitals Bristol Foundation Trust); the programme for the City Centre, and the Redcliffe and Temple areas forms the first phase of wider plans for a City-wide Heat network that will take a number of years to develop and incorporates the delivery of a number of Gas CHP and biomass energy centers to supply council, public and private buildings; £13million is allocated to developing and installing Heat Networks, but it is subject to change depending upon opportunities; the following targets are reported:
  - Completion of Redcliffe & Temple Heat network Phase 1 – February 2016;
  - Redcliffe Phase 2 (expanded R&T Heat network – 2020);
  - City Centre Phase 1 Heat network completed – 2019;
- *Energy Efficiency Improvements to BCC Corporate Buildings*
  a programme of corporate energy efficiency projects that includes:
  - Finalizing a major retrofit of City Hall which is currently underway;
  - Retrofitting the M-Shed, Central Library, City Museum and Colston Hall;
  - Retrofitting two exemplar schools to attract other schools to do similar work;
  - Upgrading the core BMS system to improve energy management across 8 core BCC buildings;
  - Developing an overarching strategy for retrofitting the Council's remaining buildings;
  - Creating an energy efficiency procurement framework to allow for large-scale cost-effective delivery;
  - Working with Bristol Workplace, Property, Housing, and Education work streams to increase energy efficiency by adding capital funding to exiting programmes.

  Budget:
  - The Capital Programme includes provision for the Bristol Workplace of £40.5M;
  - In principal agreement has been made to increase SALIX funding from £ 1.2m to £1.7m;
  - Total pipeline is ca. £1m for 2015/16 financial year; BCC aimed to deliver a similar amount in 2016/17; long term they will try to get other Local authorities and public sector on board under our framework.

- *Solar Photovoltaic Programme*
  A programme to secure funding and deliver solar photovoltaic (PV) on council land, buildings, including homes, schools and council's corporate properties, and further investment in public buildings including University of Bristol.

A gross evaluation of the CO_2 reduction is about 20,000 Mg/CO_2 year corresponding to about 5% of City of Bristol residential fuel consumptions. With the information available it is not possible to allocate these reductions at the LSOA or MSOA level for which they have been allocated uniformly throughout the territory of City of Bristol Local Authority District.

3.1.1.3 Projection drivers

Socio-economic drivers' definition is reported in Table 3 while technologic drivers' definition is reported in Table 4.

For drivers coming from EU NEC "with measures" data, as it's impossible to derive from available information the split between socio-economic measures, such as for example fuel consumptions reductions, and technological measures, such as for example advanced combustion technologies, all the measures are inserted as technological ones. The NEC measures are evaluated net of BEIS ones.

While the BEIS and NEC drivers are applied to all the area of the simulation City population variation (CITYPOP) and District heating (DH) drivers are applied only to City of Bristol Local Authority District.

Table 3 – Bristol: Socio-economic drivers used to project emissions in industrial, residential and commercial sector

Code	Name	Domain
020131A0	BEIS 2017: Commercial boilers - Hard Coal	All MSOAs
020131F0	BEIS 2017: Commercial boilers – LPG	All MSOAs
020131I0	BEIS 2017: Commercial boilers – Gasoil	All MSOAs
020131M1	BEIS 2017: Commercial boilers - Natural gas	All MSOAs
020220A0	BEIS 2017: Residential boilers - Hard Coal	All MSOAs
020220F0	BEIS 2017: Residential boilers – LPG	All MSOAs
020220I0	BEIS 2017: Residential boilers – Gasoil	All MSOAs
020220M1	BEIS 2017: Residential boilers - Natural gas	All MSOAs
CITYPOP	City population variation	Only Bristol MSOA
DH	Bristol Council Framework for Climate and Energy Security	Only Bristol MSOA

Table 4 – Bristol: Technological drivers used to project emissions in industrial, residential and commercial sector

Code	Name	Domain
NEC_B_PM	NEC Building PM	All LSOAs
NEC_I_PM	NEC Industry PM	All LSOAs
NEC_I_NOx	NEC Industry NOx	All LSOAs
NEC_B_NOx	NEC Building NOx	All LSOAs

3.1.2 Results

3.1.2.1 Industrial emissions

The evolutions of industrial area emissions are reported in Figure 7 for nitrogen oxides (NO_x) and in Figure 8 for suspended particles with diameter less than 10μ (PM_{10})..

In Figure 9 the evolution of emissions for nitrogen oxides (NO_x) are reported for main point sources. For the Seabank Power Station in Severnside there is a proposal to extend the plant with two additional CCGTs in a project known as Seabank 3. The proposal includes the development of two additional combined cycle gas turbines (CCGT) with a combined capacity of up to 1,400 MW integrated with existing gas and electricity transmission infrastructure. During late 2014 the decision was taken to pause the development of the Seabank 3 project. This situation remains unchanged, stakeholders will be updated should the development of the project recommence[13].

More information is necessary to evaluate the state of evolution of new sections planned in Avonmouth Bio Power Energy Limited, while no notice we have of evolution of Wessex Water Services Ltd. Both are considered constant in BAU.

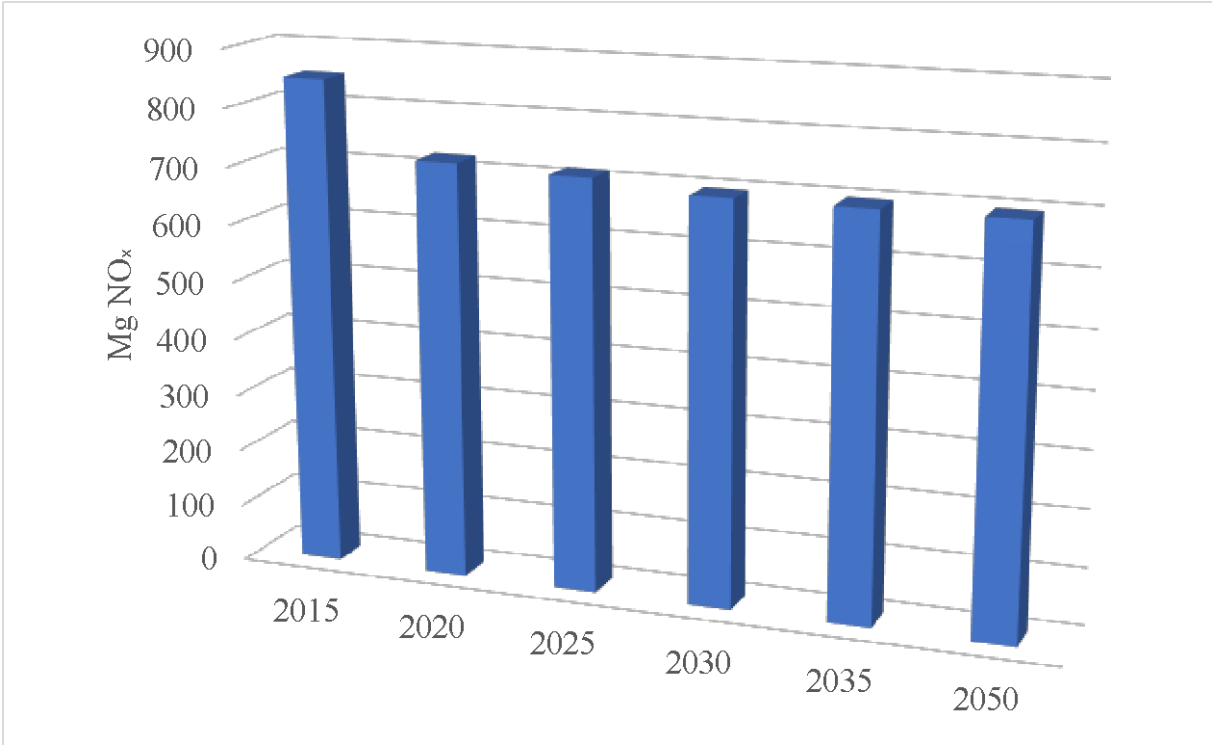

Figure 7 – Bristol BAU NO_x Industrial area emissions

[13] Sebank 3

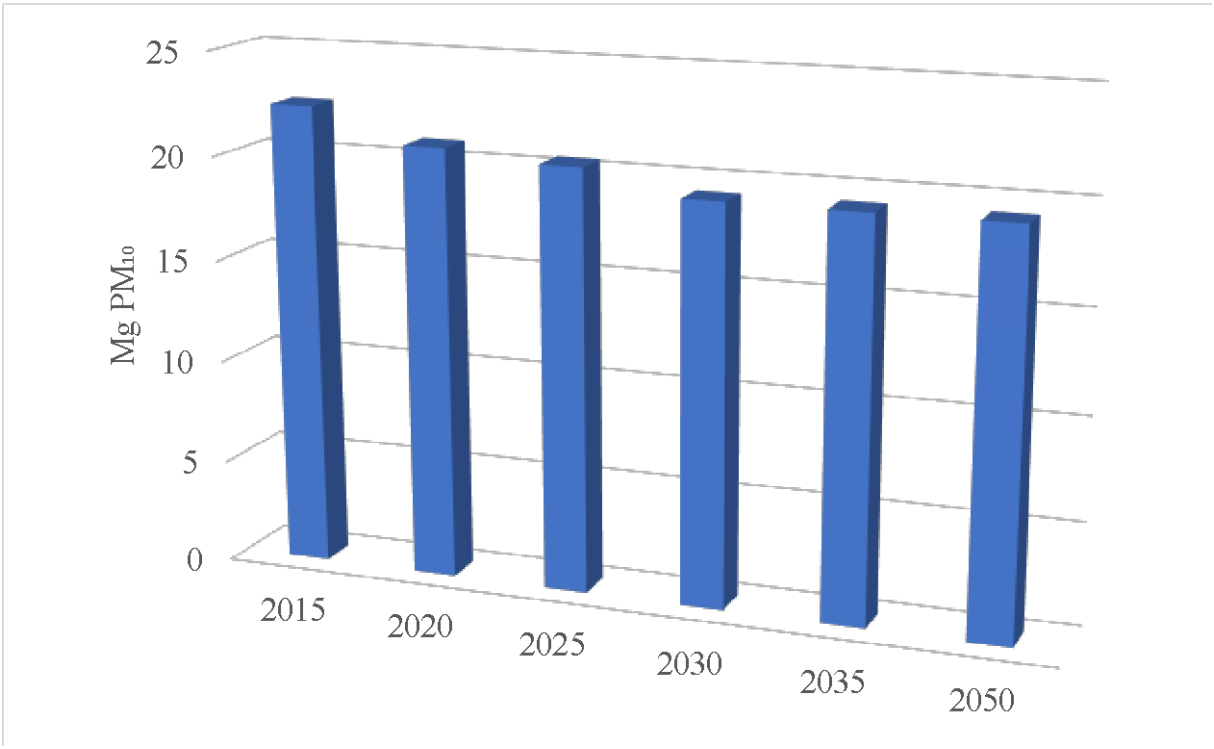

Figure 8 – Bristol BAU PM_{10} Industrial area emissions

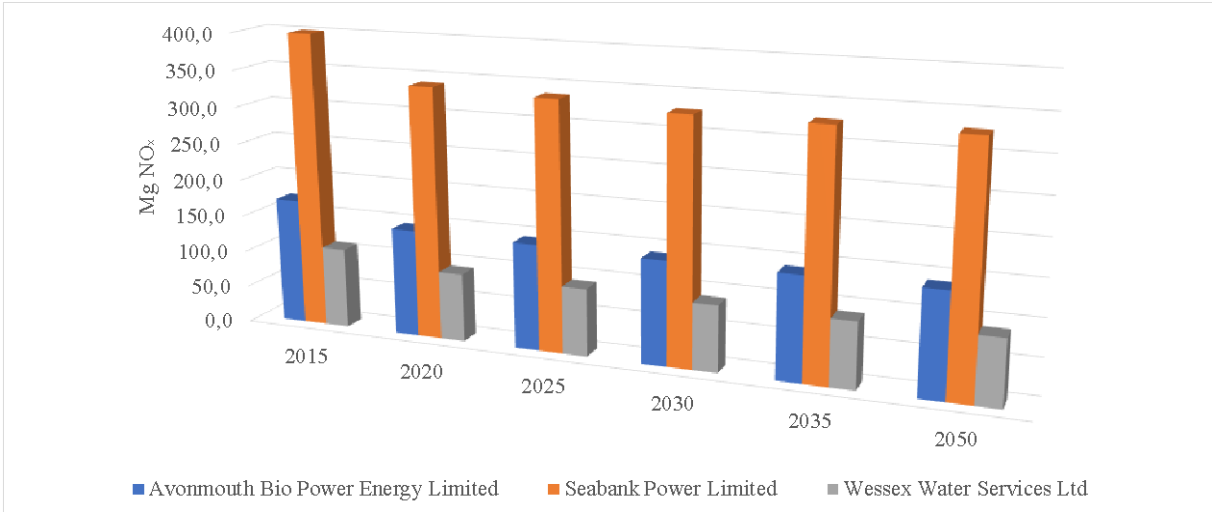

Figure 9 – Bristol BAU Industrial NO_x emissions: main point sources

3.1.2.2 Residential, commercial & institutional emissions

In Figure 10 for nitrogen oxides (NO_x) and in Figure 11 for suspended particles with diameter less than 10μ (PM_{10}) the evolutions of emissions are reported.

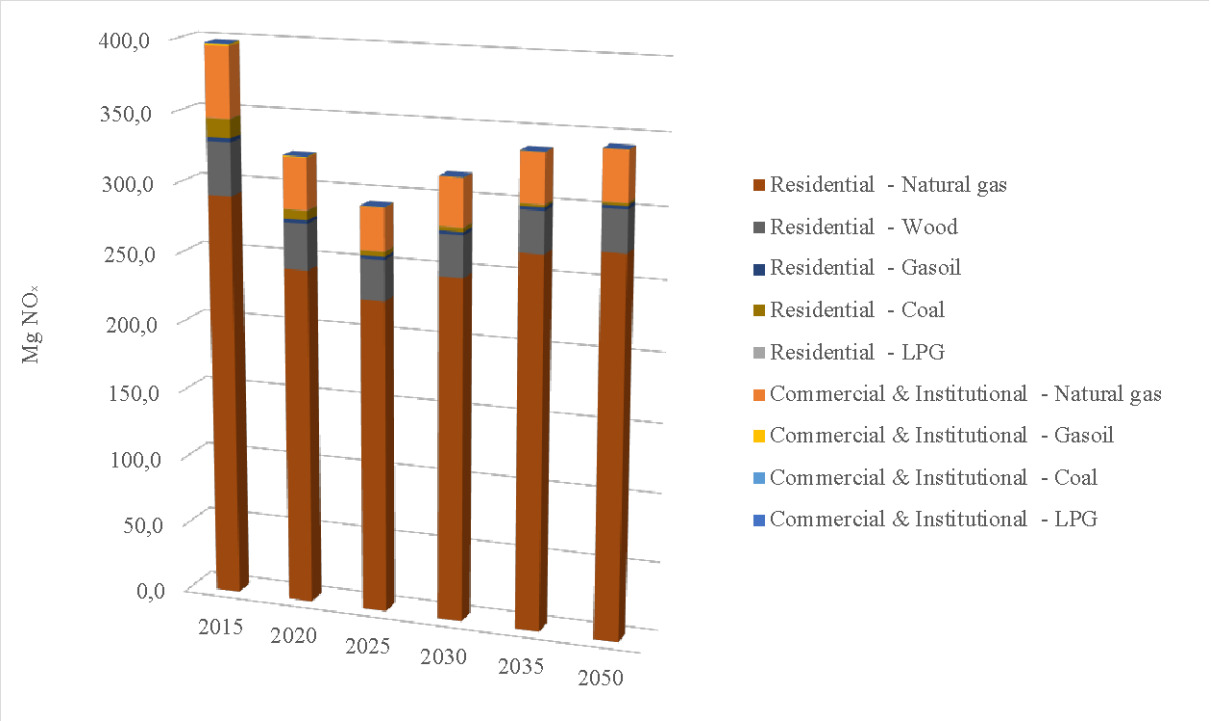

Figure 10 – Bristol BAU total Residential, Commercial & Institutional NO_x emissions

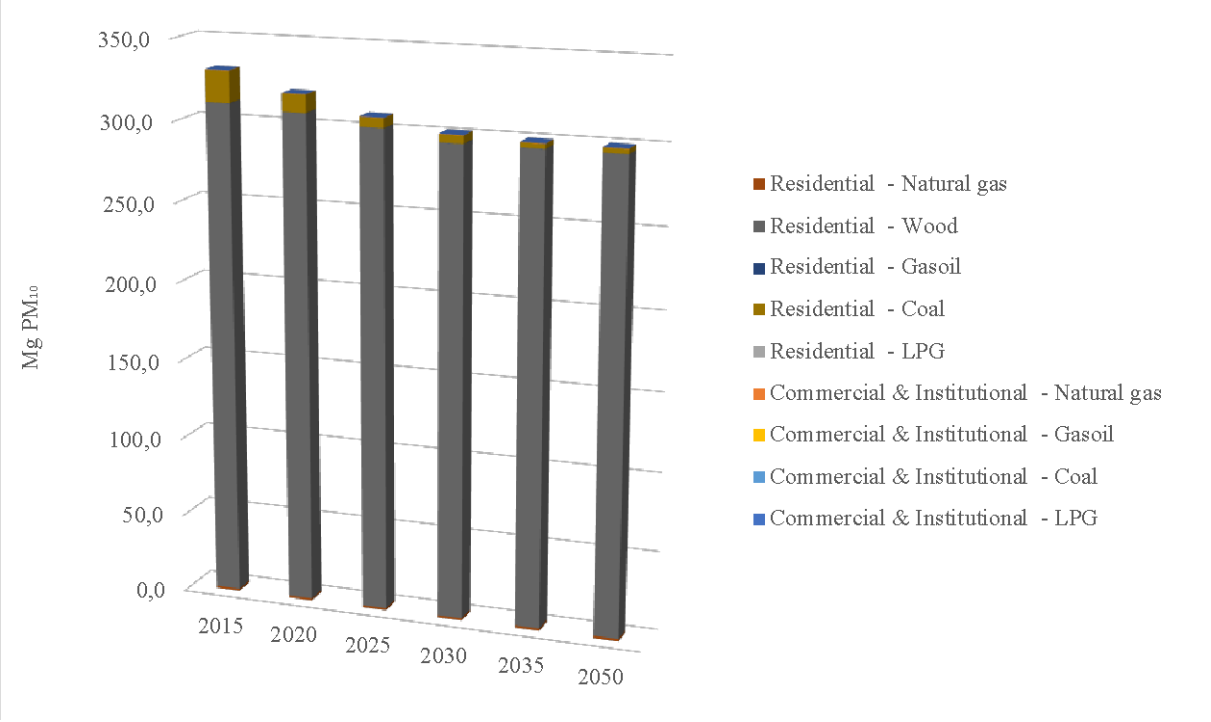

Figure 11 – Bristol BAU Residential, Commercial & Institutional PM_{10} emissions

3.2 Scenario projections

Scenario projections take into consideration city level additional measures.

3.2.1 Modelling

3.2.1.1 Scenarios from the Stakeholder dialog workshop

Bristol City Council (BCC) has reviewed its existing commitments, has reflected upon its progress against these commitments, and has decided to incorporate milestone targets for citywide emissions and energy demand reduction (Table 5); these target include the EU target of Table 1.

Table 5 – City Of Bristol Proposed Reduction Targets on 2005 baseline

	2020	2025	2035	2050
Citywide CO_2 emissions	40%	50%	60%	80%
Citywide Energy consumption	30%	35%	45%	55%
Citywide Renewable Energy	To be developed thorough consultation			

At the citywide level these targets are designed to broadly align with the West of England's Joint Local Transport Plan (2011-2026) and the West of England's Joint Spatial Plan (2036) cycles so that the contributions of these processes can be measured against the revised targets. BCC proposes to adopt the targets of from the 2005 baseline, in the context of those targets already adopted for 2020 and 2050. The overall planning was conjugated into local one where the Local Plan[14] includes policies for deciding planning applications in Bristol.

The strategy highlights how, within the city centre[15], there is significant potential for climate change mitigation and adaptation through sustainable energy measures and building design Policy. BCS14 measure of the Core Strategy sets out requirements relating to on-site renewable energy in new development and is applicable within the Central Area Plan area. The policy also places the whole of central Bristol within a Heat Priority Area. Some of the highest demands for heat in Bristol exist in the central area, and as such this area will be one of the key starting points from which the council will seek to grow a district heating network.

Scenarios from the Stakeholder dialog workshop (SWD) includes the measures of Table 6 relating to the IRCI sector (the codes are defined in this report).

Table 6 – Bristol: Measures coming from the Stakeholder dialog workshop

Code	Description
B_SWD_B_1	Increase generation of solar and wind power (Scenario 1 & Scenario 3)
B_SWB_B_2	Make property developers consider air pollution and climate change (Scenario 3)
B_SWB_B_3	Improve energy efficiency of housing (rented/existing/new) (Scenario 3)

Without any policy to limit or prohibit the most polluting fuels, no change in the share of use of the different fuels has been foreseen.

We will assume that:

[14] Bristol City Council, Bristol Development Framework Core Strategy – Adopted June 2011
[15] Bristol Local Plan – Bristol Central Area Plan – Adopted March 2015

- the Residential, Commercial & Institutional sector percentage reductions are the same as the total figures of Table 5;
- the measures SW_B_3 will drive the reduction of Citywide Energy consumption and include also services fuel consumptions,
- the measures SW_B_2 will counterbalance the growth in the number of dwellings and population with a goal of almost zero fossil energy consumption of new dwellings;
- the measure SWD_B_1 will drive the increase in the share of renewables over total consumption; therefore, the further reduction of carbon footprint will mainly reduce emission factor of electricity but it does not affect the reduction of fuel consumptions of housing already considered in SW_B_3;
- there will be no promotion of wood combustion in the domestic sector.

In the following the results for the Scenario 3 are reported. Scenario 2 has no measures affecting the IRCI sector while Scenario 1 has only measures that affect the carbon footprint and not the pollutant emissions. We indicate as “renewables and efficiency” the Scenario 3.

As no indications are available for industrial emissions, in scenario analysis, were kept constant with respect to the BAU scenario.

3.2.2 Results

The only scenario from the stakeholder dialog workshop that include measures about Residential, commercial & institutional sector is the Scenario 3, while no indications are available for industrial emissions that, in scenario analysis, were kept constant with respect to the BAU scenario. In the following we discuss in consequence the results for Scenario 3 in Residential, commercial & institutional sector.

The Scenario include only the Bristol MSOA while the emissions from surrounding MSOA are kept constant. As a consequence, in the following figures emissions trend are reported for the Bristol MSOA only.

In Figure 12 for nitrogen oxides (NO_x) and Figure 13 for suspended particles with diameter less than 10μ (PM_{10}) the trends of emissions are reported for scenario 3.

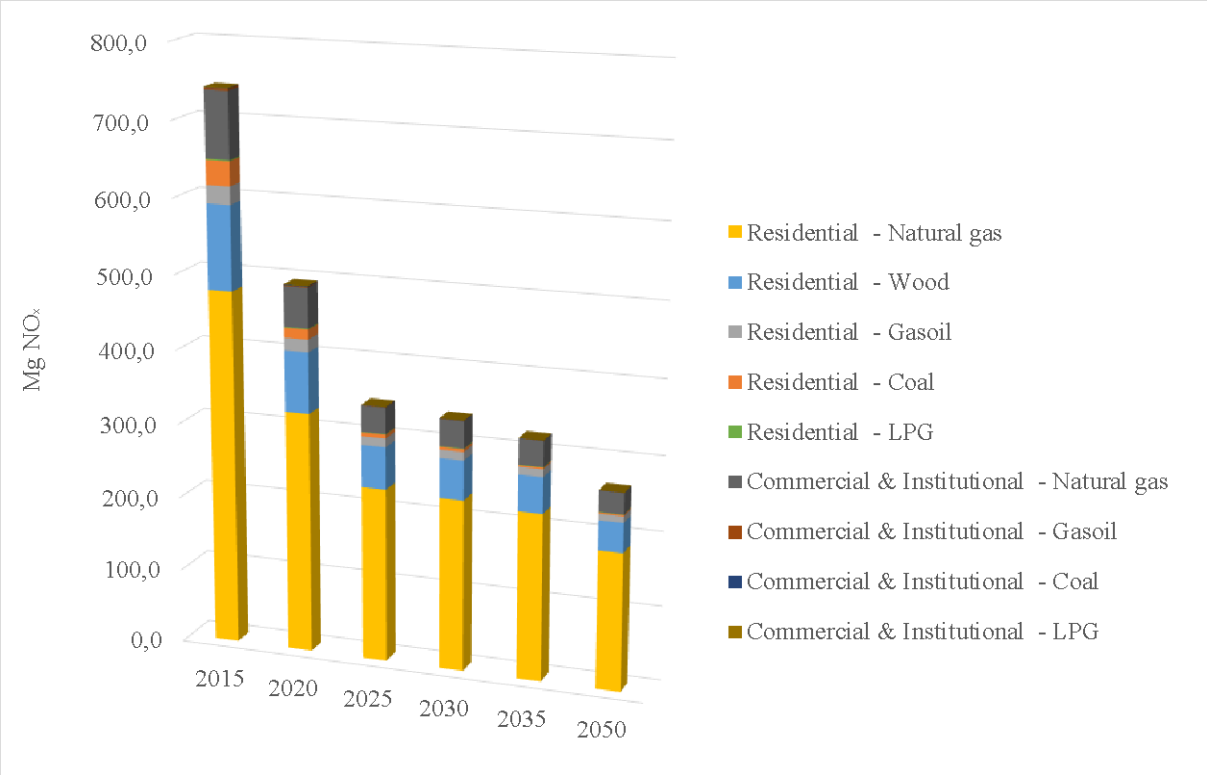

Figure 12 – Bristol Scenario 3 (renewables & efficiency): Residential, Commercial & Institutional NO_x emissions – all sectors and fuels

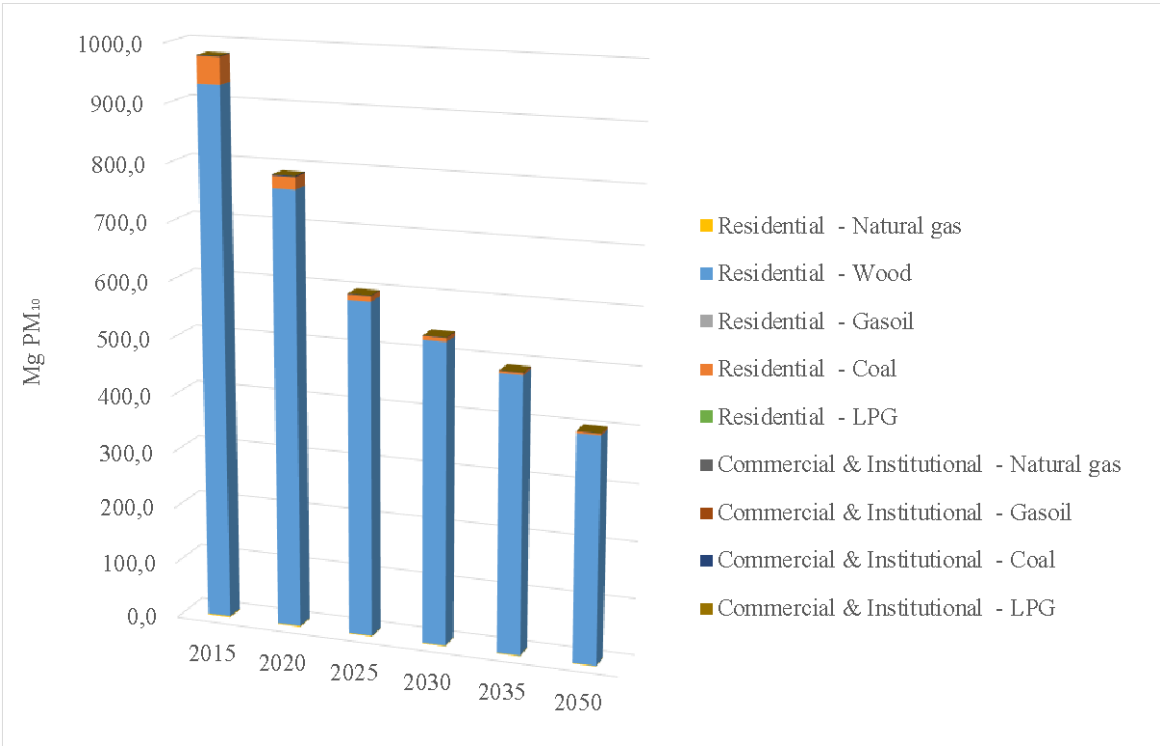

Figure 13 – Bristol Scenario 3 (renewables & efficiency): Residential, Commercial & Institutional PM_{10} emissions – all sectors and fuels

3.2.3 BAU and Scenarios comparison

In Figure 14 for nitrogen oxides (NO_x) and in Figure 15 for suspended particles with diameter less than 10μ (PM_{10}) the comparison of the trends of emissions are reported for the different scenarios.

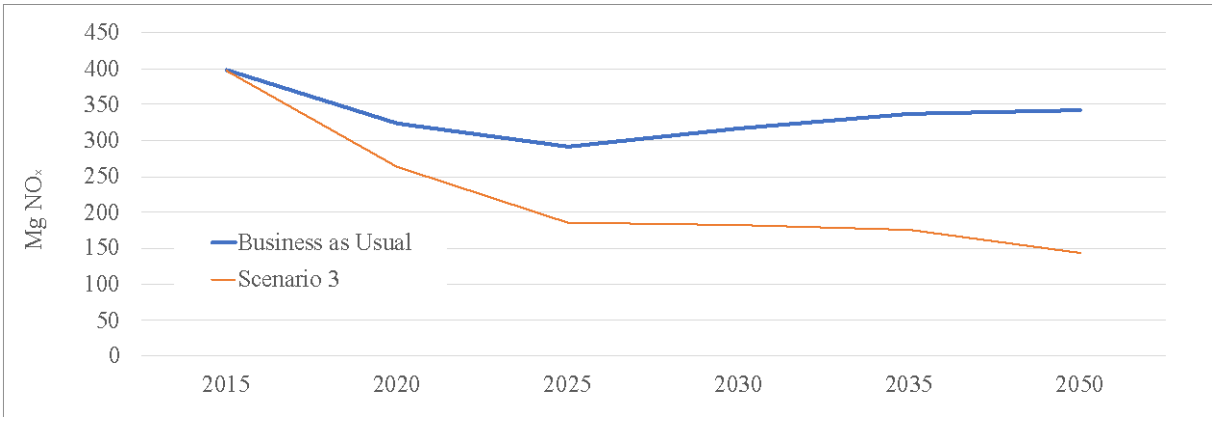

Figure 14 – Bristol BAU & Scenario 3 (renewables & efficiency) comparison: Residential, Commercial & Institutional NO_x emissions – all sectors and fuels

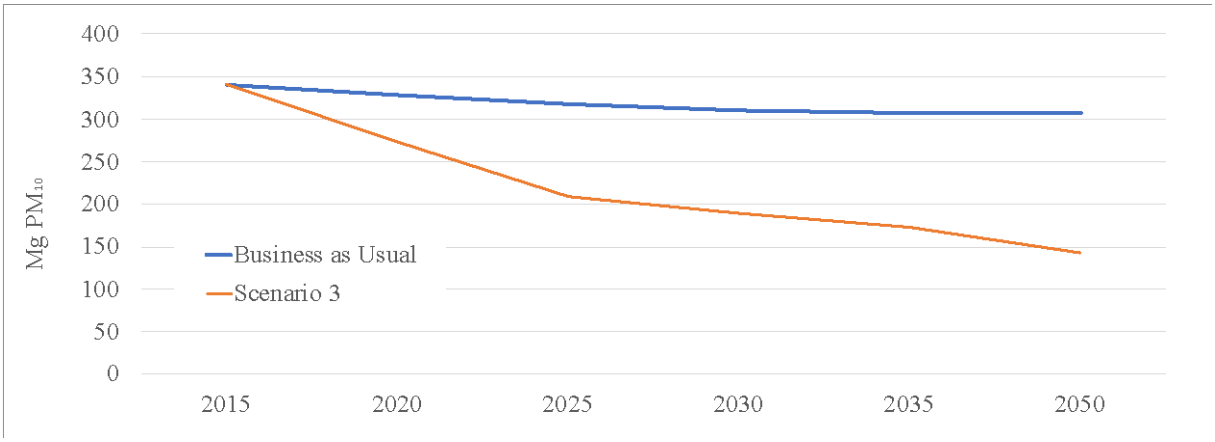

Figure 15 – Bristol BAU & Scenario 3 (renewables & efficiency) comparison: Residential, Commercial & Institutional PM_{10} emissions – all sectors and fuels

3.3 Unified Policy Scenario

3.3.1 Modelling

The final Unified Policy Scenario includes the measures of Table 7 relating to the IRCI sector (the codes are defined in this report). For the supplementar measure *Bristol Carbon Neutral* we assume the results of the Bristol City Council strategy[16] for carbon neutrality on 2050.

[16] Element Energy Limited, An evidence based strategy for delivering zero carbon heat in Bristol. A report for Bristol City Council, October 2018

Table 7 – Bristol: Measures for the Unified Policy Scenario

Code	Description
B_SWD_B_1	Increase generation of solar and wind power
B_SWB_B_2	Make property developers consider air pollution and climate change
B_SWB_B_3	Improve energy efficiency of housing (rented/existing/new)
BRI_CN	Bristol Carbon Neutral

3.3.2 Results

In Figure 16 for nitrogen oxides (NO_x) and Figure 17 for suspended particles with diameter less than 10μ (PM_{10}) the trends of emissions are reported for Unified Policy Scenario.

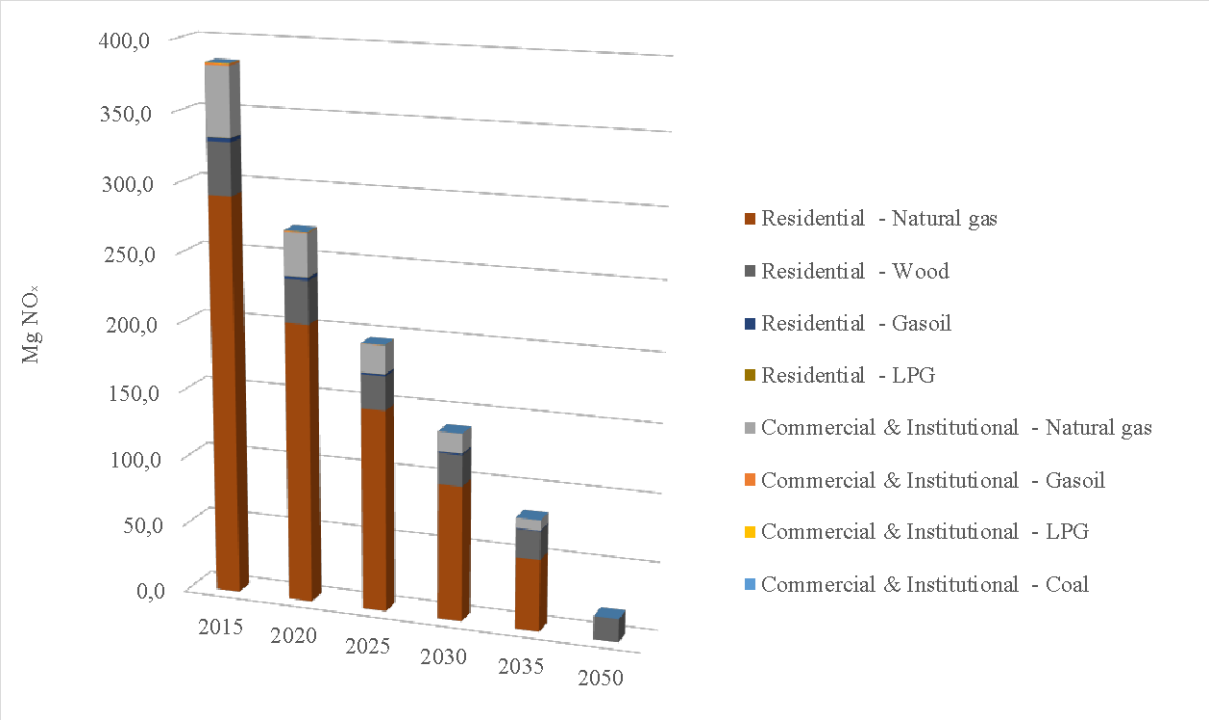

Figure 16 – Bristol Unified Policy Scenario: Residential, Commercial & Institutional NO_x emissions – all sectors and fuels

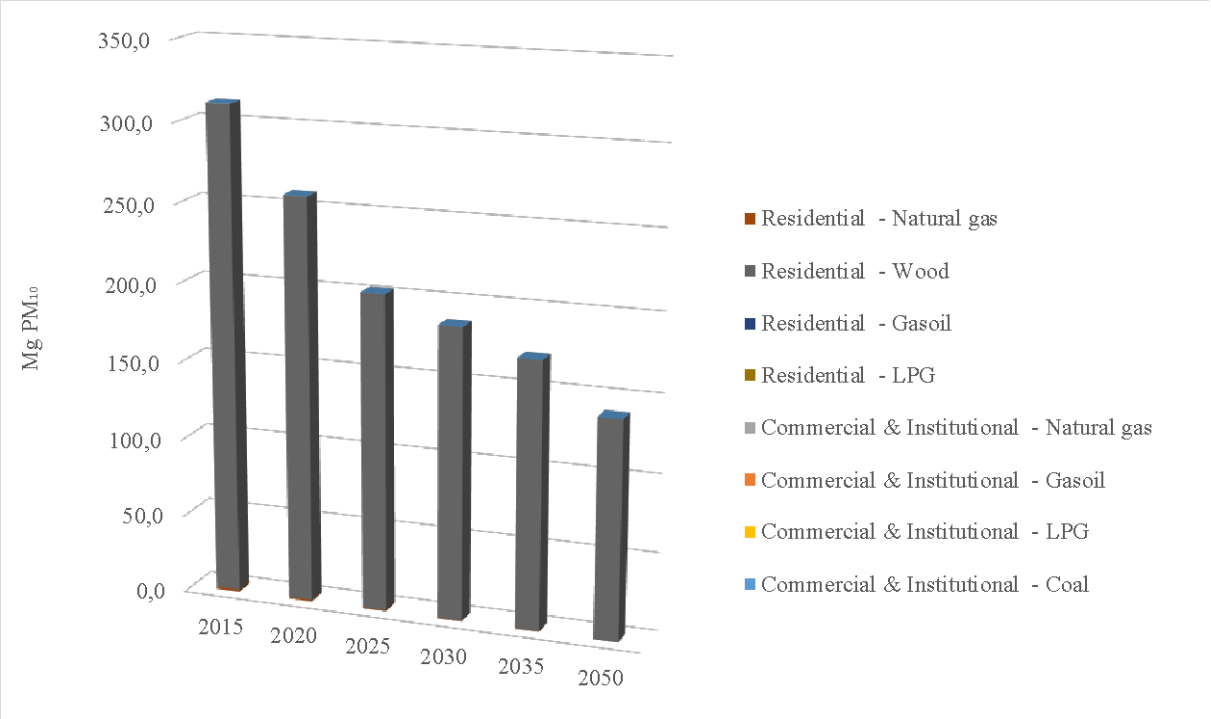

Figure 17 – Bristol Unified Policy Scenario: Residential, Commercial & Institutional PM_{10} emissions – all sectors and fuels

3.3.3 BAU and Unified Policy Scenario comparison

In Figure 18 for nitrogen oxides (NO_x) and in Figure 19 for suspended particles with diameter less than 10μ (PM_{10}) the comparison of the trends of emissions are reported for Business As Usual (BAU) and Unified Policy (UP) scenarios.

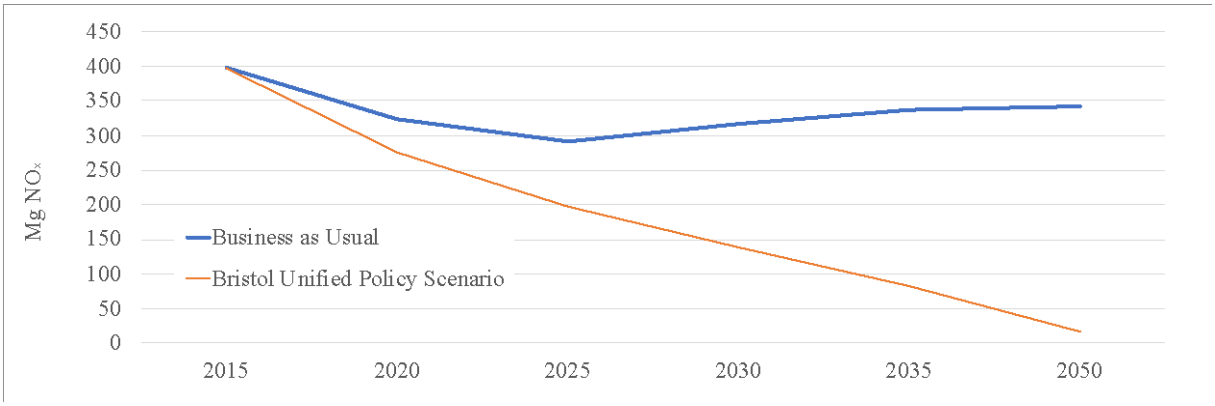

Figure 18 – Bristol BAU & Unified Policy Scenarios comparison: Residential, Commercial & Institutional NO_x emissions – all sectors and fuels

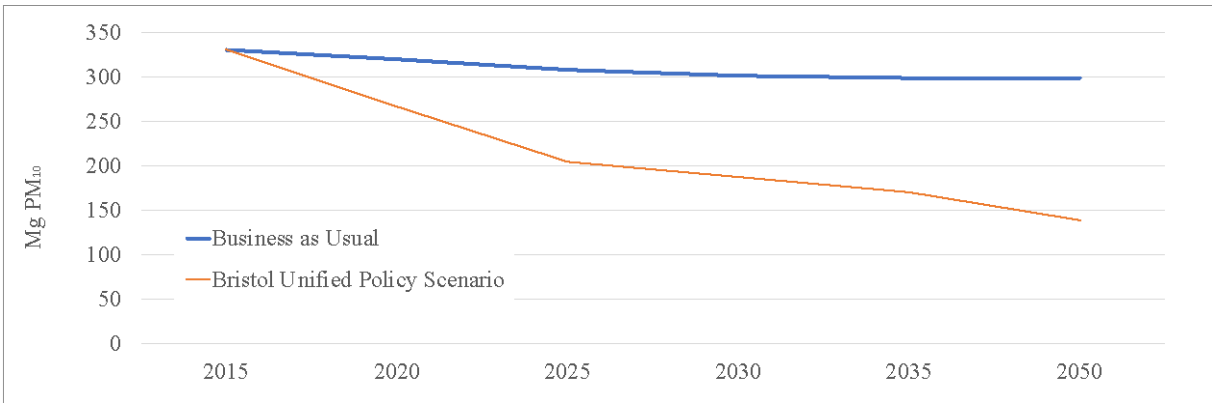

Figure 19 – Bristol BAU & Unified Policy Scenarios comparison: Residential, Commercial & Institutional PM_{10} emissions – all sectors and fuels

4 AMSTERDAM

4.1 Business As Usual projections

Business as Usual (BAU) scenario takes into consideration national and city level measures already defined/decided.

4.1.1 Modelling

4.1.1.1 National BAU Projections

National BAU scenario evaluates national emission reduction starting from Netherland official projections.

The scenario was built in different steps using:

- the projections of greenhouse gas emissions and energy demand from the 7th national communication to UNFCCC[17] using scenario with additional measures (WAM)
- the projections of greenhouse gas emissions and energy demand over 2030 from Ministry of Economic Affairs and Climate *Energy Policy*[18];
- the national measures defined in the 'with measures' (adopted measures) projection in the frame of NECD[19];
- the coal power plants ban by Dutch government in 2018[20].

[17] Ministry of Economic Affairs and Climate Policy, Seventh Netherlands National Communication under the United Nations Framework Convention on Climate Change
[18] Ministry of Economic Affairs and Climate Policy, Energy Report, Transition to sustainable energy
[19] EEA Eionet, Reporting Obligations Database (ROD), Deliveries for National Emission Ceiling Directive (NECD) - Projected emissions by aggregated NFR sectors
[20] Rijksoverheid , Kabinet verbiedt elektriciteitsproductie met kolen

In the first step the fuel consumption was varied following the energy demand projection with socioeconomic drivers, in the second step the emissions were varied to meet the NECD emissions considering technological drivers.

Regarding coal ban, the government prohibits electricity production in the Netherlands with coal as fuel from 2030 onwards[21]. The two oldest power plants - the Hemweg and the Amer power station - have to stop electricity production by the end of 2024 by means of coal. In conseguence in the BAU scenario we close Hemweg 8 coal fired power plant by 2025.

4.1.1.2 Amsterdam BAU projections

The Amsterdam BAU projections consider:

- *Demographic evolution*. The city population will grow[22] with time (7% by 2020, 13% by 2025, 18% by 2030, 23% by 2035, and 27% by 2040 on 2015 levels for Amsterdam and 6% by 2020, 11% by 2025, 16% by 2030 , 19% by 2035, and 23% by 2040 on 2015 levels for Greater Amsterdam). Also private housholds will growt in future (3% by 2020, 7% by 2025, 11% by 2030, 15% by 2035, and 19% by 2040 on 2015 levels for Amsterdam and Greater Amsterdam)[23].
- *Sustainable Amsterdam: Agenda for renewable energy, clear air, a circular economy and a climate-resilient city* [24]

The Municipality of Amsterdam is working with numerous partners to create a more renewable energy-based economy, which in time should be entirely fossil fuel-free – thus not dependent on coal, oil or gas.
Since Amsterdam is likely to continue its strong growth rate over the coming years, we aim to improve our renewable energy performance per capita. The city has set the following main targets:

- By 2020, they will generate 20 per cent more renewable energy per capita compared to 2013. They will achieve this in the following ways:
  - Producing more wind and solar energy;
  - Making more use of renewable heating.
- By 2020, they will use 20 per cent less energy per capita compared to 2013. They will achieve this in the following ways:
  - Making existing housing stock more sustainable;
  - Reducing energy consumption by corporate real estate and social real estate;
  - Encouraging energy-neutral construction.
  - Reducing the use of (fossil-based) energy and increasing renewable energy production will result in a lowering of Amsterdam's CO_2 emissions. This effort will thus contribute to building an economy that will emit 40 and 75 per cent less CO_2 by 2025 and 2040 respectively, compared to 1990.

The Agenda don't reports specific measures to insert in the model but only general goals.

[21] Rijksoverheid , Kabinet verbiedt elektriciteitsproductie met kolen
[22] CBS, Regionale prognose 2017-2040; bevolking, intervallen, regio-indeling 2015
[23] CBS, Regionale prognose 2017-2040; huishoudens, intervallen, regio-indeling 2015
[24] Sustainable Amsterdam, Agenda for renewable energy, clear air, a circular economy and a climate-resilient city. Adopted by the Municipal Council of Amsterdam, March 2015

- *'Grand Design' for a regional heating network* [25]

In December 2016, 32 public and private parties in the Amsterdam Metropolitan Area (MRA) voted to go ahead with the 'Grand Design' for a regional heating network stretching from IJmuiden to Almere and from Zaanstad to Aalsmeer. This move will prepare the area for a gas-free future with heating networks as an attractive alternative for the built environment. Research carried out by independent research organisation CE Delft has shown that the planned collective heating network ('district heating') would be much cheaper than an approach involving individual measures in each home, and it would generate considerable energy savings too. The Roadmap to Sustainable Heating in the Amsterdam Metropolitan Area (Routekaart Duurzame Warmte in de MRA), which includes agreements on how district heating can be established, has also been determined. The district heating grid will need to provide homes, greenhouses and businesses with the equivalent amount of sustainable energy that would be required to heat 500,000 homes.

4.1.1.3 Projection drivers

Socio-economic drivers' definition is reported in Table 8 while technologic drivers' definition is reported in Table 9. Inally point sources driver are reported in Table 10.

For drivers coming from EU NEC "with measures" data, as it's impossible to derive from available information the split between socio-economic measures, such as for example fuel consumptions reductions, and technological measures, such as for example advanced combustion technology, all the measures are inserted as technological. The NEC measures are evaluated net of UNFCCC NC ones.

Table 8 – Amsterdam: Socio-economic drivers used to project emissions in industrial, residential and commercial sector

Code	Name	Domain
AMS_BAS_CFF	Amsterdam 7NC WAM: Commercial - Fossil fuels	All Buurts
AMS_BAS_RFF	Amsterdam 7NC WAM: Residential - Fossil fuels	All Buurts
AMS_BAU_CFF	Amsterdam NEC: Residential & Commercial - Fossil fuels	All Buurts
AMS_HOUSE	Amsterdam Private Households Growth	All Buurts

Table 9 – Amsterdam: Technological drivers used to project emissions in industrial, residential and commercial sector

Code	Name	Domain
AMS_NEC_B_PM	AMS NEC Building PM	All Buurts
AMS_NEC_I_PM	AMS NEC Industry PM	All Buurts
AMS_NEC_I_NOx	AMS NEC Industry NOx	All Buurts
AMS_NEC_B_NOx	AMS NEC Building NOx	All Buurts

Table 10 – Amsterdam: point sources drivers used to project emissions for point sources

Code	Name	Domain
AMS_Coal	AMS Coal ban	Nuon Hemweg Coal unit

[25] Press: Amsterdam Metropolitan Area prepares for a gas-free future

4.1.2 Results

4.1.2.1 Industrial emissions

The evolutions of industrial area emissions are reported in Figure 20 for nitrogen oxides (NO_x) and in Figure 21 for suspended particles with diameter less than 10µ (PM_{10}). The variation is evaluated as the average variation of industrial emissions in national projection.

In Figure 22 the evolution of NOx emissions from main point sources is reported. It is worth mentioning the strong reduction of nitrogen oxide emissions for the Nuweg plant at Hemweg due to the planned closure of the coal unit as for the coal power plants ban by Dutch government in 2018.

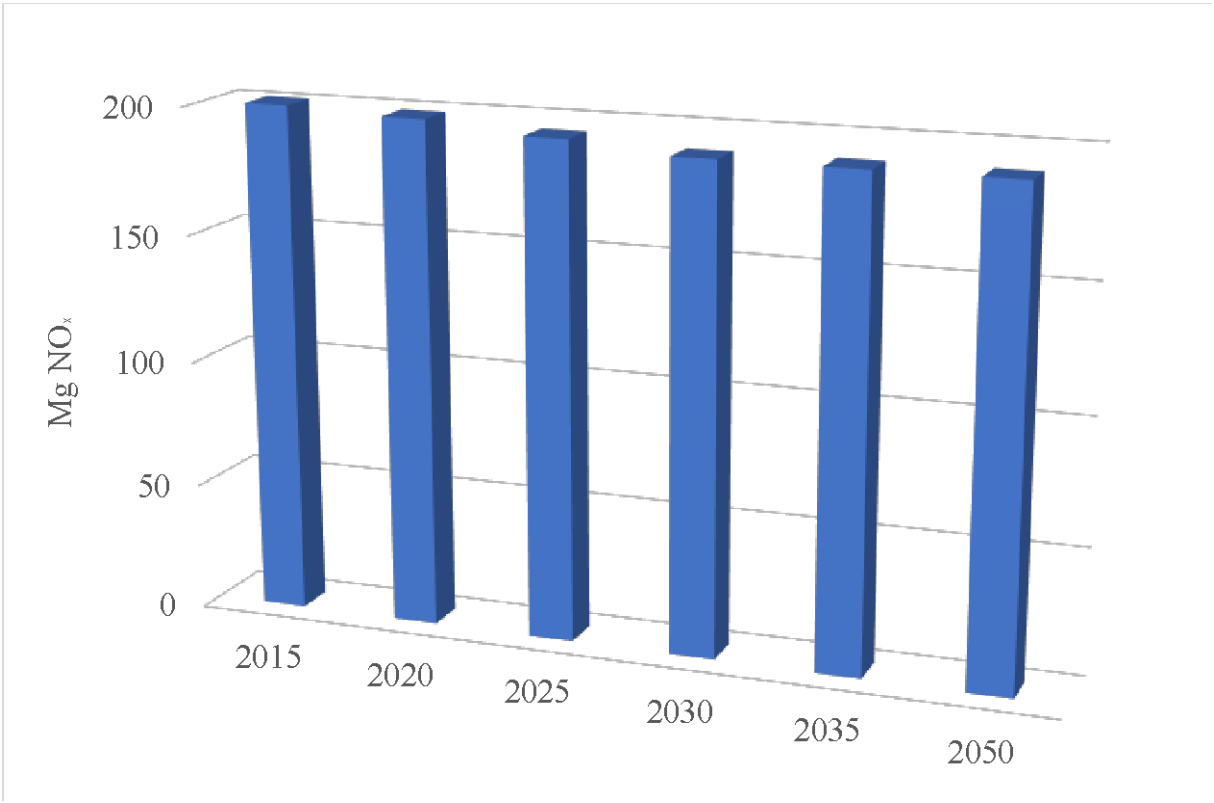

Figure 20 – Amsterdam BAU NO_x Industrial area emissions

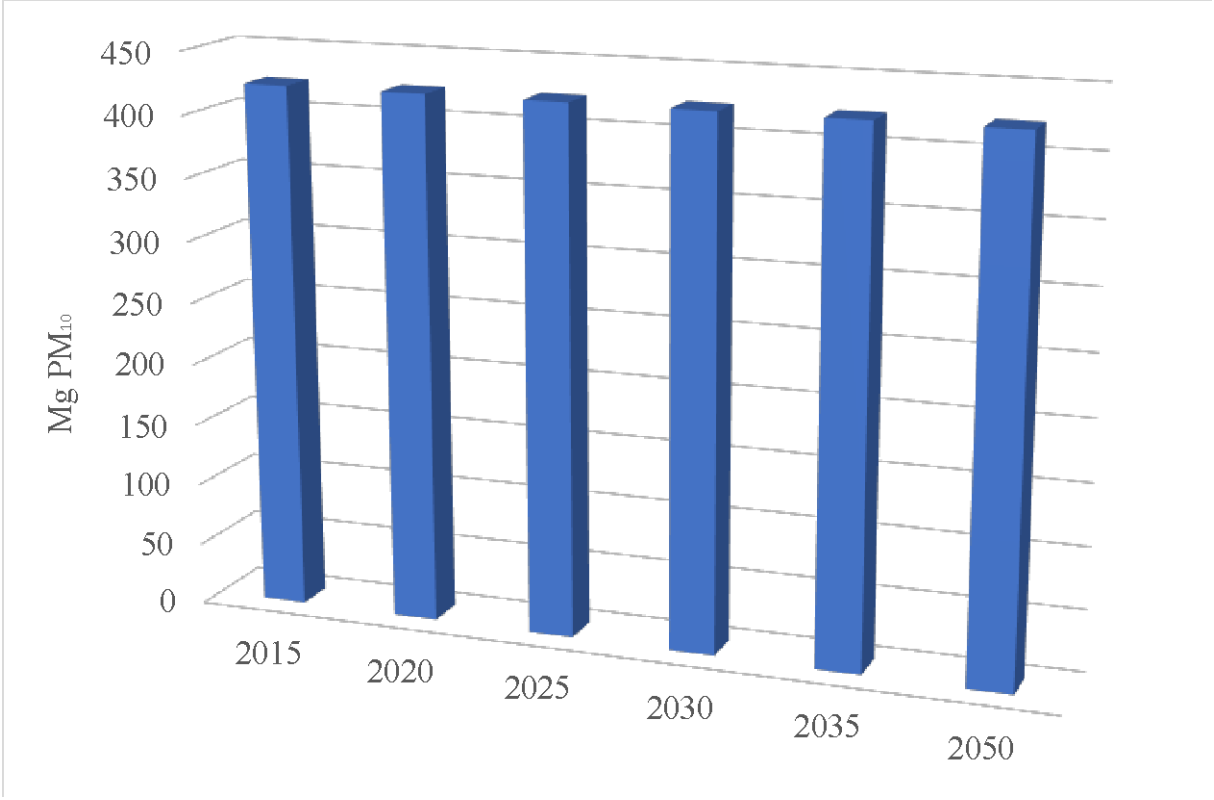

Figure 21 – Amsterdam BAU PM_{10} Industrial area emissions

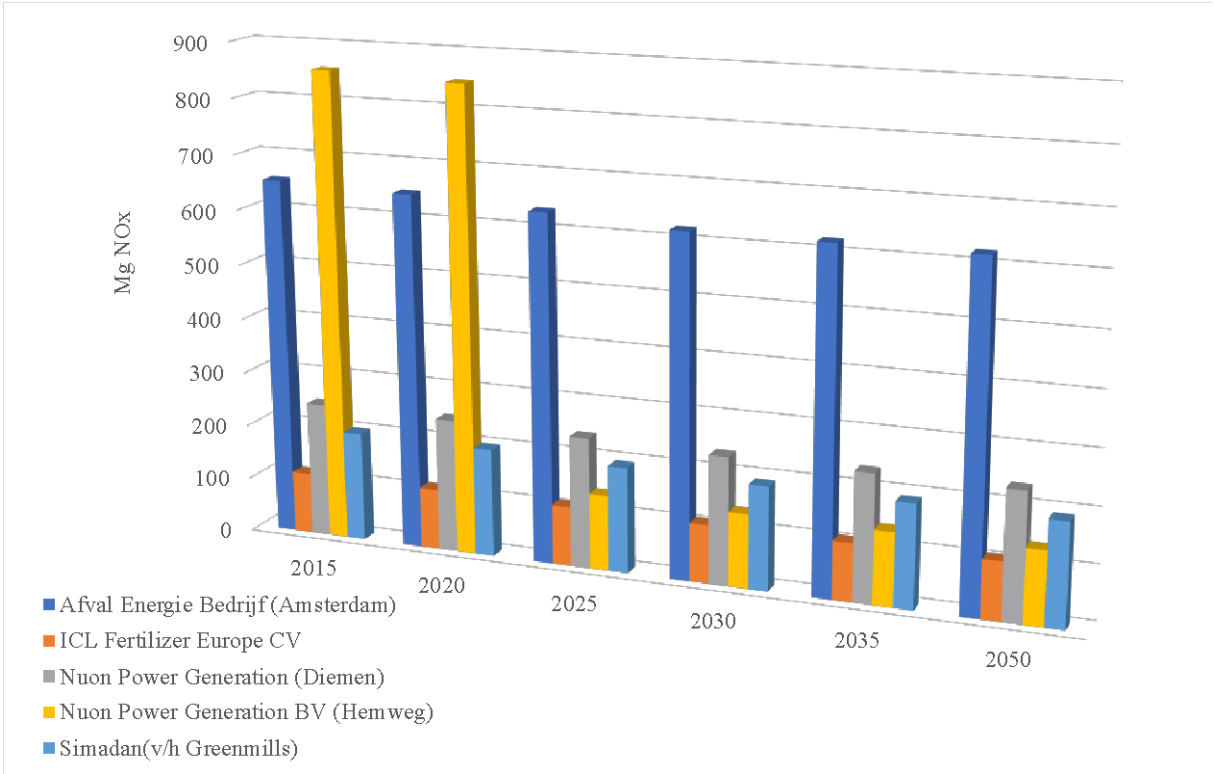

Figure 22 – Amsterdam BAU Industrial main point sources NO_x emissions

4.1.2.2 Residential, commercial & institutional emissions

In Figure 23 for nitrogen oxides (NO_x) and in Figure 24 for suspended particles with diameter less than 10μ (PM_{10}) the evolutions of emissions in Amsterdam are reported.

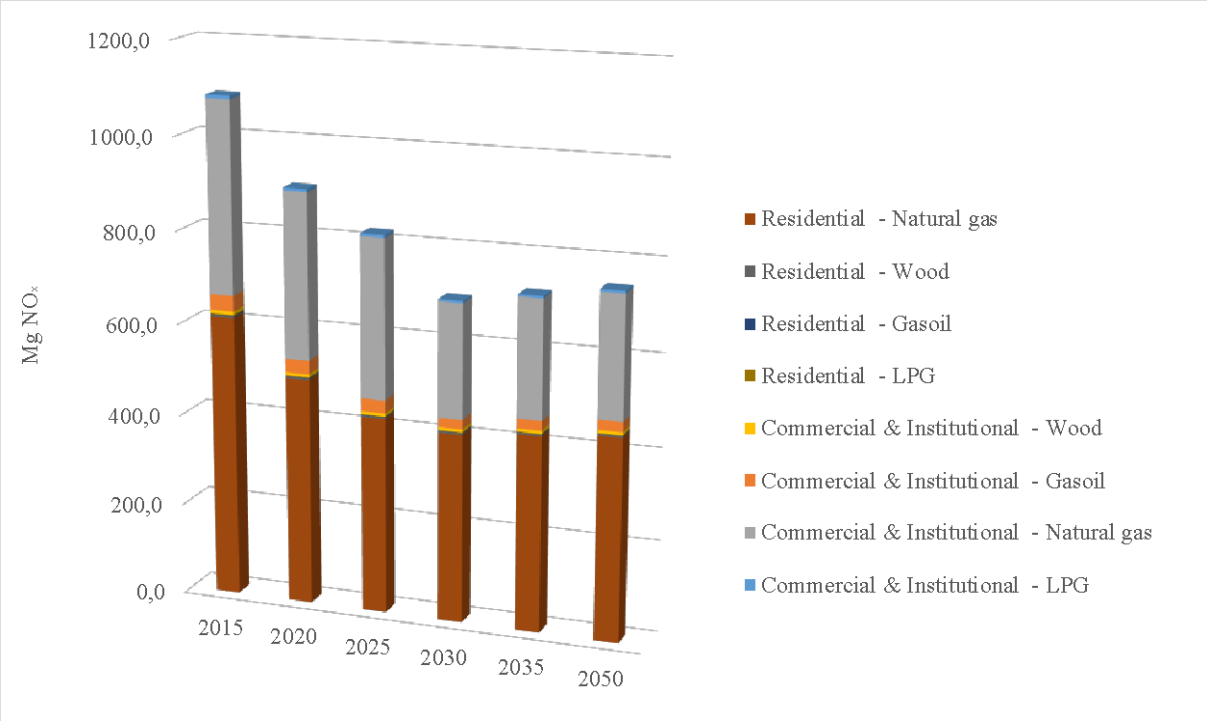

Figure 23 – Amsterdam BAU total Residential, Commercial & Institutional NO_x emissions

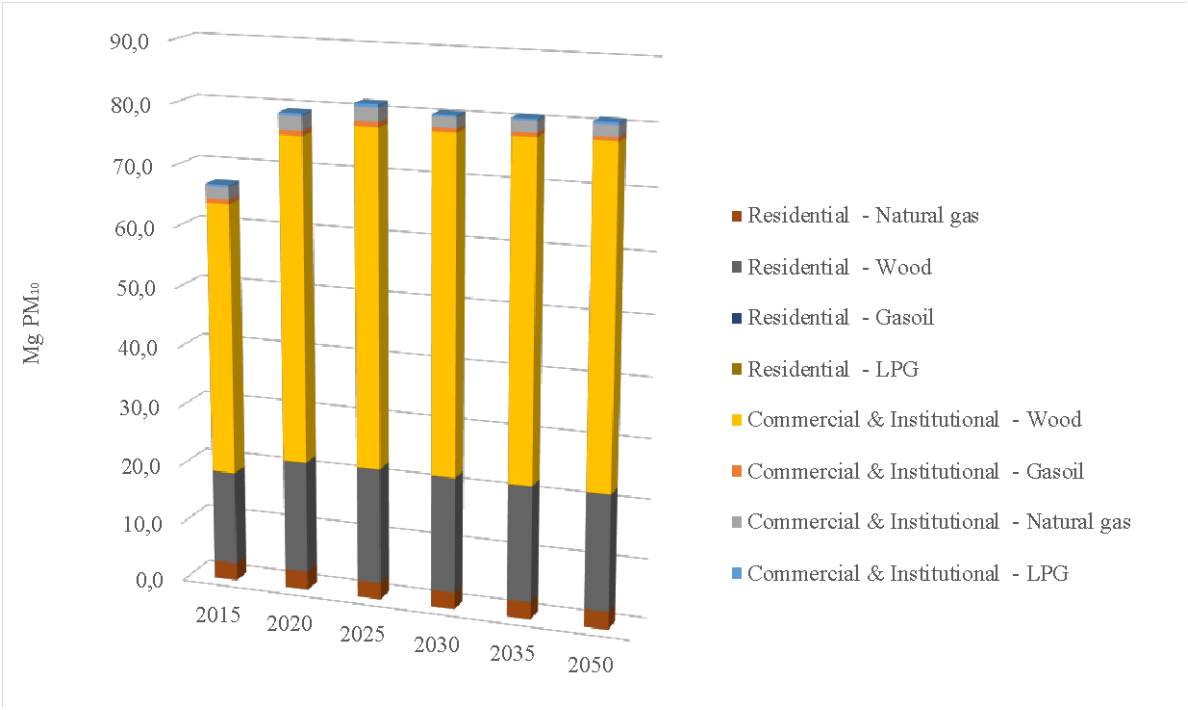

Figure 24 – Amsterdam BAU Residential, Commercial & Institutional PM_{10} emissions

4.2 Scenario projections

Scenario projections take into consideration city level additional measures.

4.2.1 Modelling

Scenarios from the Stakeholder dialog workshop (SWD) includes the measures relating of Table 11 relating to the IRCI sector (the codes are defined in this report).

Table 11 – Amsterdam: Measures coming from the Stakeholder dialog workshop

Code	Description	Scenario
AMS_LblBC	Amsterdam house label B&C	Low
AMS_LblA	Amsterdam house label A	High
AMS_Wood	Amsterdam ban wood stoves and fireplaces	Low & High
AMS_SunMand	Amsterdam Solar Panel mandatory	High
AMS_GFNMand	Amsterdam Gas free no mandatory	Low
AMS_GFMand	Amsterdam Gas free mandatory Natgas	High
AMS_GFMandBg	Amsterdam Gas free mandatory Biogas	High
AMS_GFMandGg	Amsterdam Gas free mandatory Greengas	High

We will assume that:

- Regarding the measures on the acceleration of energy efficiency renovations for all houses belonging to housing associations (*Amsterdam house label*):
  - The house association own about 42% of the total amount of dwellings in Amsterdam[26];
  - Less than 10 percent of dwellings in the municipalities Amsterdam have an energy label as of 2009 and one in three of the nearly one million homes in the Netherlands with an energy label fall in energy category E, F or G[27] reach an energy label B or C by 2050;
  - for the measure *Amsterdam house label B&C* (*AMS_LblBC*), we assume that the 42% of house reduce the energy consumptions of 50%;
  - for the measure *Amsterdam house label A* (*AMS_LblA*), we assume that the 42% of house reduce the energy consumptions of 80%;
- with the measure *Amsterdam ban wood stoves and fireplaces* (*AMS_Wood*), wood combustion is set to 0 from 2025;
- for the measure *Amsterdam Solar Panel mandatory* (*AMS_SunMand*), that prescribes mandatory solar panels in all suitable roofs and provide subsidies for it, we assume that[28]:
  - Amsterdam actualy generate solar energy on about 2% of total number of households

[26] Amsterdam Federation of Housing Associations, Information in english
[27] CBS, One third of homes with an energy label can use a lot less energy
[28] Gemeente Amsterdam, Zonvisie Amsterdam - Burgers en bedrijven gaan voor de zon!', juni 2013

- Amsterdam will generate in 2020 solar energy on about 12% of of total number of households in Amsterdam;
- Amsterdam will generate in 2050 solar energy on about 60% of total number of households in Amsterdam;

- for the measure *Amsterdam Gas free no mandatory* (*AMS_GFNMand*) we assume a reduction of 20% of gas consumptions at 2030;
- for the measures *Amsterdam Gas free mandatory Natural gas* (*AMS_GFMand*), *Amsterdam Gas free mandatory Biogas* (*AMS_GFMandBg*), *Amsterdam Gas free mandatory Greengas AMS_GFMandGg* we assume in the city of Amsterdam at *2030*[29]:
  - no fossil fuel for 100% of buildings;
  - residual use of gas allocated to biogas (45%) and greengas (55%).

4.2.2 Results

In Figure 25 for nitrogen oxides (NO_x) and Figure 26 for suspended particles with diameter less than 10µ (PM_{10}) the trends of emissions are reported for scenario 1 ("low"); in Figure 27 for nitrogen oxides (NO_x) and Figure 28 for suspended particles with diameter less than 10µ (PM_{10}) the trends of emissions are reported for scenario 2 ("high"). The Scenario include only the Amsterdam Geemente while the emissions from surrounding Geemente are kept constant.

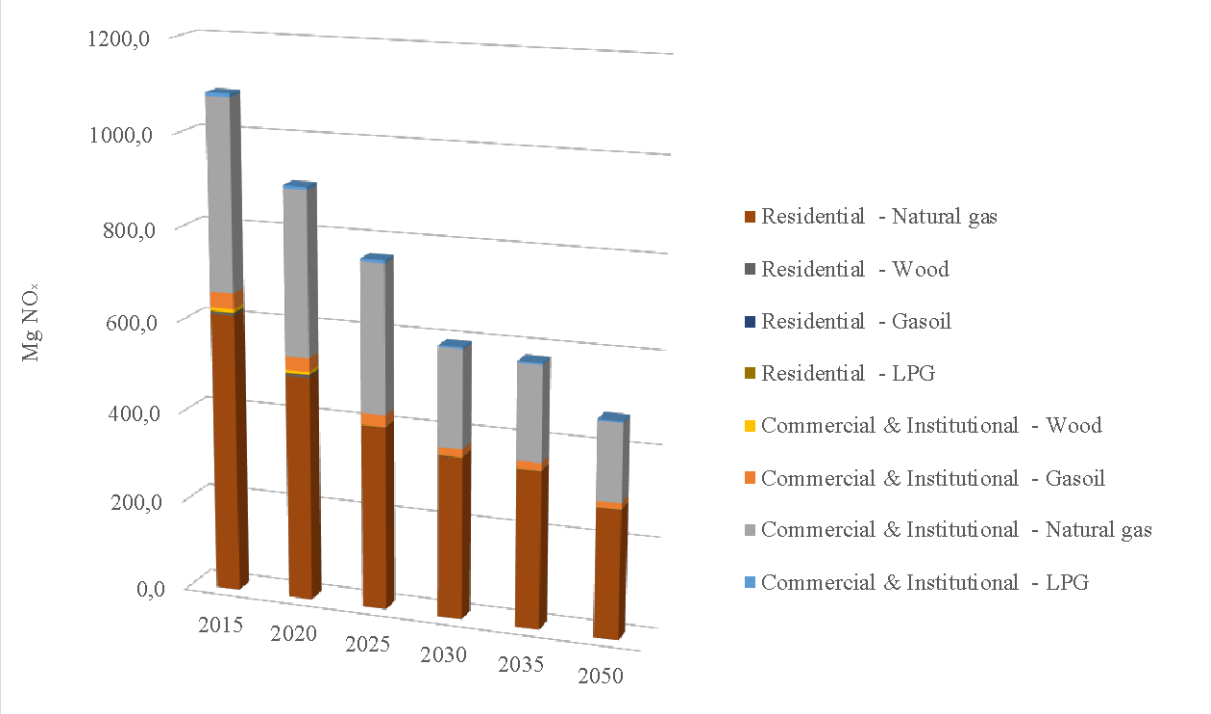

Figure 25 – Amsterdam Scenario 1 (low): Residential, Commercial & Institutional NO_x emissions – all sectors and fuels

[29] CE Delft, Towards a climate-neutral built environment in 2050, update 2016

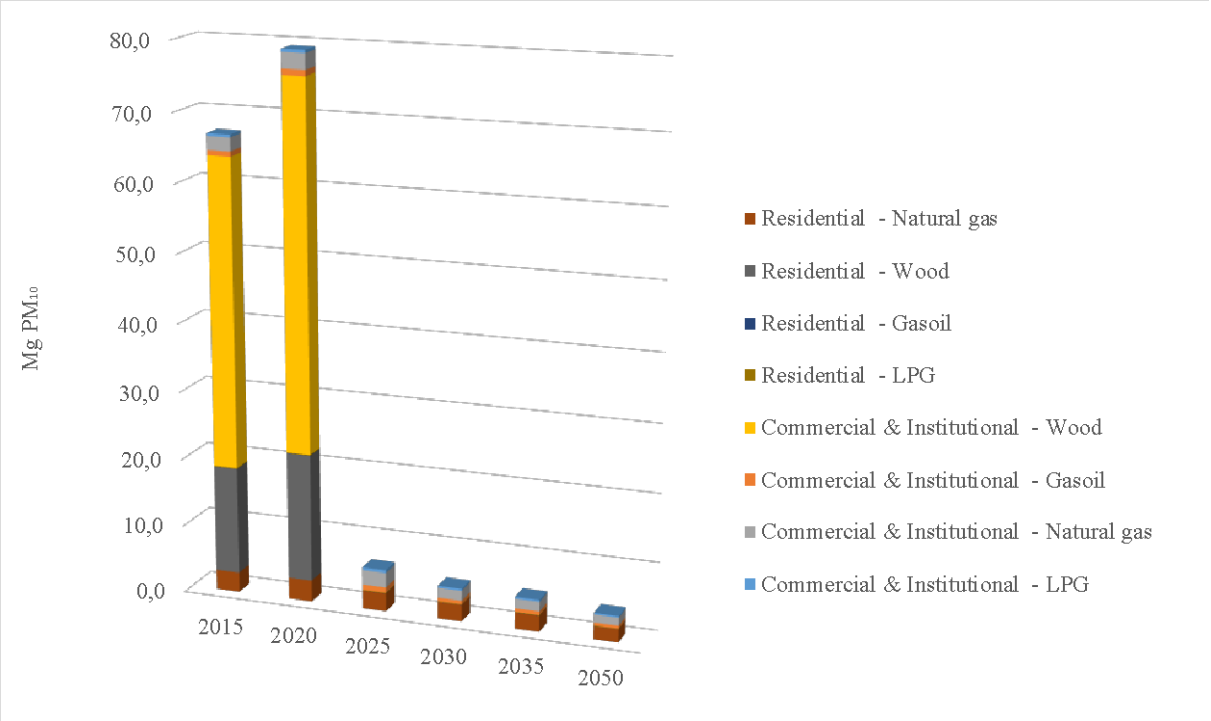

Figure 26 – Amsterdam Scenario 1 (low): (renewables & efficiency): Residential, Commercial & Institutional PM_{10} emissions – all sectors and fuels

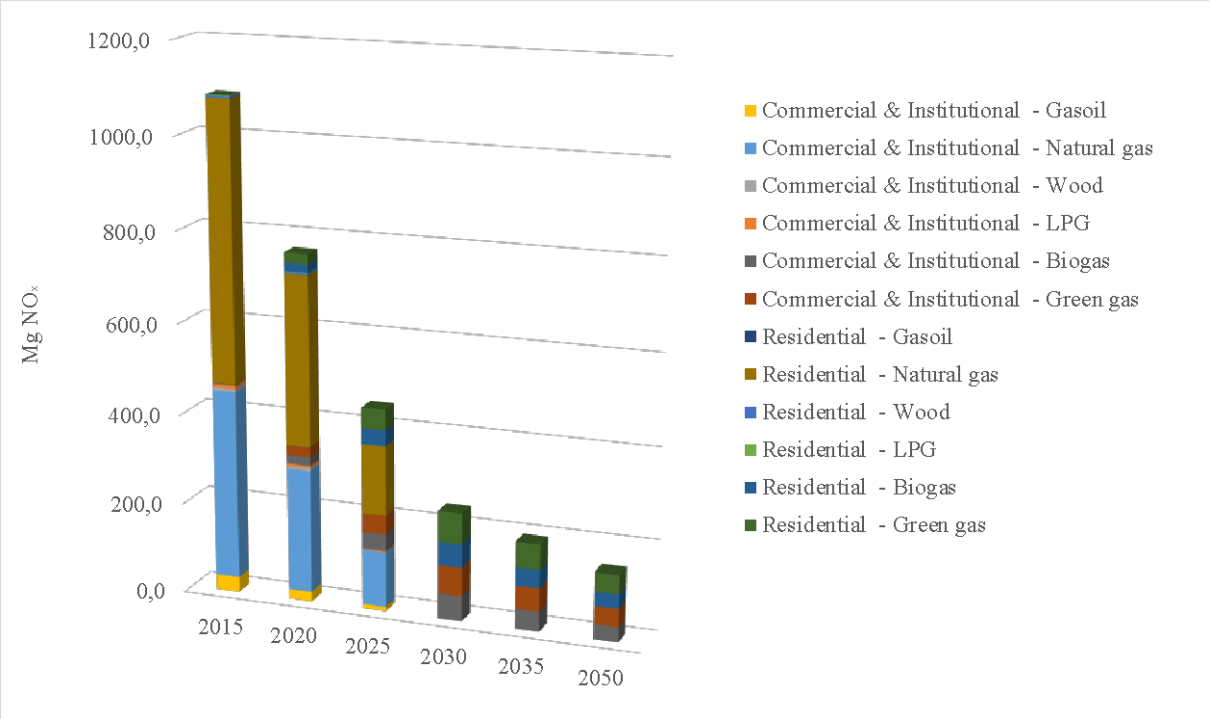

Figure 27 – Amsterdam Scenario 2 (high): Residential, Commercial & Institutional NO_x emissions – all sectors and fuels

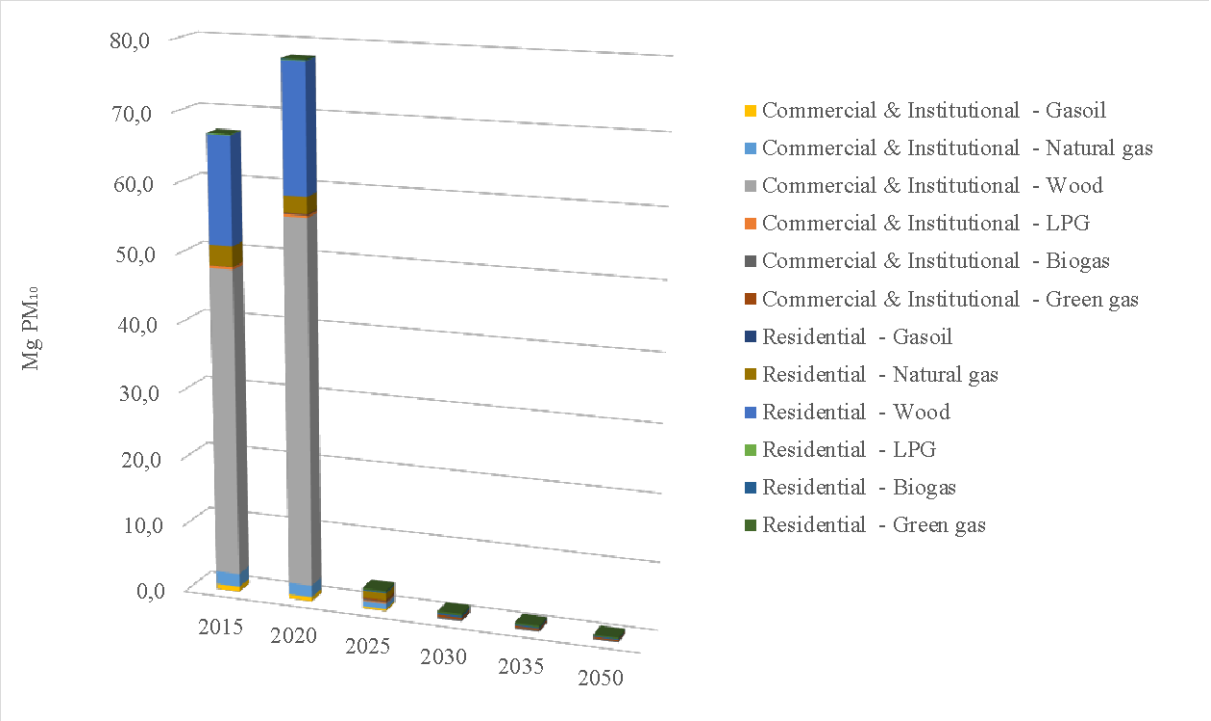

Figure 28 – Amsterdam Scenario 2 (high): (renewables & efficiency): Residential, Commercial & Institutional PM_{10} emissions – all sectors and fuels

4.2.3 BAU and Scenarios comparison

In Figure 29 for nitrogen oxides (NO_x) and in Figure 30 for suspended particles with diameter less than 10μ (PM_{10}) the comparison of the trends of emissions are reported for the different scenarios.

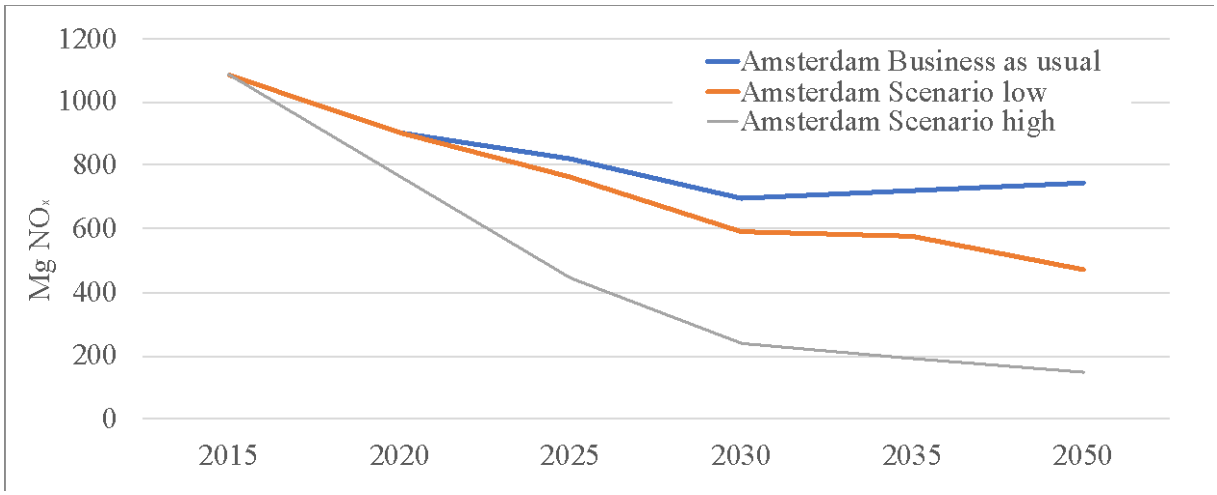

Figure 29 – Amsterdam BAU & Scenarios comparison: Residential, Commercial & Institutional NO_x emissions – all sectors and fuels

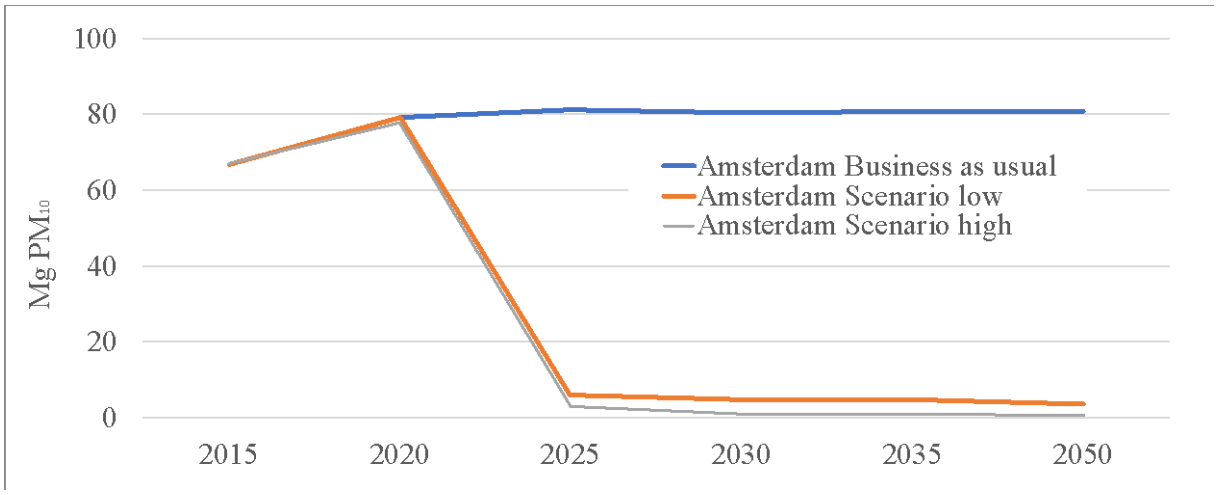

Figure 30 – Amsterdam BAU & Scenarios comparison: Residential, Commercial & Institutional PM_{10} emissions – all sectors and fuels

4.3 Unified Policy Scenario

4.3.1 Modelling

The final Unified Policy Scenario includes the measures of Table 12 relating to the IRCI sector (the codes are defined in this report). The scenario posticipate at 2040 the measures "*Gas green*" with the measures *Amsterdam Gas free mandatory Natural gas in 2040* (*AMS_GFM40*), *Amsterdam Gas free mandatory Biogas in 2040* (*AMS_GFM40Bg*), *Amsterdam Gas free mandatory Greengas in 2040* (*AMS_GFMandGg*) that assume in the city of Amsterdam at *2040*[30]:

- no fossil fuel for 100% of buildings;
- residual use of gas allocated to biogas (45%) and greengas (55%).

Table 12 – Amsterdam: Measures for the Unified Policy Scenario

Code	Description
AMS_LblBC	Amsterdam house label B&C
AMS_Wood	Amsterdam ban wood stoves and fireplaces
AMS_SunMand	Amsterdam Solar Panel mandatory
AMS_GFMand40	Amsterdam Gas free mandatory in 2040
AMS_GFM40	Amsterdam Gas Free Mandatory in 2040 Natgas
AMS_GFM40Bg	Amsterdam Gas free mandatory 2040 Biogas
AMS_GFM40Gg	Amsterdam Gas free mandatory 2040 Greengas

4.3.2 Results

[30] CE Delft, Towards a climate-neutral built environment in 2050, update 2016

In Figure 31 for nitrogen oxides (NO_x) and Figure 32 for suspended particles with diameter less than 10μ (PM_{10}) the trends of emissions are reported for Unified Policy Scenario.

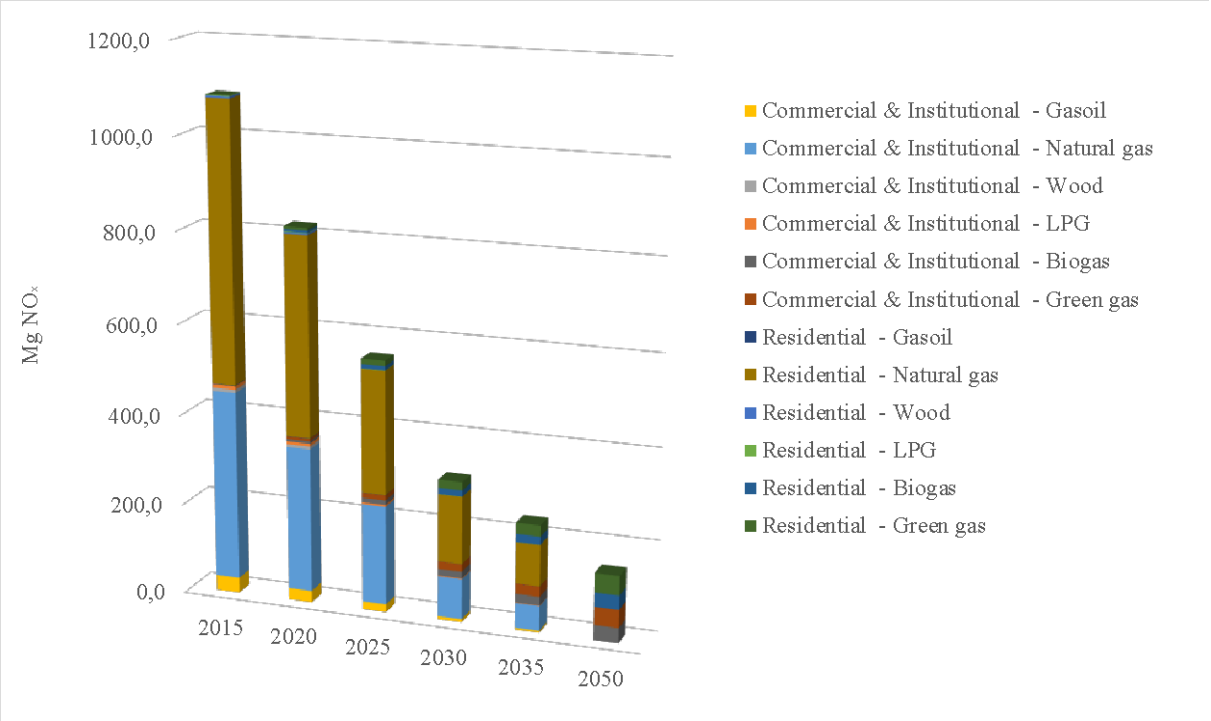

Figure 31 – Amsterdam Unified Policy Scenario: Residential, Commercial & Institutional NO_x emissions – all sectors and fuels

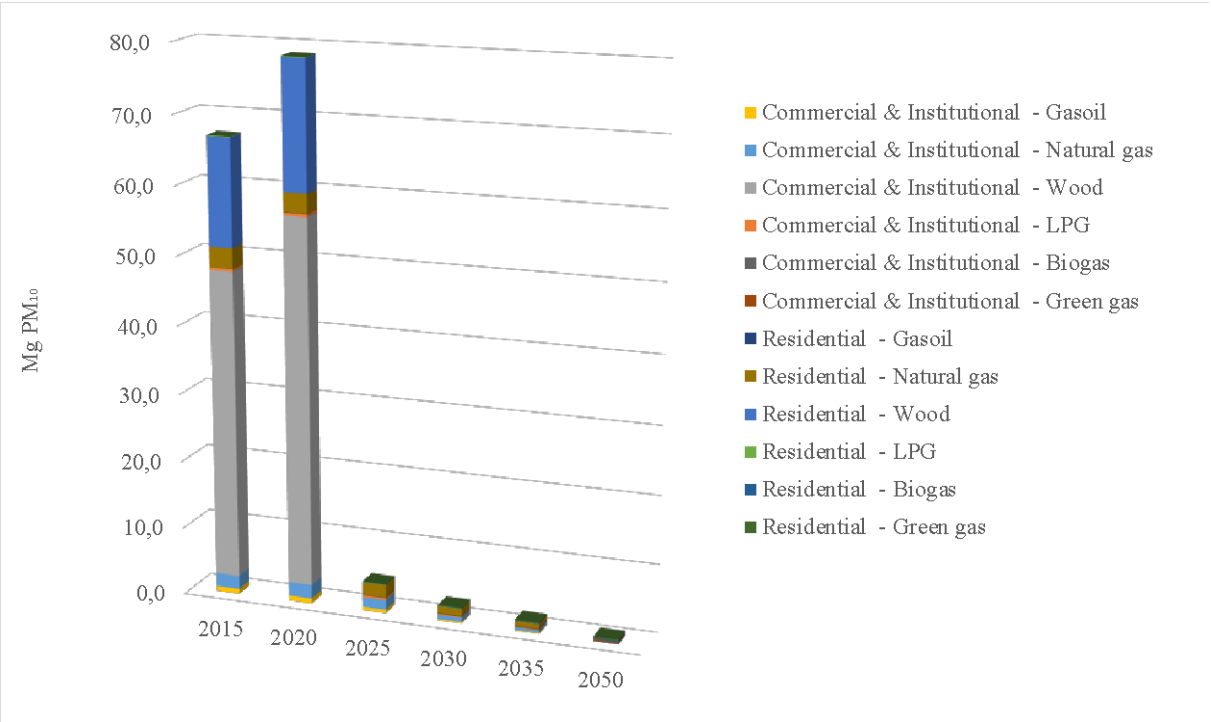

Figure 32 – Amsterdam Unified Policy Scenario: Residential, Commercial & Institutional

PM_{10} emissions – all sectors and fuels

4.3.3 BAU and Unified Policy Scenario comparison

In Figure 33 for nitrogen oxides (NO_x) and in Figure 34 for suspended particles with diameter less than 10μ (PM_{10}) the comparison of the trends of emissions are reported for Business As Usual (BAU) and Unified Policy (UPS) scenarios.

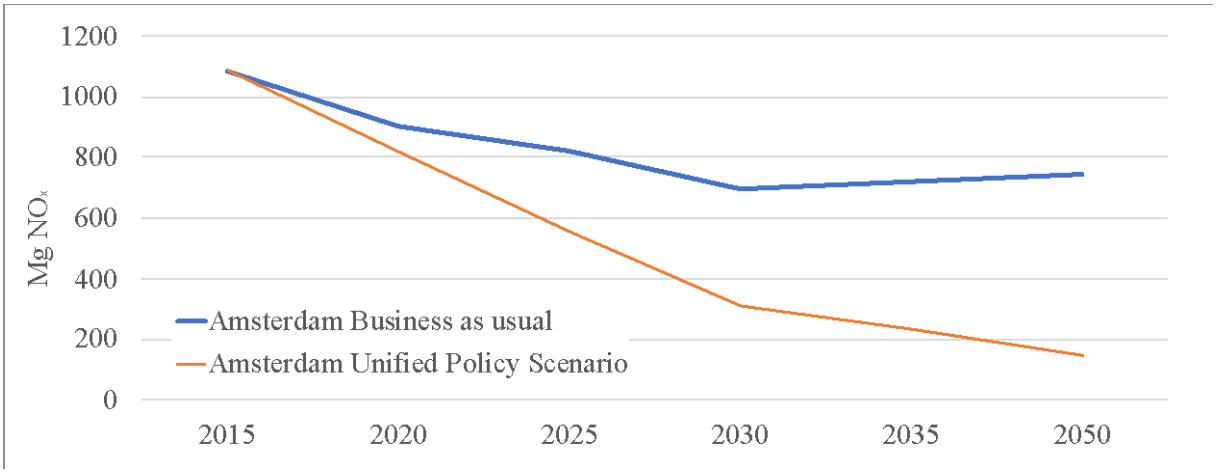

Figure 33 – Amsterdam BAU & Unified Policy Scenarios comparison: Residential, Commercial & Institutional NO_x emissions – all sectors and fuels

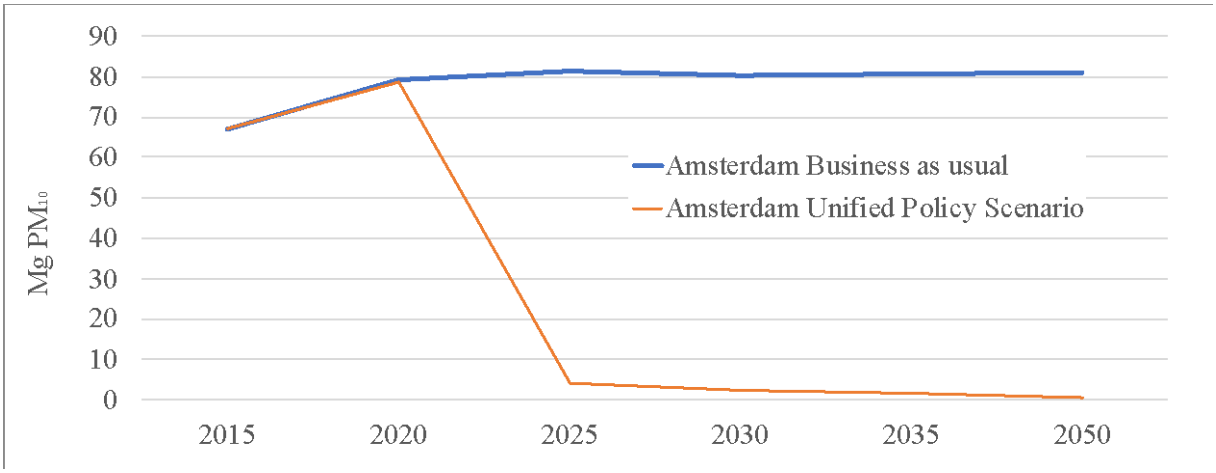

Figure 34 – Amsterdam BAU & Unified Policy Scenarios comparison: Residential, Commercial & Institutional PM_{10} emissions – all sectors and fuel

5 SOSNOWIEC

5.1 Business As Usual projections

Business as Usual (BAU) scenario takes into consideration national and city level measures already defined/decided.

5.1.1 Modelling

5.1.1.1 National BAU Projections

National BAU scenario evaluates national emission reduction starting from Poland official projections.

The scenario was built in two steps using:

- the projections of greenhouse gas emissions and energy demand from the 7th national communication to UNFCCC[31] using scenario with additional measures (WAM)
- the national measures defined in the 'with measures' (adopted measures) projection in the frame of NECD[32].

In the first step the fuel consumption was varied following the energy demand projection with socioeconomic drivers, in the second step the emissions were varied to meet the NECD emissions considering technological drivers.

5.1.1.2 Sosnowiec BAU projections

The Plan for a low-carbon economy was published in 2015 and updated[33] in 2016 and since then has been shaping city policy and strategies around energy and climate.

The plan lists goals for the city which include, by 2020:

- Reducing energy consumption to 3 840 GWh/year (a 5.6% reduction on 2013 consumption);
- Reducing CO_2 emissions to 1 517 ktCO2 (a 5.2% reduction on 2013 levels); and,
- Increasing renewable energy to 104.5 GWh/year (an increase of 12% on 2013 levels).

Two main actions involve building sector:

- Thermal renovations of buildings (with 196 811 MWh/year saving and about 11%);
- Modernization District Heating (with 10 855 MWh/year saving and about 1%).

These reductions have been added to national reductions discussed before.

[31] The Republic of Poland, Seventh National Communication and Third Biennial Report Under the United Nations Framework Convention on Climate Change
[32] EEA Eionet, Reporting Obligations Database (ROD), Deliveries for National Emission Ceiling Directive (NECD) - Projected emissions by aggregated NFR sectors
[33] Kompleksowy plan gospodarki niskoemisyjnej dla miasta Sosnowiec, Aktualizacja 2016

5.1.1.3 Projection drivers

Socio-economic drivers' definition is reported in Table 13 while technologic drivers' definition is reported in Table 14.

For drivers coming from EU NEC "with measures" data, as it's impossible to derive from available information the split between socio-economic measures, such as for example fuel consumptions reductions, and technological measures, such as for example advanced combustion technology, all the measures are valuated as technological. The NEC projections for residential & commercial are higher that emissions resulting from application of measures from UNFCCC NC. No more reductions are introduced other than UNFCCC NC ones. For industry the drivers introduced are reported in Table 14 from NEC.

Table 13 – Sosnowiec: Socio-economic drivers used to project emissions in industrial, residential and commercial sector

Code	Name	Domain
SOS_B_DH_C	Sosnowiec BAU District heating- Hard Coal	all Sosnowiec Gminy
SOS_B_DH_NG	Sosnowiec BAU District heating- Natural gas	all Sosnowiec Gminy
SOS_B_DH_W	Sosnowiec BAU District heating- Solid biomass	all Sosnowiec Gminy
SOS_B_MDH	Sosnowiec BAU Modernisation District Heating.	all Sosnowiec Gminy
SOS_B_RC_C	Sosnowiec BAU Residential & Commercial - Hard Coal	all Sosnowiec Gminy
SOS_B_RC_G	Sosnowiec BAU Residential & Commercial - Gas/Diesel Oil	all Sosnowiec Gminy
SOS_B_RC_L	Sosnowiec BAU Residential & Commercial – LPG	all Sosnowiec Gminy
SOS_B_RC_NG	Sosnowiec BAU Residential & Commercial - Natural gas	all Sosnowiec Gminy
SOS_B_RC_W	Sosnowiec BAU Residential & Commercial - Solid biomass	all Sosnowiec Gminy
SOS_B_TRB	Sosnowiec BAU Thermal renovations of buildings	all Sosnowiec Gminy

Table 14 – Sosnowiec: Technological drivers used to project emissions in industrial, residential and commercial sector

Code	Name	Domain
SOS_NECI_NOx	Sosnowiec NEC Industry NOx	all Sosnowiec Gminy
SOS_NECI_PM	Sosnowiec NEC Industry PM	all Sosnowiec Gminy

5.1.2 Results

5.1.2.1 Industrial emissions

In Figure 35 the evolution of NOx emissions from main point sources is reported. The variation is evaluated as the average variation of industrial emissions in national projection.

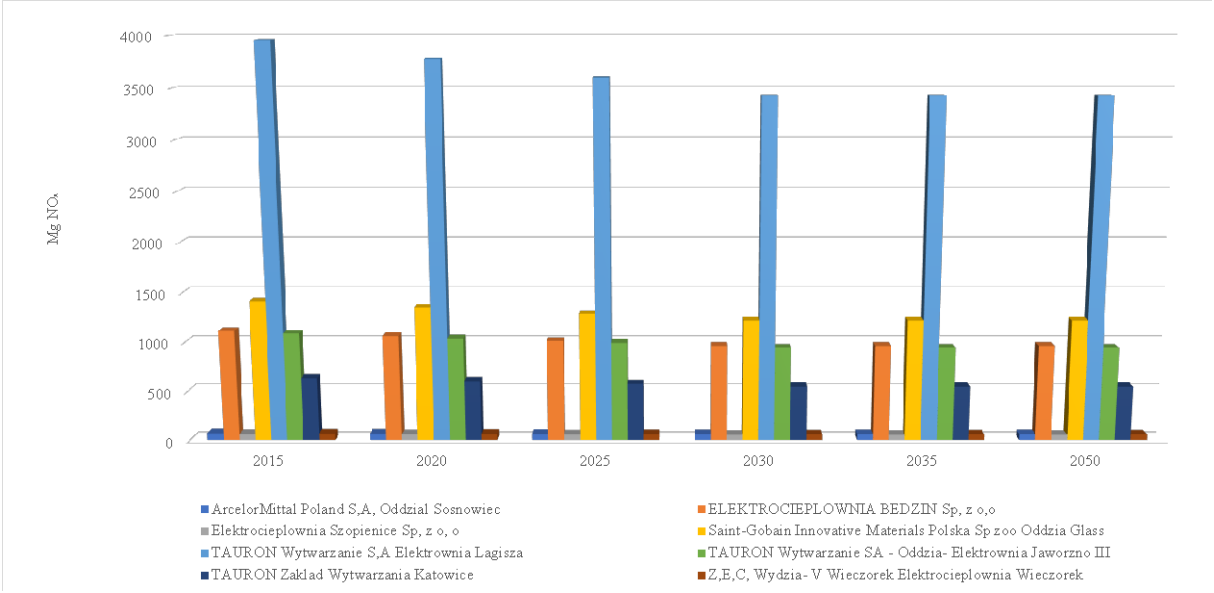

Figure 35 – Sosnowiec BAU Industrial main point sources NO_x emissions

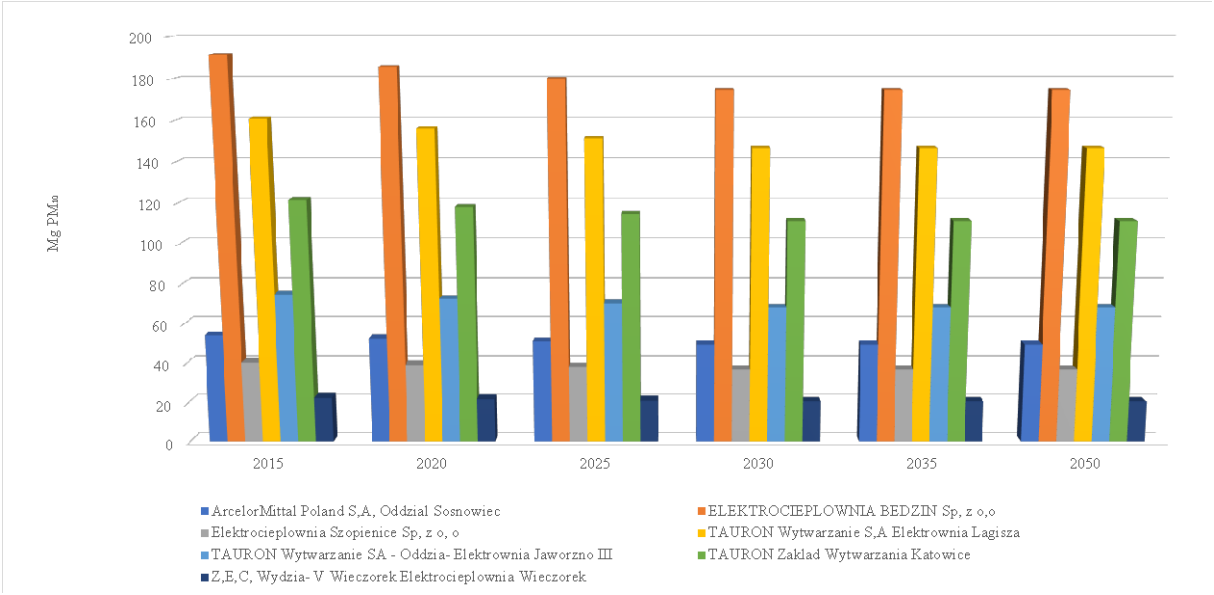

Figure 36 – Sosnowiec BAU Industrial main point sources PM_{10} emissions

5.1.2.2 Residential, commercial & institutional emissions

In Figure 37 for nitrogen oxides (NO_x) and in Figure 38 for suspended particles with diameter less than 10µ (PM_{10}) the evolutions of emissions in Sosnowiec are reported.

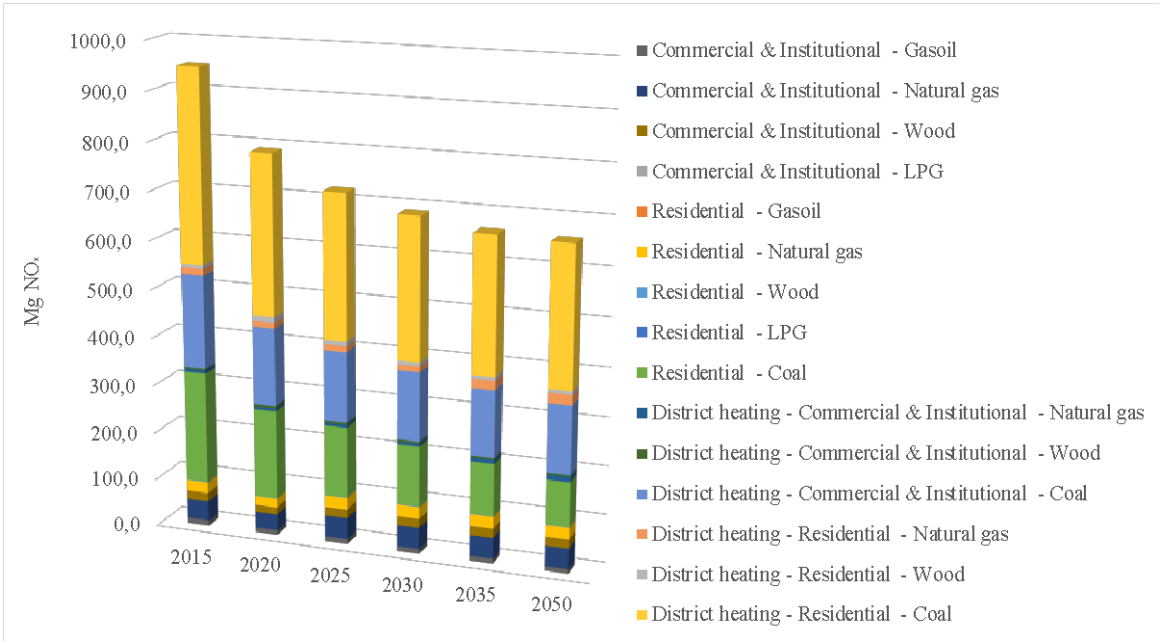

Figure 37 – Sosnowiec BAU total Residential, Commercial & Institutional NO_x emissions

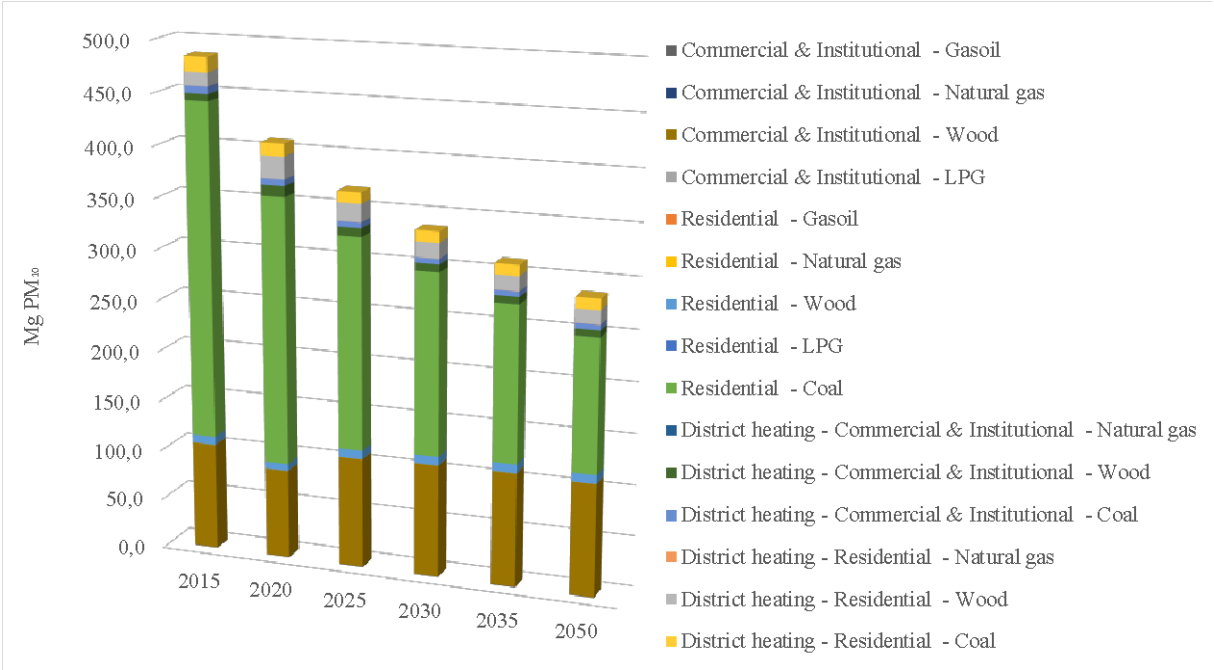

Figure 38 – Sosnowiec BAU Residential, Commercial & Institutional PM_{10} emissions

5.2 Scenario projections

Scenario projections take into consideration city level additional measures.

5.2.1 Modelling

Scenarios from the Stakeholder dialog workshop (SWD) includes the measures relating of Table 11 relating to the IRCI sector (the codes are defined in this report).

Table 15 – Sosnowiec: Measures coming from the Stakeholder dialog workshop

Code	Description	Scenario
SOS_CoalB20	Sosnowiec Ban coal on Residential & Commercial from 2020	High
SOS_CoalPB25	Sosnowiec Partial Ban coal on Residential & Commercial	Low
SOS_I-50%25	Sosnowiec Reduce industrial emissions by 50% on 2025	High
SOS_I-25%25	Sosnowiec Reduce industrial emissions by 25% on 2025	Low
SOS_RH75%NOx	Sosnowiec Replace 75% >10 years old by 2025 NOx	Low
SOS_RHallNOx	Sosnowiec Replace all >10 years old by 2025 NOx	High
SOS_RH75%PM	Sosnowiec Replace 75% >10 years old by 2025 PM	Low
SOS_RHallPM	Sosnowiec Replace all >10 years old by 2025 PM	High

The following assumptions apply to the simulations:

- Regarding the measures on Ban coal on Residential & Commercial:
  - we assume that the measures don't apply to heat generated by district heating;
  - for the partial ban, we assume the ban in the areas of (2445 households), follo (1446), (1002) and consider 10% of total households.
- Regarding measures to replace 75% or 100% of heating system with more that 10 years old we:
  - apply this measure to wood stoves and fireplaces, where the measure produces a strong reduction of PM emissions (wood stoves and fireplaces);
  - we take into consideration the available data about age of appliances[34] and assume 75% of stoves and 50% of fireplaces have more than 10 years of life;
- Regarding measures to reduce industrial emissions the Scenarios include the only plant into Sosnowiec Wojewodztwa while the emissions from plants on surrounding Wojewodztwa are kept constant.

5.2.2 Results

5.2.2.1 Industrial emissions

In Figure 39 for nitrogen oxides (NO_x) and and suspended particles with diameter less than 10µ (PM_{10}) the trends of emissions are reported for the only industrial plant inside the Sosnowiec Wojewodztwa.

[34] Central Statistical Office, Energy consumption in households in 2012

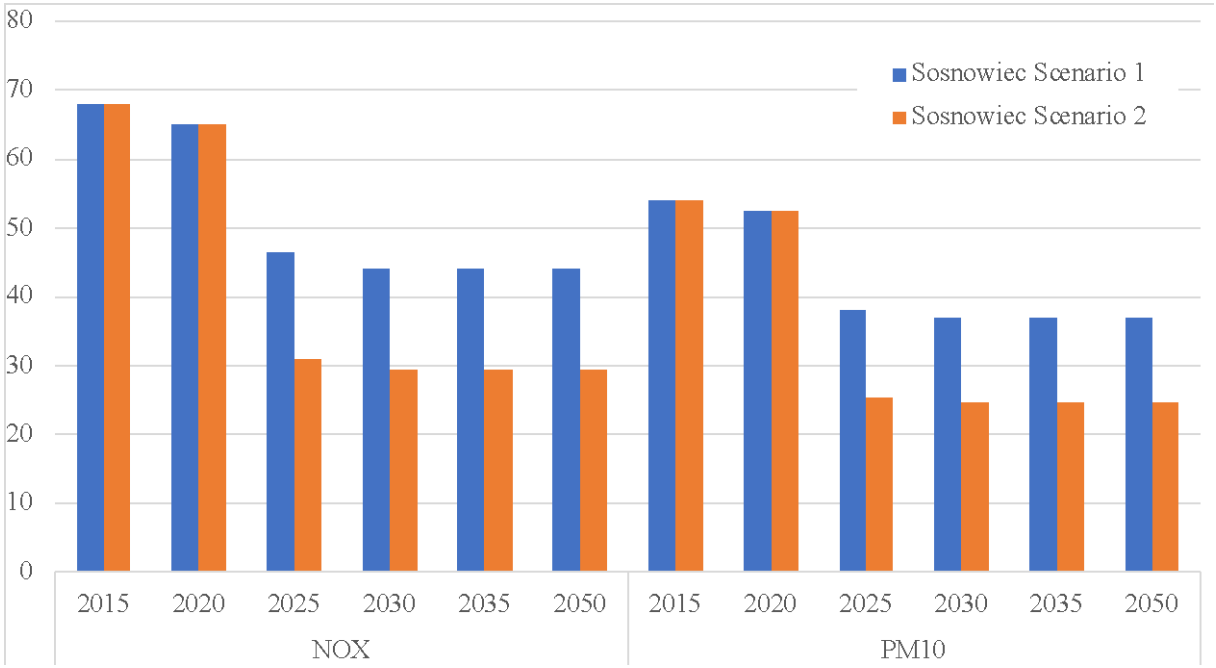

Figure 39 – Sosnowiec Scenario 1 (low) & 2 (high): Industrial point sources NO_x and PM_{10} emissions inside the municipality

*5.2.2.2 **Residential, commercial & institutional emissions***

In Figure 40 for nitrogen oxides (NO_x) and Figure 41 for suspended particles with diameter less than 10µ (PM_{10}) the trends of emissions are reported for scenario 1 ("low"); in Figure 42 for nitrogen oxides (NO_x) and Figure 43 for suspended particles with diameter less than 10µ (PM_{10}) the trends of emissions are reported for scenario 2 ("high"). The Scenario include only the Sosnowiec Wojewodztwa while the emissions from surrounding Wojewodztwa are kept constant.

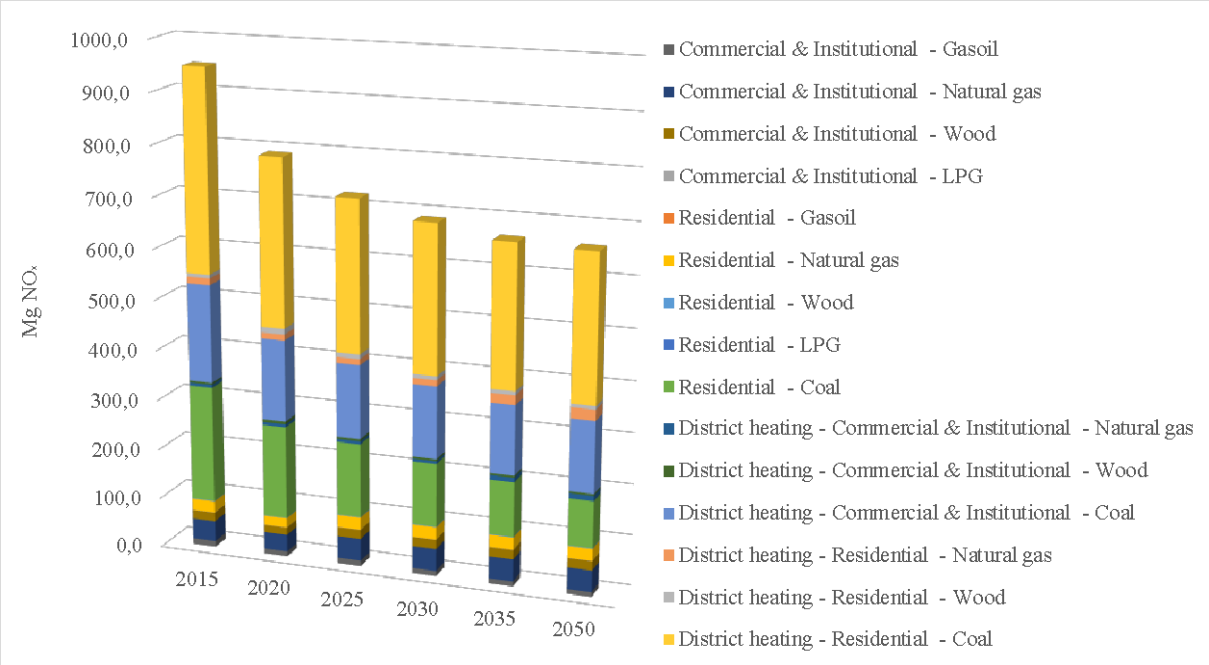

Figure 40 – Sosnowiec Scenario 1 (low): Residential, Commercial & Institutional NO_x emissions – all sectors and fuels

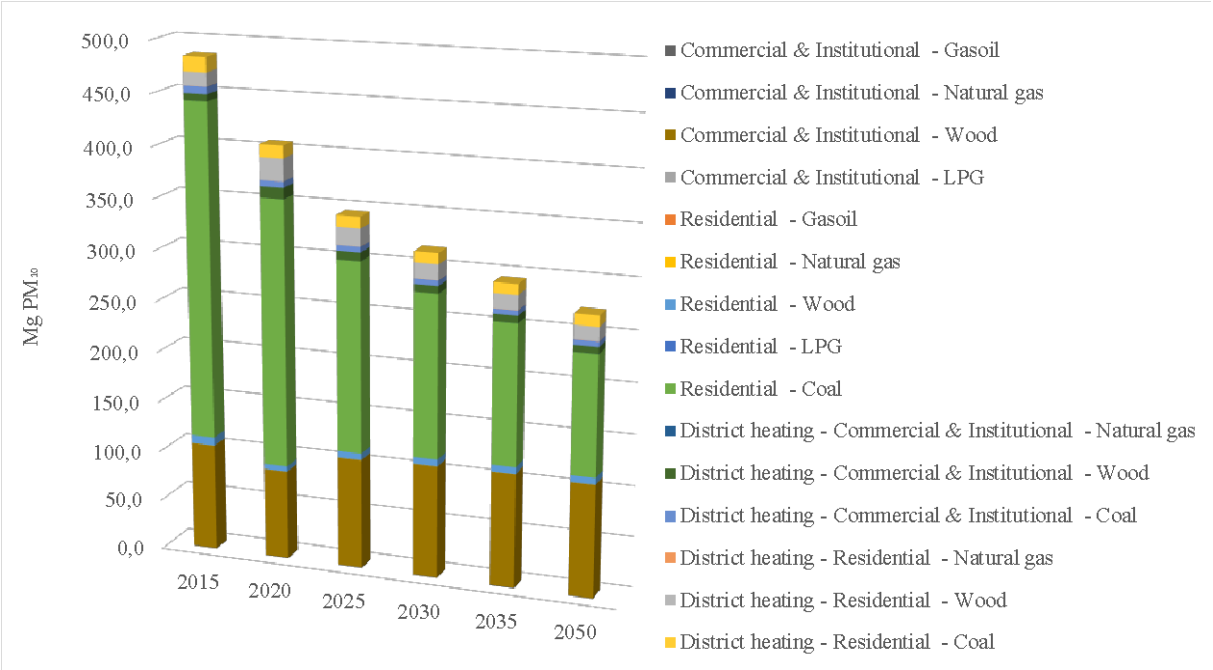

Figure 41 – Sosnowiec Scenario 1 (low): (renewables & efficiency): Residential, Commercial & Institutional PM_{10} emissions – all sectors and fuels

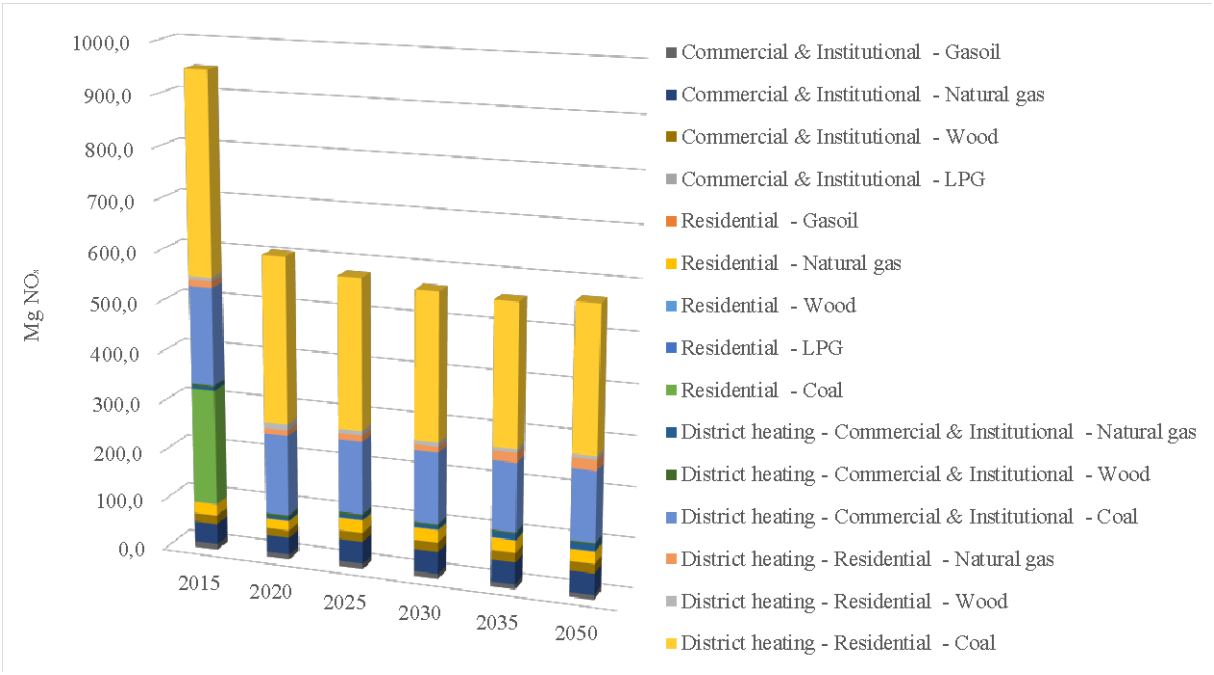

Figure 42 – Sosnowiec Scenario 2 (high): Residential, Commercial & Institutional NO_x emissions – all sectors and fuels

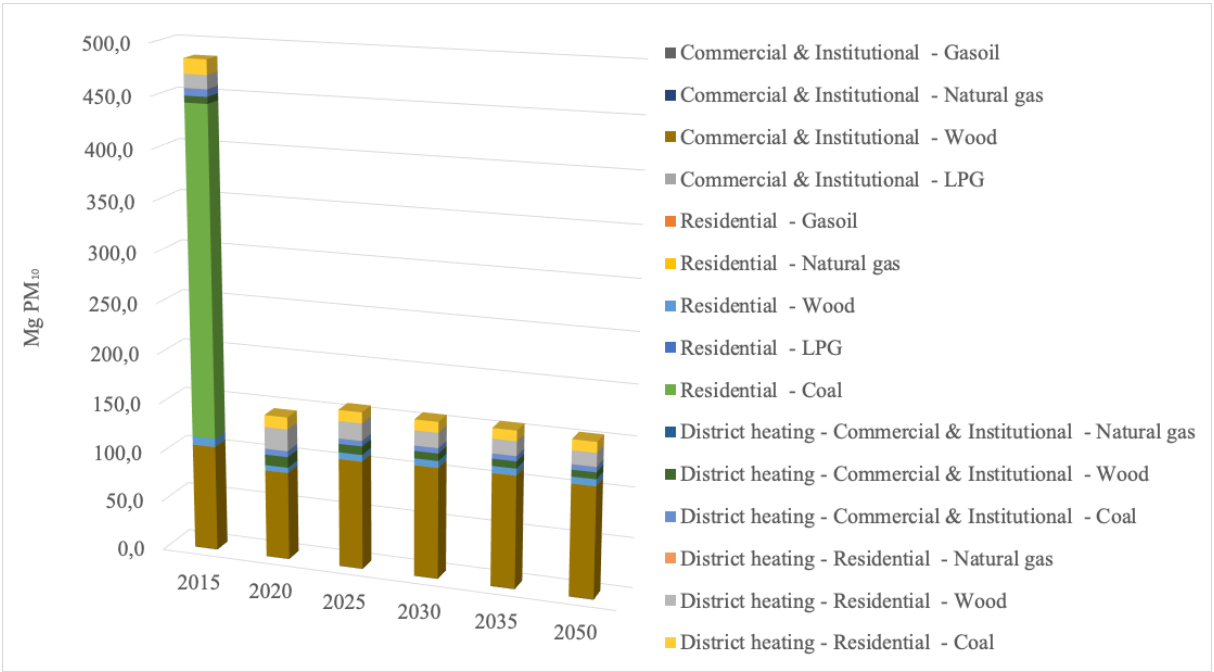

Figure 43 – Sosnowiec Scenario 2 (high): (renewables & efficiency): Residential, Commercial & Institutional PM_{10} emissions – all sectors and fuels

5.2.3 BAU and Scenarios comparison

5.2.3.1 ***Industrial emissions***

In Figure 44 for nitrogen oxides (NO_x) and Figure 45 for suspended particles with diameter less than 10μ (PM_{10}) the trends of emissions in the different scenarios are reported.

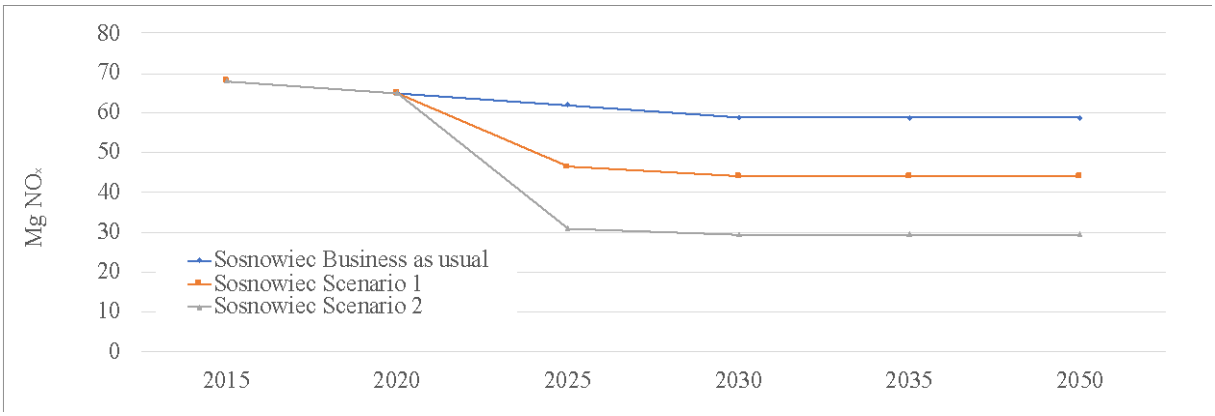

Figure 44 – Sosnowiec Scenarios: Industrial sources NO_x emissions

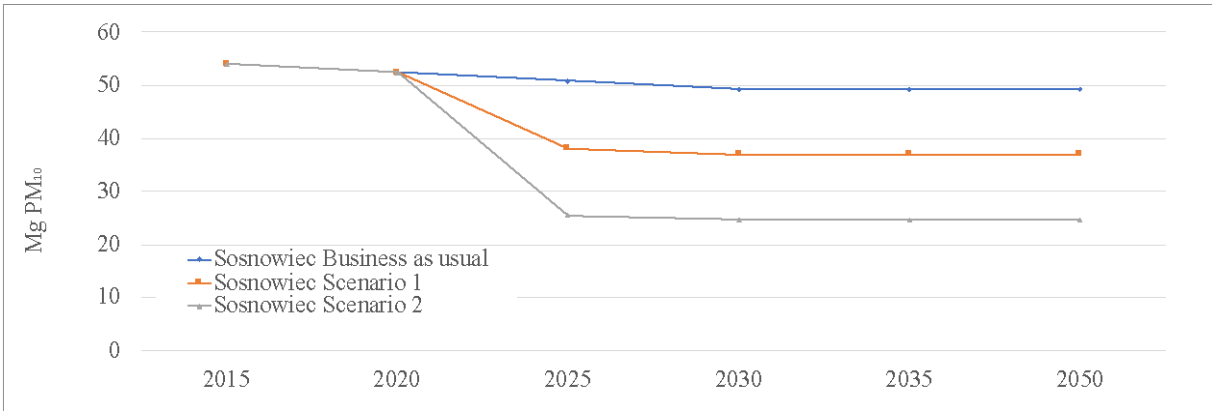

Figure 45 – Sosnowiec Scenarios: Industrial sources PM_{10} emissions

5.2.3.2 ***Residential, Commercial, Institutional emissions***

In Figure 46 for nitrogen oxides (NO_x) and in Figure 47 for suspended particles with diameter less than 10μ (PM_{10}) the comparison of the trends of emissions are reported for the different scenarios.

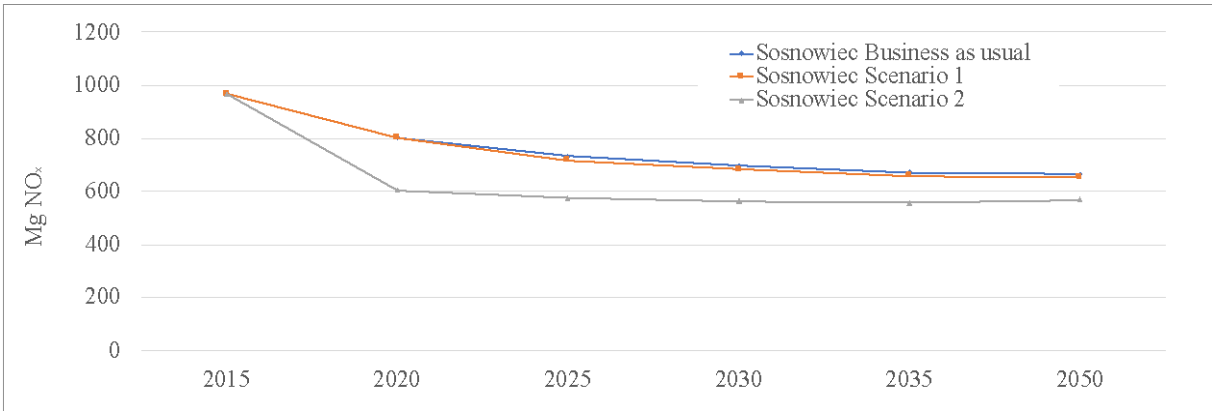

Figure 46 – Sosnowiec BAU & Scenarios comparison: Residential, Commercial, Institutional NO_x emissions – all sectors and fuels

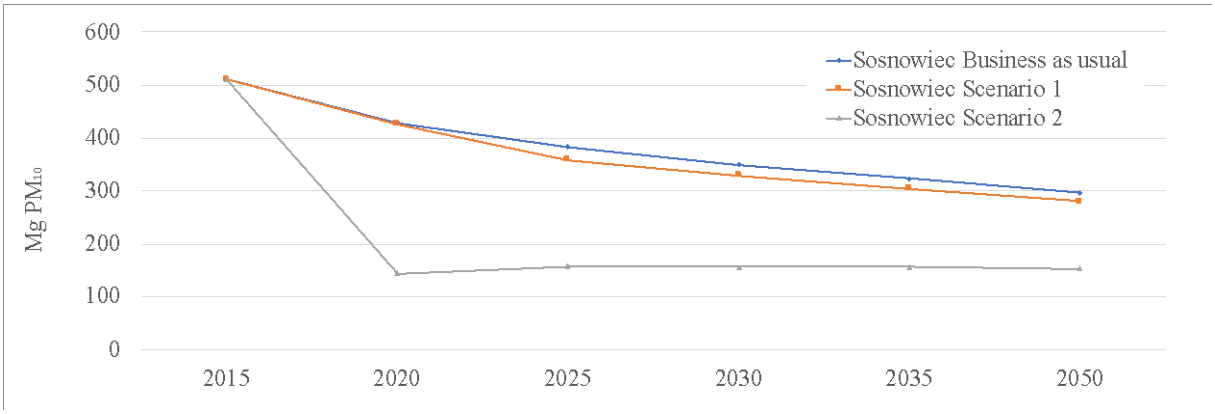

Figure 47 – Sosnowiec BAU & Scenarios comparison: Residential, Commercial & Institutional PM_{10} emissions – all sectors and fuels

5.3 Unified Policy Scenario

5.3.1 Modelling

The final Unified Policy Scenario includes the measures of Table 16 relating to the IRCI sector (the codes are defined in this report).

Table 16 – Sosnowiec: Measures for the Unified Policy Scenario

Code	Description
SOS_CoalPB25	Sosnowiec Partial Ban coal on Residential & Commercial
SOS_I-25%25	Sosnowiec Reduce industrial emissions by 25% on 2025
SOS_RHallNOx	Sosnowiec Replace all >10 years old by 2025 NOx
SOS_RHallPM	Sosnowiec Replace all >10 years old by 2025 PM

5.3.2 Results

In Figure 48 for nitrogen oxides (NO_x) and Figure 49 for suspended particles with diameter less than 10μ (PM_{10}) the trends of emissions are reported for Unified Policy Scenario.

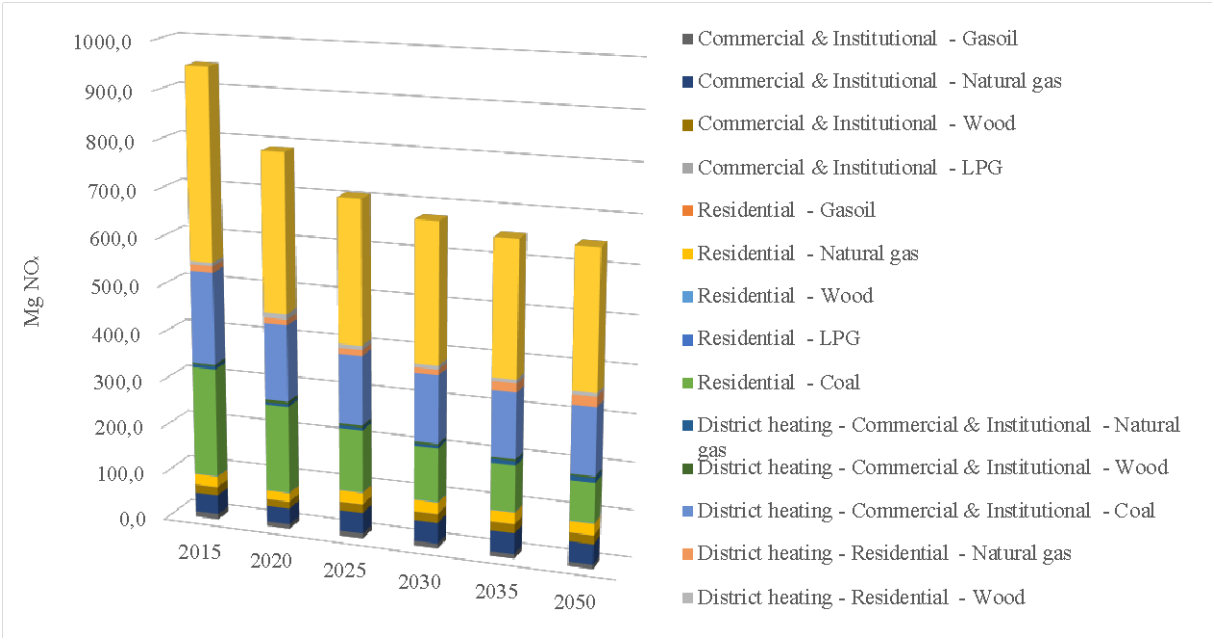

Figure 48 – Sosnowiec Unified Policy Scenario: Residential, Commercial & Institutional NO_x emissions – all sectors and fuels

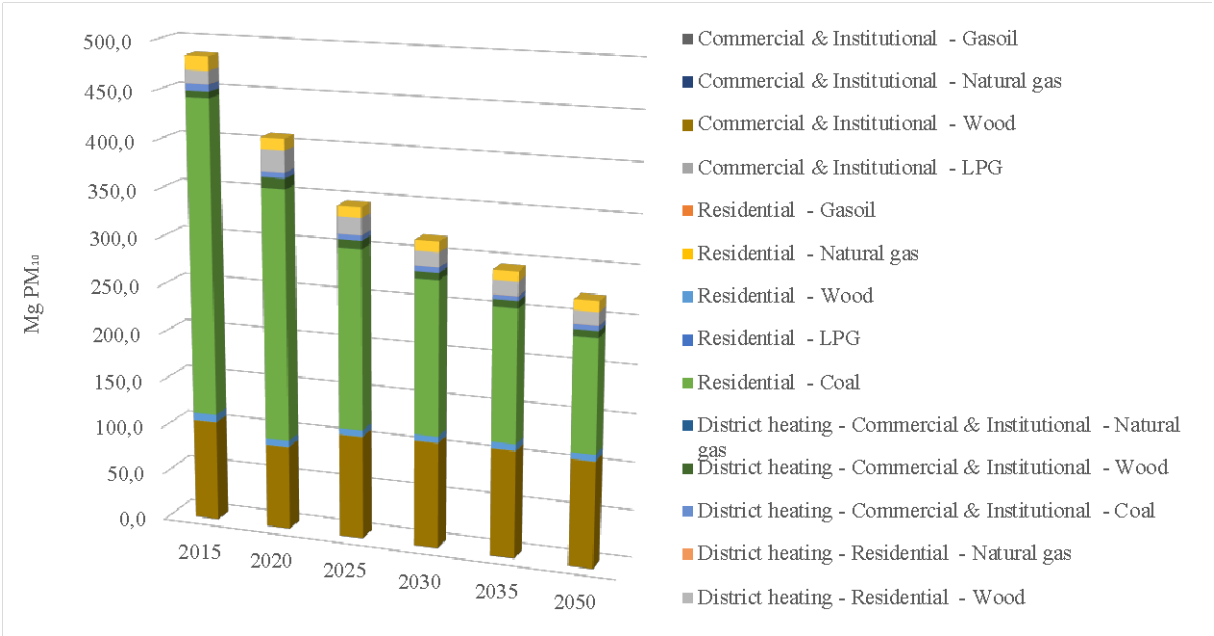

Figure 49 – Sosnowiec Unified Policy Scenario: Residential, Commercial & Institutional PM_{10} emissions – all sectors and fuels

5.3.3 BAU and Unified Policy Scenario comparison

5.3.3.1 ***Industrial emissions***

In Figure 50 for nitrogen oxides (NO_x) and Figure 51 for suspended particles with diameter less than 10μ (PM_{10}) the trends of emissions in the different scenarios are reported.

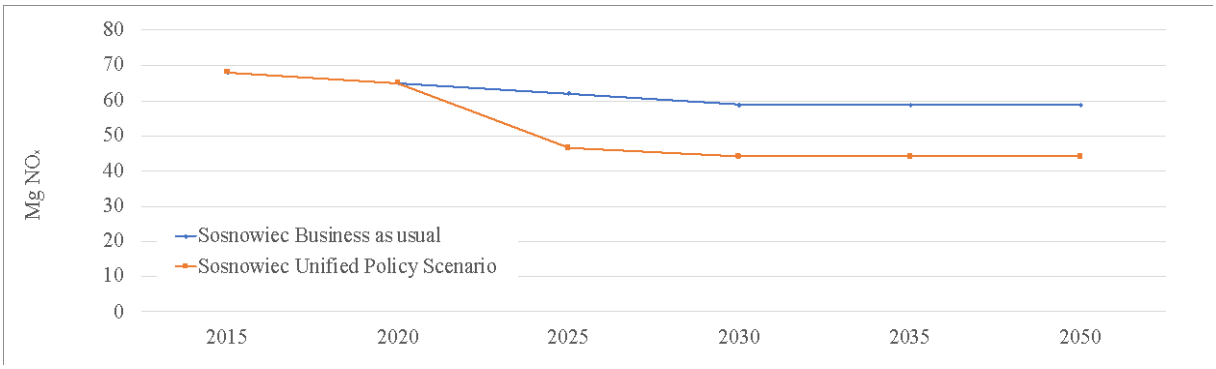

Figure 50 – Sosnowiec BAU & Unified Policy Scenarios comparison: Industrial sources NO_x emissions

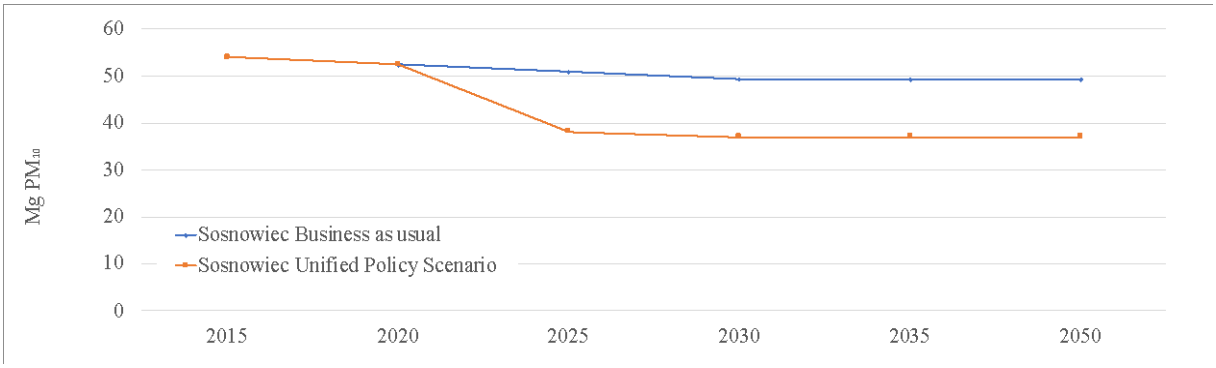

Figure 51 – Sosnowiec BAU & Unified Policy Scenarios comparison: Industrial sources PM_{10} emissions

5.3.3.2 ***Residential, Commercial, Institutional emissions***

In Figure 52 for nitrogen oxides (NO_x) and in Figure 53 for suspended particles with diameter less than 10μ (PM_{10}) the comparison of the trends of emissions are reported for Business As Usual (BAU) and Unified Policy (UPS) scenarios.

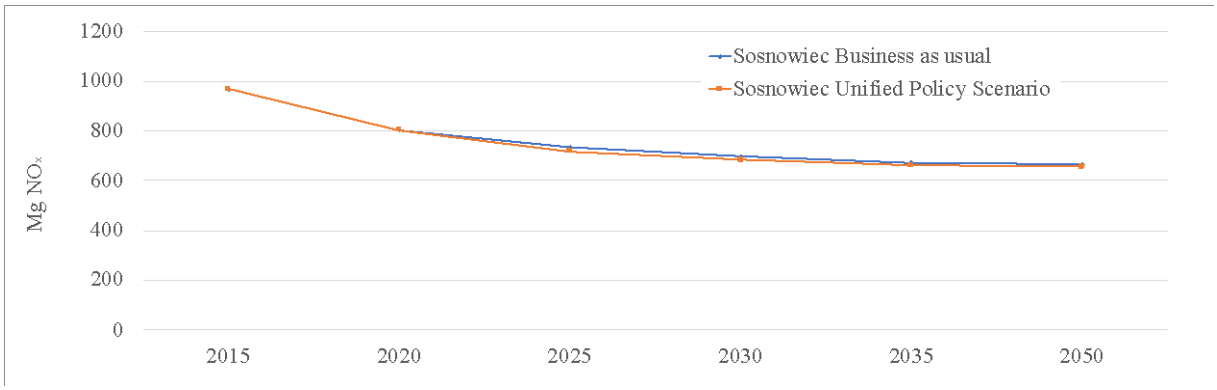

Figure 52 – Sosnowiec BAU & Unified Policy Scenarios comparison: Residential, Commercial & Institutional NO_x emissions – all sectors and fuels

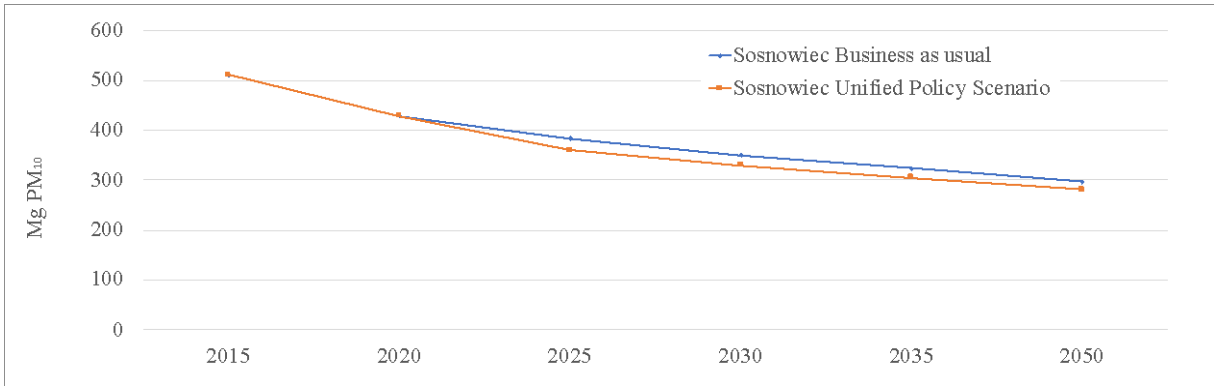

Figure 53 – Sosnowiec BAU & Unified Policy Scenarios comparison: Residential, Commercial & Institutional PM_{10} emissions – all sectors and fuel

6 LJUBLJIANA

6.1 Business As Usual projections

Business as Usual (BAU) scenario takes into consideration national and city level measures already defined/decided.

6.1.1 Modelling

6.1.1.1 National BAU Projections

National BAU scenario evaluates national emission reduction starting from Slovenia official projections.

The scenario was built in two steps using:

- the projections of greenhouse gas emissions and energy demand from the 7th national communication to UNFCCC[35] using scenario with additional measures (WAM)
- the national measures defined in the 'with measures' (adopted measures) projection in the frame of NECD[36] and in the Integrated National Energy and Climate Plan for Slovenia[37].

In the first step the fuel consumption was varied following the energy demand projection with socioeconomic drivers, in the second step the emissions were varied to meet the NECD emissions considering technological drivers.

On 29 October 2017, the Government adopted the Long-Term Strategy for Mobilizing Investments in the Energy Renovation of Buildings (DSEPS), determining the important objectives of reducing energy use in buildings. The vision, defined in DSEPS, is to achieve carbon-neutral energy use in buildings by 2050; Slovenia will achieve this by making considerable improvements in energy performance and by increasing the use of renewable energy sources in buildings. This will, in turn, significantly reduce emissions of other harmful substances into the atmosphere.

6.1.1.2 Ljubljana BAU projections

The Decree on the air quality plan in the area of the City of Ljubljana[38] in 2017 sets out key measures to tackle air pollution in Ljubljana. It aims at reducing the pollution of particulate matter to below limit values, to ensure compliance with the EU Ambient Air Quality Directive (2008/50/EC). It provides a detailed set of measures to reduce PM_{10} pollution and foresees a program to analyse the causes of pollution and analyse the effects of the implemented measures[39].

The following important actions are foresee to promote efficient use of energy and renewable energy sources:

- Increasing energy consumption, energy efficiency and utilization, and expanding district heating systems;
- Supply of district heating system from wood biomass;
- Increasing the consumption and utilization and expansion of natural gas networks by connecting the facilities to the gas network;
- Further promotion of the replacement of existing combustion plants with more appropriate combustion plants, more appropriate heating methods and other ways of

[35] Republic of Slovenia, Ministry of the Environment and Spatial Planning 7th National Communication & 3rd Biennial Report from Slovenia under the United Nations Framework Convention on Climate Change, March 2018
[36] EEA Eionet, Reporting Obligations Database (ROD), Deliveries for National Emission Ceiling Directive (NECD) - Projected emissions by aggregated NFR sectors
[37] Integrated National Energy and Climate Plan for Slovenia, December 2018
[38] Odlok o načrtu za kakovost zraka na območju Mestne občine Ljubljana
[39] Odlok o načrtu za kakovost zraka na območju Mestne občine Ljubljana. Priloga 2: Podrobnejši program ukrepov na območju Mestne občine Ljubljana

heating with renewable energy sources and resources that ensure efficient use of energy;
- Advising the public on the proper use of small combustion plants and measuring the moisture content of wood biomass;
- Education and creation of a special website for the intelligent use of wood biomass as a fuel in small combustion plants;
- Conducting more rigorous monitoring of the burning of waste in small combustion plants;
- Ensuring the quality of wood fuels in small combustion plants via a common online platform;
- Establishment and operation of a mobile demonstration center for burning in small combustion plants
- Rehabilitation of Slovenian forests and the use of still usefull biomass as solid fuel in boiler rooms in district heating;
- Management of sudden large surpluses of wood biomass after the impacts and outbreaks of forest diseases;
- Use of wood residues for heating in collective combustion plants;
- Local energy concept;
- Informing and encouraging the reduction of heat losses of buildings;
- Reservation of areas for low-energy construction of massive wooden buildings, heated with renewable energy sources, designed and built up taking into account the values and criteria in the city environment, identifiable identities - traditional architecture;
- Exact evidence of combustion plants;
- Energy recovery of municipal property.

Taking into account the importance of Ljubljana in the general context of Slovenja and by virtue of the observation that governance structure of air quality and carbon policies is centralized in Slovenia, we assume the goal of national planning in the residential and commercial sector also for the city.

6.1.1.3 Projection drivers

Socio-economic drivers' definition is reported in Table 17 while technologic drivers' definition is reported in Table 18.

For drivers coming from EU NEC "with measures" data, as it's impossible to derive from available information the split between socio-economic measures, such as for example fuel consumptions reductions, and technological measures, such as for example advanced combustion technology, all the measures are valuated as technological.

Table 17 – Ljubljiana: Socio-economic drivers used to project emissions in industrial, residential and commercial sector

Code	Name	Domain
LJU_B_R_L	Ljubljiana BAU Residential - Liquid Fuels	all Naselje
LJU_B_R_G	Ljubljiana BAU Residential - Natural gas	all Naselje
LJU_B_R_W	Ljubljiana BAU Residential – Wood	all Naselje

Table 17 – Ljubljiana: Socio-economic drivers used to project emissions in industrial, residential and commercial sector

Code	Name	Domain
LJU_B_C_L	Ljubljiana BAU Commercial - Liquid Fuels	all Naselje
LJU_B_C_G	Ljubljiana BAU Commercial - Natural gas	all Naselje
LJU_B_C_W	Ljubljiana BAU Commercial – Wood	all Naselje

Table 18 – Ljubljiana: Technological drivers used to project emissions in industrial, residential and commercial sector

Code	Name	Domain
LJU_NECI_NOx	Ljubljiana NEC Industry NOx	all Naselje
LJU_NECI_PM	Ljubljiana NEC Industry PM	all Naselje
LJU_NECB_NOx	Ljubljiana NEC Building NOx	all Naselje
LJU_NECB_PM	Ljubljiana NEC Building PM	all Naselje

6.1.2 Results

6.1.2.1 Industrial emissions

In Figure 54 the evolution of NOx emissions from industrial sources is reported. The variation is evaluated as the average variation of industrial emissions in NEC national projection.

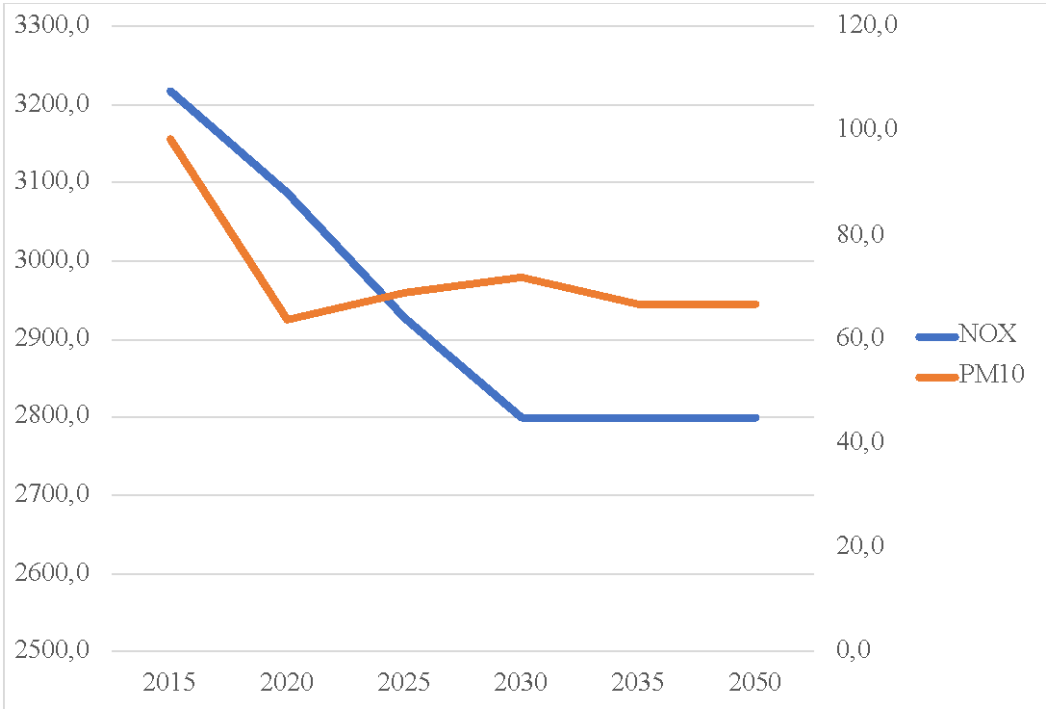

Figure 54 – Ljubljiana BAU Industrial sources NO_x and PM_{10} emissions (Mg)

6.1.2.2 Residential, commercial & institutional emissions

In Figure 55 for nitrogen oxides (NO_x) and in Figure 56 for suspended particles with diameter less than 10μ (PM_{10}) the evolutions of emissions in Ljubljiana are reported.

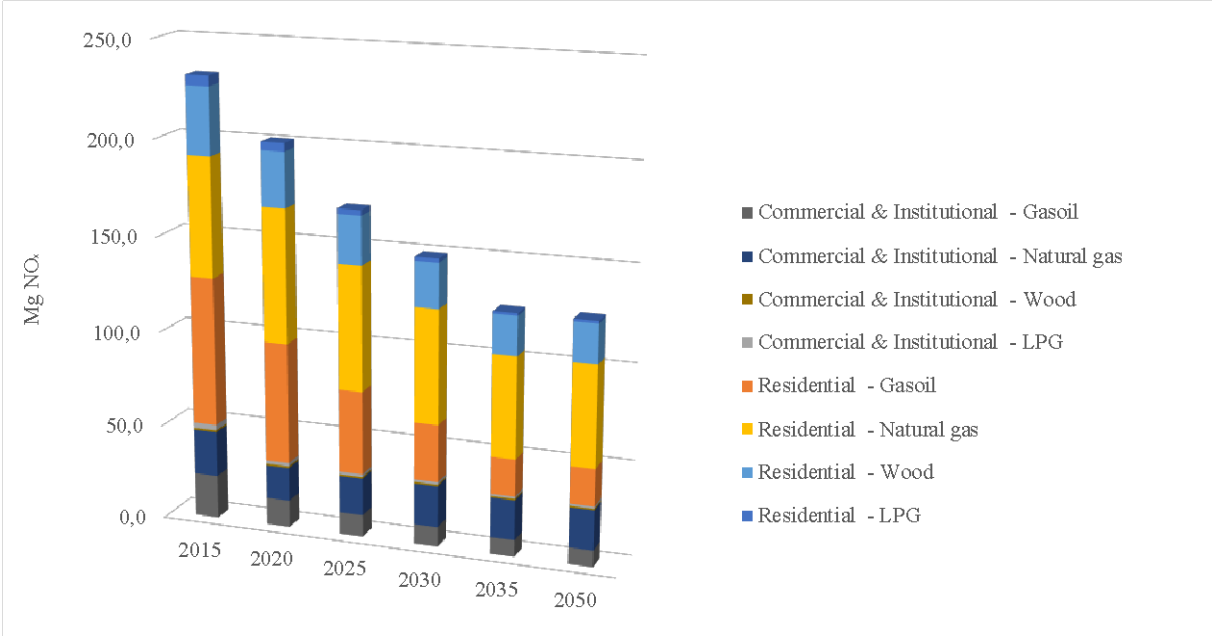

Figure 55 – Ljubljiana BAU total Residential, Commercial & Institutional NO_x emissions

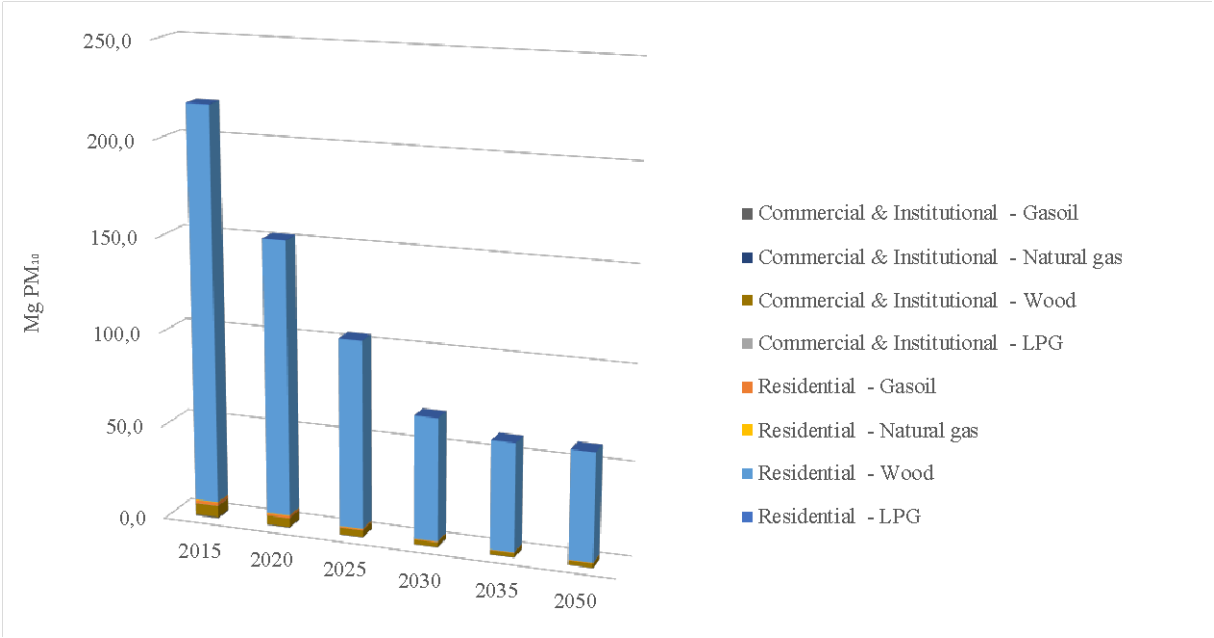

Figure 56 – Ljubljiana BAU Residential, Commercial & Institutional PM_{10} emissions

6.2 Scenario projections

Scenarios from the Stakeholder dialog workshop (SWD) includes no measures relating to the IRCI sector.

6.3 Unified Policy Scenario

Unified Policy Scenarios includes no measures relating to the IRCI sector.

7 LIGURIA REGION (GENOA AREA)

7.1 Business As Usual projections

Business as Usual (BAU) scenario takes into consideration national and city level measures already defined/decided.

7.1.1 Modelling

7.1.1.1 National BAU Projections

National BAU scenario evaluates national emission reduction starting from Italy official projections.

The scenario was built in two steps using:

- the projections of greenhouse gas emissions and energy demand from the 7th national communication to UNFCCC[40] using scenario with additional measures (WAM)
- the national measures defined in the 'with measures' (adopted measures) projection in the frame of NECD[41];
- the new "Proposal for an integrated national energy and climate plan" of 31 december 2018[42].

In the first step the fuel consumption was varied following the energy demand projection with socioeconomic drivers, in the second step the emissions were varied to meet the NECD emissions considering technological drivers.

7.1.1.2 Liguria Region (Genoa Area) BAU projections

The most important event in the area is the definitive shut-down of Genoa Coal Thermal power plant.

In the residential and commercial sector, due to the structure of the city, the national goal for energy saving is already very ambitious and there are no further objectives at local level. For

[40] Ministry for the Environment, Land and Sea, Seventh National Communication under the UN Framework Convention on Climate Change. Italy, December 2017
[41] EEA Eionet, Reporting Obligations Database (ROD), Deliveries for National Emission Ceiling Directive (NECD) - Projected emissions by aggregated NFR sectors, 14 March 2019
[42] Ministero dello Sviluppo Economico, Ministero dell'Ambiente e della Tutela del Territorio e del Mare, Ministero delle Infrastrutture e dei Trasporti, Proposta di piano nazionale integrato per l'energia e il clima, 31/12/2018

industrial emissions the national projections for NO_x are too high and local emissions are kept constant while the PM_{10} emissions are kept constant as the national ones.

7.1.1.3 Projection drivers

Socio-economic drivers' definition is reported in Table 19 while technologic drivers' definition is reported in Table 20.

For drivers coming from EU NEC "with measures" data, as it's impossible to derive from available information the split between socio-economic measures, such as for example fuel consumptions reductions, and technological measures, such as for example advanced combustion technology, all the measures are valuated as technological. The NEC reduction are higher that emissions resulting from application of measures of UNFCCC NC. No more reductions are introduced other than NEC ones.

Table 19 – Liguria Region (Genoa Area): Socio-economic drivers used to project emissions in industrial, residential and commercial sector

Code	Name	Domain
PSClose16	Closure of Plant from 2016	Centrale termoelettrica di Genova (Genoa power plant)

Table 20 – Liguria Region (Genoa Area): Technological drivers used to project emissions in industrial, residential and commercial sector

Code	Name	Domain
SOS_NECB_NOx	Liguria NEC Building NOx	all Genova sezioni censuarie
SOS_NECB_PM	Liguria NEC Building PM	all Genova sezioni censuarie

7.1.2 Results

7.1.2.1 Industrial emissions

In Figure 57 the evolution of NOx and PM_{10} emissions from industrial sources is reported. The only significative modification comes from the definitive shut-down of Genoa Coal Thermal power plant.

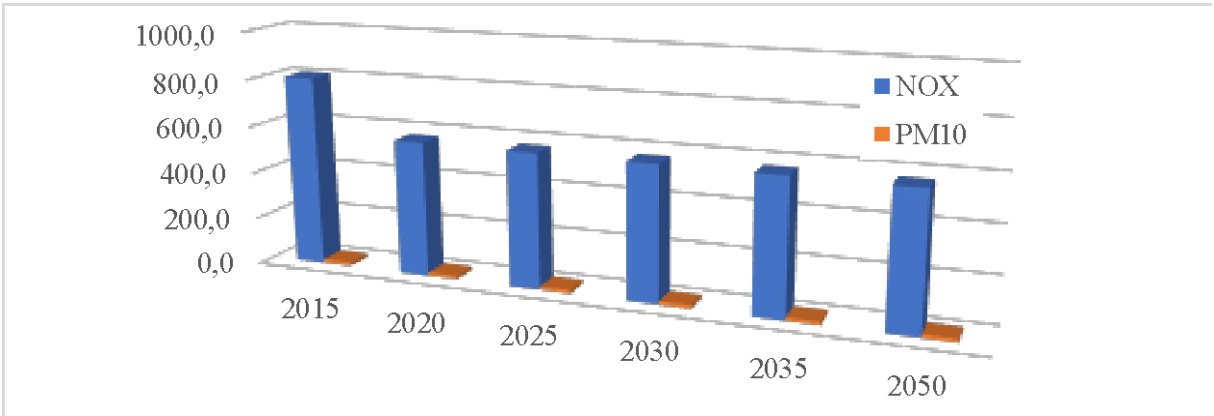

Figure 57 – Liguria Region (Genoa Area) BAU Industrial main point sources NO_x emissions

7.1.2.2 Residential, commercial & institutional emissions

In Figure 58 for nitrogen oxides (NO_x) and in Figure 59 for suspended particles with diameter less than 10μ (PM_{10}) the evolutions of emissions in Genoa Area of Liguria Region are reported.

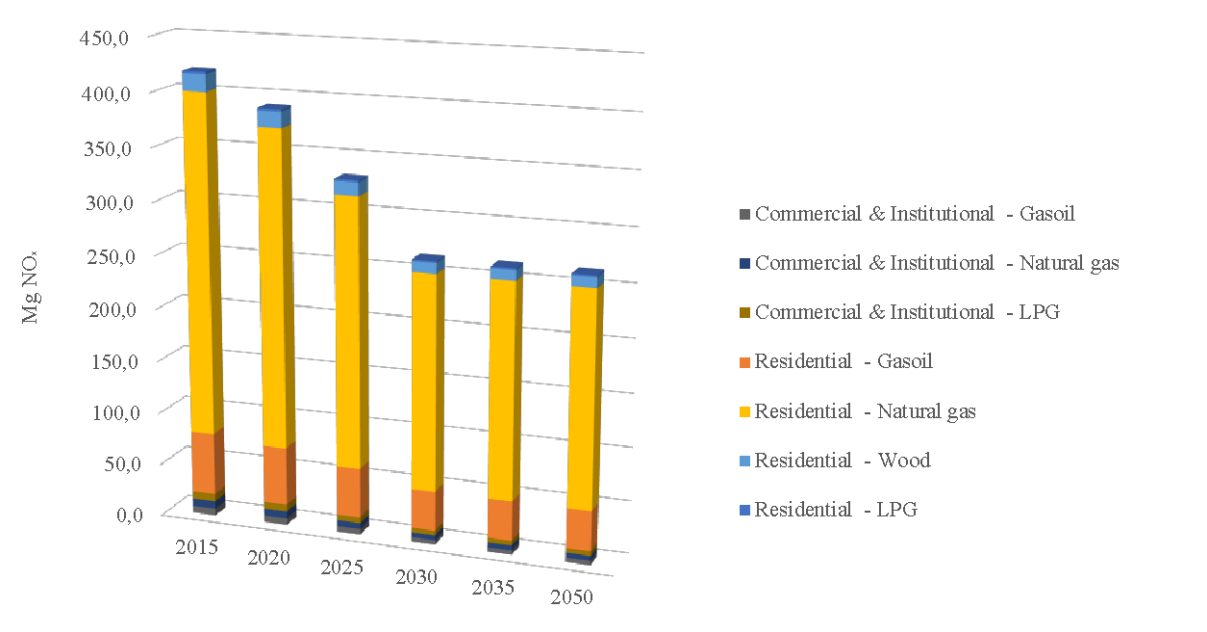

Figure 58 – Liguria Region (Genoa Area) BAU total Residential, Commercial & Institutional NO_x emissions

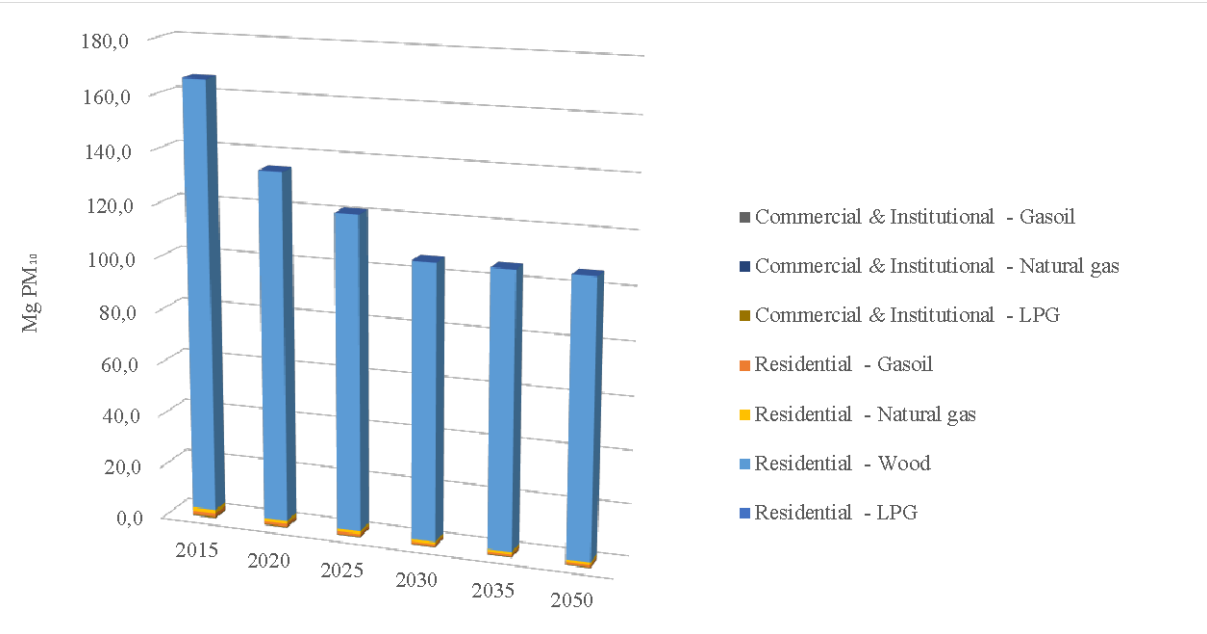

Figure 59 – Liguria Region (Genoa Area) BAU Residential, Commercial & Institutional PM_{10}

emissions

7.2 Scenario projections

Scenarios from the Stakeholder dialog workshop (SWD) includes no measures relating to the IRCI sector.

7.3 Unified Policy Scenario

Unified Policy Scenarios includes no measures relating to the IRCI sector.

8 AVEIRO

8.1 Business As Usual projections

Business as Usual (BAU) scenario takes into consideration national and city level measures already defined/decided.

8.1.1 Modelling

8.1.1.1 National BAU Projections

National BAU scenario evaluates national emission reduction starting from Portugal official projections.

The scenario was built in two steps using:

- the projections of greenhouse gas emissions and energy demand from the 7th national communication to UNFCCC[43] using scenario with additional measures (WAM);
- the national measures defined in the 'with measures' (adopted measures) projection in the frame of NECD[44].

In the first step the fuel consumption was varied following the energy demand projection with socioeconomic drivers, in the second step the emissions were varied to meet the NECD emissions considering technological drivers.

8.1.1.2 Aveiro projections

Regarding industrial emissions from main point source, at the Aveiro Navigator Company Industrial Complex (Fabrica de Cacia)[45], a sleeve filters system was planned to be fitted on

[43] Portuguese Environment Agency, 7th National Communication to the United Nations Framework Convention on Climate Change
[44] National emission ceilings (NEC Directive 2001/81/EC), 2015 submission on NECD, Annex IV Projections reporting
[45] The Navigator Company, Sustainability Report 2018

the biomass boiler in the first quarter of 2019 with reduction in particle emissions by 2020 of 90% on limit value and an effective reduction of 77% on 2015 PM_{10} emissions.
The Navigator Company also has a commitment to minimizing the use of fossil fuels in industrial processes by 2035, leading the Company to be a Carbon Neutral Company by 2035.

Regarding Residential, Commercial and Institutional sources, the measures included are only the national ones, as the measures adopted by the municipalities of the Aveiro Region for residential and commercial sectors in the frame of Covenant of Mayors, such as the replacement of street light bulbs for LED lighting and the installation of PV panels in public buildings (e.g. municipal swimming pools), don't seems to give supplemental reduction in addition to national measures.

8.1.1.3 Projection drivers

Point sources drivers' definition is reported in Table 21 while technological drivers' definition is reported in Table 22.

Table 21 – Aveiro: Point source technological drivers used to project emissions in industrial, residential and commercial sector

Code	Name	Domain
SFS	Sleeve Filters System	Fábrica de Cacia (Portucel)

For drivers coming from EU NEC "with measures" data, as it's impossible to derive from available information the split between socio-economic measures, such as for example fuel consumptions reductions, and technological measures, such as for example advanced combustion technology, all the measures are valuated as technological. As the NEC projections are lower than emissions resulting from application of measures of UNFCCC NC ones and there is no specification about reductions by fuel in UNFCCC NC only NEC measures are taken into consideration.

Table 22 – Aveiro: Technological drivers used to project emissions in industrial, residential and commercial sector

Code	Name	Domain
AVE_NECB_NOx	Aveiro NEC Building NOx	all Aveiro Freguesia
AVE_NECB_PM	Aveiro NEC Building PM	all Aveiro Freguesia
AVE_NECI_NOx	Aveiro NEC Industry NOx	all Aveiro Freguesia
AVE_NECI_PM	Aveiro NEC Industry PM	all Aveiro Freguesia

8.1.2 Results

8.1.2.1 Industrial emissions

In Figure 61 for NO_x and PM_{10} emissions from industrial sources are reported.

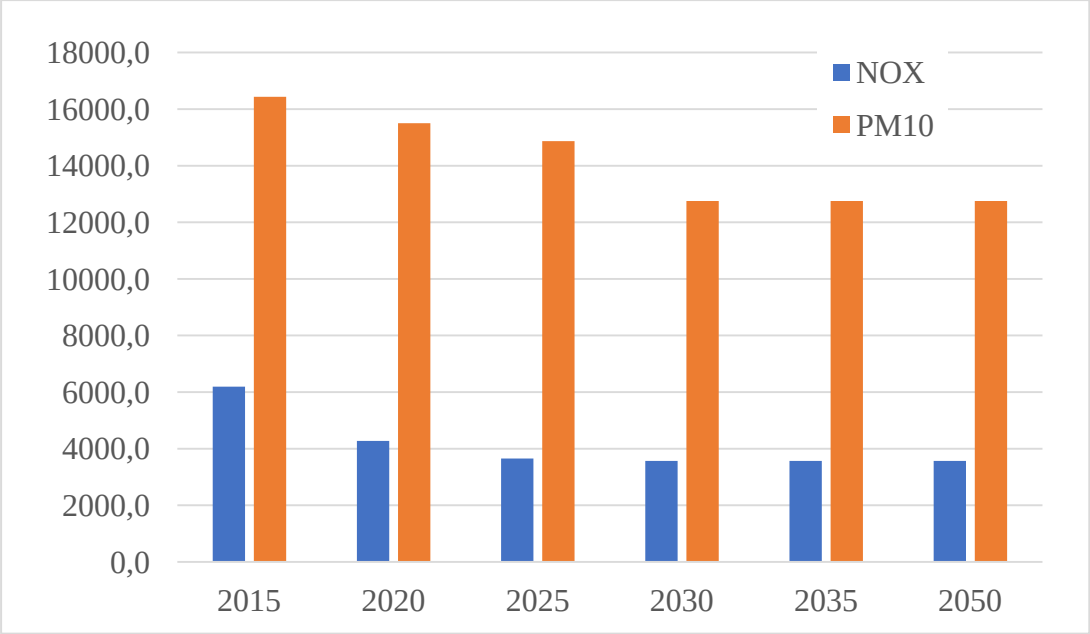

Figure 60 – Aveiro BAU Industrial sources NO_x emissions

8.1.2.2 Residential, commercial & institutional emissions

In Figure 61 for nitrogen oxides (NO_x) and in Figure 62 for suspended particles with diameter less than 10μ (PM_{10}) the evolutions of emissions in Aveiro are reported.

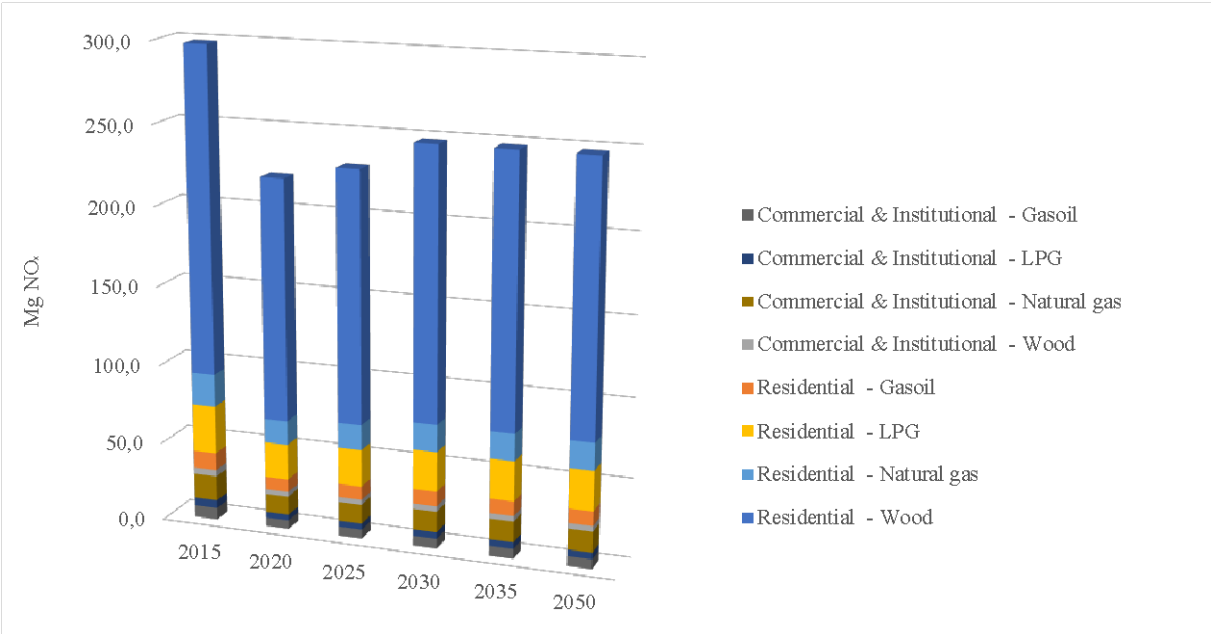

Figure 61 – Aveiro BAU total Residential, Commercial & Institutional NO_x emissions

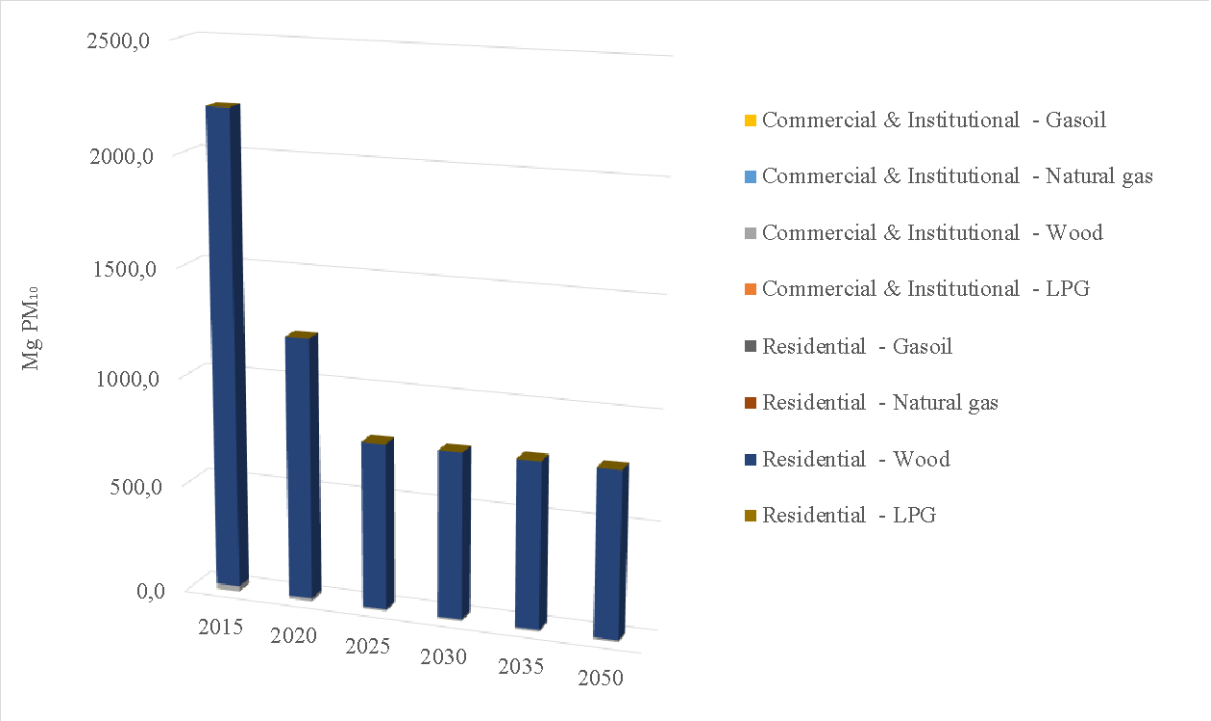

Figure 62 – Aveiro BAU Residential, Commercial & Institutional PM_{10} emissions

8.2 Scenario projections

Scenario projections take into consideration city level additional measures.

8.2.1 Modelling

Scenarios from the Stakeholder dialog workshop (SWD) includes the measures of Table 23 relating to the IRCI sector (the codes are defined in this report).

Table 23 – Aveiro: Measures coming from the Stakeholder dialog workshop

Code	Description	Scenario
AVE_I-15%PM	Aveiro Reduce PM industrial emissions by 15% on 2025	Low
AVE_I-45%PM	Aveiro Reduce PM industrial emissions by 45% on 2025	High
AVE_I-45%NOX	Aveiro Reduce NO_x industrial emissions by 45% on 2025	High

The following assumptions apply to the simulations:

- No measures for residential and commercial sector were proposed by SWD;
- The industrial measures are considered as complementary to national NECD ones;
- Regarding NO_x emissions, the reduction by SWD measures in the low scenario are lower than national NECD ones; no supplemental driver was introduced for NO_x in this scenario.

8.2.2 Results

In Figure 63 for nitrogen oxides (NO_x) and Figure 64 for suspended particles with diameter less than 10µ (PM_{10}) the trends of emissions in the different scenarios are reported for industrial sector.

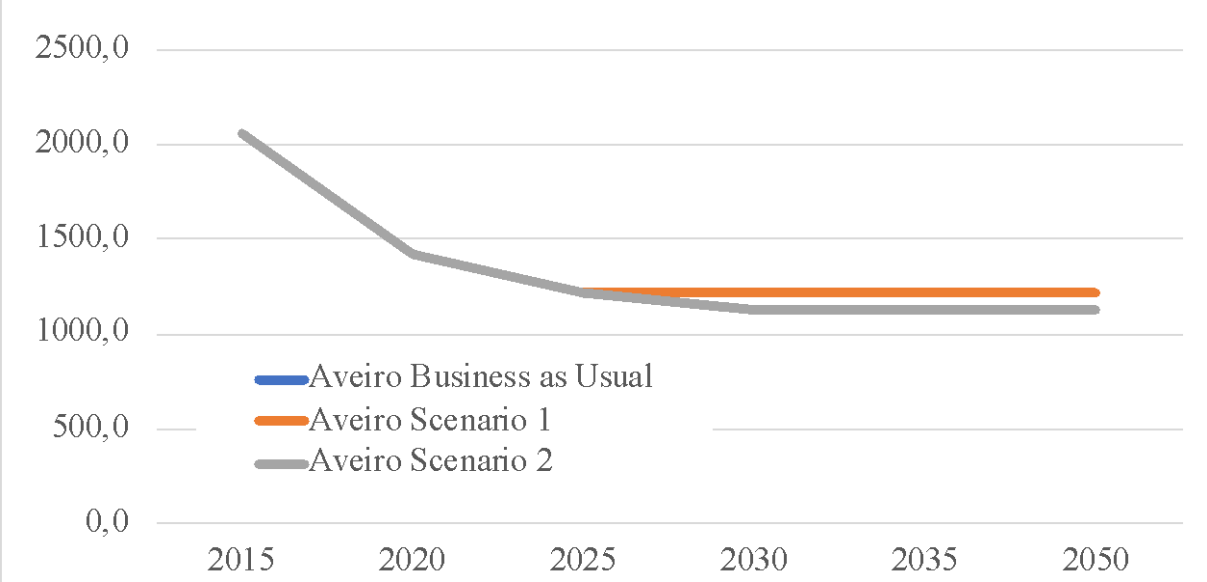

Figure 63 – Aveiro Scenarios: Industrial sources NO_x emissions

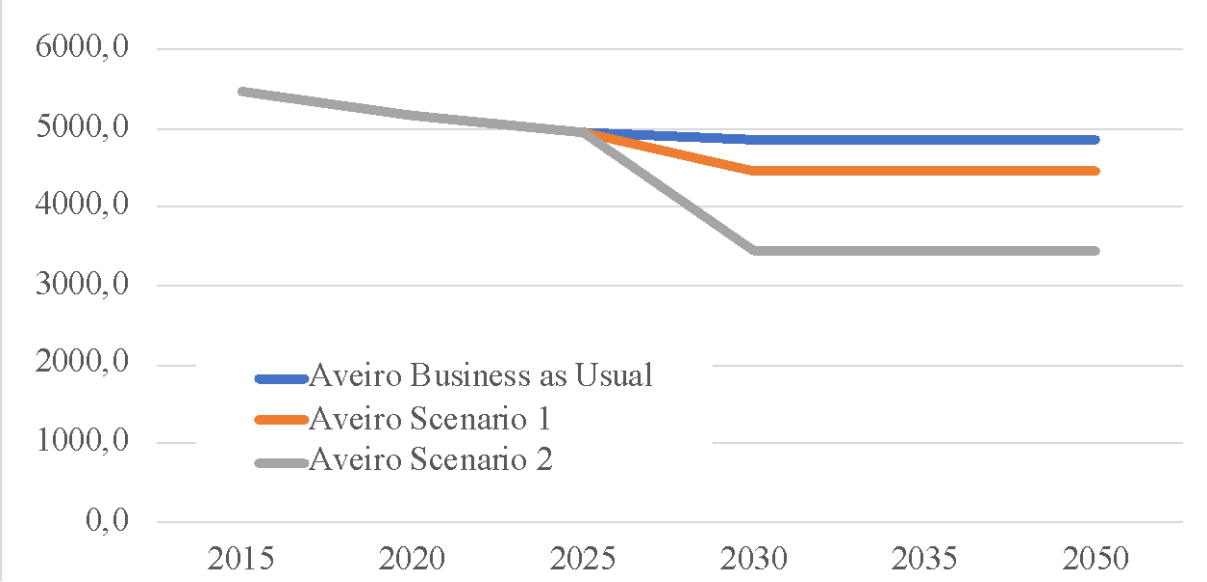

Figure 64 – Aveiro Scenarios: Industrial sources PM_{10} emissions

Scenarios from the Stakeholder dialog workshop (SWD) includes no measures relating to the Residential, Commercial and Institutional sector.

8.3 Unified Policy Scenario

8.3.1 Modelling

The final Unified Policy Scenario includes the measures of Table 16 relating to the IRCI sector (the codes are defined in this report).

Table 24 – Sosnowiec: Measures for the Unified Policy Scenario

Code	Description
AVE_I-15%PM	Aveiro Reduce PM industrial emissions by 15% on 2025

8.3.2 Results

In Figure 65 for suspended particles with diameter less than 10µ (PM_{10}) the trends of emissions in the different scenarios are reported.

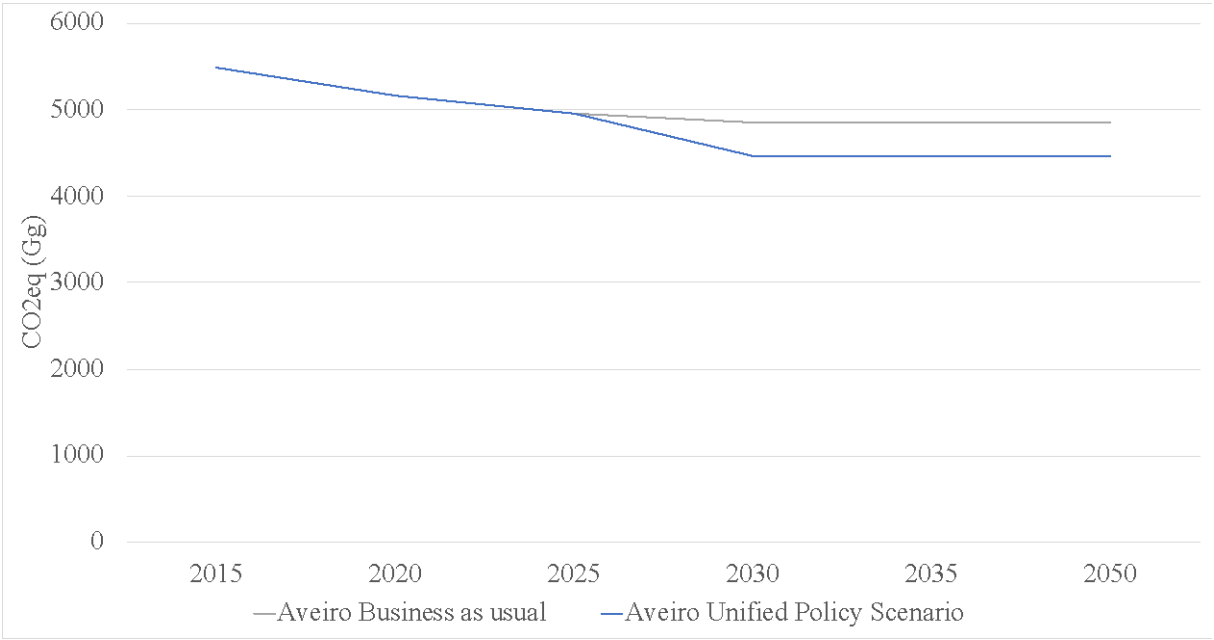

Figure 65 – Aveiro BAU & Unified Policy Scenarios comparison: Industrial sources PM_{10} emissions

Unified Policy Scenarios includes no measures relating to the Residential, Commercial and Institutional sector and no additional reduction on BAU regarding NOx from industrial sources.