ClairCity: Citizen-led air pollution reduction in cities

D4.10 ClairCity Skylines Game User Manual and Data Report

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Description	A document provides a guide to the concept, purpose, implementation, operation and headline data results of the final multi-language version of the ClairCity Skylines Game. This report also includes evaluation data and practical steps/advice for future serious game projects. The deliverable is orientated towards game designers and/or air quality/carbon/public health practitioners who want to learn more about the Skylines Game in terms of its development, deployment, results and transferrable lessons.

Version History

Version	Updated By	Date	Changes / Comments
V1.1	Andrew King	11/09/2019	First version
V1.2	Enda Hayes	16/09/2019	Provision of additional data and outline comments to support development of next iteration
V1.3	Andrew King	19/10/2019	Significant update plus inclusion of additional gameplay data
V1.4	Andrew King and Enda Hayes	23/10/2019	Circulated to the ClairCity EMG for approval
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Executive Summary

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. This allows the ClairCity project to 'crowd-source' and understand the public perceptions and acceptability of various policies.

The ClairCity Skylines Game is available as a mobile application for Android and iOS devices where data on the areas, ideas and policies favoured by citizens was captured anonymously for use across the ClairCity project along with game evaluation feedback informing elements such as the development of city specific policy packages and public engagement activities.

Bristol (United Kingdom) was the first of the six partner cities and regions to be included in the ClairCity Skylines Game, and launched in April 2018. An updated, localised version of ClairCity Skylines was launched in Amsterdam (the Netherlands) following a significant database upgrade in November 2018 based on the lessons learned during the Bristol pilot. The upgrade allowed the final four cities/regions to launch simultaneously in Ljubljana (Slovenia), Sosnowiec (Poland), Aveiro region (Portugal) and Liguria region (Italy) 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, user interface (UI) and the policy database.

Players have to provide some simple demographic data (e.g. age, gender and rate their knowledge of air pollution from "nothing" to "expert") that will allow the project to undertake case attribute analysis of the results in the future to allow for demographically targeted scenarios and policy development. Players move around their stylised city to recognisable landmarks where they are randomly presented "ideas" from the CPL and they must chose the "ideas" they like. Chosen "ideas" are then promoted to "policies" by the player every five years with the aim to improve air quality, carbon and health in the city while maintaining citizen satisfaction and the city economy. At the end of each play (win or fail) the "ideas" and "policies" are recorded and can then be assessed to understand the public perception and acceptability of specific policies and policy areas thereby allowing ClairCity to "crowd-source" potential citizen-led policy pathways and scenarios. To enhance the playability of the game the attribute scores (i.e. how well or how bad a player is doing against each of the four attributes) is linked to the game world effects so that the game world can either decay or regenerate.

To date (October 2019), a total of 2 628 unique players of the game were registered (as of July 2019) with the following headline engagements recorded during the data capture window:

- 6,705 plays of the game occurred across all six cities;
- 106,910 ideas for policies were presented to players;
- 83,339 'years' of the game were played (unique user, session, year); and
- 69,476 ideas were selected by players.

Bristol (836) and Sosnowiec (949) were most successful in getting players followed by Amsterdam (371) and Aveiro (243). Ljubljana (24) and Liguria (66) did not recruit substantial player numbers due to a lack of promotion. Across the player data, 63% of players were male

and 38% female. Of the youngest players aged 13-15, 70% were male, but female players reported higher levels of experience in relation to air quality/pollution.

When analysis policy choices there are notable differences in player perceptions and policy acceptability based on gender, age and self-reported knowledge of air pollution prior to engaging with the game

The game players that completed the post-gameplay evaluation stated that they enjoyed the game (90% gave it more than 3 out of 5), it improved their understanding of air quality and carbon emission challenges (82% gave it more than 3 out of 5) and it raised awareness and may influence their future behaviour (80% stated they would change their behaviour).

Finally, the report provided some recommendations related to future game development based on the lesson learned in ClairCity Skylines. These related to

- In house game development with a particular focus on the importance of co-creation with stakeholder and risk management
- Devising the game mechanics and ensuring that you clear set the scope and system boundaries.
- The cost-benefit of game localisation especially the effort and reward from text translations.
- The value of game analytics and the differences between IoS and Android.
- The importance of effective and sustained marketing and promotion of the game to ensure player engagement.

To find ClairCity Skylines on Google Play (http://play.google.com) search “ClairCity” or click the following link: https://play.google.com/store/search?q=ClairCity&hl=en_GB

To find ClairCity Skylines on an iOS device, open App Store and search “ClairCity” or view the following App Store Preview: https://apple.co/2HknEBM

1 Introduction to the ClairCity Skylines Game

1.1 The positioning of the Skylines Game in the ClairCity process

The ClairCity Project (www.claircity.eu) aims to substantially improve future air quality and carbon policies in European cities by initiating new modes of engaging citizens, stakeholders and policymakers. The latest social science thinking is applied to understand citizens' behaviour and source apportion air pollution emissions and concentrations, carbon emissions and health outcomes in order to attribute them not just by technology but by citizens' behaviour and daily activities. By putting people at the heart of both the problems and the solutions (primarily framed around transport and domestic energy use), ClairCity stimulates the public engagement necessary to tackle our challenging problems through the development of a range of citizen-led future scenario and policy packages. The four primary objectives of the ClairCity project are:

1. To put citizens' behaviour and activities at the heart of air quality and carbon management and policy making;
2. To develop a suite of innovative toolkits for enhanced quantification, engagement and impact evaluation;
3. To explore the integration of citizens behaviour in relevant city policies and ensure that future city policies are reflective of citizens visions for their future city; and
4. To raise awareness of environmental challenges and their solutions through proactive dissemination of the project outcomes.

The ClairCity process has three key process phases with a number of activities which work towards achieving the project aims and objectives. These three phases and related activities are briefly summarised here and illustrated in Figure 1 to help the reader understand the flow of evidence and the positioning of the Skylines Game within the wider ClairCity process. This process has been applied across all six ClairCity case study areas with some localisation and adaptation as required.

1.1.1.1 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 (WP3).
2. **Quantify the baseline**: Quantification of the baseline air quality emissions and concentrations, carbon emissions and public health impacts in our city (WP5).
3. **Assessment of Policy**: Collation and analysis of current policies (local, regional, national and EU) that influence the city (WP6).

1.1.1.2 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 becomes 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.
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.

1.1.1.3 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).

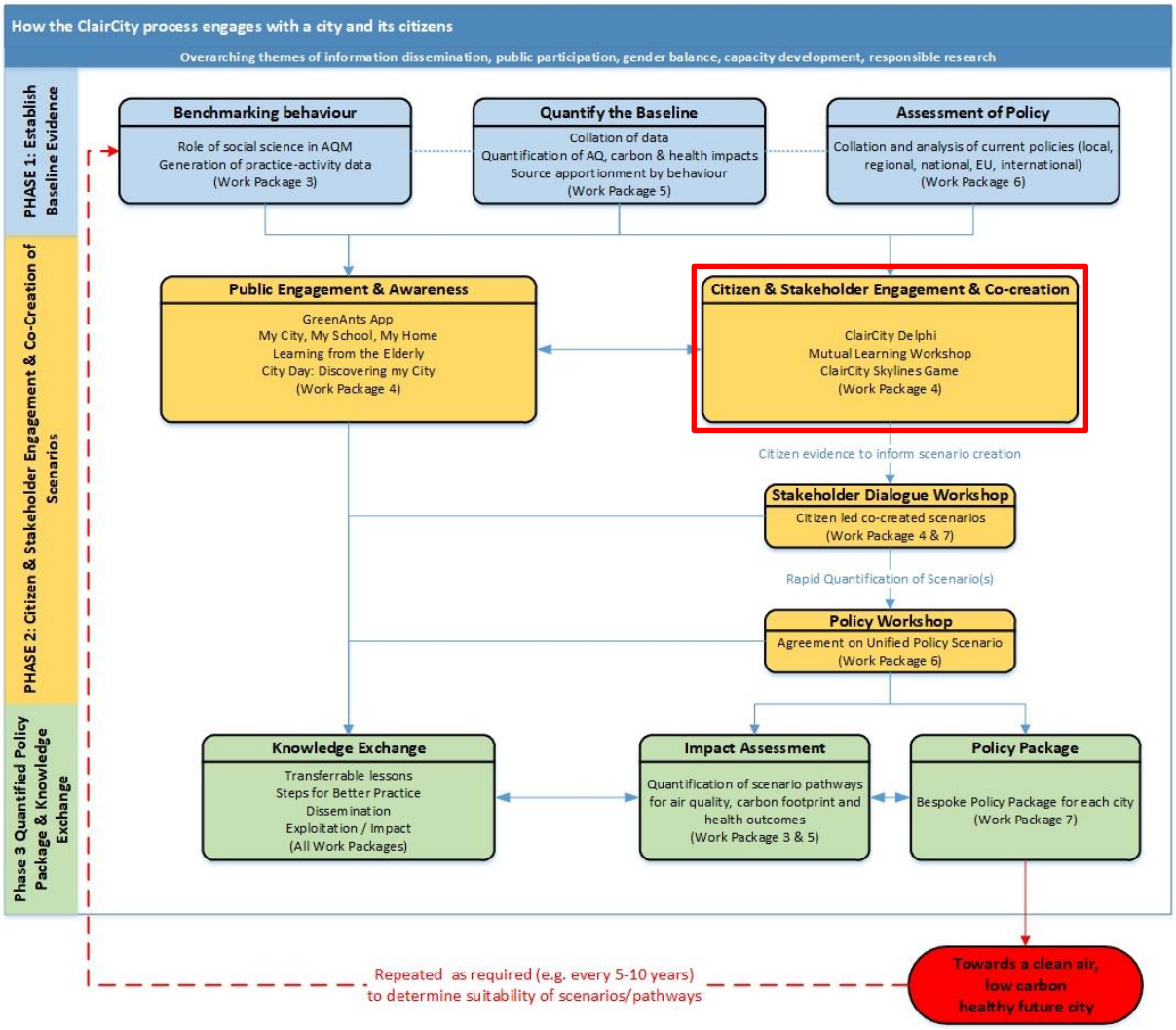


Figure 1: ClairCity process including key phases and activities (Delphi highlighted in red box)

1.2 ClairCity Skylines Game Overview

1.2.1 ClairCity Skylines Game Purpose

ClairCity Skylines is a unique policy-making mini-strategy game where citizens become players taking up the role of 'the City Mayor' and are responsible for passing policies in order to save the city by unlocking a successful clean-air, low carbon future. The player must select and enact policies without bankrupting or polluting the city, as well as keeping their city's virtual inhabitants healthy and satisfied with their lives.

The game seeks to establish what citizens might do if they were in charge of achieving a green future for their city, while also exposing them to some complexities of running a city. The core game mechanic in ClairCity Skylines presents the player with the challenge of managing competing objectives that the game calls 'attributes' while encouraging players to consider and engage with a wide range of policy-making and air quality measures for their city in an accessible, and engaging manner.

Through the game, the ClairCity project can understand the varying strategies and policy combinations enacted by different groups of citizens as they attempt to achieve a clean air future for their city. The game works by 'crowdsourcing' the public acceptability of different policy options, supporting the basis of a citizen-led and citizen-inclusive, bottom-up policy-making approach where citizens also gain further understanding of how policies could affect their daily lives.

1.2.2 ClairCity Skylines Game Design

Citizens play the game by visiting major areas of their city, investigating ideas that will affect the games **four key 'attributes'** (Environment, Health, Citizen Satisfaction and City Economy). As players 'listen' to competing '**ideas'** (an 'idea' is policy option which has not yet been chosen or enacted by the player), and choose the ones they feel are beneficial, the positive or negative attribute weightings (similar to scores) contained within each idea are applied across the city's four attributes. Weightings can be positive and/or negative, meaning players must make conscious decisions about how an idea could affect the attributes of their city. An idea becomes a '**policy'** to be enacted by the city through a two-stage process – firstly, the idea is chosen by the player and secondly, is it stamped and elevated at the town hall by the 'Mayor' at a later date. By exposing players to competing demands via the attributes display at the top of the game screen in a simple way, and by representing policy impacts by improving/reducing the appearance of both city and citizen graphics accordingly, the game makes real-world policies accessible that could have short/medium/long term consequences for their city.

Every five years, players are offered the chance to elevate their favoured ideas into 'policies'. By doing so, idea attributes are transformed into a series of prolonged impacts for the city which will last the specified duration of the policy, which can vary, typically between 5-30 years. As the player continues to choose ideas annually and selectively upgrade them into policies quinquennially, the city will ebb and flow as the four key attribute scores change. Players experience audio-visual effects of their choices in the city, such as air pollution and particulates, noisy traffic, road deterioration and changes in citizen health. If any of the four attributes reaches zero, the game is over, and the player must try again. The game is won when the player raises the green environment attribute and one other attribute to full.

The game has been designed to be as accessible and straightforward as possible, with each member city having a distinctive colour scheme while maintaining with the overall ClairCity project visual style. The game uses a simple 'rotating world' mechanic to make interactions simple for gamers and non-gamers alike, harnessing only typical smartphone gestures such as 'drag', 'tap' or 'swipe'.

Figure 2: ClairCity Skylines Game promotional material – flyer/postcard used in Bristol

The game aesthetic is simple by design, and significant effort was put into trying to represent the look, feel and problems each city/region were facing. To achieve cohesive yet distinct environments and 'game feel' the Development Team undertook a range of design approaches. In Amsterdam, we produced a photo-tour of the city and pitched the prototype mechanics to the consortium for feedback. In Sosnowiec we recorded a video tour and with the help and feedback of ClairCity partners learned about the industrial history of Silesia and selected areas all citizens could identify with. In Ljubljana, we presented the first alpha build to the consortium and ran a workshop on game features, where feedback from Aveiro and Liguria was essential in terms of the iconography and attributes system in the game.

The game contains 36 famous city '**areas**' (6 for each city/region), with custom animations, language, music and sound effects that all change when players make decisions. This was a complex and intricate process, ensuring players recognise the effects of their policy choices. For example, a poorer economy will make the bank fall apart, and vehicles older, while good environment clears the air, and citizens can become healthy. The biggest challenge for the team was worked with partners to localise the game to be available in all local languages, even where the Apple App Store did not support them, in order to maximise potential engagement. For more about the conceptualisation of ClairCity Skylines, see Section 3.

1.2.3 Playing the Game

By creating a player profile which captures basic demographic data and giving informed consent, the game records player choices to a behavioural database. Actions recorded during play sessions include areas visited, ideas collected and policies elevated for each anonymous user and for each play session. There is also a game evaluation survey unlocked once the game is won or lost.

Citizens play as the Mayor and visit areas that represent the four key attributes of indicators: city environment (green leaf), citizen health (red heart), citizen satisfaction (blue people) and city economy (gold coins). Ideas suggested at each location are more likely to influence the indicator linked with the area (e.g. visiting the bank displays ideas with impact on the economy, visiting hospital affects citizen health etc). The positive or negative scores are applied to the game attributes when a player collects an 'idea' (instant) or elevates an 'idea' (temporal) into a 'policy. The ideas are harvested from a database of measures, called the ClairCity Policy Library (CPL), in which the policies have been 'scored' against the four attributes. Players see CPL measures as 'ideas' for future policies whenever they visit an area of the city and can choose those they think have potential by dragging one into their briefcase to later elevate into policy at the city hall every five years. Ideas (measures from the CPL) contain only simple icons that 'hint' at potential impacts, but in the city hall more impact details for each idea is visible. Each partner was able to work with the Development Team and ClairCity stakeholders to customise which policies exist for their city/region. For example, measures within the CPL that refer to shipping can be 'disconnected' for the Ljubljana players as they are a land-locked city and therefore those measures may not be applicable to that region. Every five years, players visit 'city hall' to upgrade at least one 'idea' into a lasting 'policy'. Their ideas, are now displayed as prospective policy binders that must be 'stamped' that include more information on the policy impact and duration, causing players to consider policy outcomes thoroughly. Gameplay continues in the form of idea collection and policymaking until the player achieves a win or fail state. Active policies are visible in the player's briefcase at any time throughout the game, and are also displayed during progress reports to ensure players know which policies the attribute impacts are attributed to. To win the game players must fill the green environment attribute and at least one other, achieving a successful, clean-air future for their city. A win in less than 15 years receives a gold medal, a silver medal in less than 25, bronze for 50 or less. Images of the player sign up, attributes, areas, ideas/polices and win screens are illustrated below.

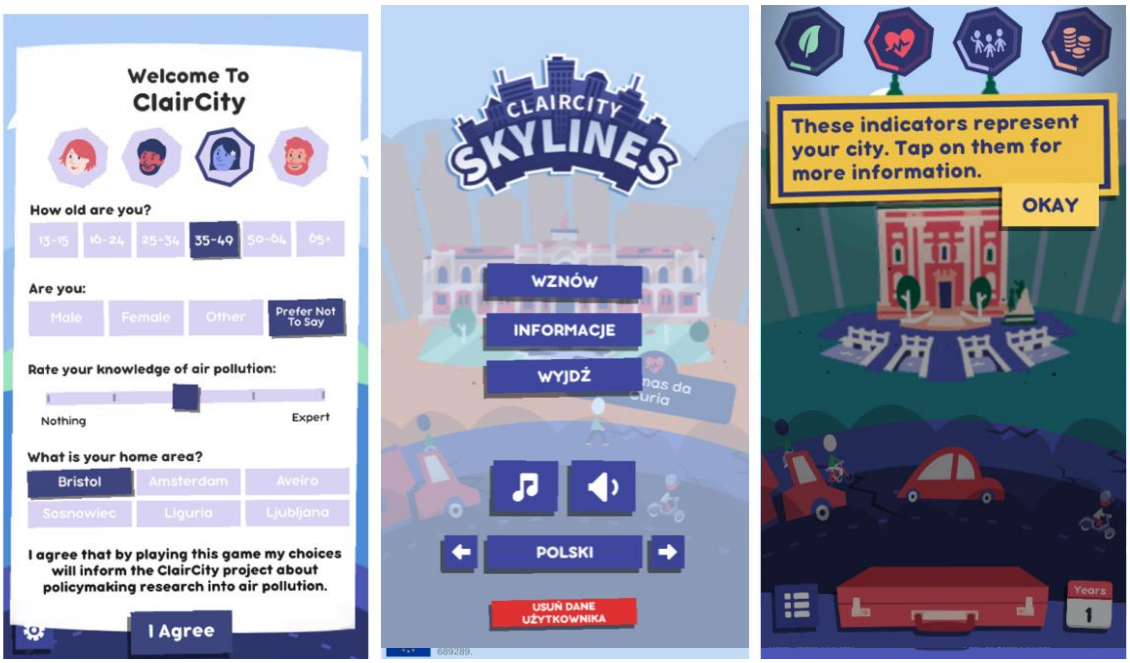


Figure 3: Player sign-up (left), language selection (middle) and four game attributes (right)

Figure 4: ClairCity Skylines Game areas: Amsterdam hospital (left), Liguria landmark (middle) and Bristol city hall (right)

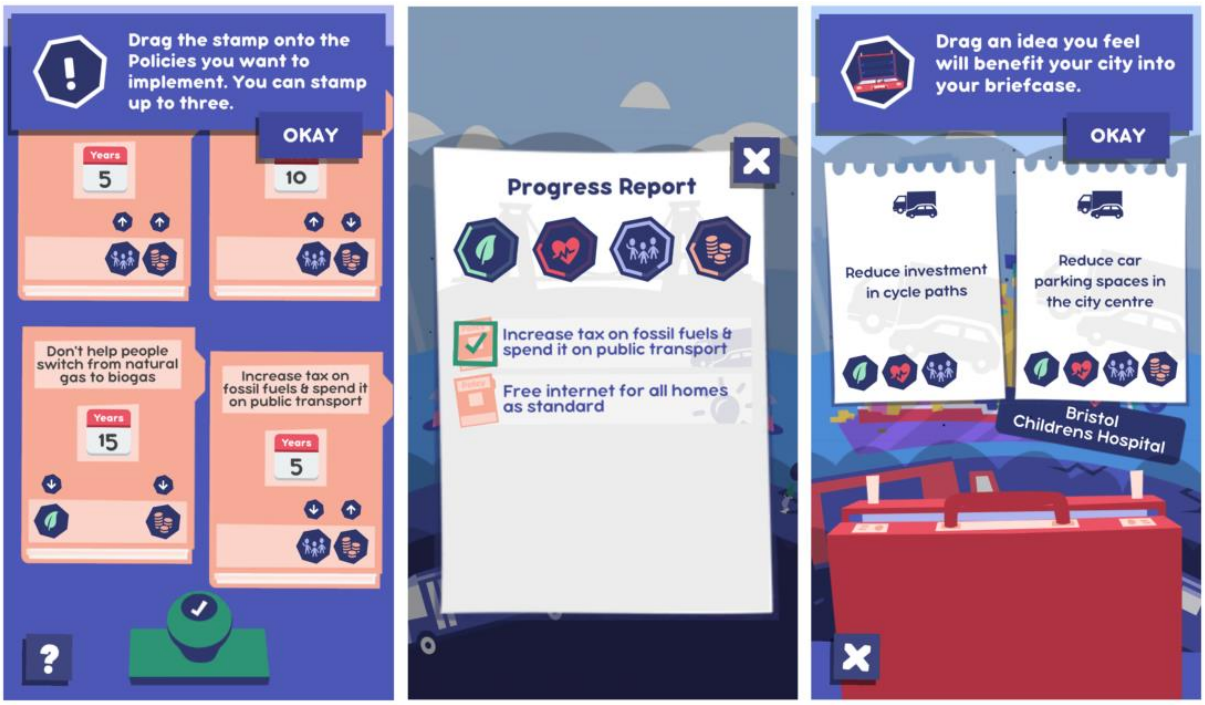


Figure 5: ClairCity Skylines Policy elevation (left), policy end report (middle) and ideas (right)

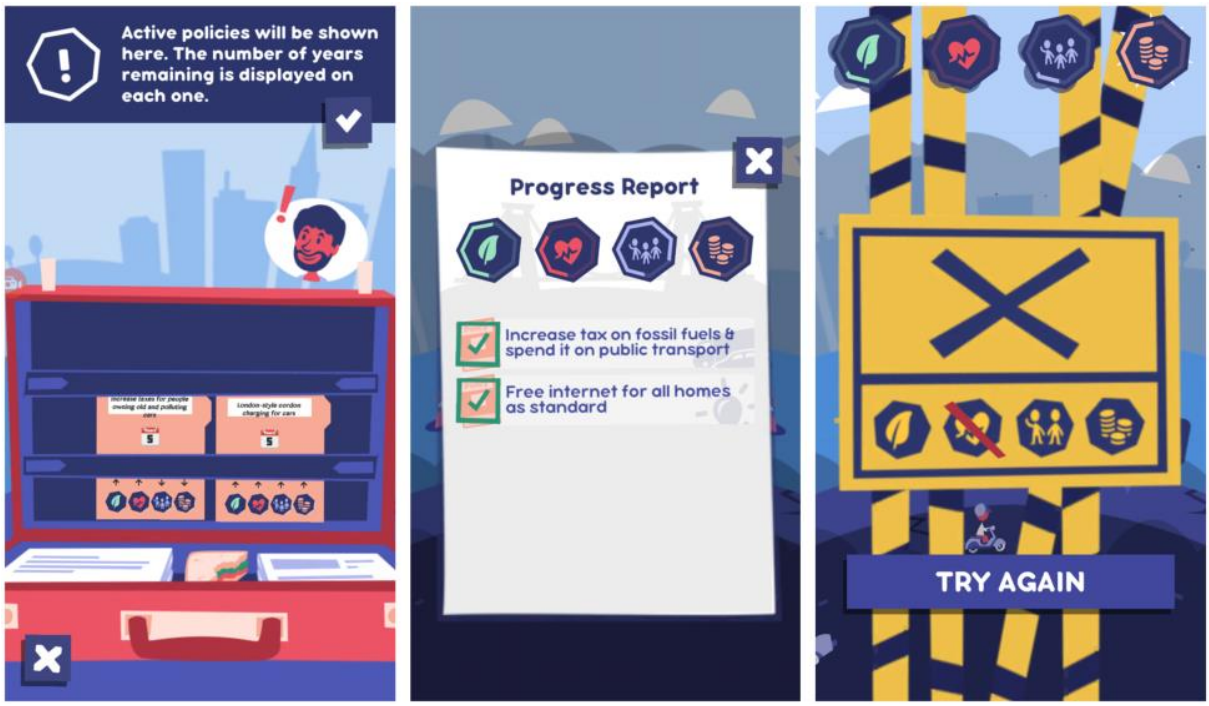


Figure 6: Player briefcase showing active policies (left), policy progress update (middle) and failure reason (right)

Figure 7: ClairCity Skylines win screens: Bronze Medal (left), Gold and years to completion (middle) and silver medal (right)

Where possible real city data has been used to inform the game. For example, existing quantifiable data from each city is used to determine both the baseline and endpoints for the Game attributes that is relatable to each cities specific situation. For example, baseline city per capita CO_2e emissions as a start point with an endpoint of 2T CO_2e per capita by 2050.

While the game play data captured only considers the ideas displayed, collected and elevated into policies, in future it may also be possible to extract 'plays' of the game that achieved a given medal win, and areas most visited. Players will be challenged to 'try again' to achieve a better medal for their city, until they achieve a gold medal, they can then play the other 5 cities if they like.

Citizens from one city playing other cities is demarcated in the data, and while not being key to the primary outputs of the project, does provide re-playability value for users and may in time provide additional insight into how citizens from across the EU approach city problems from different perspectives with regards to air quality and policymaking.

1.3 ClairCity Skylines Game Development Steps

1.3.1 Development Team

The ClairCity Skylines game was primarily developed by a two-person team from the University of the West of England. The senior team member (Mr Andy King) was responsible for the serious game design, overall production process, with significant responsibility for the successful creation, localisation, launch and data capture that required working alongside colleagues across the ClairCity team. A lead technical developer was also recruited to work alongside Andy King, (Mr Alastair Callum), responsible for implementation of the game design, design and operation of the game database and analytics, as well as integrity of the project

codebase and data export at the end of each city's capture window. Significant design input was provided by the wider game development team from Prof Enda Hayes (UWE), Dr Corra Boushel (UWE) and Mr Kris Vanherle (TML). Work on citizen behaviour with Dr Tim Chatterton (UWE), the Delphi process with Dr Jo Barnes (UWE), game promotion with Dr Laura Fogg-Rogers (UWE) was also key to the success of the initial design of the game.

Professional game art assets and 'spine' animations that allowed the cities to degrade or upgrade were produced by a local game design partnership, while dynamic sound design for the audio and music elements that could also evolve as the player made policies were also created by a local game audio professional. It was critical that ClairCity Skylines looked and felt like a game for intrinsic player motivation as opposed to a research project with gamified elements, and the difference between the placeholder assets developed internally by the team and the professional work is significant (Figure 8). The game was developed in the Unity development engine, a leading package for multiplatform game development. An in-depth overview of ClairCity Skylines technical design is located in the appendix.

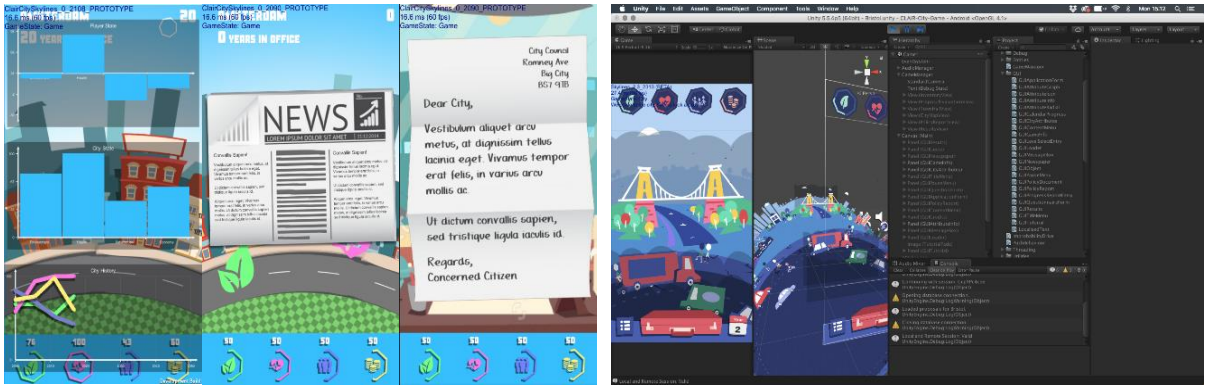


Figure 8: ClairCity Skylines early prototype (left) and Unity project (right)

1.3.2 Game Development Process

Initially, to ensure the scope of work was possible by a small internal game development team, an agile, iterative, yet relatively traditional 'indie game' development process was adopted. The development team established key objectives, game and project connectivity and data outputs required from the game to the wider project. Rapid conceptualisation and development of a high concept from several competing concepts was established before consultation with the ClairCity consortium to form a "green light" for the proposed development. In broad terms, the project went through an iterative flow of pre-production, production and post-production in the run-up to completion of the Bristol pilot launch, and then a subsequent refinement process before launching in Amsterdam and then rolling out to the remaining four cities/regions post an intensive period of localisation.

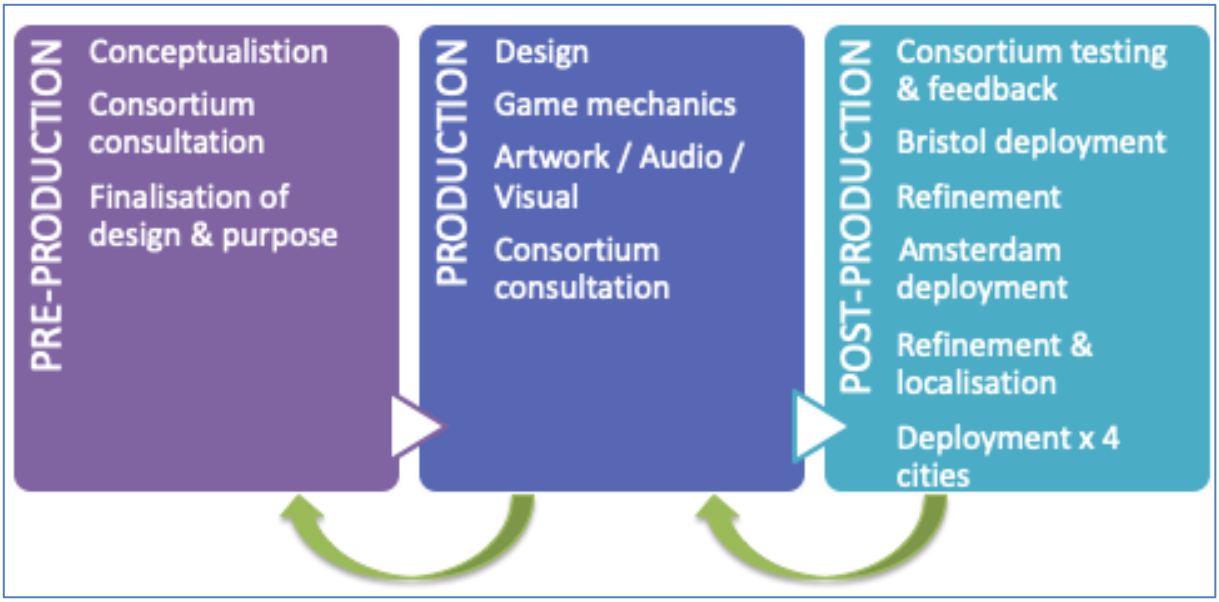


Figure 9: Simplified Game development process

The game design and development was not a linear process as numerous alternative visions for the game were considered during the Pre-Production phase. For example, an alternative vision for ClairCity Skylines (CCS) which was discarded due to issues of game mechanics, player engagement and scope/workload was a version of the game with a stylised isometric skyline driven by real-world, live-data from cities where the player could start to build a city from a blank starting point. While CCS may seem simple in comparison to what this version might have looked like, it would have been erosive to what the project required for a variety of reasons:

- CCS needed players to grasp the current situation of a city, but still feel the freedom to change it.
- "SimCity" style visuals would have increased perceptions of complexity and reduced and even limited the appeal of the game to a certain genre.
- Live data for weather / pollution / other was not consistently available across the city partners.
- Such features were not core to a behavioural mechanic and were liable to impact game performance on slower handsets and data connections.
- Live data reduced the likelihood of the player being able to see changes in their virtual city, and attributes from decisions would have conflicted with real data.
- The use of 'timelines' was also dropped; where originally we sought to understand when players reached a tipping point in decision making for their city.

After extensive internal testing, ClairCity Skyline Bristol (launched April 2018)(available for download from Apple and Google stores respectively) was the first pilot of both the behavioural player database and the game platform. The pilot was a success, but it was decided that a refinement of the behavioural player database was required before the ClairCity Skylines Amsterdam launch (November 2018) as there were issues in the performance of both data being written but also read from the database which, while acceptable for a single city, would not scale to simultaneous operation across six cities and multiple data collection windows.

After the successful run of ClairCity Skylines Amsterdam, further refinement was required before the launch of the final four regions/cities (Ljubljana, Sosnowiec, Aveiro and Liguria) as it quickly became apparent that the simultaneous localisation of four additional languages across the entire game user interface, the evaluation survey and the additional wording of hundreds of CPL policy entries would be exceptionally challenging. Different cities and stakeholders had different language standards for what was acceptable in a game, and each of the city partners was responsible for the translations, testing and feeding-back of required changes, which all happened at different rates and qualities. As a result of this, the project agreed that all minor changes reported to us once the game was live would be aggregated and packaged in a weekly update for the game, but by the launch only a few minor errors remained and the game was able to meet it launch window and data capture closure dates in Ljubljana, Sosnowiec, Aveiro and Liguria (launched January 2019).

Game promotion and awareness raising by the local partners is essential to the successful uptake of the game in each city. The behavioural player database was able to capture lists of offered/selected/elevated ideas/policies and demographic and anonymous user_ID data.

1.4 ClairCity Policy Library

The ClairCity Skylines Game has a comprehensive policy library of measures (the ClairCity Policy Library (CPL)) that underpins the “ideas” that are presented to the players. This database design, scoring and evaluation lead by Prof Enda Hayes (UWE) and Kris Vanherle (TML). Each of the >500 environmentally positive and negative “ideas” in the CPL has been mined and adapted from a number of existing publicly available databases and from the results of various ClairCity project activities. These include but are not limited to:

1. Existing publicly available databases of city solutions such as the JOAQUIN Database (www.joaquin.eu), INHERIT Database (http://inherit.eu/), KONSULT Knowledgebase on Sustainable Urban Land use and Transport (www.konsult.leeds.ac.uk) and the FAIRMODE Catalogue of Air Quality Measures (http://fairmode.jrc.ec.europa.eu/measure-catalogue/) etc.,
2. The results of the ClairCity citizen and stakeholder engagement processes including the Delphi process, Mutual Learning Workshops and baseline policy assessments; and
3. The knowledge of the ClairCity consortium.

Each individual measure within the CPL has the following descriptive measure:

1. **Unique Identifier**: This is internally facing and each policy measure has a simplistic unique identifier that is assigned sequentially.
2. **Action title game display text**: This externally facing text is the title of the policy measure is adapted from the technical terminology that may be used in a policy database to make it easier for the public (i.e. game player) to understand. This brief text is very short (max 15 words) and is translated into 6 languages for each of the city/region case studies.
3. **Timespan:** Years for the measure to come to fruition.

1.4.1 CPL categorisation structure

The CPL has a categorisation structure to allow for rapid categorisation (re-categorisation) of the policy options. The CPL structure has four categorisation levels/processes and each unique policy measure is categorised accordingly. Each individual idea is also categorised at four levels:

CPL Category Level 1: Source Sector: This includes sources such as transport, energy, industry, waste, agriculture etc. Each policy measure is assigned to one of the following categories:

- Transport
- Energy
- Waste
- Industry
- Agriculture
- Land use
- Other

CPL Category Level 2: Source Sub-Sectors: Each Level 1 category is further subdivided. For example for transport measure we have applied further categorised as follows:

- Private Cars
- Buses
- HGV
- Taxi
- Motorcycles
- Rail
- Aviation
- Shipping
- Active Travel

CPL Category Level 3: Policy Type: Each measure in the database is classified by policy type as follows:

- New technology
- Technological improvements
- Infrastructure / Land Use
- Funding / Finance
- Regulation / Legislation
- Awareness raising
- Behaviour change

Policy Level: Responsible Authority: Each unique policy measure is categorised according to the responsible authority for the implementation of that measure:

- Individual
- Community

- Local / Regional
- National
- International

1.4.2 CPL scoring methodology

Each individual "idea" has been scored (+/- 10 points) for both the short and long term impacts against the four key attributes: city environment (climate/carbon), citizen health (air quality/health), citizen satisfaction/happiness and city economy.

The scoring process for the measures (ideas) within the CPL was relatively simplistic to ensure the functionality of the game. First, the CPL and Game team developed a scoring and weighting methodology for each of the four key attributes which was uniformly applied across each measure. Second, each individual measure was scored independently by a minimum of three project team members and the interpretation of the wording of the measures assessed. The scoring was based on the professional judgement and expertise of the scoring team. Third, the independent scores were combined and were further evaluated where substantial deviation in the scoring existed (most often the deviation was due to the vague wording or misinterpretation of the measure). Finally, the wording of the measures were refined to remove any ambiguity and the CPL was given to the Game Development Team to be 'balanced' to ensure the playability of the game (i.e. the balancing step was to sure that no single measure/idea would win or lose the game). Additionally, each measure was given a short and long term score and the lifespan of each measure from initiation to fruition was included. It should be noted that the player never sees the actual scores within the game but only sees an impact on the attribute as it moves in either a positive or negative direction.

The following provides a working example of a measure from the CPL:

- Action title: Ban solid fuel for home heating
- Policy duration = 5 years
- Level 1: Source: Energy
- Level 2: Source Sub-sector: Switch Energy
- Level 3: Policy Type: Regulation
- Level 4: Responsible Authority: Local Government

Table 1: Example of CPL scoring for a single measure

Game Attribute	Short Term Impact Score	Long Term Impact Score
City Climate/ Environment	1.3	2.0
Citizen Health / Air Quality	2.6	1.3
Citizen Satisfaction	-2.0	-0.7
City Economy	-0.8	-0.3

2 Skylines Game Data

The following section illustrates the key headline data from the ClairCity Skylines Game across the six city / regions. At the time of writing this report (October 2019), the ClairCity Skylines Game was still being played and generating data. The game has been downloaded over 400 times since the original data window 'closed', with new installs on a daily basis, therefore, the project team intends to do a final end of project export of player data at the end of the ClairCIty project (April 2020) to fully understand the users engaging with serious games. It is the intention of the ClairCity team to update this analysis at the end of the project and make the data open access as appropriate.

2.1 Player Data

Given the complexity of promoting the game across six cities, the game had a target of 3000 play sessions in order to be viable for data analysis purposes. While numbers have continued to rise as the game is still freely available online, a total 2 628 unique players of the game were registered (as of July 2019) with the following headline engagements recorded during the data capture window:

- 6,705 plays of the game occurred across all six cities;
- 106,910 ideas for policies were presented to players;
- 83,339 'years' of the game were played (unique user, session, year); and
- 69,476 ideas were selected by players.

The demographic data for serious game players across the EU is sporadic, but in the UK by 2014 there were an estimate 33 million gamers, with a gender balance of 52% female, 48% male[1]. In Poland, the current number of gamers is lower 6.5 million, with a 53% male and 47% female distribution[2]. In 2010, 31% of all males and 20% of all females played games, comprising broadly 25% of all adults, with a total of 95.2 million gamers in the EU[3], but these figures are significantly higher in 2019 given the growth of mobile and online gaming in recent years.

Preconceptions about game success by geographic location were challenged by the number of users engaging with the game by city. For example, it is seen as difficult to engage citizens in Poland, where Amsterdam are perhaps seen as a progressive go-to city for green initiatives, but, Sosnowiec topped the chart with Amsterdam in third place and Bristol in second. A minority of users devices

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

[1] Internet Advertising Bureau UK. (2014). Gaming Revolution. *IAB.* Retrieved from https://iabuk.net/research/library/gaming-revolution
[2] *Polish Gamers Research 2019*, Polish Gamers Observatory, viewed 20 September 2019, < https://polishgamers.com/#>.
[3] Interactive Software Federation of Europe. (2010). Video Gamers in Europe. *ISFE.* Retrieved from https://www.isfe.eu/wp-content/uploads/2018/11/isfe_final_combined.pdf

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

were registered in China, Russia, India & USA (11%) but this data can be filtered out of the city-by-city analysis.

There were a total of 2748 unique Android and iOS devices used in the game, with the majority of players playing on just one device, although for Bristol, this value was 85%, suggesting more multi-device usage in the city that both developed and piloted the game. Just over half of all users played the game through once (52%). For Bristol that figure was 62%, with Amsterdam (57%), Aveiro (43%) and Sosnowiec (42%) in order. Despite the opportunity to play other cities, the majority of players visited one city in the Game (Table 2).

Table 2: Number and percentage of players that played one or more cities in the Game

Number of cities played	Number of players	% of players
1	2477	88%
2	198	7%
3	60	2%
4	65	2%

Given the opportunities to play across all 6 cities after completing their own city, during the data capture period, 78% of users played their own city or their own and others, with slight variation by, with 26% of Amsterdam players not playing their own city, while only 4% of Polish players avoided playing Sosnowiec (Table 3).

Table 3: Number and percentage of players for each city

User specified city	Number of players	% of played own city
Amsterdam	371	74%
Aveiro	243	93%
Bristol	836	85%
Sosnowiec	949	96%

In the ClairCity Skylines data, the gender of the players was: 63% male and 38% female. The youngest players aged 13-15, were predominantly male (70%), but female players reported higher levels of experience in relation to air quality/pollution. Sosnowiec reported 65% male, Bristol 64% male and Aveiro 54% male. The most significant body of players was in the 16-24 (31%), 25-34 (27%) and 35-49 (21%) age categories across all cities. Amsterdam and Aveiro had less under 16 year old players, Aveiro and Sosnowiec having more 16-24 aged players than average and Amsterdam having twice as many 50-64 aged players than other cities. This data is illustrated in the graphics below – Figure 10 shows the age profile of all players across the six cities/regions and Figure 11 shows the profile for players across the four most successful cities: Amsterdam, Aveiro, Bristol and Sosnowiec.

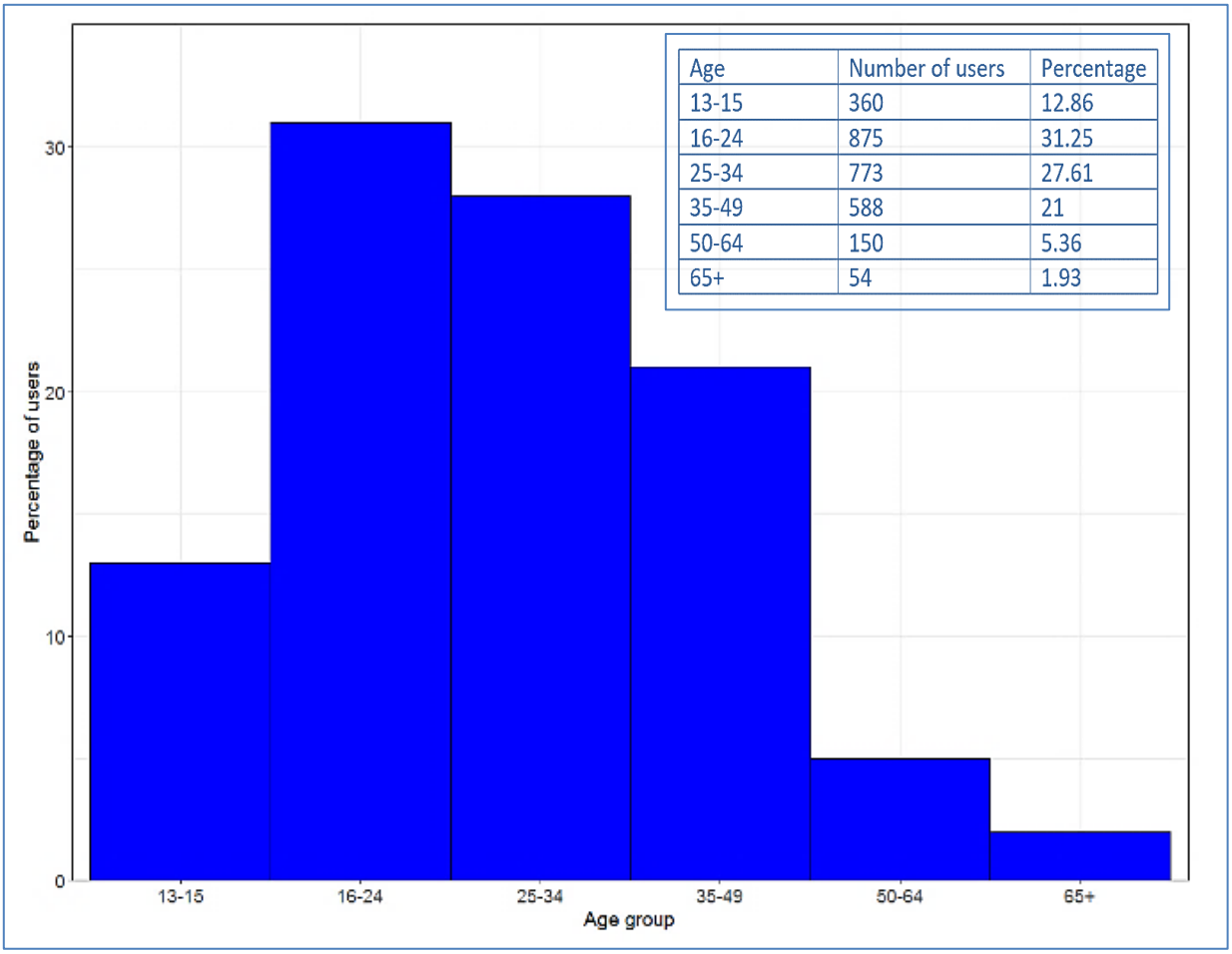


Figure 10: Profile of ClairCity Skylines Game players across all six cities/regions

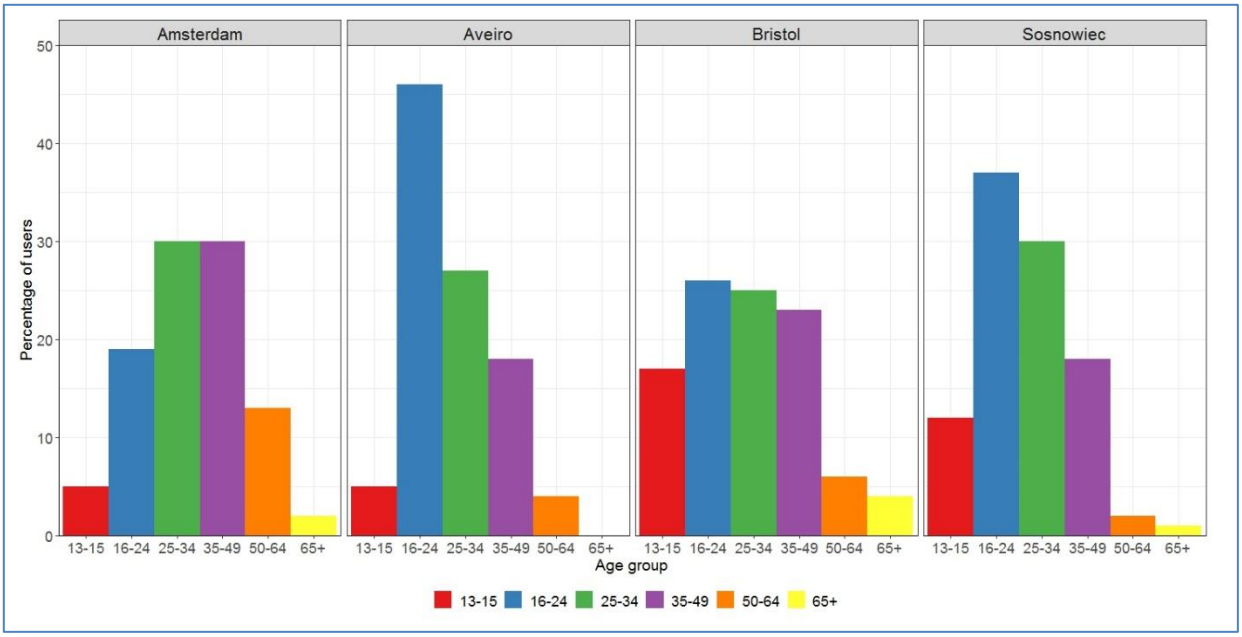


Figure 11: Profile of ClairCity Skylines Game players across all Amsterdam, Aveiro, Bristol and Sosnowiec

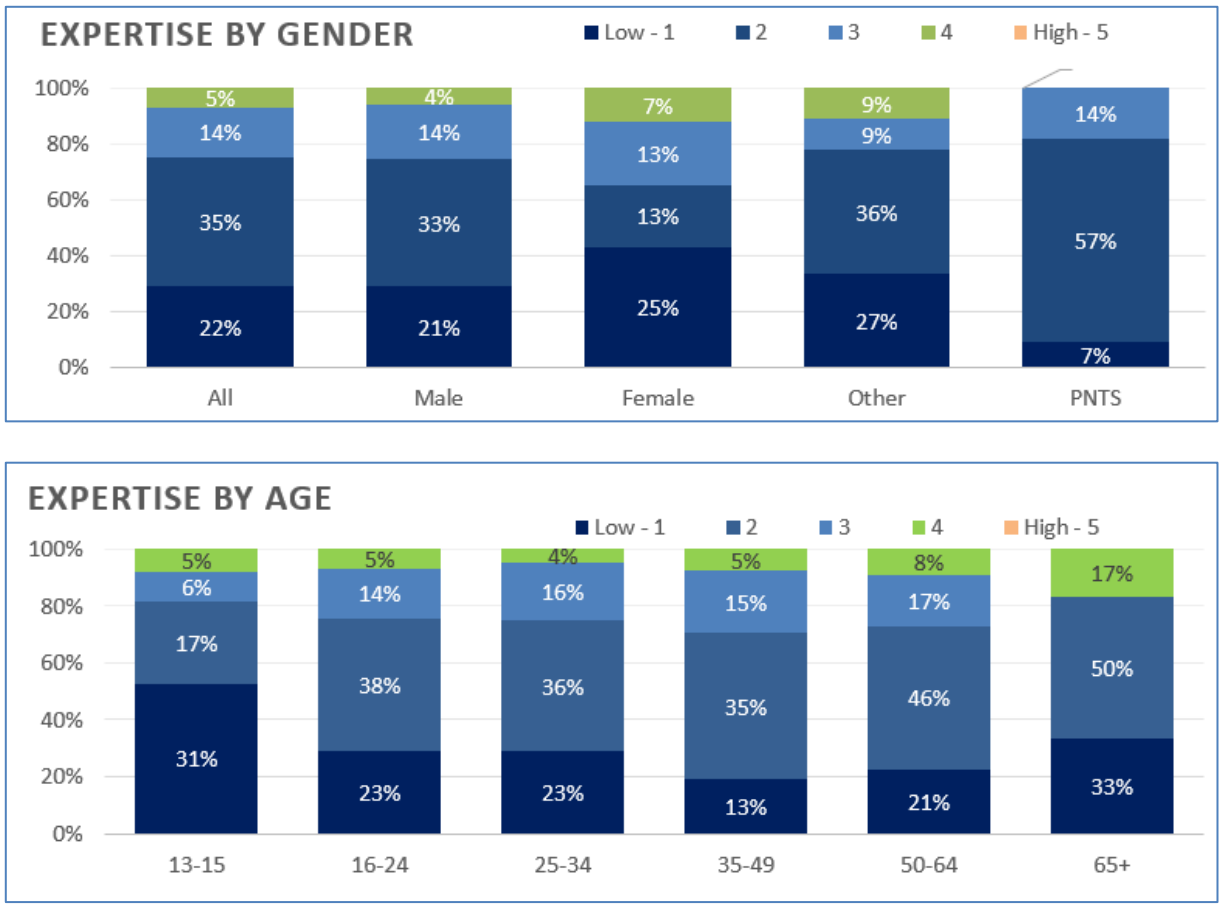


Figure 12: ClairCity Skylines Game players expertise by gender and age across all six cities/regions

Figure 12 above show how player-perceived expertise varied by age and gender based on the data submitted when players registered to play the game. Game sign up data shows that 28% of players reported the lowest level of expertise about air quality/pollution, with less users in Amsterdam and Aveiro reporting this level compared to the other cities. This requires further investigation, but could pertain to the higher age of players (Amsterdam) or number of female players (Aveiro) compared to the other four cities.

2.1.1 Idea Selections

Measures from the CPL presented to the player in pairs are called 'ideas' and are randomly generated every time a player visits a certain area of the city that corresponds to a given attribute. How players interacted with these ideas provides some useful headline measures as to how effectively players engaged with our game about air quality and policy making.

Across all cities available in the game, 76% of players selected or elevated *more than* 10 ideas during their play time. For Amsterdam this figure was slightly lower at 70%. The option to reject the ideas presented was very rarely utilised in-game (i.e. if a player did not like the two ideas presented the had the option to reject and get two new ideas), and only 36 out of the 69,476 policy selections undertaken involved the player triggering a replacement set of two new ideas. This is interesting and may relate to a players sense of needing to move forward as with boardgames, or it could be that perhaps not all players understood that the "X" icon did on that screen.

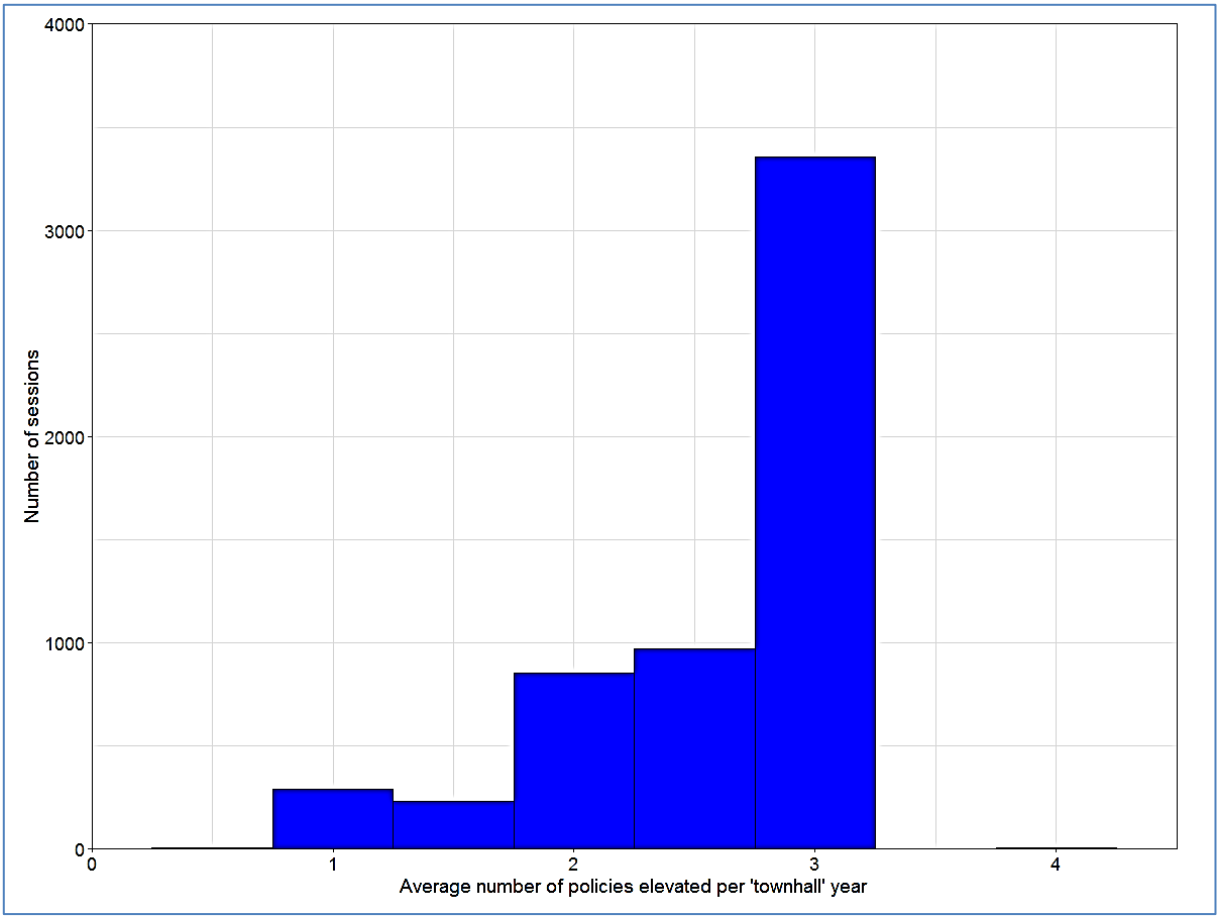


Figure 13: Elevation of policies at the townhall across all six cities/regions

In terms of the opportunity to elevate ‘ideas’ into ‘policies’ every five years at the town hall, male players were slightly more likely to elevate the maximum possible of 3 policies every 5 year rotation (71%) while female players did this slightly less (67%) (Figure 13).

The top and bottom ten most selected policies are presented in the table below by selection rate. Only policies presented more than 50 times were included in this analysis, and note, the bottom 10 policies do not generally include the opposite to the top 10 policies (Table 4). Transport policies accounted for 58% of the policies offered more than 50 times, appearing eight times in both the top ten and bottom 10 policies selected. It also appears that policy duration had no impact of the probability of a policy being selected.

Table 4: 'Top 10' and 'Bottom 10' policy options selected in the game

Policy	Level 1	Level 2	Number of times idea offered	Percentage of times selected
Power traffic lights with solar panels	Energy	Switch energy	182	90
Encourage people to use public transport	Transport	Public Transport	200	89
Make buses cleaner and greener	Transport	Public Transport	434	88
Encourage children to walk or cycle to school	Transport	Active Travel	410	87
Restrict traffic in some areas at certain times	Transport	Any Transport	372	86
Free bicycles and electric bikes available to residents	Transport	Active Travel	190	86
Ban polluting vehicles from some parts of the city	Transport	Any Transport	393	86
Ban coal except low sulphur coal	Energy	Switch energy	371	85
All official council cars should be clean energy	Transport	Any Transport	187	85
Make travel tickets transferrable across transport types	Transport	Public Transport	399	85
Provide less information about environmental issues	Other	Information provision	187	11
Don't make buses cleaner or greener	Transport	Public Transport	345	11
Decrease taxes on HGVs	Transport	Van/HGV	190	11
Sell high polluting fuels	Transport	Any Transport	174	10
Less bicycle parking in public places	Transport	Active Travel	337	10
Don't limit the speed of ships	Transport	Shipping	90	10
Allow industry to use any kind of fuel	Industry	Switch energy	183	10
Remove bike space from trains	Transport	Active Travel	358	10
Don't restrict HGV access to the city	Transport	Van/HGV	191	9
Remove support for bike sharing schemes	Transport	Active Travel	189	8

Policies that were offered more than 50 times to male and female players respectively can also illustrated. Tables below show 20 policies with the **largest difference in acceptance rates between the two groups (Table 5).** Notable conclusions regarding gender differences include[4]:

- Males more likely to support policies encouraging road transport such as more lanes, reduced taxes and removal of speed limits.
- In a number of cases, males are more supportive of policies which reduce regulation (or are less supportive of policies which increase regulation).

[4] Only male and female as insufficient responses in 'other' and 'prefer not to say'

Table 5: Policy options selected in the game by gender

Rank	Policy	Female	Male
1	Don't introduce new taxes for energy efficiency of houses	16	37
2	Increase the number of road lanes for cars	15	35
3	Make property developers consider air pollution & climate change	88	68
4	Free internet for all homes as standard	47	66
5	Promote car sharing clubs for personal & business use	93	75
6	Reduce taxes on petrol and diesel fuel	13	30
7	Allow delivery drivers to use any route through the city	21	38
8	Don't force bus companies to use clean engines	19	35
9	Allow public sector to use any kind of fuel	26	41
10	Switch all diesel cars and vans to use biofuel	92	77
11	Remove hedges and widen roads	14	28
12	Keep the 40 hour working week	55	69
13	Regulate construction & farm machinery pollution more heavily	84	70
14	Promote use of air conditioning	39	53
15	Make ship fuels cleaner	69	56
16	Remove all 20 mph speed limits in the city	36	50
17	Sell high polluting fuels	2	15
18	Encourage use of geothermal for home heating and cooling	90	76
19	Don't force councils to use hybrid vehicles	19	32
20	Make all buses meet minimum clean engine standards	75	62

In comparing two largest age groups of players (Table 6) the following observations are noted:

- Some differences (e.g. less support for nuclear in the lower age group) are consistent between competing policies
- In other cases, there are apparent inconsistencies, for example the younger group are more likely to support building fewer roads, yet they are more supportive of increasing the number of road lanes for cars, supportive of decreasing taxes on cars, and less supportive of increasing toll road charges.

Table 6: Policy options selected in the game by age groups

Rank	Policy	Aged 16-24	Aged 25-34
1	Keep separate ticketing systems for all transport types	42	18
2	Make property developers consider air pollution & climate change	70	92
3	Ban bonfires	46	26
4	Don't build new nuclear power stations to replace coal	54	35
5	Build cycle superhighway lanes in the city	84	66
6	Always use cheapest building materials	27	10
7	Tax developers to spend on health and environment	80	63
8	Increase toll road charges to spend on public transport	46	62
9	Shorter working day in winter	47	64
10	Build more nuclear power to replace coal	50	67
11	Decrease tax on cars cut spending on public transport	50	34
12	No requirement for buildings to use district heating systems	47	30
13	Charge road tolls for low emission vehicles	37	21
14	Don't fund work that will increase uptake of hydrogen vehicles	41	56
15	Compulsory cycling lessons at schools	81	96
16	Cycling lessons are optional for students	33	18
17	Build less roads	63	49
18	Force industry to recycle waste water for heat	77	92
19	Increase the number of road lanes for cars	32	18
20	Do not require new housing estates to include green space	34	20

In comparing the two most successful cities in terms of player numbers (Table 7) the following observations are made between Bristol and Sosnowiec:

- More Energy policies and fewer Transport policies are in the top policy options compared to the overall top-20 of all cities combined.
- Bristol more interested in cycling policies and Sosnowiec in reducing costs for cars (although not low emission vehicles)
- There appears to be more support in Sosnowiec for various energy switching policies, although not for the building of wind turbines

- Possibly area specific reasons, e.g. toll roads not an issue in Bristol? Nor farmers burning vegetation?

Table 7: Policy options selected in the game: Bristol v Sosnowiec

Rank	Policy	Bristol	Sosnowiec
1	Fit solar panels on all roofs in the city	52	85
2	All parcel deliveries using drones	23	55
3	Ban farmers from burning vegetation near the city	48	79
4	Increase taxes for companies buying low emission vehicles	9	39
5	Free charging and parking for electric cars	90	62
6	Make property developers consider air pollution & climate change	64	90
7	Ban the idea of drone parcel deliveries	55	30
8	Remove toll road charges spend less on public transport	34	58
9	Increase car parking cut the cost of fuel for cars	18	41
10	Increase tax on fossil fuels & spend it on public transport	70	46
11	Subsidise switching to gas home heating	43	66
12	Continue use of gas for domestic heating & cooking	16	38
13	Use wood instead of concrete for construction	58	79
14	More infrastructure for electric bikes	69	50
15	Reduce investment in walking & cycling routes	8	27
16	Help people switch from natural gas to biogas	50	69
17	Onsite renewable energy for public buildings	59	78
18	Make it cheaper to open shops and amenities in neighbourhoods	86	67
19	Prevent building of wind turbines	12	31
20	Stop using gas for domestic heating & cooking	74	55

In comparing people with self-reported low (1-2) knowledge of air pollution with people with high (4-5) levels of knowledge (Table 8), the following observations are made:

- High expertise more likely to support transport policies to restrict private car use and encourage the use of public transport

Table 8: Policy options selected in the game by self reporting level of knowledge about air pollution

Rank	Policy	Low expertise	High expertise
1	Improve connections between buses and trains	63	84
2	Increase tax on fossil fuels & spend it on public transport	55	77
3	Don't invest in trams or light railways	42	21
4	Allow all vehicles can access all of the city	31	12
5	Allow parents to choose any school they like	71	52
6	Ban old lightbulbs except LED bulbs	70	51
7	Increase parking space in the city centre	38	19
8	More reliable and affordable bus services	77	94
9	Ban diesel cars on high pollution days	76	94
10	Restrict citizen access to air pollution information	20	3
11	Cash-only ticket payments on public transport	30	13
12	Ban burning wood and coal for home heating	43	60
13	Redirect traffic to less busy roads during rush hour	55	72
14	Introduce air pollution & fuel efficiency labels for new cars	81	97
15	Run a 'right to drive' car ownership campaign	21	37
16	More childcare at or near to workplaces	60	76
17	Increase garden waste collection fees	38	23
18	Reduce car parking spaces in the city centre	71	85
19	Ban rooftop gardens	24	10
20	Allow traffic into all areas at all times	21	7

2.1.2 Policy Elevations

The following illustrated the policy elevations in the game that occur in the town hall, every 5 years. The top 20 policies elevated across the game are illustrated below as a percentage of the times they were available for elevating (Table 9). The following observations are made:

- The top three ideas selected also appear on this list (but not at the top)

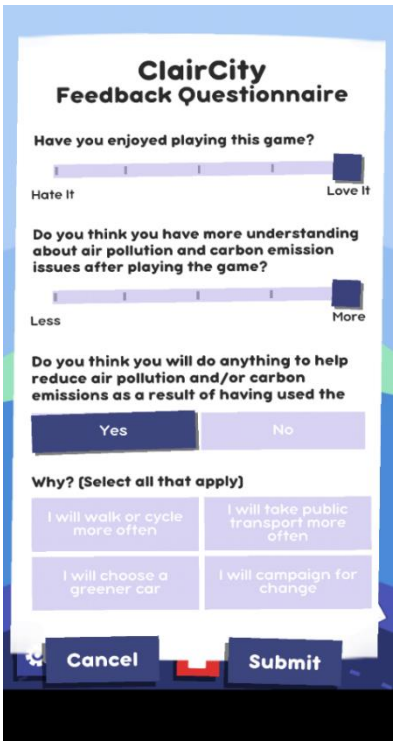
- Some policies, e.g. 40 hour working week, do not have the broadest appeal, but those who do agree with the policy are confident in its efficacy.
- Of the top four are 'Other' category policies. Only one 'Other' category policy appears in the top 20 most selected policies, and that policy is not on this list.

Table 9: Top 20 policies elevated across the game

Policy	Category 1	Number of times idea offered	Number of times idea selected	Percentage of times selected	Rank of policies based on % selected	Number of times policy elevated	Percentage of times elevated
Keep the 40 hour working week	Other	360	232	64.4	187	202	87.1
Tax developers to spend on health and environment	Other	369	261	70.7	141	219	83.9
Encourage people to use public transport	Transport	200	177	88.5	**2**	148	83.6
Increase council tax on un-used buildings	Other	456	315	69.1	154	260	82.5
Create journey planning tools for all modes of transport	Transport	173	132	76.3	99	108	81.8
Power traffic lights with solar panels	Energy	182	163	89.6	**1**	131	80.4
Only sell high performance fuels	Transport	185	136	73.5	125	109	80.1
Reduce prices for peak-time travel on trains and buses	Transport	382	288	75.4	110	230	79.9
Make buses cleaner and greener	Transport	434	381	87.8	**3**	304	79.8
Give 16-25 year olds reduced fares on buses	Transport	364	283	77.7	88	225	79.5
Build less roads	Land Use	352	200	56.8	225	159	79.5
Night time delivery of goods in cities	Transport	181	140	77.3	92	111	79.3
Major investment in cycle paths	Transport	425	359	84.5	**12**	284	79.1
Ban burning of farm waste	Agriculture	238	195	81.9	45	154	79.0
More police action on bike security	Transport	423	337	79.7	67	266	78.9
Allow electric cars to use public transport lanes	Transport	186	150	80.6	61	118	78.7
More roadside emission checks on lorries	Transport	203	149	73.4	128	117	78.5
Make it easier to carpool	Transport	195	144	73.8	121	113	78.5
Force industry to recycle waste water for heat	Energy	242	194	80.2	64	152	78.4
Introduce a congestion charge	Transport	390	286	73.3	129	224	78.3

2.2 Game Evaluation Responses

The following graphics represent initial findings from the player sign up and game evaluation sections at the beginning and end of the game, where both were simple 'slider dragging' and option selecting surveys, with the latter made available to players if they completed a play session of their city, win or lose.



In the post-game play evaluation, four main questions were asked:

- Have you enjoyed playing the game? Response was on a scale of 1 = Hate it to 5 = Love it
- Do you think you have more understanding about air pollution and carbon emission issues after playing the game? Response was on a scale of 1 = Less to 5 = More
- Do you think you will do anything to help reduce air pollution and/or carbon emissions as a result of having used the game? Response was a simple Yes or No
- Why? Respondants were asked to select four options
    - I will walk or cycle more often
    - I will take public transport more often
    - I will chose a greener car
    - I will campaign for change

A good distribution of player age exists from those who undertook the end of game survey across gender options that the player sign-up provided (Figure 14).

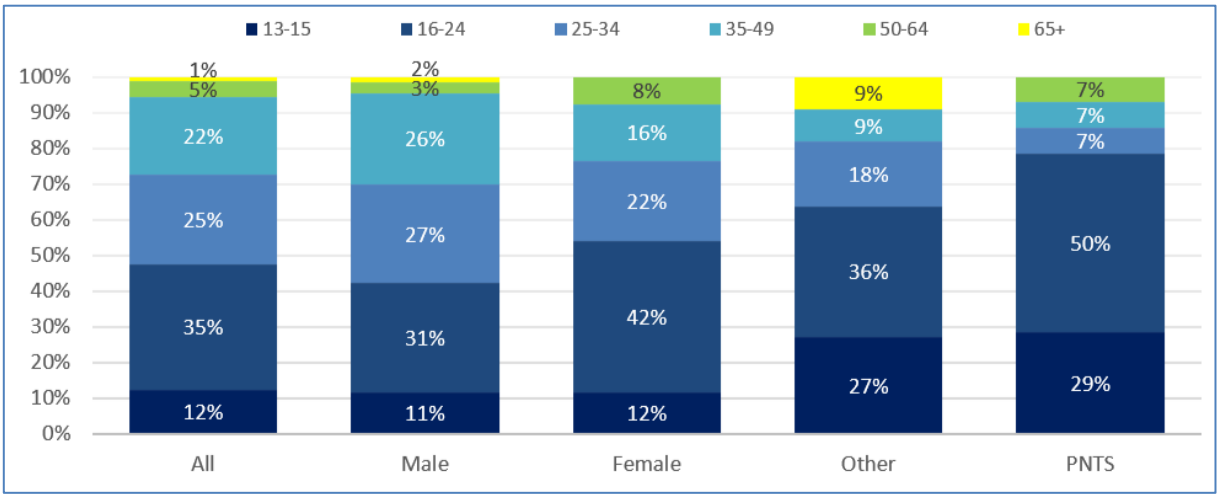


Figure 14: Gender and age of evaluation respondents

2.2.1 Evaluation by Gender and Age

Developing 'serious games' designed to 'appeal to all' is a technically challenging task, as player taste varies dramatically over a multitude of videogame genres. Commercial software entertainment experiences typically provide deeper engagement and the prospect of intrinsic not extrinsic player motivation when compared to interactive surveys and gamification approaches, but also have the affordance of being able to appeal to specific player types. The challenge of getting players of different ages and backgrounds to like the same serious game should not be underestimated. Players who enjoy immersive, multi-million pound 'AAA' shooting games, will not find the same things enjoyable as someone who plays sim-city style games, and the differences should perhaps be considered akin to, and as stark as, the enjoyment of musical genres, where it is not unusual for a listener to 'hate' a particular style. For a serious game such as ClairCity Skylines, a positive outcome would be that more people broadly enjoyed the game than did not, and more specifically that those that loved it outweigh those that hated it by 2-3 times.

2.2.1.1 Game enjoyment

Figure 15: How much the players 'enjoyed' the game by gender (top) and age (bottom)

Figure 15 illustrates the enjoyment of the game by gener and age. Overall, 10% gave a rating of '1' or '2', while 53% either really enjoyed or loved the gameplay, with approval of 53% and the remaining 37% enjoying the game with a rating of '3'. Of male and female players there was only a difference of 1% between men at 90% and women at 91% rating the game positively

at a 3-5 score. By age group, it is clear that a clear majority of players aged 13-15 and 16-24 gave the game a top rating of 5 out of a possible 5, and that overall ratings of 4 and 5 for enjoyment show small decline towards the upper player ages. By the age 65+, 50% of players were giving scores of 3/5, compared to just 23% at age 13-15.

2.2.1.2 How the Game improved players understanding

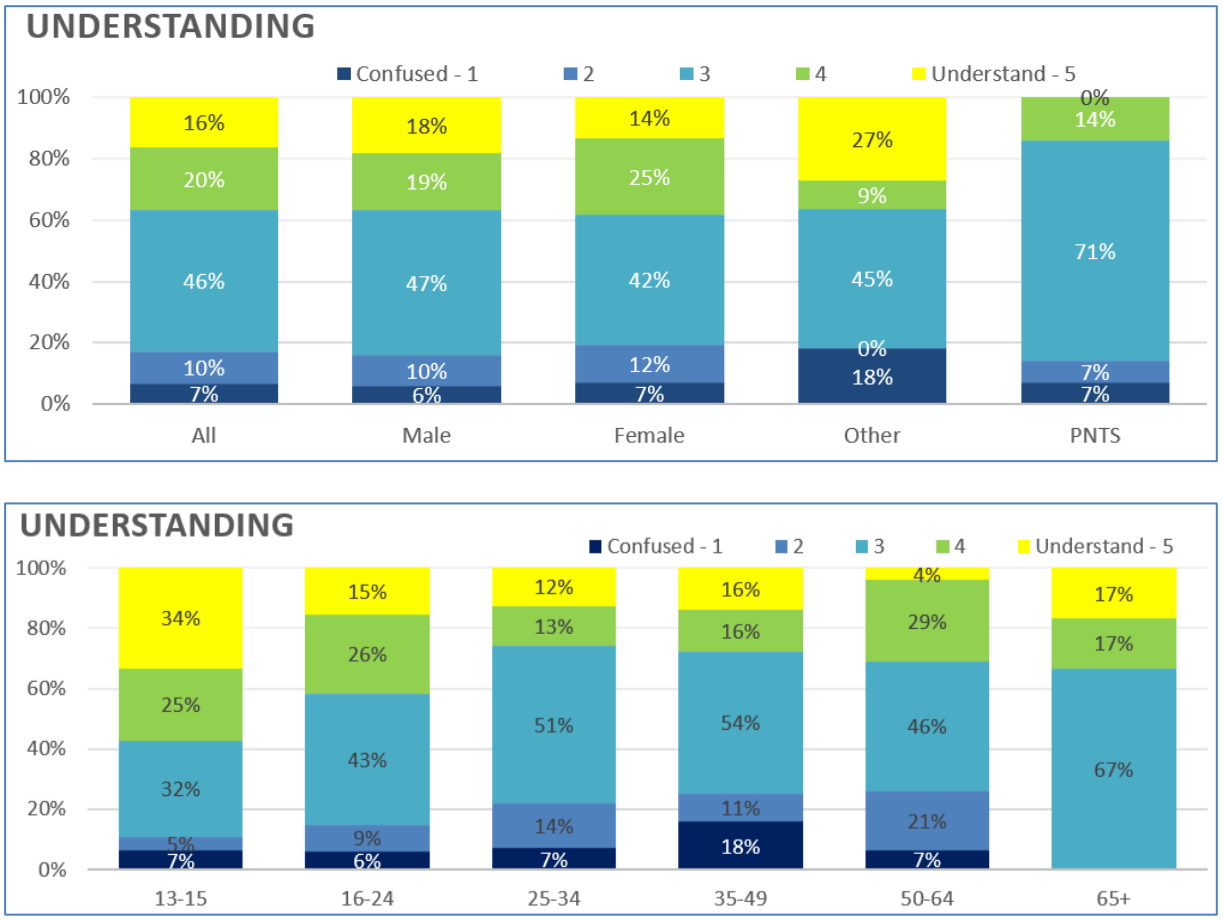


Figure 16: How much the players 'improved their understanding' by gender (top) and age (bottom)

In terms of expertise of knowledge about air pollution, players starting the game showed a majority response of 57% knowing little (35%) to nothing (22%) about the subject, with women and other having the largest share of 'experts' (7%, 9%) and those prefering not to say the lowest overall understanding and least 'experts' (27%). In terms of player understanding about air pollution and carbon emissions after playing the game(Figure 16), 36% overall felt they understood more strongly, 46% felt it stayed the same, 10% were more unsure and just 7% felt they understood less well. The 17% of negative responses here stand in contrast to the 57% of those having little to no knowledge of the area before playing. There is very little difference between the overall breakdown by gender.

By age there is an interesting, if subtle pattern, that shows the younger and older players felt that they had improved their understanding the most with the highest number of 4/5 and 5/5 ratings, while age categories in-between show marginally higher scores of just 1/5 and 2/5.

2.2.1.3 *Inflence player behaviour*

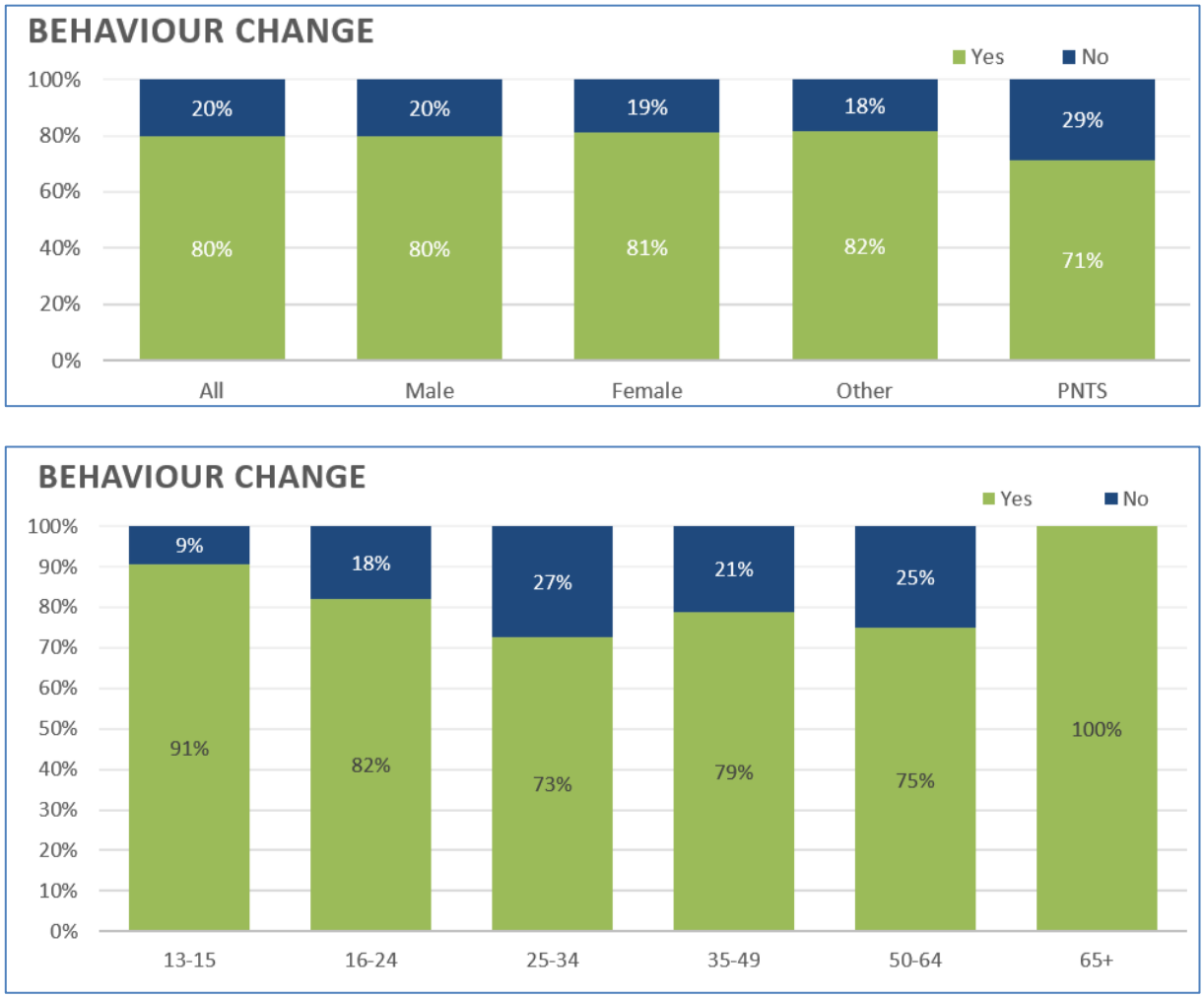


Figure 17: Player-perceived behaviour change by gender (top) and age (bottom)

Players reacted overwhelmingly positively to the question of whether the experience of playing ClairCity Skylines would change their behaviour around achieving a low carbon clean air future for their city, with an average of 80% of players across the gender options and 83% across all age ranges. It is interesting that those who prefer not to state (PTNS) their gender felt slightly less confident (71%), and those aged 65+ were most confident (100%) although both of these are statistically far smaller groups.

3 Steps for Better Practice

The following section provides further advice for developers and researchers who may be thinking of developing serious game content for their research project. It is not intended to be an exhaustive list of recommendations but does illustrate the key learnings from the design through to the implementation of the ClairCity Skylines Game.

3.1 'In-house' game development: co-creation and risk mitigation

ClairCIty Skylines had a number of consultation and co-creation steps with the project partners but a more immersive co-creation process may have avoided many developmental hurdles. Even after formal 'sign-off' of a concept, the game should be pitched and demonstrated back to project stakeholders for feedback and scrutiny at every stage of development. Prototypes and proof of concept work, pre-alpha, alpha and beta builds can showcase and build rapport with the wider project through social media, focus groups and presentations allowing for the uptake of a multitude of different perspectives and experiences of science communicators, social and environmental scientists. Even if stakeholders do not fully understand 'gaming' or the proposed mechanics, facilitating their understanding will lead to a better overall project, even if it is not possible to see eye to eye with those who see citizen engagement as unscientific. Serious games should be inclusive and accessible and success with these stakeholders are an indicator of potential game success once development is concluded.

Additional steps to mitigate risk in small game development teams is essential. Extra effort should be made to ensure that the project and it's codebase are as extensible and as easy to understand as possible in case of unforeseen personnel or technology changes. While extra layers of documentation and enforced coding standards are good practice in general, technology failures can challenge even seasoned developers at critical times in the project. For ClairCity Skylines, while approaching the final deadline for the four remaining cities that were currently being localised, we experienced a well-known database service provider going into administration, meaning we had to migrate the database at a critical time, but we were confident that had we needed additional support there was enough documentation to ensure other developers could be added to the project with the minimum of disruption. In this light, due diligence should always be conducted to ensure 'go-to' technology platforms will likely be available and stable for the duration of the project.

3.2 Game mechanics for serious games

3.2.1 Setting the scope: you are building a game not a real-world model

Early in the project, the development team was able to scope-back the game-design requirements to remove a great deal of advanced technical content that in retrospect would have added very little to the game. Even when in full production, time to reflect on if the game is still serving project goals and outcomes effectively is essential otherwise 'feature-creep' or design by committee may set in. It is important to be clear from the outset what the game is (e.g. behaviour change, awareness, reinforcement) and the outcomes that are desired.

Most gamification and serious game experiences simply reinforce information being given to employees through 'on the nose' messaging, pop-ups, awards or badges but good serious

games mount a 'procedural rhetoric'[5] in as much as they assemble rules that suggest a particular function rather than telling the player why they must do what they are doing explicitly; "the art of persuasion through rule-based representations and interactions rather than the spoken word, writing, images or moving pictures.". The game should let players live the problems you want them to understand and solve, not merely 'tell them'. It was through this lens and through consciously trying to avoid a technical simulation, ClairCity Skylines was able to conceptualise the two simple interactions players could undertake in-game that would allow them to take ownership of a city through effective policy-making.

3.2.2 Game loops

Serious consideration should be given to the different game loops that operate within the game mechanics of the project at different levels, which are core to extended periods of engagement. We teach game design students the notion of micro, macro & meta loops when thinking about gameplay, and having a clear understanding of these loops will allow the team to instinctively know which aspects of the design should have primacy in their implementation of the project. In ClairCity Skylines, the micro loop is a players ability to rotate the city and choose areas and ideas they like that affect an attribute; the macro loop is the ability to elevate an idea into a policy and save the city over time and for a given medal; and the meta could be the ability to complete all of the ClairCity Skylines playable cities, or to become the best player in the world, through a high-score or similar.

Even the earliest games have a micro loop – the core interaction between a player and the game - this could be driving a race car and winning a race. Nearly all games have a macro loop, this could be winning a series of races within a championship, and most now have a meta loop, this could be a global championship, high score boards, or other extended reasons to come back to play. These loops are return triggers of a sort, and fill out the promise games that were 'easy to play' but 'hard to master', where in each loop a player can achieve a state of 'flow'[6], in pursuit of their chosen goal in a channel between boredom and anxiety[7]. Serious games very rarely have a macro loop, and ClairCIty Skylines includes perhaps only a partial one at best. While meta loops can run into issues of data protection (high score) or scope (budget), if extended engagement is important, they should be given due consideration.

3.2.3 Understanding the game 'oil' and 'juice'

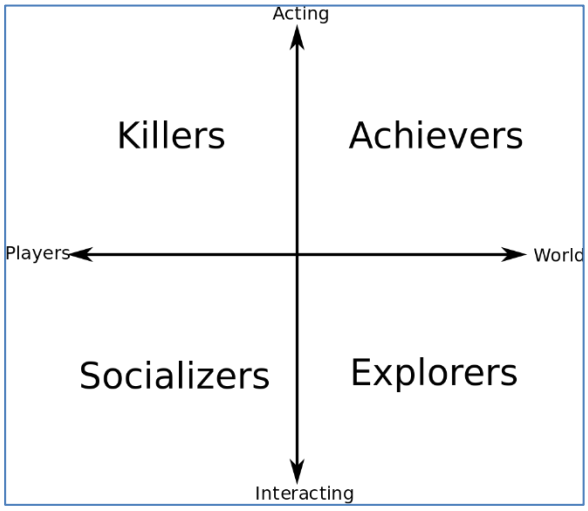
Game 'Oil' and game 'Juice' are both familiar terms to seasoned game developers and have come to parlance from indie developers looking to create professional-looking games on a budget. This is relevant to serious games as there is often limited budget (compared to AAA entertainment titles), and often overtly technical content which may make these elements seem somehow less important. Oil is literally how slick the different states of the game flow into each other, how well the flow of the overall experience fits together. What might traditionally have been considered via storyboarding, good serious games are far from linear, and sections of the game can usually be accessed in a variety of ways from different parts of the game, so oil is core to the experience of the game (and its game loops.). 'Juice' is a related, but far more

[5] Bogost, I. (2007). Persuasive Games: The expressive power of videogames. Cambridge, MA: MIT Press.
[6] Mihaly Csikszentmihályi (1990). Flow: The Psychology of Optimal Experience. Harper & Row.
[7] Mihály Csíkszentmihályi (1975). Beyond boredom and anxiety. Jossey-Bass Publishers.

specific and localised effect pertaining to how much audio-visual 'flourish' there is in a game. This may also seem superficial, but it directly relates to a sense of reward felt by the player through everything they do in the game, not just as a reward for achieving a specific objective. Juice can take the form of particle effects, sound effects, animations, and even extra features that embellish the sense of achievement be it bite-size progress or the sense of completing the entire game. It is a good rule of thumb that if the game wishes to 'tell' the player something, the quality of interaction with the player will be increased if the experience is both smooth in transition between different scenes of the game, and polished in terms of the audio-visual flourish that is presented.

3.2.4 Understanding player types: Bartle types

The game design should also consider 'Bartle' player types, especially when the game considers player behaviour and data capture as part of a research project. While the games industry has sought to broaden out these terms into 'consumer types' the four original types defined by Bartle[8] are most appropriate to serious games as they force a certain kind of consideration as to the types (and combination of types of player) that will be using their game, and if this has implications on the quality of data captured. The Bartle taxonomy defines Socialisers, Explorers, Achievers and Killers, where (as with player loops) we have our adaptation of this, where Killers are 'Attackers' allowing for a wider range of disruptive activity.



Attackers / Killers are aggressive, subversive player-types who challenge norms and may want to break the game. Achievers will go 'all out' to be the best and achieve a high score or perfect record. For socializers it's about their ability to communicate with others in and out of the game and the quality of interactions with non-player characters (NPCs) in the game, while for Explorers it's about the breadth of experience and discovering everything the game world has to offer.

While not exhaustive, these player types provide a lens to consider the types of ways different players will engage with a game experience. An attacker-achiever might play to win at all costs, while a socializer-explorer might just want to experience everything a game has but the winning aspects may not be as much of a high priority. These behaviour combinations can all be planned for, designed around and mitigated, but when ignored it could end in a serious game failure. The ClairCity Skylines game design considers the interactions of attacker, achiever, explorer and socialiser 'player types' as well as varying levels of gaming ability. For example, an 'attacker' may play subversively to crash the game to 'see what happens', but the game responds by clearly informing the player of the attribute that caused the failure. An

[8] Bartle, R. (1996). Hearts, clubs, diamonds, spades: Players who suit MUDs. Journal of MUD Research, 1 (1). Retrieved October 3, 2019, from http://www.mud.co.uk/richard/hcds.htm

‘achiever’ might disregard personally held beliefs in pursuit of a ‘win at all costs’ but in this case (and especially for gold medals), shows they have implicitly understood the aim of the game, and have harnessed real-world policies they believed would be successful – showing belief and understanding of a policy if not overall acceptability.

3.2.5 Know where to set your system boundary and technical challenges

For serious game mechanics, only go out of your way to harness ‘advanced technology’ if it is core to one of your game loops or project requirements. This also applies to using ‘real world data’. For ClairCity Skylines , the CPL was entirely derived from real-world policies which were weighted by scientists and researchers so that policy impacts move the game in the right direction – but this data is never made explicit to the player, and is at the very core of the game mechanics (loops) of the game, so it is justifiable in the amount of time taken to create the system. It is also worth considering that too much real-world data will result in the game becoming a simulation and not a game. Games, as with films create an emotional reality and can be intrinsically interesting and motivating. A deep simulation that excites a scientist will likely not necessarily be interesting or engaging for the majority players. In ClairCity Skylines, we had to develop a system of four “attributes” (City economy & environment, Citizen Satisfaction & Health) to allow the game to take real world policy data and to make it not only ‘playable’ but ‘balanceable’ and ‘winnable’. These easements are acceptable in serious games so long as the data collection is unaffected. In ClairCity Skylines, the valuable data was the ideas chosen and the policies enacted, not exactly how happy enacting a particular policy made citizens in one city versus another.

3.3 Localisation of game and CPL

Consider if localisation is really important for a serious game. Alternatives such as stronger use of iconography as opposed to text elements can be far cheaper than exhaustive translation and transcription – although it should be noted that icons should still be checked for localisation issues. Where it is absolutely essential that technical or heavier text content needs to be localised, this should be completed at least six months in advance of the launch, as the quality of translation for non-standard game localisation varies greatly – especially so if a project plans on using stakeholders for localisation.

It should also be noted that at the time of writing the Apple play store does not support the full alphabetic symbols of many European Languages and that gamers often do not require a perfect translation in order for the game to be playable. Extra time should be taken to on-board all stakeholders with the challenges and complexities of localisation so problems can be addressed when they arise and issues of “lack of faith” from regional partners can be mitigated.

3.4 Game analytics and app store markers of success

It may seem simple to state a number of ‘players engaged’, ‘play sessions held’ or even ‘downloads by platform’ as KPI’s or targets for success, but there remains a great deal of inconsistency in attempting to record this data and work should be done at the outset to select criteria available on both Google and Apple stores. For ClairCity Skylines, we discovered that the manner in which these two stores report downloads and installs was significantly different in terms of the resolution, granularity and detail of the data captured. We also did not anticipate

the effect on high-level phone security restrictions re. app “permissions” that would render certain technical data impossible to capture – a feature that we designed around through use of a demographic survey at the start of the game, and a game survey evaluation upon completion.

Before establishing metrics such as the above, give consideration to whether or not there is an established game analytics platform that can give you the KPI’s required. For ClairCity Skylines, we looked at the systems used by mobile games as well as the Unity platform in terms of informing the team as to the quality of interaction, e.g. playtime, exit points, session funnelling, return triggers etc. rather than just raw downloads by handset and ensured that the database would capture certain data in another way if it did not look possible to extract it from platform analytics. Also consider the issue of geo-locking (or inability to geo-lock) your game if the location of your users is important. For ClairCity Skylines we found we picked up players in China and Russia as well as ‘bots’ from the stores and analytics platforms, but were able to differentiate this through the user signup process and the overall database design.

3.5 Launching a serious game, marketing & expectations

With serious games, it is usually “required activities” that achieve the best engagement, but if a game is to be released publicly, much can be done to improve the likely success of the game in terms of numbers engaged. With ClairCity Skylines, the ClairCity dissemination and communication team was able to create a communications strategy around the game, promoting it across all activity within the project and co-ordinating on branding, marketing, engagement events and audience opportunities. Without this communication strategy the project would not have had the strong a launch with media exposure from the Mayor in Bristol which set the tone for the following cities. See https://twitter.com/ClairCity/media for more examples of how ClairCity used media.

Figure 18: Large format display promoting the game in Sosnowiec information kiosk.

For ClairCity Skylines, the sixth city, Sosnowiec achieved the strongest media representation of all of the cities featured. They ran radio advertisements on ESKA.pl, projected huge digital billboards as well as a smaller digital posters and pop-up events across the city. This communication and promotion effort resulted in excellent player numbers. Conversely, Ljubljana and Liguria did not promote the game extensively and the player number suffered as a consequence. Prior to the launch our expectations had been Bristol, Amsterdam, Liguria, Aveiro, Ljubljana and Sosnowiec in order of engagement, based on stats of smartphone usage and gaming, but this shows the value of having highly engaged project partners who have felt part of the project from day one.

Figure 19: Social media promotion of new cities and physical leaflets (Sosnowiec).

4 ClairCity Skylines Game – Next Steps

There are a number of additional step that are being applied to maximise the game mechanics, artwork, data and lessons learned. These include:

'Stand-alone' workshop tool: The core game engine is being minimised and utilised to create a learning tool using a "random city" generated from the attributes of the six within the ClairCity Skylines game. This ClairCity Skylines 'light' version can be used in real time in a classroom or workshop space, and the results presented on screen as a talking point for further dissemination. It is also possible that the methodology used to triangulate player choices can be disseminated and applied to other research projects worldwide. A future possible step could be to adapt the 'light' learning tool into a 'universal city' level that illustrates what the software is capable of, regardless of the policies and graphics loaded. It is also possible that idea-collection and elevation could be applied far beyond the realms of air quality for serious games.

Augmented Reality: Using the artwork and design features of the Game coupled with the infographics generated by the wider project, the ClairCity team is developing a proof-of-concept immersive visualisation VR/AR/MR as other outputs of the data collected by the game. This would be linked to the game mechanics and can be added to the arena of public engagement activities generated by ClairCity project as a whole.

Further data exports and analysis: This report has illustrated the headline data but further data exports for the period elapsed between the close of the first primary data collection and the close of the project is planned, so that the evaluation data and player choices across the six cities can be added to an already rich dataset for use across the project and in evaluating ClairCity impact. This combined with the granular data from each city and each players choices will be incorporated into subsequent deliverables and publications. It is the intention that all game data will be open access as appropriate by the end of the ClairCity project (April 2020).

5 ANNEX 1: Technical Design Documentation

The following serves only as a summary of the main game development methods and systems. A full technical design document (TDD) is available for ClairCity Skylines and will be uploaded to the repository / portal before the close of the project.

Policy measures are loaded to the game as ‘ideas’ or ‘policies’ that the players see from the CPL database (ClairCity Policy Library) and presented to the user via the Database Provider within the game, along with appropriate indicator weightings and temporal data supplied by the wider ClairCity team. Player actions such as ideas and policies chosen in-game are then packaged with anonymised profile data and sent to the remote ParseServer.

The game was developed using Unity and Visual Studio. Unity is a multipurpose game engine that provides the core components for development (graphical rendering, audio support and asset management). Visual Studio is the Interactive Development Environment (IDE) that supports the compilation of the C# programming language used by Unity.

The game has been developed on Windows based PC’s, however to deploy and test for iOS devices a Mac based laptop has also been used. The game has been tested on a wide range of mobile devices with varying specifications and operating systems (Android and iOS).

Unity assets were also utilised to complete aspects of the game. iTween and Spine were used for in-game animations and adding interpolated transitions of movement, colour, and scale. Graph Maker was used to display information in charts, while Input Event was used to detect and handle simple touch interactions such as touch, tap, and drag. Lunar Console was used at runtime to allow users to do bug testing and submit error reports.

Development of the game also required SQLite, a database management solution for internal data on the target platform device and Parse, a NoSQL database solution for remote database access. The database also stores responses from the ClairCity Feedback Questionnaire.

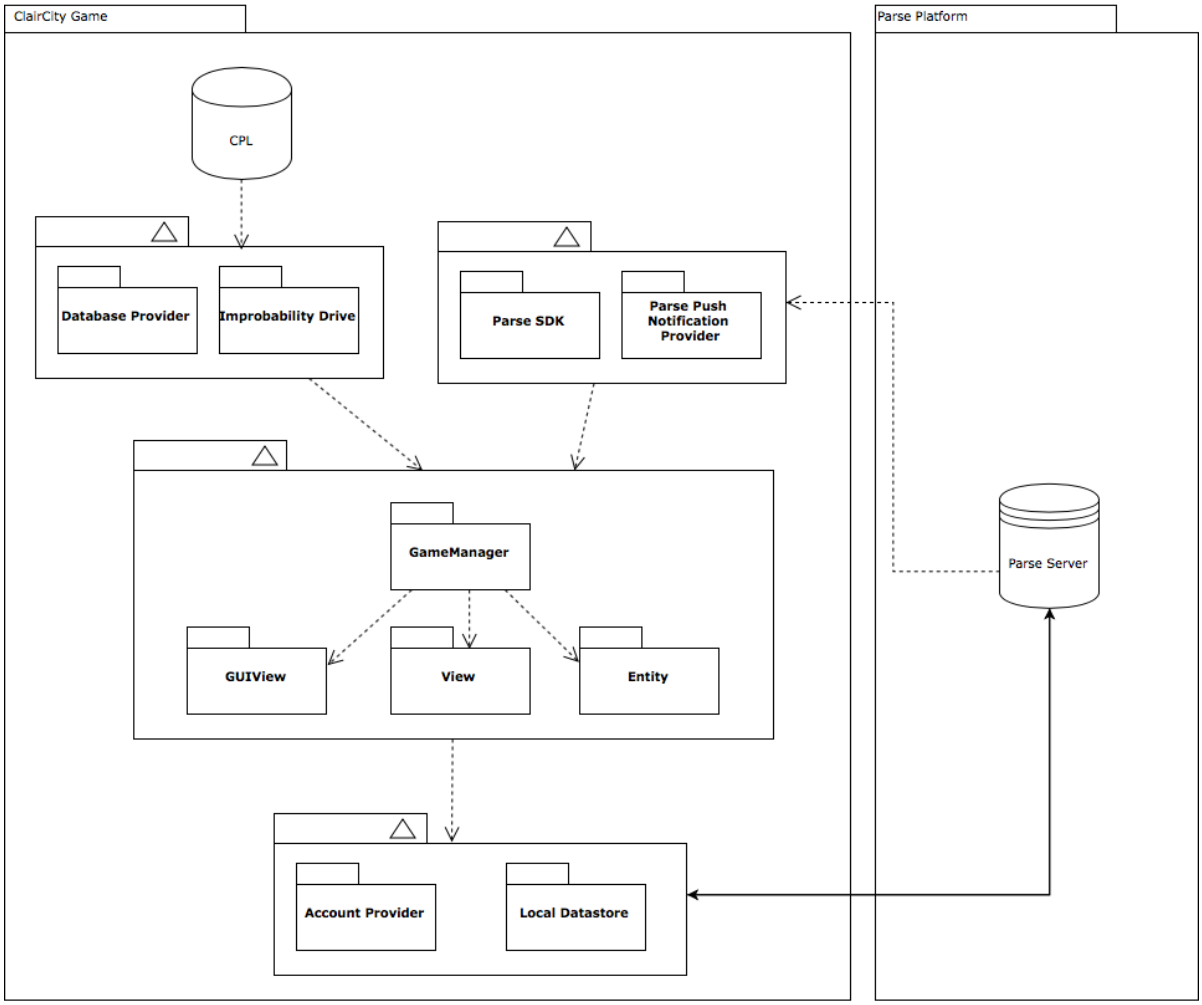


Figure 20: Overview of the ClairCity Skyline process schematic