

Sprint Documentation

Team Teal

GitHub Link: <https://github.com/Filippo-Santiano/SECW2>

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1 Sprint 1: 30/10/2024 to 06/11/2024

1.1 Overview

During the first sprint, the team was focussed on getting the environment and processes setup for development to successfully begin. In this sprint we decided on the sustainable tycoon game idea and created an MVP for it.

Allocated roles: Jake was responsible for the documentation in sprint 1, Calum was the product owner and Filippo was the Scrum master. All other members were developers.

Table 1: Snapshot of the sprint backlog for sprint 1.

Identifier	Task	Assignee
T1-1	Source carbon data	Chih-Ting Chang
T1-2	Find initial concept art / research existing art	Calum Ogilvy
T1-3	Setup GitHub repository	Filippo Santiano
T1-4	Create grid layout to place buildings on	Chris Seadon
T1-5	Define the 2 basic business and forest tiles in Godot	Chris Seadon
T1-6	Setup Continuous Integration (CI) workflow	James Sue-Ling
T1-7	Create a running score for money and carbon footprint in Godot	Chris Seadon
T1-8	Install Godot on local machines and become familiar with software	All members
T1-9	Gather and combine different sections for the documentation from team members	Jake Hulme
T1-10	Produce user stories	Anshu Singh

The identifier, T, stands for task, the first number following that is the sprint number. The second number after the hyphen is the order in which the task was conceived.

The identifier, U, stands for user story, the first number following that is the original sprint number. The second number is the order in which the user story was conceived in that sprint. The third number is the version of the user story. E.g. U1-1-1 is sprint 1's first user story, version 1.

1.2 Review

All tasks assigned in the [sprint backlog](#) were completed apart from [T1-6](#) which was completed shortly after sprint 1 concluded. This required further discussion on our testing process, which has been documented in this week's [sprint review](#).

1.3 Meeting Minutes

1.3.1 Group Meeting 27/10/2024

Note: This meeting took place before sprint 1 but has been included for completeness.

Meeting attendees: All group members

Meeting aim: Develop game ideas further

Meeting summary:

- Filippo presented his ideas on the cooking game. He expanded on the initial ideas by drawing a mock-up of the interface and explained the game mechanics, reward scheme and the Oracle's purpose. We discussed this further as a group.
- James presented his ideas on the mindfulness game. This included the reward scheme, in which a seed is rewarded everyday for logging in which could then be used by the player to plant trees. We discussed the trade-off's between 2D and 3D and the possibility of pixel art or sprites to save implementation time. The Oracle would be running guided meditations. Following this, the group went on to discuss these ideas in more depth.
- Anshu presented her ideas, which built upon James' mindfulness game. Her idea focused on different sections of the world to represent different aspects of life, including relationships, career, health and family. There would be tasks in each section which would level the player up. The Oracle would give advice on how to complete these sections.
- Calum presented his ideas which were also built upon James' mindfulness game idea but simplified the interface and added in a biodiversity educational element, where users are rewarded for building a diverse biome.
- As a group we also built upon the sustainability tycoon game idea, discussing in more detail about the game mechanics and feasibility of the game art.
- We brainstormed and then organised our thoughts for the customer meeting which included questions on the scope of the overall project and to get feedback on our initial game ideas.

Meeting actions:

- All members to add any more questions to the customer meeting document.

1.3.2 Document Meeting 30/10/2024

Meeting attendees: All members

Meeting aim: To gain clarity on the documentation expectations and sprint roles for each sprint

Meeting summary:

- The TAs recommended a sprint length of 1 week.
- Each sprint, we will set the role of each team member and rotate these between sprints.

Meeting actions:

- Set roles for each team member for sprint 1
- Create a backlog of tasks using Jira
- Assign tasks to members for sprint 1

1.3.3 Group Meeting 30/10/2024

Meeting attendees: All members

Meeting aim: Decide on the final game idea, create a product backlog, assign roles/tasks to members and set up processes for the project.

Meeting summary:

- Went through each game idea, each member voted 'Yes' or 'No' on whether to develop that game idea, giving reasons for their choice. Collectively decided to develop the sustainable

tycoon game as a result, which aims to teach the trade-offs between growing a sustainable economy and reducing carbon footprint. Reasons for this choice included the wide scope of freedom this type of game provided and the simplicity of a grid-based layout that allowed the team to rapidly develop functionality and make iterative improvements.

- The proposed processes and tools were:
 - Group meetings scheduled 3 times per week (Monday, Wednesday & Friday) lasting 15 minutes each, following Scrum guidelines.
 - Godot for game development since Chris had experience with this software.
 - Pair programming to enhance everyone's understanding of the game development process and to pair less experienced coders with more experienced coders. Furthermore, it will enhance everyone's collective understanding of the system which should reduce development roadblocks.
 - Jira for project management. Use of a Kanban board within Jira as Anshu had experience with this software.
 - Test-Driven Development (TDD): Unit tests followed by integration tests, followed by end-to-end tests. Our proposed end-to-end test was running the game locally and checking out the feature just implemented before pushing any code to the repository. CI tests will then run before merging code when it is pushed to the repository.

1.3.4 Group Meeting 04/11/2024

Meeting attendees: All members

Meeting aim: Discuss progress, plans and raise any issues / ask questions

Meeting summary:

- **Filippo:** familiarised himself with Godot. Got clarification on some questions relating to the product and sprint backlog.
- **Calum:** found some initial concept art from [Kenney](#) which is a site containing free game assets. As the product owner, Calum had also been adding items to the product backlog.
- **Anshu:** created some initial user stories with acceptance criteria. Once approved by Calum, these will be added to the product backlog.
- **James:** familiarised himself with Godot. Started a discussion about testing, proposing his ideas for TDD to allow him to set up a CI workflow.
- **Chris:** created the grid layout in the game with tiles from the art that Calum found. He then added flat pollution levels for the 'tree' and 'building' assets. He also provided a quick tutorial for the team, explaining how he achieved this. His next tasks were to make the tiles placeable by the player and create a running total for pollution levels.
- **Chih-Ting:** found some research papers on carbon data for different buildings and planned to have a quantitative table ready for the end of the sprint. We discussed that we only need carbon data for a few different assets as a wide variety of buildings was outside the project scope for now.

Meeting review: This meeting was 22 minutes long, 7 minutes over the 15 minute time-box we had proposed. However, this was our first meeting since the proposal and so could be expected to run over.

1.3.5 Group Meeting 06/11/2024

Meeting attendees: All members

Meeting aim: Plan the agenda for customer meeting

Meeting summary:

- Discussed questions from the document for the customer meeting
- Discussed our general plans for sprint 2. These would be formally added into the sprint backlog, following the customer and document meetings, to ensure that we were acting upon customer feedback.

1.3.6 Document Meeting 06/11/2024

Meeting attendees: All members

Meeting aim: Inform the TAs on our game choice and discuss our progress so far.

Meeting summary:

- Discussed our game and the specific learning objectives.
- The TAs gave us some advice on how to structure our customer meetings: Present the current sprint progress and propose our plans for the next sprint. This allows the customer to give their opinion on future plans to ensure the team are aligning deliverables with the customer's wants.
- We also discussed including meeting summaries in the documentation. The advice was to ensure all key points are recorded so that any decision we make is backed up by information in the documentation.

1.3.7 Sprint 1 Review 06/11/2024

Meeting attendees: All members

Meeting aim: Each member presented their completed work. As a team, we inspected the outcome of the sprint. We will determine what to do next based on the information gathered from this week's main meetings ([customer](#) and [document](#) meetings which happened before this review).

Meeting summary:

- All members, jointly assigned [T1-8](#), were able to install Godot and familiarise themselves with GDScript for development, with some watching tutorials and reading documentation. This task was an ongoing process but we had each made a start.
- Chih-Ting, assigned to [T1-1](#), presented the carbon data that he collected from literature. We stored this on Teams to use for user story [U2-1-1](#).
- Anshu, assigned to [T1-10](#), presented the user stories she had created. As a team we went through them and added them to this week's [product backlog](#).
- Filippo, assigned to [T1-3](#), created a GitHub repository and invited us all as collaborators.
- James, assigned to [T1-6](#), discussed his thoughts on testing as this would affect the CI workflow setup. He found that, due to most CI tools being paid services, the simplest way to implement CI was to use an autoload script in Godot that would run all the tests as the game was launched. The script allowed the team to write any test script in the `./tests` directory which would then be run along with existing tests. As a team, we reiterated on specific testing methods. Writing acceptance tests and writing the minimum amount of code to pass those tests. Writing unit, and integration tests for the addition and making sure they all pass before doing an end-to-end test of your feature locally before merging. He had not finished setting up the script yet.

- Calum was able to complete [T1-2](#) and obtain the assets early on in the sprint. This gave Chris enough time to create an MVP, which he presented and walked the rest of the team through. We discussed the code and how the game can be developed further. This completed his combined tasks of [T1-4](#), [T1-5](#) and [T1-7](#) that he had been assigned.
- We discussed the difficulty of representing time in the game. We came to a general consensus that time would pass quickly (i.e., a year would be represented by a few minutes) to speed up the growth of trees and construction times for buildings.
- We decided that each person responsible for a task will document it in the sprint backlog, and the member assigned to documentation will ensure everyone is doing this. We also decided to have 2 editors per week who would format, spellcheck and grammar check the document. Jake completed his assigned task of documentation for this week ([T1-9](#)) which included setting up an Overleaf project and inviting all team members.

Meeting actions:

- Due to the [customer's requirement](#) on the role of the Oracle being made clear in our game, we would focus on the development of the Oracle in sprint 2. User stories [U2-1-1](#) and [U2-7-1](#) were created as a result to incorporate this feedback.
- After seeing the MVP, the customer also requested that the game environment should be developed further. In response, we created the user story, [U2-2-1](#), involving updating the initial layout of the map, which was then added to the next week's [sprint backlog](#).
- Since we had information on carbon data from [T1-1](#), we assigned a pair the task of displaying this information in a pop-up when a building is clicked (see user story [U2-1-1](#)).

1.3.8 Sprint Retrospective 06/11/2024

Meeting attendees: All members

Meeting aim: Reflect on group interactions, processes and tools used in the first sprint

Meeting summary:

- Since we were mostly working individually and then coming together as a group, there was not much collaboration this week. This is something that we wanted to improve on, going forward in future sprints.
- As there were 7 team members, we would now have 1 member being solely responsible for documentation and the rest of the team would be split into 3 pairs. We aimed to rotate these pairs to ensure optimal allocations, for maximum productivity and pair synergy, and to build on the pair programming theory learned in coursework 1.

1.4 Product Backlog

Table 2: Snapshot of the product backlog after sprint 1

Identifier	Details	Category
U2-1-1	See user story for further details. This user story is linked to tasks T1-12 and T1-14.	User story
U2-2-1	See user story for further details. This user story is linked to task T1-11	User story
U2-5-1	See user story for further details.	User story
U2-6-1	See user story for further details.	User story
U2-7-1	See user story for further details.	User story
U2-8-1	See user story for further details.	User story
U2-9-1	See user story for further details.	User story
U2-10-1	See user story for further details.	User story
U2-11-1	See user story for further details.	User story
T1-11	Develop the game environment / Update initial map layout	Task
T1-12	Create the information box that pops up when tiles are clicked	Task
T1-13	Create a win and lose criteria	Task
T1-14	Create a Twitter feed feature for messages from the residents (Oracle)	Task
T1-15	Create a list of different minigames that we could implement, define all the different sustainable practises we want to teach and then match the two up to have a more fleshed out idea	Task
T1-16	Consider some luck element in the generation of income from businesses, could be based on real market data from a certain time	Task

1.4.1 New Product Backlog Items

The user stories that Anshu had created (based on her assigned task [T1-10](#)) were added to the product backlog (U2-1-1 through U2-11-1). Furthermore, Anshu and product owner Calum collaborated to create the tasks [T1-11](#) through [T1-16](#), which were all added after sprint 1's [second customer meeting](#). These were added as a result of discussion in the team and feedback from the customers.

1.5 Exception Handling

No exceptions occurred during sprint 1.

1.6 Product Documents

1.6.1 Customer Meeting 1 30/10/2024

Note: This meeting took place before sprint 1 but has been included for completeness.

Meeting attendees: All members

Meeting aim: To gain clarification on our team's questions curated in the [group meeting](#)

Meeting summary:

- Discussed the difficulties associated with developing a 3D game.
- Gained clarification on the expectations regarding the scope of the game. The game needs to be reasonably fleshed out, but we can expand on further development of the game in the documentation.

- A game that has an incremental development approach would be better to fit a short sprint length (1 week) since it would allow the team to produce sufficient deliverables for each sprint.
- The broad method of development should be: identify learning objectives and design features in the game that teach these objectives.

1.6.2 Customer Meeting 2 06/11/2024

Meeting attendees: All members

Meeting aim: Present the MVP to the customer and discuss development plans

Meeting summary:

- Demoed the MVP to the customer. At this stage, the user was able to place the very basic tiles (building and grass) around the environment.
- Discussed how time should be represented in the game. We needed to ensure that construction and growing times are accurate (as trees take a long time to become fully grown) so it was proposed that time would move relatively fast to keep the user engaged. We would also need to ensure that all assets have accurate construction times.
- Discussed the inclusion of a tutorial at the beginning of a game. The customer suggested that we should aim for a game where a tutorial is unnecessary and players learn through playing the game.
- The customer was keen to learn about the role of the Oracle and how it would fit into the game. We discussed our ideas of having a 'news' feed, which would provide the user with feedback on the state of their city, or using the Oracle to help the user make decisions. The customer liked the proposal for a combination of these ideas and wanted to see the Oracle's role more clearly defined at the end of sprint 2.

Meeting actions:

- Use this feedback to inform our sprint planning session for sprint 2. There will be a focus on defining the role of the Oracle and developing the MVP further.
- Make a final decision on our game concept (decision was made [here](#)).

1.6.3 User Stories

Since this was the first sprint, this lists all initial user stories. These are likely to be updated and refined in future sprints.

In sprint 1 we created and then completed the following user story which assimilated these tasks: [T1-4](#), [T1-5](#) and [T1-7](#) which were related to setting up the base game.

User Story	Details
<p>AS A user I WANT to interact with a grid layout, place an office tile, and track running scores for money and pollution SO THAT I can dynamically observe how my actions impact the game.</p> <p>Version: 1 — Priority: 1 — Size: 3 — ID: U1-1-1</p>	<p>Acceptance criteria (tests): A grid layout is visible and interactive upon starting the game.</p> <p>Tiles can be placed on valid grid cells, visually confirmed upon placement.</p> <p>Money and pollution scores update dynamically after tile placement.</p> <p>Note: This user story was fulfilled by use case Interact with grid layout and track scores</p>

The following user stories were created in the sprint plan of sprint 1 for the sprint backlog of sprint 2:

User Story	Details
<p>AS A user I WANT real-time information about my city SO THAT I can make informed decisions</p> <p>Version: 1 — Priority: 1 — Size: 4 — ID: U2-1-1</p>	<p>Acceptance criteria (tests): The user can click on each tile in their city and see details about it, including its yearly pollution.</p> <p>The user receives live updates from the Oracle through a message feed that informs them of the recent pollution changes in their city.</p> <p>Note: This user story was fulfilled by use case Tooltip (V1)</p>

User Story	Details
<p>AS A user I WANT the game to be responsive and visually pleasing SO THAT I can stay engaged and focus on the game itself.</p> <p>Version: 1 — Priority: 1 — Size: 4 — ID: U2-2-1</p>	<p>Acceptance criteria (tests): The main menu features interactive buttons which are visually appealing and responsive.</p> <p>All game elements must have high quality assets</p> <p>Interactive elements must have responsive animations and visual feedback</p> <p>The game must maintain a consistent frame rate and smooth performance</p> <p>The user must have the option to customize graphics settings through the settings menu</p> <p>If the game adjusts graphics settings due to hardware limitations, the user must be notified with a clear message</p> <p>Note:</p> <ul style="list-style-type: none"> • This user story was fulfilled by the use case: Enhance game aesthetics • This user story was created based on the sprint 1 review.

The following user stories were created in sprint 1 by Anshu and Calum based on the group's collective brainstorming. These included ideas for future development.

User Story	Details
<p>AS A user I WANT see in real time the current status of my city SO THAT I can strategise about how to play</p> <p>Version: 1 — Priority: 3 — Size: 1 — ID: U2-4-1</p>	<p>Acceptance criteria (tests): The UI should display information about what the city's state is</p> <p>This information should take the form a progress bar</p>

User Story	Details
<p>AS A user I WANT be taken through a tutorial at first login SO THAT I know how to play the game.</p> <p>Version: 1 — Priority: 1 — Size: 2 — ID: U2-5-1</p>	<p>Acceptance criteria (tests): The tutorial opens automatically on player's first login.</p> <p>The tutorial takes the user through placing buildings, showing health bars, and using the Oracle.</p> <p>At any moment in time, the player is able to skip or return to the tutorial</p>

User Story	Details
<p>AS A user I WANT have a main menu feature SO THAT I can start, load or save my game.</p> <p>Version: 1 — Priority: 5 — Size: 1 — ID: U2-6-1</p>	<p>Acceptance criteria (tests): The main menu has options for Start, Load, and Save.</p> <p>Each option exists and functions accordingly.</p> <p>Save option provides feedback about the data saved.</p>

User Story	Details
<p>AS A user I WANT have an Oracle to educate me on sustainable choices. SO THAT I can make educated decisions balancing economic growth with environmental health.</p> <p>Version: 1 — Priority: 5 — Size: 1 — ID: U2-7-1</p>	<p>Acceptance criteria (tests): Access to Oracle guidance shall be provided through either clicking an Oracle icon or by choosing from the menu a guidance option.</p> <p>The Oracle guidance option shall be accessible at all times while playing the game.</p> <p>Oracle provides recommendations concerning the status of the current game, like the level of pollution, health of the economy, and happiness of the population.</p> <p>The guidance of the Oracle changes dynamically as the conditions in the player's city change.</p> <p>Comments: Recommendations will outline the pros and cons of a given decision, focusing on sustainability.</p> <p>The Oracle's recommendations will specifically aim to balance population happiness and environmental and economic health.</p> <p>The Oracle will offer insights into the long-term impacts of various decisions, such as the increase in pollution from supporting heavy industries.</p> <p>Recommendations will include green practices that will reduce carbon footprint.</p>

User Story	Details
<p>AS A user I WANT automatically regenerating trees when they are placed next to grass tiles SO THAT I can create green areas that would improve environmental health over time.</p> <p>Version: 1 — Priority: 1 — Size: 5 — ID: U2-8-1</p>	<p>Acceptance criteria (tests): Trees grow on their own whenever placed next to a grass tile.</p> <p>Growth Speed - The speed of the tree regeneration is based on how many grass tiles are around it. Environmental Impact - Regrown trees have a positive impact on the environmental health bar.</p>

User Story	Details
<p>AS A user I WANT housing blocks to have their minimum and maximum capacity defined SO THAT I can balance the growth of population and maintain the resources in cities efficiently.</p> <p>Version: 1 — Priority: 1 — Size: 4 — ID: U2-9-1</p>	<p>Acceptance criteria (tests): Each block has a minimum and maximum capacity.</p> <p>Housing blocks will show current, minimum and maximum capacity upon click.</p> <p>Comments: The block's population will shift depending on the minimum capacity, which again depends on happiness, affecting the economic vitality.</p>

User Story	Details
<p>AS A user I WANT TO play a realistic game that includes natural disasters SO THAT I can learn about the consequences of pollution and/or how these disasters can be handled.</p> <p>Version: 1 — Priority: 1 — Size: 5 — ID: U2-10-1</p>	<p>Acceptance criteria (tests): When the pollution exceeds an acceptable level (this level is to be determined), trigger a natural disaster.</p> <p>When a natural disaster is triggered, the economic health and population happiness should decline.</p>

User Story	Details
<p>AS A user I WANT TO receive notification warnings about economic health or city happiness reaching its critical threshold SO THAT I can make changes based on this information to sustainably improve the environmental/economic health of the city.</p> <p>Version: 1 — Priority: 4 Size: 3 — ID: U2-11-1</p>	<p>Acceptance criteria (tests): Notifications are shown when the city's economic health or the citizens' happiness reaches below their threshold values. A different type of notice is given at each threshold and for each metric (e.g. the warning for entering the low threshold for economic health will be different to that for entering the medium threshold for population happiness). Notifications pop up with icons or colour-coded indicators that highlight critical issues. Optional sound alerts raise notifications to attract the player's attention. Each notification will include brief guidance on possible actions to improve economic health or happiness. Suggestions for possible actions provide relevant options, such as increasing public services, creating jobs, or building amenities. Notifications update in real time and disappear when their levels recover above critical thresholds. Continuous monitoring prevents repeated alerts from displaying within a very short period of time. The text of the notifications is concise, so the player knows right away what's wrong. The player can close notifications by themselves or let them auto-dismiss after a few seconds.</p>

1.6.4 User Story Tests

User Story U1-1-1 Test

As shown in [Figure 1](#):

- There is a visible grid layout
- The office is clearly placed
- Pollution values were printed to the terminal

** User story [U1-1-1 PASSED](#) **

1.6.5 Use Cases

1.6.5.1 Use Case: Interact with Grid Layout and Track Scores

This use case was used to fulfil the user story [U1-1-1](#)

Goal:

To enable the user to place tiles on a grid and dynamically update the game's money and pollution scores.

Actors

- **Primary actor:** User
- **Secondary actor:** Game System

Basic Flow

1. The user starts the game.
2. The game system initializes and displays the game interface with a grid layout.
3. The user selects a tile type.
4. The user places the selected tile on a grid cell.
 {**Score Update**}
 - The game system updates and displays changes to:
 - The **money score** based on the tile placed.
 - The **pollution score** based on the tile placed.
5. The system continues to track and display updated scores after each action.

Alternative Flows

- **Alternative Flow : Occupied Grid Cell**
 - At {**Score Update**}, if the user attempts to place a tile on an already occupied grid cell:
 - * The game system prevents tile placement and does not update scores.
 - Resume basic flow at step 4 after selecting a different grid cell.

Extension Points

- {**Score Update**}: The point at which the game updates the money and pollution scores after a tile is placed.

Preconditions

- The game system initializes successfully with an interactive grid layout.
- Basic tiles (business and forest) are defined with properties that affect money and pollution.
- A scoring mechanism is in place to calculate and display money and pollution changes.

Postconditions

- The grid reflects the tiles placed by the user.
- Money and pollution scores are dynamically updated based on the properties of the placed tiles.

Relationships

- This use case relates to the [third version of the building menu use case](#) as the building menu is required to select a tile to place.

Interact with Grid Layout and Track Scores Tests

Basic Flow Tests

- **Load Game and Grid Layout**
 - **Precondition:** The game is installed.
 - **Action:** User starts the game.
 - **Expected Result:** The grid layout is displayed, and all interactive elements are functional.
- **Place a Tile on the Grid**
 - **Precondition:** The grid and scoring mechanism are operational.
 - **Action:** User selects and places a "Business" tile.
 - **Expected Result:**
 - * The business tile appears on the grid.
 - * Money and pollution scores update dynamically.

** This use case **PASSED** ** in this sprint as users were able to place an office (business) tile only if the grid cell was empty. The money and pollution scores were updated in the terminal.

Relationships

- This is the only use case so far, meaning no relationships have been identified. However, it is likely that this use case will extend to many others, as it represents a core action in the game.

1.6.6 Screenshots

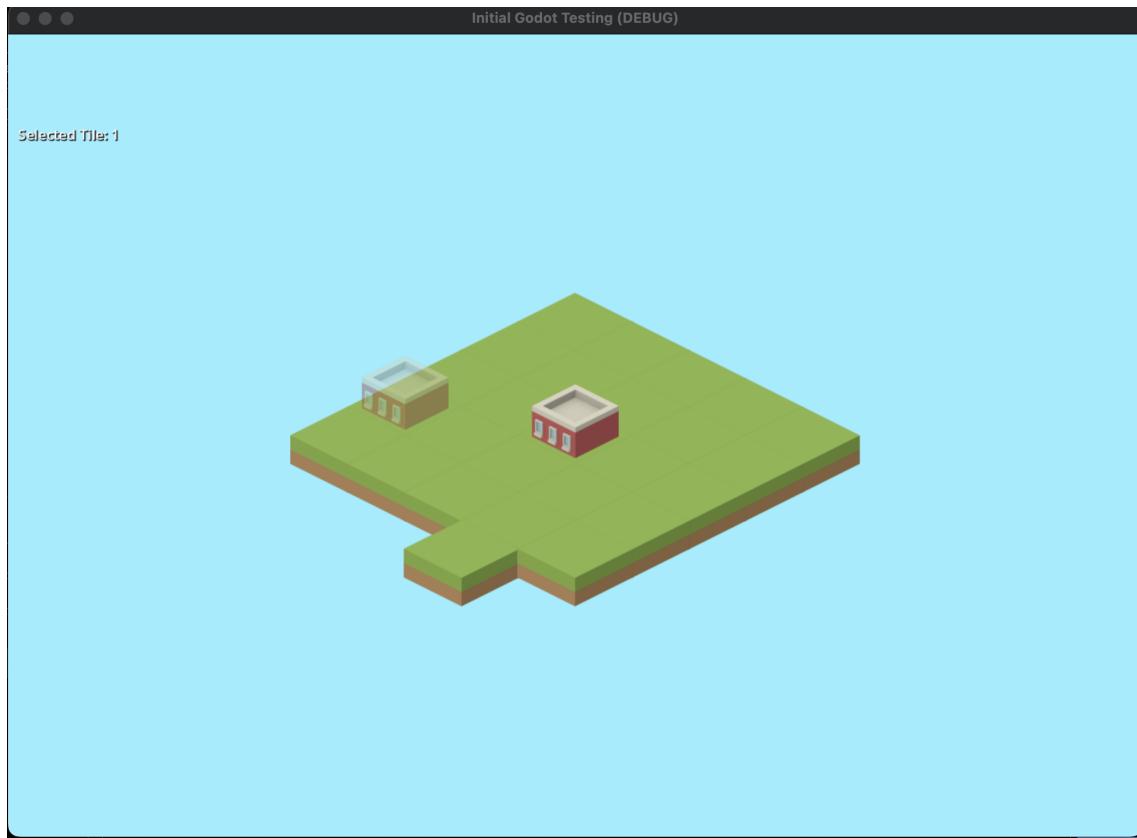


Figure 1: Screenshot of the product after sprint 1.

Linked to user story [U1-1-1](#)

2 Sprint 2: 06/11/2024 to 13/11/2024

2.1 Overview

The primary focus of sprint 2 was around how the user interacts with the game, having a fixed map with interactive tiles, how the Oracle guides the player, displaying information about the state of the game and sustainable choices, through the twitter feed and on-click tooltips.

Allocated roles: Calum was responsible for the documentation, Jake was the Scrum master and Filippo was the product owner. All other members were developers.

Table 14: Snapshot of the sprint backlog for sprint 2

Identifier	Item	Assignee	Epic	Story Points
T2-1	Display Oracle Guidance for Sustainable Choices (Linked to user story U2-1-1 and assimilated the task T1-14)	Filippo Santiano and James Sue-Ling	Decision-making and Educational Guidance	6
T2-2	Display Pop-up Information Block on Click (Linked to user story U2-1-1 and assimilated the task T1-12)	Chih-Ting Chang and Anshu Singh	UI and Player Experience	5
T2-3	Create and fix the base map, create boundaries with fog for the user to expand into. Add tile logic. (Assimilated the user story U2-2-1 and the task T1-11)	Chris Seadon and Jake Hulme	UI and Player Experience	5

2.2 Review

All items assigned in this week's [sprint backlog](#) were completed, with the exception of [T2-3](#). Chris and Jake encountered difficulties acquiring an appropriate fog asset and writing the code for an expandable map, instead they created a temporary fixed boundary with tree tiles (see this week's [sprint review](#) for further details). [T2-3](#) was partially completed, as user story [U2-1-1](#) passed its test. The team did not feel the fog was necessary for the product, therefore the task was removed from the backlog.

2.3 Meeting Minutes

2.3.1 Group Meeting 08/11/2024

Meeting attendees: All members

Meeting aim: All members discuss progress, plans and raise any issues / ask questions

Meeting summary:

- **Filippo and James:** implemented the basic layout and logic for the twitter feed. Placeholder good and bad comments appear in the top right of the screen whenever the pollution/sustainability score is updated. These comments are capped at 5 to restrict the space taken up on the screen ensuring a clean UI. They also restricted the ability to push code directly to the main branch on GitHub. From now, all the code is merged to the main branch by pull request and another developer must first review the code.
- **Filippo:** created basic Start and Main Menu screens with placeholder buttons for settings, quit etc.

- **James:** finished implementing the test runner script. This automatically runs all tests which must pass before the game will run.
- **Calum:** no updates, will be working on the documentation over the weekend as well as familiarising himself with Godot and developing ideas for mini-games.
- **Anshu and Chih-Ting:** no updates, the team collectively clarified their task of developing the pop-up information box for each tile, and the team assisted with some issues they were having navigating Godot's interface. They expected to make progress over the coming weekend.
- **Chris and Jake:** no updates, they will be working on their assigned task together on Monday.

Meeting review: This meeting significantly ran over the time-box proposed by Scrum theory (the meeting took 44 minutes as opposed to 15 minutes). A short review at the end of the meeting highlighted a need for a separate problem solving meeting, that could start after the main meeting concluded.

2.3.2 Group Meeting 11/11/2024

Meeting attendees: All members

Meeting aim: All members discuss progress, plans and raise any issues / ask questions

Meeting summary:

- **Filippo and James:** added a randomisation feature to the message feed that displays whenever a good or bad pollution event occurs.
- **Calum:** working on documentation and pitched several mini-game ideas for our game.
- **Anshu and Chih-Ting:** created a function that grabs the location of a clicked tile such that it can be applied in further functions. However, they encountered some technical errors whilst programming, preventing further progress. We created a separate meeting to follow on from the main meeting, utilising mob programming, to fix errors and enable team members to learn from each other's collective experience.
- **Chris:** was focussed on developing the tile logic, preventing tiles being built over existing tiles in that layer.
- **Jake:** was familiarising himself with Godot, using an online tutorial.

Meeting review: Taking on the feedback from our last meeting, we ensured that the main meeting, with all team members, was used for high-level updates and small collective decisions, with a separate meeting for more in-depth problems. This distinction enabled the meeting to run within the allotted time (9 mins).

2.3.3 Group Meeting 13/11/2024

Meeting attendees: All members

Meeting aim: Plan the agenda for the customer meeting.

Meeting summary:

- Wanted to highlight our new implementation of the Oracle in response to the [previous customer meeting](#).
- Discussed how best to pitch further development of the back-end mechanics during the next customer meeting such that our development would be aligned in our goals.

2.3.4 Document Meeting 13/11/2024

Meeting attendees: All members

Meeting aim: Inform the TAs on our game choice and discuss our progress so far.

Meeting summary:

- Gave an update and demo of the game.
- The TAs provided clarity on the testing section of the documentation. Not all tests must be written in code, user stories can be accepted through visual inspection and then documented.
- The TAs responded to our question from the previous sprint about being required to copy out meetings "verbatim". Customer meetings should be summarised and then analysed, explaining how it affected the team and/or development for next week.
- The TAs gave confirmation that it is fine to have sections empty and our level of detail was appropriate.

2.3.5 Sprint 2 Review 13/11/2024

Meeting attendees: All members

Meeting aim: Each member presented their completed work. As a team, we inspected the outcome of the sprint. We will determine what to do next based on the information gathered from this week's main meetings ([customer](#) and [document](#) meetings which happened before this review).

Meeting summary:

- **Filippo and James:** assigned to [T2-1](#), they presented an MVP for the Oracle, highlighting a few ideas for how to improve it in future sprints. These included making messages more relevant to current buildings that have been placed, a log option as was discussed in this week's [customer meeting](#), and various ways to improve the UI.
- **Calum:** is continuing to work on the documentation which, now the sprint has concluded, can be completed.
- **Anshu and Chih-Ting:** assigned to [T2-2](#), presented their box which displays information about each tile when clicked. They highlighted version control issues within this sprint due to miscommunication about branches in the repository.
- **Chris and Jake:** assigned to [T2-3](#), presented their base map with roads, rivers and grass. Buildings and trees could now be built only on grass tiles. They discussed issues with finding an appropriate fog asset that fits with the game style. This meant they were only partially able to complete their assigned task. As a result, the player currently interacts with the game from a fixed viewpoint with tree tiles providing a fixed boundary.

Meeting actions:

- Taking into account the [customer feedback](#), we will focus on developing more of the game mechanics, specifically looking at adding in a time component. This will allow us to then develop a system for generating money and pollution over time and adding in our win/lose conditions.
- Thus far, the UI for each of our features has been decided by the relevant developer. Now we have a greater understanding of what is possible within our game, we can begin to unify designs and create a clearer UI.

2.3.6 Sprint Retrospective 13/11/2024

Meeting attendees: All members

Meeting aim: Reflect on group interactions, processes and tools used during the sprint.

Meeting summary:

- James suggested a pair allocation score to evaluate each pair and optimise future pairing. As a group we refined this process from a blind individual score to a pair discussion that concludes with an agreed number out of 5, promoting more open and honest conversation.
- Filippo and James found that they worked well together and their combined effort improved their problem solving abilities.
- Jake mentioned how beneficial Chris's experience was in learning how to develop within Godot, and they experienced no issues working as a pair.
- Chih-Ting and Anshu mentioned difficulties arising from working within different branches. Despite these initial communication issues, they concluded that they worked well as a pair.
- Collectively we felt more could be achieved during the sprint, and we discussed various ideas around how to best achieve this. We wanted to avoid a pair being set a task so large that they have to continue working on it during the next sprint. This would fix those members into that pair for another sprint when that pair allocation could be suboptimal. It could also overburden them depending on the size of the task.
- We decided that the product owner should take a more active role in assessing the current status of tasks and adding the more urgent stories from the backlog into the current sprint where appropriate.
- To fix issues with members working on old versions of code, members should now send a WhatsApp message when code has been pushed to the main branch and needs to be reviewed. By developing our continuous integration practice further, we hoped to keep developers working on more recent versions and prevent problems when merging branches down the line.
- We also discussed whether to assign our more experienced developers together or pair them with those less experienced. We concluded that the long term benefit of developing those less experienced would outweigh the early boost in progress from pairing those more experienced together.
- With Chris having more experience in game development than the rest of the team, we decided he would provide the best estimate for story points and as such will be assigning all story points for user stories going forward.

2.4 Product Backlog

Identifier	Details	Category	Epic	Story Points
U2-4-2	See user story for further details.	User story	UI and Player Experience	4
U2-2-2	See user story for further details.	User story	UI and Player Experience	3

Identifier	Details	Category	Epic	Story Points
U3-1-1	See user story for further details.	User story	Environmental Health and Sustainability	5
U3-2-1	See user story for further details.	User story	Game logic	7
U3-3-1	See user story for further details.	User story	City Building and Resource Management	5
U2-5-1	See user story for further details.	User story	UI and Player Experience	2
U2-6-1	See user story for further details.	User story	UI and Player Experience	1
U2-7-1	See user story for further details.	User story	Environmental Health and Sustainability	2
U2-8-1	See user story for further details.	User story	City Building and Resource Management	2
U2-9-1	See user story for further details.	User story	City Building and Resource Management	1
U2-10-1	See user story for further details.	User story	Environmental Health and Sustainability	1
U2-11-1	See user story for further details.	User story	Game Logic	2
T1-13	Create win and lose criteria	Task	Game Logic	3
T1-15	Create a list of different minigames that we could implement, define all the different sustainable practises we want to teach and then match the two up to have a more fleshed out idea	Task	Unassigned	2
T1-16	Consider some luck element in the generation of income from businesses, could be based on real market data from a certain time	Task	Unassigned	1

Table 15: Snapshot of the product backlog after sprint 2

2.4.1 New Product Backlog Items

- User story [U2-2-1](#) passed its user story test in this sprint. It was then updated to user story [U2-2-2](#) and readded into the product backlog. The newer version now contained a further acceptance criteria condition related to the base map being more aesthetically pleasing for the user, directly as a result of customer feedback.
- User story [U2-4-1](#) was also updated to [U2-4-2](#). The acceptance criteria were made more measurable such that we could test this user story in future sprints. The TAs had given us advice to this end in the document meetings.
- User story [U3-1-1](#), about collecting environmental data to make the game educational,

formalised the previously related tasks into a user story.

- User story [U3-2-1](#), concerning in-game time, was a necessary addition for us to be able to build features on top of (e.g. rate of change, win/lose).
- User story [U3-3-1](#), regarding adding a building menu to the UI, was added after group discussion on consistent user interface and playability.
- These changes were made after this week's [customer meeting](#) collectively under the guidance of sprint 2's product owner (Chris).

2.5 Exception Handling

The first [group meeting](#) of this sprint significantly ran over the time-box. Going forward, we proposed that the current scrum master should time the meetings, allocating each pair a fixed amount of time and allowing for separate issues to be resolved post-main meeting.

2.6 Product Documents

2.6.1 Customer Meeting 13/11/2024

Meeting attendees: All members

Meeting aim: Present the MVP to the customer and discuss development plans

Meeting summary:

- Demoed the MVP to the customer. At this stage, the user was able to place buildings and trees onto the grass sections of a fixed map. As the pollution score changed in relation to what was built, 'tweets' (messages in-game) would pop-up on the top right of the screen highlighting, with either a positive or negative message, how this pollution score is changing.
- In response to the Oracle we had implemented at their [previous request](#), the customer was pleased with what we had developed, commenting, "it looks nice". They inquired further about an option to see historic messages. However, we concurred that this was a problem best solved with user feedback. Furthermore, we proposed that our priority should now be how to provide the user with more information about their game progression. Our initial ideas were some form of chart showing the various levels of pollution and income over time.
- The customer was curious about the win condition to keep the player engaged. We discussed ideas such as a personal leader-board where the game ends after 100 days or where pollution rates increase over time and the game gets progressively harder until it is impossible to continue.
- The customer inquired about removing buildings. Whilst this is a feature we have currently, the interface for doing so is not yet clear and intuitive. We also explained our ideas for upgrading buildings with potentially more climate-friendly/efficient parts (like double-glazing) which would have an effect on the in-game building output.
- We highlighted the need to develop the game mechanics further and implement a time feature, to which the customer agreed. This will allow us to set a cost for each building, both financially and environmentally, and from there calculate a rate of change, of income and pollution, over time.

Meeting actions:

- Use this feedback to inform our sprint planning session for sprint 3. There will be a focus on developing a time component and cleaning up the UI.

2.6.2 New/Updated User Stories

User Story	Details
<p>AS A user I WANT the game to be responsive and visually pleasing SO THAT I can stay engaged and focus on the game itself.</p> <p>Version: 2 — Priority: 1 — Size: 4 — ID: U2-2-2</p>	<p>Acceptance criteria (tests): The main menu features interactive buttons which are visually appealing and responsive.</p> <p>All game elements must have high quality assets</p> <p>The base map must have an interesting setting, with roads, ocean, trees etc</p> <p>Interactive elements must have responsive animations and visual feedback</p> <p>The game must maintain a consistent frame rate and smooth performance</p> <p>The user must have the option to customize graphics settings through the settings menu</p> <p>If the game adjusts graphics settings due to hardware limitations, the user must be notified with a clear message</p> <p>Note: This user story was fulfilled by several use cases including: Building menu (V2) and Enhance Game Aesthetics</p>

User Story	Details
<p>AS A user I WANT to see my current stats displayed clearly SO THAT I can make informed decisions about my city.</p> <p>Version: 2 — Priority: 1 — Size: 3 — ID: U2-4-2</p>	<p>Acceptance criteria (tests): The user can see the current year, total pollution + pollution threshold, income and total money.</p> <p>The user can see the current health of their city through the four health bars: environmental health, happiness of citizens, economic health and electricity supply.</p> <p>Note: This user story was fulfilled by use case Display current statistics.</p>

User Story	Details
<p>AS A user I WANT the game's assets to be based on real-world data SO THAT I can get a realistic and accurate understanding of their environmental impact.</p> <p>Version: 1 — Priority: 1 — Size: 3 — ID: U3-1-1</p>	<p>Acceptance criteria (tests): Each asset affects the city's pollution levels, economy, and population happiness in a way that reflects their real-life impact.</p> <p>Each asset will have a unique impact on the city's health bars. The extent of an asset's influence on pollution, the economy and happiness will vary depending on the tile type.</p> <p>Note: This user story was fulfilled by use case Building Data is based off Real-world Data.</p>

User Story	Details
<p>AS A user I WANT the game to change over time SO THAT I can understand the consequences of my actions.</p> <p>Version: 1 — Priority: 1 — Size: 3 — ID: U3-2-1</p>	<p>Acceptance criteria (tests): The game system has a time element and displays this to the user</p> <p>The game becomes progressively harder over time, making it harder for the player to survive.</p> <p>Note: This user story was fulfilled by use case Dynamic in-game time.</p>

User Story	Details
<p>AS A user I WANT to have a building menu SO THAT I can select and place the desired building on the grid.</p> <p>Version: 1 — Priority: 1 — Size: 3 — ID: U3-3-1</p>	<p>Acceptance criteria (tests): The menu is visible on the screen and can be opened/closed with a icon.</p> <p>The menu displays available buildings with clear labels, icons, and costs.</p> <p>Clicking on a building in the building menu highlights it and allows the user to place it.</p> <p>Buildings can be placed on valid grid cells, and placement is visually confirmed.</p> <p>Note: This user story was fulfilled by use case Building menu (V1)</p>

2.6.3 User Story Tests

User story U2-1-1 Tests

As shown in [Figure 2](#):

- A (blue) pop-up displays on the screen when the user clicks a building. At this stage, the pollution values for the building were not printed in the pop-up.
- In the top right-hand corner, positive messages are displayed by the message feed (Oracle) indicating the current state of the city's pollution

** User Story [U2-1-1 PASSED](#) **

User story U2-2-1 Tests

As shown in [Figure 3](#):

- The main menu has buttons which are interactive and responsive (change shade upon hover)
- Graphics were not inside the scope and therefore have not been implemented.

As shown in [Figure 2](#):

- The game assets are high-quality isometric images

** User Story [U2-2-1 PASSED](#) **

User story U2-4-1 Tests

As shown in [Figure 2](#):

- There isn't any information about the city's state displayed on the screen and there are no progress bars.

Although there was no direct task associated with this user story, the team felt that it was critical for user experience which we therefore prioritised and tested for. Going forward, this user was given a new version (see user story [U2-4-2](#)) and put into the product backlog.

** User Story [U2-4-1 FAILED](#) **

2.6.4 Use Cases

2.6.4.1 Use Case: Live Message Feed (V1)

This use case was used to fulfil user story [U2-1-1](#). This use case has a 2nd version.

Goal

Provide the user with positive messages when pollution is decreasing and negative ones when pollution is increasing.

Actors

- **Primary actor:** User
- **Secondary actor:** Game system

Basic Flow

1. User starts a new game.
2. Game system tracks the city's pollution in real time.
3. Game system displays an empty feed in the top-right corner, where messages about the city's pollution levels will be displayed.
4. User interacts with the game, making decisions such as placing or selling tiles.

{Pollution Message Update}

- The game system tracks recent changes in pollution and displays:
 - A **positive message** if pollution has **decreased** by more than 500.
 - A **negative message** if pollution has **increased** by more than 500.

{Pollution Tracking}

5. The system continues to track pollution and display messages as needed based on further changes.

Alternative Flows

- **Alternative Flow A: No Changes in Pollution**
 - At {Pollution Message Update}, if the detected change in pollution is less than 500:
 - * Game system does not display any messages.
 - Resume basic flow at {Pollution Tracking}.

Extension Points

- **{Pollution Message Update}**: The point at which the game evaluates the changes in pollution levels and determines what message, if any, should be displayed.
- **{Pollution Tracking}**: Monitoring of pollution levels after the initial update. This allows the system to detect future changes in pollution and add new messages to the feed as needed.

Preconditions

- The game system tracks the city's pollution in real time.
- The user is actively making decisions (placing or selling tiles) that affect pollution.
- The message feed is set up to display messages based on the changes in pollution.

Postconditions

- The game system provides real-time updates on the city's pollution through the message feed.
- The user is notified whether their city's pollution is increasing or decreasing through the content of the message.

- The game system continuously updates city pollution metrics.

Live Message Feed (V1) Tests

Basic Flow Tests

- **Display Messages Based on City Pollution**

- **Precondition:** The game tracks pollution in real time, and the user is actively interacting with the game.
- **Action:** User starts the game, places tiles, and watches the message feed.
- **Expected Result:**
 - * Negative messages are displayed if the user places tiles that increase pollution.
 - * Positive messages are displayed if the user places tiles that decrease pollution.

- **Show/Hide Message Feed**

- **Precondition:** The message feed is visible, and the user is playing the game.
- **Action:** The user presses the “Show More” button followed by the “Show Less” button.
- **Expected Result:**
 - * “Show More” pressed – the message feed displays older messages alongside the new ones.
 - * “Show Less” pressed – the message feed hides the older messages and only shows the newest ones.

All basic flow tests for this use case passed.

Alternative Flow Tests

- **No Significant Changes in Pollution**

- **Precondition:** The game detects that pollution has not changed by more than 500 in the past year.
- **Action:** User waits for the messages to update at the end of the year.
- **Expected Result:** At the end of the year, no messages are displayed.

All alternative flow tests for this use case passed.

Relationships

- This use case is associated with the [Help section in pause menu](#) use case as they are both related to offering guidance to the user through the Oracle.
- Given that the message feed is determined by the city's current pollution, this use case includes the [Interact with grid layout and track scores](#) use case.

**** This use case PASSED ****

2.6.4.2 Use Case: Tooltip (V1)

This use case was used to fulfil user story [U2-1-1](#). This use case has a [2nd](#) and [3rd](#) version.

Goal

Provide the user with live pollution values for each tile in their city so that they can better understand each tile's contribution to the city's overall pollution levels and make informed decisions to reduce it.

Actors

- **Primary actor:** User
- **Secondary actor:** Game system

Basic Flow

1. Game system tracks the pollution levels for all tiles in the city based on tile type.
 2. User clicks on a placed tile (e.g., office building or tree).
- {Display Tooltip}
3. Game system displays a tooltip showing the tile's type and its yearly pollution output (positive for office, negative for tree).
 4. User reviews the pollution information displayed in the tooltip.
 5. User clicks anywhere outside the tooltip.
 6. Game system hides the tooltip.

Alternative Flows

- **Alternative Flow A: No tooltip shown for invalid tiles.**
 - At {Display Tooltip}, if the user clicks on a non-interactive space (not a tile), the game system does not show a tooltip.

Extension Points

- {Display Tooltip}: The point at which the game system gathers the tile's data and displays it.

Preconditions

- The game system has access to each tile's yearly pollution.
- The user has tiles placed on the map and can click on them.

Postconditions

- The user can see the yearly pollution for any tile on their city's map.
- The tooltip is hidden once the user clicks outside it or navigates to another tile.

Tooltip (V1) Tests

Basic Flow Tests

- **Clicking a tile to display a tooltip:**
 - **Precondition:** The map has at least one tile placed on it.
 - **Action:** User clicks on a tile.
 - **Expected Result:** A tooltip appears near the clicked tile, displaying:
 - * The tile's type.
 - * The yearly pollution output (positive or negative).
- **Closing the tooltip:**
 - **Precondition:** A tooltip is visible for the selected tile.
 - **Action:** User clicks anywhere outside the tooltip.
 - **Expected Result:** Tooltip is hidden. If another tile is clicked, a new tooltip appears.

All basic flow tests for this use case passed.

Alternative Flow Tests

- **Clicking a non-interactive area:**
 - **Precondition:** The game has been loaded.
 - **Action:** User clicks outside any placed tiles.
 - **Expected Result:** No tooltip appears. If a tooltip was previously visible, it disappears.

All alternative flow tests for this use case passed.

Relationships

- This use case requires pollution to be tracked, meaning it depends on the [Interact with grid layout and track scores](#) use case.

** This use case [PASSED](#) **

2.6.4.3 Use Case : Enhance Game Aesthetics

This use case was used to fulfil user story [U2-2-1](#)

Goal

To ensure the game looks visually appealing to engage the user.

Actors

- **Primary actor:** User
- **Secondary actor:** Game system

Basic Flow

1. **User** opens the game.
 {**Detect Hardware Capabilities**}
2. **Game System** loads the menu with visually appealing graphics.
3. **User** starts a new game.
4. **Game System** displays the base map with high-quality assets and smooth animations.
 Load Graphics
5. **User** interacts with the game elements.
6. **Game System** ensures all interactions are visually appealing.

Alternative Flows

Alternative Flow A: Hardware limitations disable user from viewing high-quality graphics

1. **User** opens the game.
2. **Game System** attempts to load the game with visually appealing graphics.
 - 2.1A At {**Detect Hardware Capabilities**}, game system detects limitations in the hardware
 - 2.2A **Game System** adjusts the graphics to a lower quality.
 {**Apply Graphics Settings**}
 - 2.3A **Game System** notifies user of the adjustment.
 - 2.4A **User** acknowledges the adjustment and proceeds with the game.
 - 2.5A **Game System** loads game with adjusted graphics settings
3. **User** interacts with the game elements.
4. **Game System** ensures all interactions are visually appealing.

Extension Points

- {**Detect Hardware Capabilities**} : The point at which the game system detects the hardware capabilities of the user's device.
- {**Apply Graphics Settings**} : The point at which adjusted graphics settings are applied.

Preconditions

- The game is installed and functional on the User's device.
- The device meets the minimum requirement for the high-quality graphics.

Postconditions

- The User is engaged with the game due to its aesthetically pleasing visuals.
- The game maintains a consistent frame rate and smooth performance.

Enhance Game Aesthetics Tests

Basic Flow Tests

- Game system loads the start menu
 - **Precondition:** The game has been installed.
 - **Action:** User opens the game.
 - **Expected result:**
 1. The start menu appears on the screen.
 2. The buttons in the menu are interactive, visually appealing and responsive (i.e., visuals change upon 'hover' and 'click')
- Loading the base map
 - **Precondition:** The start menu is functional.
 - **Action:** User clicks 'Start Game'.
 - **Expected result**
 1. The base map loads smoothly, containing high-quality assets.

The basic flow test passed. Not all buttons and assets had been added at this point in the project, but using the same approach with existing buttons we could ensure that this use case passed after the final sprint.

Alternative Flow Tests

- Game system detects hardware limitations.
 - **Precondition:** The Game System has access to User's hardware information.
 - **Action:** User opens the game.
 - **Expected results:**
 1. Game System adjusts the graphics to a lower quality
 2. Game System notifies User of the adjustment
 3. User acknowledges the adjustment.
- Game system applies appropriate graphics settings .
 - **Precondition:** Game system has detected hardware limitations.
 - **Action:** User acknowledges adjustment
 - **Expected result:**
 1. Game system loads game with adjusted graphics settings Game runs smoothly, in-line with the User's hardware capabilities.

Alternative flow A test did not pass as we did not have scope in the project to implement graphics adjustment features. This is something we would plan to do if the game went into further development.

Relationships

- This use case extends the [Live message feed](#) and [Tooltip \(V1\)](#) use case as both must be visible and clear for the user to use.

** This use case **FAILED** **

2.6.5 Screenshots



Figure 2: Screenshot of the product after sprint 2

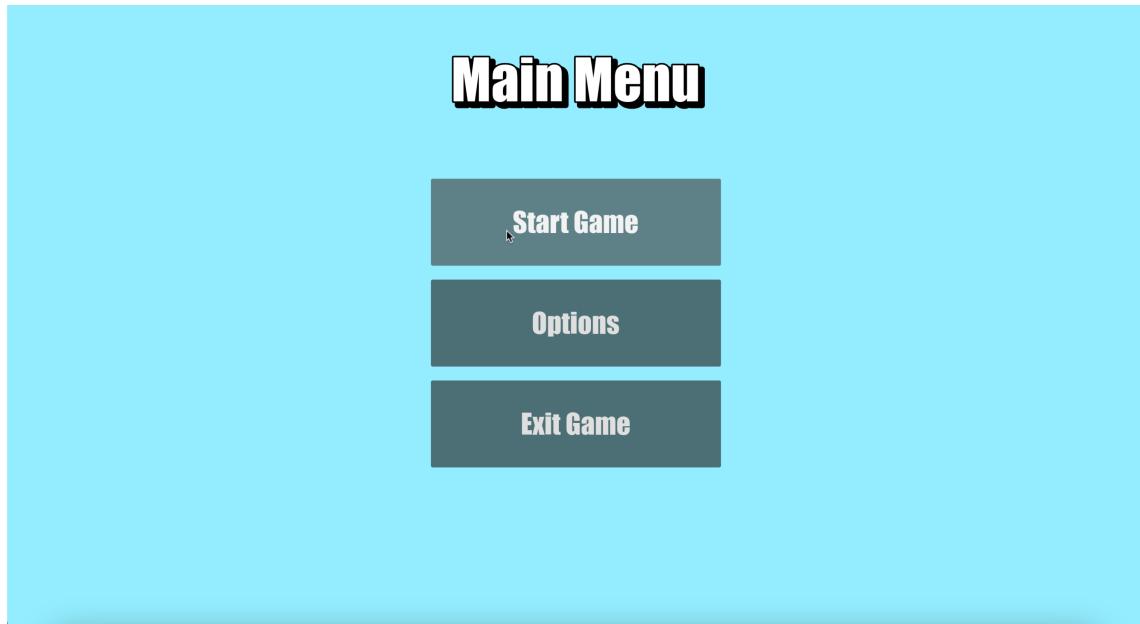


Figure 3: Screenshot of Main Menu

3 Sprint 3: 13/11/2024 to 20/11/2024

3.1 Overview

Based on group discussion in the sprint plan and the feedback received from sprint 2's [customer meeting](#), the primary focus was adding a time component, including how it interacts with all of our game features, and cleaning up the UI.

Allocated roles: Filippo was responsible for the documentation, Jake was the product owner and James was the Scrum master. All other members were developers.

Table 21: Snapshot of the sprint backlog for sprint 3

Identifier	Task	Assignee	Epic	Story Points
T3-1	Find additional data for our in-game assets, incorporating the data obtained from T1-1 along with additional research on energy consumption/production into the game so that assets realistically influence the city's pollution levels and economy (Linked to user story U3-1-1).	Chih-Ting Chang and James Sue-Ling	Decision-making and Educational Guidance (Oracle)	4
U2-4-2	Design and implement the city's current status display on the main screen, including pollution levels, economic health, and population happiness.	Anshu Singh and Jake Hulme	UI and Player Experience	3
U3-3-1	Design and add an asset selection menu.	Anshu Singh and Jake Hulme	UI and Player Experience	2
U3-2-1	Add the passing of time into the game.	Calum Ogilvy and Chris Seadon	Game Logic	4

3.2 Review

- User story [U3-3-1](#) was completed and removed from the backlog, since it passed its user story test.
- User story [U2-4-2](#) failed its user story test since the current pollution value existed but had not been added to the main screen yet, therefore it was carried forward into the product backlog.
- User story [U3-2-1](#) failed its user story test since the game did not get progressively harder at this stage of development.
- Task T3-1 could not be fully completed since additional data was needed to complete the set of data for the 12 asset types outlined in the [sprint 3 review](#). Therefore user story [U3-1-1](#) remained in the product backlog.

3.3 Meeting Minutes

3.3.1 Group Meeting 15/11/2024

Meeting attendees: All group members

Meeting aim: All members discuss progress, plans and raise any issues / ask questions

Meeting summary:

- **Anshu and Jake:** shared a visual concept for the UI they intend to create. Jake asked the team for clarification on how best to display the asset selection menu. The team decided that the assets should be placed in a horizontal scroll window, accessible via a button located at the bottom of the screen.
- **James and Chih-Ting:** have started to gather data on the cost, size, and energy consumption of real-world assets. However, they expressed their concerns that directly using this data might impact gameplay, and that small adjustments/scaling may be needed to ensure the game functions as intended. The team acknowledged this concern but agreed that it is not urgent or likely to cause significant issues, so it can be addressed later in the development process.
- **Calum and Chris:** have started planning what considerations need to be made and what needs to be done when implementing time into the game. They plan on adding some working functionality this afternoon.
- **Calum:** is finishing up the documentation from the previous week so that it is ready for review over the coming days.
- **Filippo:** no updates, will be working on the documentation over the weekend.

Meeting Review:

- The meeting lasted 25 minutes, 10 minutes over the 15-minute time box proposed by Scrum. Like previous meetings that have exceeded their time limits, this meeting was conducted online via Teams. Although this meeting was shorter than the [last one conducted online](#), regularly exceeding 15 minutes has led to the team agreeing upon stricter time limits per pair (4 minutes) and considering the option of conducting more meetings in person.
- Nonetheless, all problems and queries were addressed during the meeting, meaning the team could focus solely on developing working functionality for the next meeting.

3.3.2 Group Meeting 18/11/2024

Meeting attendees: All group members

Meeting aim: All members discuss progress, plans and raise any issues / ask questions

Meeting summary:

- **Anshu and Jake:** added health bars to the UI. Pollution levels, economic status, and population happiness will be displayed there. The bars include threshold values to help categorise the city's current state. Before the end of the sprint, the pair aims to add functionality that will change the values in the bars when placing buildings and trees. The pair is also still working on the asset selection menu and plans to have it ready by the end of the sprint.
- **Jake:** As the product owner for this sprint, Jake reviewed the product backlog and made updates and fixes to some existing user stories. These changes aim to simplify the

process for the individual responsible for documentation, allowing them to obtain user stories directly from Jira.

- **James and Chih-Ting:** Were able to find open-source data on power plants, including information about carbon footprint, energy consumption, and size. Due to the lack of aggregated data, the team agreed that using data from a single case study that James found was acceptable. James also mentioned the possibility of incorporating a decommissioning mechanic for nuclear power plants, as they do not usually last forever. This could also be applied to other buildings and a repair option could be given to the user. Chih-Ting found data for office buildings, which will be one of the three revenue-generating assets.
- **Calum and Chris:** Introduced money and the passing of time into the game. Chris plans to introduce construction times so assets are not instantly available when placed. Calum added a mechanism that increases the pollution produced by a building each year, encouraging users to prioritise upgrades or cleaner technologies.
- **Calum:** Suggested that each team member send their user story tests to the person responsible for documentation each week. This will reduce their workload and guarantee a more reliable description of the tests used during development.
- **Chris:** finally had time to update the map as requested by the customer and discussed in week 1's [sprint review](#).
- **Filippo:** Has been and plans to continue working on documentation.

Meeting Review:

- Although the meeting was in person, it ran slightly over 15 minutes (total time was 20 minutes). However, all immediate issues and questions were addressed, meaning the team was on track to complete the sprint backlog before the end of the sprint.

3.3.3 Group Meeting 20/11/2024

Meeting attendees: All members

Meeting aim: Plan the agenda for customer meeting

Meeting summary:

- Planned to showcase the cleaner UI and implementation of time, given the feedback from sprint 2's [customer meeting](#).
- Having incorporated a time element into the game, the team anticipated that the customer would be interested in how the game is won and lost. As a result, the team came up with some more concrete ideas based on the 100-day concept presented in that same customer meeting.
- The team agreed to pitch the following idea: The player will have 100 in-game years to develop a sustainable city in a dying world. As time progresses, background pollution levels will increase, raising the game's difficulty and forcing the player to make strategic decisions to keep the city's pollution, economic status and happiness above a certain threshold. Failing to maintain levels above these thresholds will result in the player losing the game. Replayability will be encouraged by giving players a final score, which they can aim to beat in future attempts.

3.3.4 Document Meeting 20/11/2024

Meeting attendees: All members

Meeting aim: Get feedback from the TAs on our documentation so far and find out if CRC cards are necessary or not.

Meeting summary:

- Gave an update to the TAs and showed a demo of the game. The TAs scanned the documentation from sprint 2.
- The TAs approved the team's decision to convert all items in the product backlog from user stories and tasks to just user stories, which will be done from sprint 3 onwards.
- CRC cards were confirmed not to be necessary and should only be included if the team has used them, which we have not.
- The TAs pointed out the necessity of use cases, which were missing from sprints 1 and 2. They provided useful guidance on what these should include and how they should relate to user stories and their tests. For completeness, the team will need to revisit sprints 1 and 2 to add the missing use cases retrospectively.

3.3.5 Sprint 3 Review 20/11/2024

Meeting attendees: All members

Meeting aim: Each member presented their completed work. As a team, we inspected the outcome of the sprint. We will determine what to do next based on the information gathered from this week's main meetings ([customer](#) and [document](#) meetings which happened before this review).

Meeting summary:

- **Anshu and Jake:** were able to complete the user story [U3-3-1](#) and made significant progress on user story [U2-4-2](#), although the user story test did not pass. By adding health bars and an asset selection menu, the team could now focus on developing the back-end mechanics of asset selection and placement. Each asset's unique impact on pollution, economic status, and population happiness will be developed using the data gathered in [T3-1](#).
- **Chih-Ting and James:** presented the data they had found for energy-generating and revenue-generating assets (task [T3-1](#)). Data for revenue-generating (factories, offices and farms) and energy-generating (wind, coal and nuclear) assets were collected. However, due to the limited availability of data and the difficulties the pair faced in finding it, some information was still missing. Specifically, data on happiness-generating assets (parks, lakes, leisure centres), as well as trees (orange, cocoa, and oil palm) had not yet been gathered. Given the importance of a complete data set, this will be completed immediately in sprint 4.
- **Calum and Chris:** made a lot of progress towards user story [U3-2-1](#) and incorporated money into the game, however the user story test did not pass. They demonstrated to the group that assets now take time to construct. Furthermore, they implemented the city's pollution, economy and happiness which were now changing over time depending on the total number of buildings and trees. Players could now place assets and monitor the status of their city over time via the health bars created in user story [U2-4-2](#), worked on this sprint by Anshu and Jake.

- **Filippo:** is continuing to work on documentation which, now the sprint has finished, can be completed.

Meeting actions:

- Taking into account the customer feedback from this sprint's [customer meeting](#), development will focus on implementing the win and lose criteria such that the game can be played from start to finish. Additional focuses include: writing the backstory for the game, storing player data so that a breakdown of their final score can be provided, and obtaining the asset data that is currently missing.

3.3.6 Sprint 3 Retrospective 20/11

Meeting attendees: All members

Meeting aim: Reflect on group interactions, processes and tools used during the sprint.

Meeting summary:

- Using the pair-review approach introduced in the [sprint 2 retrospective](#), each pair provided a score (out of 5) for how well they worked together during sprint 3.
- Calum and Chris found that they worked well together and rated their experience a 5/5. Calum found the experience particularly useful as he began the sprint with no prior experience in Godot, but was able to get up to speed with Chris' help. Chris was also happy with their work, although he noted that they could have benefitted from time-boxing their pair programming sessions. This was because their effectiveness decreased after prolonged periods of uninterrupted work. The other pairs were able to relate to this experience, so the team plans to incorporate time-boxed pair programming in future sprints.
- Anshu and Jake also worked well together, giving their pairing a 5/5 rating. However, they acknowledged that their continuous integration process could be improved. The primary issue they encountered was merge conflicts, which they attributed to dividing their development tasks without merging frequently enough.
- In response to this, Calum suggested that if pairs decide to split their development tasks, individuals should frequently inform their partners of their changes to make sure there are no conflicts. This information could be conveyed through a quick message or sending a code snippet from where the script has been changed. This approach, coupled with more frequent merges, will help reduce the likelihood of conflicting merges and minimise the amount of code that needs to be reviewed.
- James and Chih-Ting rated their collaboration a 4/5. They faced some difficulties communicating due to a language barrier. However, they managed to overcome this by using diagrams and visual representations to convey their ideas. They found this to be particularly effective and recommended that future pairs experiencing similar issues adopt this approach as well.

3.4 Product Backlog

Identifier	Details	Category	Epic	Story Points
U4-1-1	See user story for further details.	User story	Game Logic	6

Identifier	Details	Category	Epic	Story Points
U4-2-1	See user story for further details.	User story	UI and Player Experience	3
U4-3-1	See user story for further details.	User story	Game logic	4
U4-4-1	See user story for further details.	User story	Environmental Health and Sustainability	4
U4-5-1	See user story for further details.	User story	Environmental Health and Sustainability	2
T3-1	Find additional data for our in-game assets, incorporating the data obtained from task T1-1 (Linked to user story U3-1-1).	Task	Environmental Health and Sustainability	4
U2-4-2	See user story for further details.	User story	UI and Player Experience	3
U2-2-2	See user story for further details.	User story	UI and Player Experience	3
U3-1-1	See user story for further details.	User story	Environmental Health and Sustainability	5
U3-2-1	See user story for further details.	User story	Game logic	3
U2-5-1	See user story for further details.	User story	UI and Player Experience	2
U2-6-1	See user story for further details.	User story	UI and Player Experience	1
U2-7-1	See user story for further details.	User story	Environmental Health and Sustainability	2
U2-8-1	See user story for further details.	User story	City Building and Resource Management	2
U2-9-1	See user story for further details.	User story	City Building and Resource Management	1
U2-10-1	See user story for further details.	User story	Environmental Health and Sustainability	1
U2-11-1	See user story for further details.	User story	Game Logic	2
T1-16	Consider some luck element in the generation of income from businesses, could be based on real market data from a certain time	Task	Unassigned	1

Table 22: Snapshot of the product backlog after sprint 3

3.4.1 New Product Backlog Items

- Task [T3-1](#) was still ongoing, since more data was now requested, as a result of the [sprint review](#), therefore it was added to the backlog.

- User story [U4-1-1](#) was created, assimilating the task [T-13](#) since they both concerned win/lose criteria. The decision to prioritise this was based off of customer feedback.
- User story [U4-2-1](#), regarding a user-friendly building menu, was also created due to customer feedback, whom had suggested the game be intuitive enough to play without needing a tutorial.
- User story [U4-3-1](#), concerning buildings degrading over time, was created as a result of group discussion on the direction of the game. We also wanted to expand the back-end functionality, regarding the interdependency between the main game variables, to make the game engaging for the user.
- User story [U4-4-1](#) would allow the user to have more choice of buildings which all would have unique impacts on the state of the game. We thought this was lacking in our current iteration, since the user could only construct a building or a tree. Furthermore, this would allow us incorporate our data set into the game.
- Finally, user story [U4-5-1](#) assimilated the task [T1-15](#). This user story would allow us to give more ways to teach sustainable practices, through the minigames, that could also make the game more engaging, by providing incentives to play them through in-game bonuses.

3.5 Exception Handling

No exceptions occurred during sprint 3.

3.6 Product Documents

3.6.1 Customer Meeting 20/11/2024

Meeting attendees: All members

Meeting aim: Present the MVP to the customer and discuss development plans

Meeting summary:

- The team demoed the latest MVP to the customer. Since sprint 2's [customer meeting](#), users can now construct buildings and generate income over time, which increases the pollution in their city. Changes to pollution levels, the economy and happiness can be monitored at all times via the on-screen health bars. Users can also view all possible tiles through the building menu option.
- The customer was pleased to see that their requests for a cleaner UI and the implementation of time had been addressed.
- As was the case in sprint 2's [customer meeting](#), the customer was keen to understand how the game could be won or lost. In response to this, the idea from the [planning session](#) was communicated.
- The customer found the concept of a city on a doomed earth, under the pressure of rising pollution, interesting. They suggested that, for simplicity, the team create a brief introductory story explaining the current situation at the start of the game. The example provided by the customer was: "Scientists estimate you have 100 years left. See what you can do in that time!". The customer wanted the team to experiment with different storylines, game durations and scoring methods to identify "what feels right" during gameplay.

- The customer wanted a final screen displaying the player's score. They also discussed the possibility of including a leaderboard where users could compare their performance against previous attempts. However, they made it clear that this feature was optional and not essential.
- The team also proposed incorporating mini-games that teach users about sustainable actions they can take in their daily lives, such as picking up litter, recycling, and turning off lights. A limited number of these mini-games could be available daily, providing users with perks and boosts. While the customer liked this idea, as well as the concept of random events to make the gameplay less linear, they emphasized that the primary focus should be on developing a base game that works from start to finish.

3.6.2 New/Updated User Stories

User Story	Details
<p>AS A user I WANT there to be win / lose criteria SO THAT I understand the objective of the game and my performance is measurable encouraging me to return to the game.</p> <p>Version: 1 — Priority: 1 — Size: 3 — ID: U4-1-1</p>	<p>Acceptance criteria (tests): The objective of the game, to keep the pollution below a certain threshold, is made clear to the user</p> <p>Players can view their current score and see their final score when the game is over.</p> <p>Note: This user story was fulfilled by use case Exceed pollution threshold and lose game.</p>

User Story	Details
<p>AS A user I WANT the mechanism for placing tiles to be intuitive SO THAT I can start playing immediately.</p> <p>Version: 1 — Priority: 1 — Size: 3 — ID: U4-2-1</p>	<p>Acceptance criteria (tests): Players can interact with the assets displayed in the building menu</p> <p>Each tile in the building menu has a price</p> <p>The user can place a given tile on the map after buying it from the building menu</p> <p>Note: This user story was fulfilled by use case Building Menu (V2)</p>

User Story	Details
<p>AS A User I WANT I want buildings to degrade over time SO THAT The game gets harder over time and it teaches me the importance of maintaining buildings</p> <p>Version: 1 — Priority: 1 — Size: 3 — ID: U4-3-1</p>	<p>Acceptance criteria (tests): The effect of a tile on each metric changes over time depending on its type</p> <p>Note: This user story was fulfilled by use case Buildings degrade over time.</p>

User Story	Details
<p>AS A User I WANT I want a wide range of buildings that change game metrics SO THAT I can learn about their unique effects and influence the state of my city.</p> <p>Version: 1 — Priority: 1 — Size: 3 — ID: U4-4-1</p>	<p>Acceptance criteria (tests): The building menu displays a wide variety of building types grouped by their effects (e.g., power-generating, revenue-generating, happiness-generating, carbon-consuming).</p> <p>Each of these tiles has a unique impact on the health of the city.</p> <p>Note: This user story was fulfilled by use case Place a wide range of metric influencing buildings</p>

User Story	Details
<p>AS A user I WANT there to be mini-games SO THAT I can stay engaged and learn about the different sustainable practices that i can apply as an individual.</p> <p>Version: 1 — Priority: 3 — Size: — ID: U4-5-1</p>	<p>Acceptance criteria (tests): At various times, a button from which a mini-game can be accessed will appear.</p> <p>Each mini-game will teach the individual a new practice that they can apply to their daily lives (e.g. turning off the lights and recycling).</p> <p>Players will be rewarded if they successfully complete the mini-game.</p>

3.6.3 User Story Tests

User story [U2-4-2](#) Tests

As shown in [Figure 4](#):

- In the top-left corner of the screen, the user can see the current year, pollution, income and money. The current pollution exists but has not been added to the main screen yet.
- In the bottom-left of the screen, there are health bars showing the current state of the city's environment, happiness and economy.

This user story failed in this sprint so was brought over to the next sprint.

** User story [U2-4-2 FAILED](#) **

User story [U3-2-1](#) Tests

As shown in [Figure 4](#):

- There is a clear time element (year) in the top-left corner, which is updated at regular intervals if the game is running.

This user story test did not pass, as the game did not get progressively harder at this stage of development.

** User story [U3-2-1 FAILED](#) **

User story [U3-3-1](#) Tests

As shown in [Figure 4](#):

- The building menu button is in the bottom right-hand corner.
- When pressed, this button opens the building menu, which currently contains the office and tree tiles.
- Clicking a tile in the menu highlights it under the user's cursor and allows them to place it on the map.

This user story test passed because all the acceptance criteria were fulfilled.

** User story [U3-3-1 PASSED](#) **

3.6.4 Use Cases

3.6.4.1 Use Case: Display Current Statistics V1

This use case was used to fulfil user story [U2-4-2](#). The second version of this use case is here: [Display current statistics V2](#).

Goal

To provide the user with clear and accessible information about their city's current statistics to make informed decisions.

Actors

- **Primary actor:** User
- **Secondary actor:** Game System

Basic Flow

1. **User** starts the game
 - **UI:** The main game screen is displayed.
2. The **Game System** displays the current statistics in the top left-hand corner. The statistics include:

- Current year
 - Current pollution / pollution limit
 - Amount of money
 - Yearly income.
3. The **Game System** displays health bars in the bottom left-hand corner of the screen representing:
- Economic health of the city
 - Happiness of the citizens
 - Electricity generation
 - Environmental health
 - **UI:** The health bars are colour coded with percentage bars showing the value of the metric.

Preconditions

- The game is installed and functional on the user's device
- The device meets the minimum hardware requirements for displaying the UI elements.
- The game system has access to the variables storing the city's current pollution, economic health, happiness and electricity stats.

Postconditions

- The user can clearly see the current statistics of their city
- The user can access historical data on the statistics of their city. The user can make informed decisions based on the displayed statistics.

Relationships

- This use case includes the [Enhance game aesthetics](#) for screen resolution adjustments, and [Dynamic in-game time](#) for access to the changing metrics.
- This use case extends to [Exceed pollution threshold and lose game](#), when the check for the lose condition is conducted.
- The use case is associated with [Current stats in pause menu](#), as both display the user's stats.

Display Current Statistics Tests

Basic Flow Tests

- Game system loads the base map
 - **Precondition:** Game system has access to the city's stats.
 - **Action:** User clicks 'Start Game'.
 - **Expected results:**

1. The base map loads with the current year, pollution/pollution limit, money and income in the top left hand-corner and the 4 health bars in the bottom left of the screen.

The basic flow test failed as there was not a health bar to show the electricity supply nor a label to show the pollution limit. This can be seen in [Figure 4](#) which shows there is no electricity health bar. The electricity health bar will be added in sprint 4 and is linked to the use case [Display current statistics V2](#).

** This use case **FAILED** **

3.6.4.2 Use Case: Dynamic In-Game Time (V1)

This use case is linked to user story [U3-2-1](#). The second version of this use case can be found [here](#).

Goal

To ensure the game environment changes over time, making the gameplay experience dynamic and engaging

3.6.4.3 Actors

- **Primary actor:** User
- **Secondary actor:** Game system

Basic Flow

1. User starts the game.
2. Game System tracks the passing of time in-game, with years increasing one-by-one.
 { **Increment year** }
3. Game System updates the game environment based on the passing of time:
 - The score is updated for each year.
 - The income for the year is calculated and displayed.
 - The external pollution increases every year unless the air filter is repaired, in which case it resets to the original level. External pollution increases exponentially due to a yearly multiplier.
4. User interacts with the evolving game environment.
5. Game System ensures that time-based changes are applied and displayed to the User.

Alternative Flows

Alternative Flow A: User pauses the game

1. **User** starts the game.
 - 2.1A User starts the game.
 - 2.2A User pauses the game.

- 2.3A Game System stops tracking time.
- 2.4A User interacts with pause features.
- 2.5A User resumes the game.
- 2.6A Game System resumes tracking time.

Steps 3, 4, and 5 in the base flow are then executed.

Extension Points

- { **Increment year** }: The point at which the back-end game system increments the year

Preconditions

- The game is installed and functional on the user's device.
- The device meets the minimum hardware requirements for displaying the UI elements.

Postconditions

- The game environment changes over time, providing an engaging and evolving experience for the User.
- The User can see the changes in the game environment.

Dynamic In-Game Time (V1) Tests

Basic Flow Tests

- **Preconditions:** The game system loads correctly.
- **Action:** The player begins to play the game.
- **Expected results:**
 1. The years increase, one-by-one and are displayed to the user.
 2. The score is updated for each year, stored, and displayed on the 'Current Stats' screen in the pause menu.
 3. The total income is updated every year depending on the assets built in the map and displayed to the user.
 4. The health bars are updated multiple times within each year and stored and displayed on the 'Current Stats' screen in the pause menu.
 5. The external pollution becomes increasingly larger if the air filter is not repaired.

The basic flow test FAILED as the repair air filter feature had not been implemented yet. This use case therefore has a second version: [Dynamic in-game time V2](#).

Alternative Flow A Tests

- Time stops passing when the game is paused.
 - **Preconditions:** The user has paused the game.

- **Action:** User pauses the game.
- **Expected results:**
 1. The pause menu is displayed.
 2. The years stop incrementing on the screen and within the back-end functionality.
 3. The score is frozen, and this value is displayed on the 'Current Stats' page in the pause menu.
 4. The total income is frozen and is not added to total money.
 5. The health bars are frozen, and are not updated.
- Time resumes passing when the game continues.
 - **Preconditions:** User paused the game.
 - **Action:** User resumes the game.
 - **Expected results:** The basic flow of this use case is resumed.

All tests in the alternative flow A passed. Nothing is updated when the game is paused, and everything resumes being updated when the game is resumed.

Relationships

- This user story is associated with the [Display current statistics \(V1\)](#) use case, as this is how the passage of time is shown to the user.

** This use case **FAILED** **

3.6.4.4 Use Case: Building Menu (V1)

This use case was used to fulfil user story [U3-3-1](#). This use case has a [2nd](#) version and [3rd](#) version.

Goal

To provide an intuitive and user-friendly building menu that allows users to easily understand how to place buildings in the game.

Actors

- **Primary actor:** User
- **Secondary actor:** Game system

Basic Flow

1. User starts the game.
2. Game system displays a building menu in the bottom right of the screen with an icon that clearly conveys the button's purpose.
3. User clicks on the building button.
{Display Building Menu}

4. Game system displays a building menu at the bottom of the screen, which contains the following:
 - A unique and clear icon for the office and forest tiles
 - The price for each tile
5. User clicks on an office or forest tile from the menu.
6. Game system displays selected tile under the User's cursor.
{Update Cursor}
7. User clicks on a valid location to place a tile (See [placing a tile use case](#)).
{Check Place Tile}
8. Game system places the tile at the specified location and subtracts the cost of the tile from User's balance.
9. User clicks the building menu button.
{Hide Building Menu}
10. Game system hides building menu.

Alternative Flows

- **Alternative Flow A: User cannot afford to place the selected tile**
 - At **{Check Place Tile}**, if User's balance is insufficient, the Game System does not place the tile.
 - The flow resumes at **{Update Cursor}**, allowing the User to select another action.
- **Alternative Flow B: User opens and closes building menu without selecting a tile**
 - At **{Hide Building Menu}**, if the User closes the menu without selecting a tile, no changes occur on the map or to the User's balance.
- **Alternative Flow C: User clicks multiple tiles before placing one**
 - At **{Update Cursor}**, if the User selects multiple tiles consecutively, the cursor updates to reflect the last selected tile.
 - The flow resumes at **{Update Cursor}** until the User places a tile.

Extension Points

- **{Display Building Menu}**: The point at which Game system displays the building menu.
- **{Update Cursor}**: The point at which the Game system updates the selected tile and displays it under the User's cursor.
- **{Check Place Tile}**: The point at which the Game system checks if the cost of the tile can be taken from the User's balance and if the tile can be placed.
- **{Hide Building Menu}**: The point at which Game system hides the building menu.

Preconditions

- The game system has successfully loaded and initialized all tile types, icons, and associated costs for display in the building menu.
- The game system can access the User's balance.

Postconditions

- If a tile is placed:
 - The selected tile is correctly displayed on the map at the specified location.
 - The tile's cost is deducted from the user's balance.
 - The map updates visually to reflect the placed tile.
- If no tile is placed:
 - The user's balance remains unchanged.
 - The map remains unaltered.

Building Menu Tests

Basic Flow Tests

- **Opening the building menu**
 - **Precondition:** Game is running and building menu is not visible.
 - **Action:** User clicks the building button.
 - **Expected result:**
 - * The building menu appears at the bottom of the screen.
- **Selecting and placing a tile**
 - **Precondition:** The building menu is open, and the user has enough money to place the tile they will select.
 - **Action:**
 - * User selects the tile from the menu.
 - * User clicks a valid map location to place the tile.
 - **Expected result:**
 - * Before the tile is placed, it is shown under the cursor.
 - * The tile is placed at the location where the user clicks.
 - * The tile's cost is deducted from the user's balance.
 - * The map updates to show the new tile.
- **Closing the building menu**
 - **Precondition:** The building menu is open.
 - **Action:** User clicks the building button.

- **Expected result:**

- * The building menu is hidden.

All basic flow tests for this use case passed.

Alternative Flow Tests

- **Insufficient balance**

- **Precondition:** Building menu is open, the user has selected a tile and has insufficient funds for the tile.

- **Action:** User goes to place the tile on the map.

- **Expected result:**

- * A tile is not placed.

- * A warning or error message (e.g. “Not enough money”) is displayed.

- * The user’s balance remains unchanged.

- **Closing menu without selecting a tile**

- **Precondition:** Building menu is open.

- **Action:** User clicks on the building menu button.

- **Expected result:**

- * Building menu is hidden.

- **Selecting multiple tiles**

- **Precondition:** Building menu is open.

- **Action:**

- * User selects a tile.

- * Before placing that tile, user selects another tile.

- **Expected result:**

- * The cursor updates to show the most recently selected tile.

- * Only the last selected tile can be placed.

The insufficient balance flow test did not pass as the user was not shown a message when they lacked sufficient funds. Instead, this was printed to the terminal. This will be added in future development.

Relationships

- This use case extends the [Interact with grid layout and track scores](#) use case as it builds on the tile-placing functionality.
- This use case is associated with the [Enhance game aesthetics](#) use case as the building menu must run smoothly and be visually-pleasing.

** This use case **FAILED** **

3.6.5 Screenshots



Figure 4: Screenshot of the product after sprint 3

4 Sprint 4: 20/11/2024 to 27/11/2024

4.1 Overview

Based on the feedback received from the [last customer meeting](#), The primary focus is on adding win and loss scenarios, as well as enhancing the game's realism by incorporating more building structures and making the game more dynamic.

Allocated roles: Anshu was responsible for the documentation, James was the product owner and Calum was the Scrum master. All others members were developers.

Identifier	Task	Assignee	Epic	Story Points
T3-1	Find additional data for our in-game assets, incorporating the data obtained from task T1-1 (Linked to user story U3-1-1).	Chih-Ting Chang	Environmental Health and Sustainability	4
U4-1-1	As a player, I want a win and lose criteria so that the game is engaging	Calum Ogilvy and Jake Hulme	Game Logic	3
U4-2-1	As a player, I want the mechanism for placing tiles to be intuitive so that I can start playing immediately	Filippo Santiano and James Sue-Ling	UI and Player Experience	4
U4-3-1	As a player I want the amount produced/used from the different tiles to be dynamic and change over time.	Calum Ogilvy and Jake Hulme	Game Logic	4
U4-4-1	As a player, I want there to be a range of different business to build so that I can influence the state of my city.	Chris Seadon	City Building and Resource Management	3
U2-2-2	Update map to make more visually appealing	Chris Seadon	UI and Player Experience	1
T4-1	Visual update to the progress bars so that they expanded from the middle outwards and change colour depending on the variable and urgency (traffic light style) to convey information to the user	Filippo Santiano and James Sue-Ling	UI and Player Experience	2

Table 28: Snapshot of the sprint backlog for sprint 4

4.2 Review

All tasks in this week's [sprint backlog](#) were completed. All assigned user stories passed their respective user story tests except for [U4-4-1](#) which failed because not all required tiles were made in time, pushing it into the product backlog.

4.3 Meeting Minutes

4.3.1 Group Meeting 22/11/2024

Meeting attendees: All group members

Meeting aim: All members discuss progress, plans and raise any issues / ask questions

Meeting summary:

- **Calum and Jake:** had completed adding the attributes of happiness and electricity, while also adjusting other game elements such as environment, income and money.
- **Chih-Ting:** had collected data for some tiles related to power-producing buildings, such as coal, wind, and nuclear power plants. Additionally, he sought assistance from Chris in identifying which building resources should be included in the game.
- **Filippo and James:** had begun re-implementing the game's progress bars to incorporate new features. They also shared a use case diagram, for the Twitter feed within the game, with the rest of the team, so that everyone can follow a similar approach for their respective tasks.
- **Chris:** started creating new building resources for the game and had been working closely with Chih-Ting to gather data related to the buildings.
- **Anshu:** no updates, had seen the document from the previous week, it appears to be workable.

Meeting review:

- The meeting lasted about 16 minutes, making it the shortest meeting held via Teams. Despite its brevity, all issues and questions were addressed, allowing the team to focus entirely on developing working functionality before the next meeting.

4.3.2 Group Meeting 25/11/2024

Meeting attendees: All group members

Meeting aim: All members discuss progress, plans and raise any issues / ask questions

Meeting summary:

- **Calum and Jake:** had implemented the win and loss criteria, as discussed in the last customer meeting, and defined key calculations for happiness, electricity, and income. While working on these features, they inadvertently affected some existing game mechanics, but assured the team that everything is now under control and functioning as expected.
- **Chih-Ting:** had collected carbon data for building resources but was unsure on how happiness would be calculated in the game. He found data relating to green space coverage .i.e green space per person, which could be included in the happiness calculation. Calum suggested that if the data can be justified, it could be incorporated into the game. He also shared his opinion, noting that there should be a balance in the happiness calculation. While some factors might generate negative happiness, there should be positive elements to counteract that, ensuring the overall effect isn't a net negative. He emphasized that if only one factor is considered, it could skew the results.
- **Filippo and James:** had completed the progress bar changes but had questions about how happiness will be calculated. Calum suggested that happiness will be measured on a scale from 0 to 100. A threshold system has been implemented for the environment, with

values ranging from -100 to 100, affecting happiness based on environmental factors. For the economy, the team proposed displaying income as numbers instead of a bar, using up or down arrows to indicate changes and/or considering a relative value for income based on spending or earnings throughout the year, rather than as a percentage.

- **Chris:** had been working on adding new building resources to the game. However, he mentioned that data is needed before adding any additional tiles to ensure proper integration. He also mentioned that he had been busy fixing some of the game features that were broken.
- **Anshu:** had been, and planned to continue, working on documentation.

Meeting Review:

- Although the meeting was held in person and was scheduled for 15 minutes, it ran for a total of 25 minutes. However, all immediate issues and questions were addressed, ensuring that the team remains on track to complete the sprint backlog before the end of the sprint.

4.3.3 Group Meeting 27/11/2024

Meeting attendees: All members

Meeting aim: Plan the agenda for the customer meeting

Meeting summary:

- Our goal was to demonstrate the progress made in sprint 4, highlighting the key features we'd implemented so far, and outline what we aimed to achieve moving forward.
- In sprint 4 we focused on adding some key gameplay elements. We introduced a win/lose criteria and a scoring system, where players need to manage pollution, happiness, and electricity to succeed. We also added new metrics like pollution thresholds and happiness, which make the game more challenging. The UI was cleaned up, and now players can interact with the building menu more easily. We've also added progress bars to track important factors, and the Oracle system will help explain them to players. Plus, we had integrated new building resources and tiles into the game to enhance the experience.
- Looking ahead, the main priority was finalizing the integration of new tiles and resources. We'll also be developing a start screen to introduce players to the game and a final screen with a scoreboard so they can see how they performed. The Oracle system will be fine-tuned to give better feedback and explain the progress bars more clearly. We also needed to fix the Twitter feed display and polish the tooltips, including adding a repair button to make the gameplay smoother.

4.3.4 Document Meeting 27/11/2024

Meeting attendees: All members

Meeting aim: Present our documentation to the Teaching Assistants (TAs) for their review and feedback, with the aim of ensuring that our approach is aligned with the project's objectives and requirements. Additionally, we will share our use case diagram to gain their insights and verify whether we are proceeding in the right direction.

Meeting summary:

- We presented an update and demo of the game, and the TAs reviewed the sprint 3 documentation. They confirmed everything looked good and approved the progress.

- We presented one of our use case diagrams to the TAs for feedback. They reviewed it and confirmed it was done correctly, giving us the go-ahead to create the remaining diagrams in the same format. However, we later received an update from the TAs indicating a change in the approach for creating use case diagrams. They mentioned that instead of presenting the use cases graphically, we should use text in a table-like structure. They shared some resources that we can refer to for guidance on how to create use cases in the new table-like structure.
- The team had some questions regarding the testing of user stories and use cases. The TAs addressed these concerns, providing clear explanations on how to approach and structure the tests moving forward.

4.3.5 Sprint 4 Review 27/11/2024

Meeting attendees: All members

Meeting aim: Each member presented their completed work. As a team, we inspected the outcome of the sprint. We will determine what to do next based on the information gathered from this week's main meetings ([customer](#) and [document](#) meetings which happened before this review).

Meeting summary:

- **Calum and Jake:** had successfully completed their assigned user stories, [U4-3-1](#) and [U4-1-1](#). They incorporated the win and lose criteria into the game, which were the key changes agreed upon during the customer meeting. The lose criteria of the game was now that exceeding a level of pollution would end the game. They also worked on adding important features such as happiness and electricity to the game to influence the state of the game via game variable interdependency.
- **Chih-Ting:** had completed the assigned task [T3-1](#). A key objective for this sprint was to develop realistic data for the building resources in the game, which was sourced from credible journals and research papers, ensuring proper validation. These data were documented so that they could be added into the game as references for users to learn from.
- **Chris:** had made progress on his assigned user story, [U4-4-1](#), which involved adding 12 new building resources to the game. This task is on hold due to the need for credible data for the tiles. A significant portion of Chris' time was spent assisting with the collection and identification of the necessary tiles. He also managed to finish his redesign of the base map which completed his assigned user story [U2-2-2](#).
- **Filippo and James:** had completed their assigned task and user story, [T4-1](#) and [U4-2-1](#). Initially, some modifications were required for the progress bar implementation. During the previous stand-up meeting, the team suggested adjustments to how environment and happiness were calculated in the game. These changes have been implemented and represented as UI features, through the progress bars. Additionally, they added a building mode feature, which meant that users can only build tiles if they have the building menu open.

Meeting actions:

- Taking into account the customer feedback from this sprint's [customer meeting](#), development priority was focused on finalising the integration of the new tiles and resources. We also wanted to focus on creating a start screen, to welcome players into the game, and a final screen with a scoreboard so they can track their performance. Furthermore, the

team will be refining the Oracle system, to provide clearer and more targeted feedback, and making the progress bars easier to understand. On top of that, we needed to fix the live message feed display, polish the tooltips, and add a repair button to make the gameplay feel smoother and more enjoyable.

4.3.6 Sprint 4 Retrospective 27/11/2024

Meeting attendees: All members

Meeting aim: Reflect on group interactions, processes and tools used during the sprint.

Meeting summary:

- Calum and Jake found that they worked well together and rated their experience 5/5. They enjoyed the work more than expected, and while they did break some things in the game during programming, they were able to fix everything in the end. They also engaged in brainstorming and had several discussions related to the game, which helped generate new ideas and refine their approach.
- James and Filippo also worked well together, rating their pairing 5/5. However, they mentioned that they experienced some delays in the plan while fixing the progress bars, but they were able to complete all assigned tasks on time.
- Chris felt that he could have communicated better with Chih-Ting, giving their collaboration a 4/5 rating. Chih-Ting rated it 5/5, mentioning that the project experienced some delays due to the time-consuming data collection process, as their target was to collect the data first and then create the tiles. Chris noted that, because the data collection took longer than expected, he didn't have enough time to fully enhance and optimize the tiles.

4.4 Product Backlog

Identifier	Details	Category	Epic	Story Points
U2-1-2	See user story for further details.	User story	Decision-making and Educational Guidance	3
U4-3-2	See user story for further details.	User story	Game Logic	4
U5-1-1	See user story for further details.	User story	Environmental Health and Sustainability	5
U5-2-1	See user story for further details.	User story	Decision-making and Educational Guidance	3
U5-3-1	See user story for further details.	User story	UI and Player Experience	3
U4-4-1	See user story for further details.	User story	Environmental Health and Sustainability	4
U4-5-1	See user story for further details.	User story	Environmental Health and Sustainability	2
U2-4-2	See user story for further details.	User Story	UI and Player Experience	3
U3-1-1	See user story for further details.	User story	Environmental Health and Sustainability	5

Identifier	Details	Category	Epic	Story Points
U3-2-1	See user story for further details.	User story	Game logic	3
U2-5-1	See user story for further details.	User story	UI and Player Experience	2
U2-6-1	See user story for further details.	User story	UI and Player Experience	1
U2-7-1	See user story for further details.	User story	Environmental Health and Sustainability	2
U2-8-1	See user story for further details.	User story	City Building and Resource Management	2
U2-9-1	See user story for further details.	User story	City Building and Resource Management	1
U2-10-1	See user story for further details.	User story	Environmental Health and Sustainability	1
U2-11-1	See user story for further details.	User story	Game Logic	2
T1-16	Consider some luck element in the generation of income from businesses, could be based on real market data from a certain time	Task	Unassigned	1

Table 29: Snapshot of the product backlog after sprint 4

4.4.1 New Product Backlog Items

- User story [U2-1-2](#), concerning real-time information about the city, was reintroduced to the backlog as an updated version of user story [U2-1-1](#). It now included a help section as part of its acceptance criteria to explain in-game information in more detail.
- User story [U4-3-2](#), regarding buildings degrading over time, was also reintroduced as an updated version of [U4-3-1](#). Its acceptance criteria was extended so that the player must be able to repair the protective dome of the city and also repair individual buildings to regain their efficiency. The dome repair feature was related closely to our win/lose criteria.
- User story [U5-1-1](#), concerning the in-game data source menu accessible to the player, was added at the request of the customer. This was necessary to make sure that the game had clearer educational value.
- User story [U5-2-1](#), relating to a viewable graph that would show a player's in-game stats progression over time, was added due to group discussion on player engagement and game replayability.
- User story [U5-3-1](#), concerning an in-game storyline, was also added from group discussion, but also hinted at in previous customer meetings. We thought this was necessary to address since it tied together our chosen win/lose criteria and our in-game variable interdependency.

4.5 Exception Handling

No exceptions occurred during sprint 4.

4.6 Product Documents

4.6.1 Customer Meeting 27/11/2024

Meeting attendees: All members

Meeting aim: Present the MVP to the customer and discuss development plans

Meeting summary:

- The team started by giving the introduction and what had been achieved in the sprint 4 and showing the live demo of the game. Since sprint 3's [customer meeting](#), we lacked a win/lose criteria, but now we had added a lose condition and implemented a scoring system, so players can see their score at the end and aim to beat it in future attempts. We had also linked key game metrics—pollution, income, happiness, and economy—so they interact with each other.
- The customer noted that there was some added game complexity, with interacting features that require players to figure things out or have it explained. The team emphasized that these connections are necessary for engagement, ensuring none of the game dimensions are neglected. The customer asked if these features are linked, and we confirmed that they are indeed interconnected within the game.
- The customer inquired about using real-world data in the game. The team confirmed that we had sourced credible data and collected 12 new tiles, which we aimed to integrate in the next sprint. Our front-end and back-end systems were ready; we just needed to populate the game with the real-world data.
- The team mentioned that our next goal for the upcoming sprint was to integrate the new tiles and resources, and the customer agreed that this seems doable by the end of week 11, which was promising.
- The team also outlined the goals for the next sprint. We mentioned that our top priorities included: finalizing the integration of the new tiles and resources; developing a dynamic start screen, to introduce players to the game; and designing a final screen with a scoreboard so players can track their performance. Additionally, we planned to refine the Oracle system to provide more insightful feedback and improve the clarity of the progress bars. The customer agreed that these goals can be achieved within the proposed timeline.

4.6.2 New/Updated User Stories

User Story	Details
<p>AS A user I WANT real-time information about my city SO THAT I can make informed decisions</p> <p>Version: 2 — Priority: 1 — Size: 3 — ID: U2-1-2</p>	<p>Acceptance criteria (tests): The user can click on each tile in their city and see information about its yearly pollution, income, happiness generation, and electricity production and generation.</p> <p>The user receives live updates and advice from the Oracle through a message feed that informs them of the recent changes across all metrics in their city.</p> <p>The user has access to a help section with important information about the game in case they get stuck.</p> <p>Notes: First version of this user story: U2-1-1.</p> <p>This user story was fulfilled by use cases Tooltip with fun fact (V3), Help section in pause menu and Live message feed (V2).</p>

User Story	Details
<p>AS A User I WANT I want buildings to degrade over time SO THAT The game gets harder over time and it teaches me the importance of maintaining buildings to ensure their efficiency</p> <p>Version: 2 — Priority: 1 — Size: 3 — ID: U4-3-2</p>	<p>Acceptance criteria (tests): The effect of a tile on each metric changes over time depending on its type</p> <p>The dome that is protecting the city from external pollution degrades overtime, increasing the amount of pollution that enters the city</p> <p>The user is able to repair buildings to restore them to maximum capacity</p> <p>Note: The first version of this user story is user story U4-3-1.</p> <p>This user story was fulfilled by use cases Tooltip with repair button (V3) and Repair air filter</p>

User Story	Details
<p>AS A user I WANT to learn about the data sources SO THAT I can better understand the real-world context and learn more about sustainability</p> <p>Version: 1 — Priority: 1 — Size: 2 — ID: U5-1-1</p>	<p>Acceptance criteria (tests): The user can see and access all the data that has been used for the game.</p> <p>There are also additional resources that the user can access if they want to learn more about sustainability.</p> <p>The user is shown fun facts about the sustainability of the tiles in the game.</p> <p>Notes: This user story was fulfilled by use cases Tooltip with fun fact (V3) and Data sources menu</p>

User Story	Details
<p>AS A user I WANT to see how my stats change over the course of the game SO THAT I can track my performance and clearly un- derstand the impact of my decisions on my city.</p> <p>Version: 1 — Priority: 1 — Size: 2 — ID: U5-2-1</p>	<p>Acceptance criteria (tests):</p> <p>In the pause menu, the user can view their in-game stats plotted on a line graph.</p> <p>Note: This user story was fulfilled by the use case Add a "current stats" option in pause menu</p>

User Story	Details
<p>AS A user I WANT there to be a story to the game SO THAT my gameplay has an objective and is fun and engaging.</p> <p>Version: 1 — Priority: 1 — Size: 2 — ID: U5-3-1</p>	<p>Acceptance criteria (tests):</p> <p>There is a dedicated start screen for each of the following:</p> <ol style="list-style-type: none"> 1. The game's backstory 2. How to play 3. How to win or lose the game <p>Note: This user story was fulfilled by use case Add a start screen to introduce and explain the game</p>

4.6.3 User Story Tests

User story [U2-4-2](#) Tests

The tests for this user story failed in [sprint 3](#) and failed again in this sprint.

** User Story [U2-4-2 FAILED](#) **

User story 4-1-1 Tests

As shown in [Figure 5](#):

- All criteria were met.
- The current pollution level is displayed throughout the gameplay.
- Upon exceeding the pollution threshold, the game ends, and a "Game Over" message appears.
- The final score is displayed after the game ends.

This user story test passed because all the acceptance criteria were fulfilled.

**** User Story 4-1-1 PASSED ****

User story U4-2-1 Tests

As shown in [Figure 5](#):

- Users were able to select a tile from the Building Menu, place the tile on the grid map and accordingly the cost was deducted for the asset.

Since all criteria was met this user story is successful.

**** User Story U4-2-1 PASSED ****

User story U4-3-1 Tests

As shown in [Figure 5](#):

- The effect of each tile (e.g. office and Tree) on relevant metrics (e.g, pollution,income,electricity,happiness) adjusted as expected confirming the change in impact based on tile type.

This user story passed because all the acceptance criteria were fulfilled.

**** User Story U4-3-1 PASSED ****

User story U4-4-1 Tests

As shown in [Figure 5](#):

- There are still only the office and tree tile in the building menu meaning the acceptance criteria for this user story test were not met.

**** User Story U4-4-1 FAILED ****

User story U2-2-2 Tests

As shown in [Figure 5](#):

- The base map has an interesting and visually-pleasing background.

**** User Story U2-2-2 PASSED ****

4.6.4 Use Cases

4.6.4.1 Use Case: Building Menu (V2)

This use case was used to fulfil user story [U4-2-1](#). The first version of this use case can be found [here](#). The third version can be found [here](#).

Goal

To provide an intuitive and user-friendly building menu that allows users to easily understand how to place buildings in the game. This was achieved by adding a buildmode to the game, where the user can only buy and place a tile if the building menu is open.

Actors

- **Primary actor:** User
- **Secondary actor:** Game system

Basic Flow

1. User starts the game.
2. Game system blocks User from being able to place tiles.
3. Game system displays a building menu in the bottom right of the screen with an icon that clearly conveys the button's purpose.
4. User clicks on the building button.
{Display Building Menu}
5. Game system displays a building menu at the bottom of the screen, which contains the following:
 - A unique and clear icon for each type of tile
 - The price for each tile
6. User clicks on a tile from the menu.
{Update Cursor}
7. Game system displays selected tile under the User's cursor.
8. User clicks on a valid location to place a tile (See [placing a tile use case](#)).
{Check Place Tile}
9. Game system places the tile at the specified location and subtracts the cost of the tile from User's balance.
10. User clicks the building menu button.
{Hide Building Menu}
11. Game system hides building menu and blocks User from being able to place tiles.

Alternative Flows

- **Alternative Flow A: User cannot afford to place the selected tile**

- At **{Check Place Tile}**, if User's balance is insufficient, the Game System does not place the tile.
- The flow resumes at **{Update Cursor}**, allowing the User to select another action.
- **Alternative Flow B: User opens and closes building menu without selecting a tile**
 - At **{Hide Building Menu}**, if the User closes the menu without selecting a tile, no changes occur on the map or to the User's balance.
 - The Game System blocks tile placement until the menu is reopened.
- **Alternative Flow C: User clicks multiple tiles before placing one**
 - At **{Update Cursor}**, if the User selects multiple tiles consecutively, the cursor updates to reflect the last selected tile.
 - The flow resumes at **{Update Cursor}** until the User places a tile.

Extension Points

- **{Display Building Menu}**: The point at which Game system displays the building menu and puts the User into buildmode.
- **{Update Cursor}**: The point at which the Game system updates the selected tile and displays it under the user's cursor.
- **{Check Place Tile}**: The point at which the Game System checks if the cost of the tile can be taken from the User's balance and if the tile can be placed.
- **{Hide Building Menu}**: The point at which Game system hides the building menu and takes the User out of buildmode.

Preconditions

- The game system has successfully loaded and initialized all tile types, icons, and associated costs for display in the building menu.
- The game system can access the User's balance.
- The game system is set to block tile placement by default until a tile is selected from the building menu.

Postconditions

- If a tile is placed:
 - The selected tile is correctly displayed on the map at the specified location.
 - The tile's cost is deducted from the user's balance.
 - The map updates visually to reflect the placed tile.
- If no tile is placed:
 - The user's balance remains unchanged.
 - The map remains unaltered.

- The building menu state is correctly updated:
 - If closed, the system blocks tile placement.
 - If opened, the system allows tile selection and placement attempts.

Building Menu Tests

Basic Flow Tests

- **Opening the building menu**
 - **Precondition:** Game is running and building menu is not visible.
 - **Action:** User clicks the building button.
 - **Expected result:**
 - * The building menu appears at the bottom of the screen.
 - * Tile placement is enabled only after a tile is selected.
- **Selecting and placing a tile**
 - **Precondition:** The building menu is open, and the user has enough money to place the tile they will select.
 - **Action:**
 - * User selects the tile from the menu.
 - * User clicks a valid map location to place the tile.
 - **Expected result:**
 - * Before the tile is placed, it is shown under the cursor.
 - * The tile is placed at the location where the user clicks.
 - * The tile's cost is deducted from the user's balance.
 - * The map updates to show the new tile.
- **Closing the building menu**
 - **Precondition:** The building menu is open.
 - **Action:** User clicks the building button.
 - **Expected result:**
 - * The building menu is hidden.
 - * Tile placement is disabled until the building menu is re-opened.

All basic flow tests for this use case passed.

Alternative Flow Tests

- **Insufficient balance**
 - **Precondition:** Building menu is open, the user has selected a tile and has insufficient funds for the tile.
 - **Action:** User goes to place the tile on the map.

- **Expected result:**
 - * A tile is not placed.
 - * A warning or error message (e.g. "Not enough money") is displayed.
 - * The user's balance remains unchanged.
- **Closing menu without selecting a tile**
 - **Precondition:** Building menu is open.
 - **Action:** User clicks on the building menu button.
 - **Expected result:**
 - * Building menu is hidden.
 - * Tile placement is disabled until building menu is re-opened.
- **Selecting multiple tiles**
 - **Precondition:** Building menu is open.
 - **Action:**
 - * User selects a tile.
 - * Before placing that tile, user selects another tile.
 - **Expected result:**
 - * The cursor updates to show the most recently selected tile.
 - * Only the last selected tile can be placed.

All alternative flow tests for this use case passed.

Relationships

- This use case extends the [Interact with grid layout and track scores](#) use case as it builds on the tile-placing functionality, including tile costs.
- This use case is associated with the [Enhance game aesthetics](#) use case as the building menu must run smoothly and be visually-pleasing.
- This use case is associated with the [Metric-influencing buildings](#) use case as the building menu will eventually contain all of the new tiles.

** This use case **PASSED** **

4.6.4.2 Use Case: Exceed Pollution Threshold and Lose Game

This use case was used to fulfil user story [U4-1-1](#).

Goal

To determine when the player loses the game by exceeding the pollution threshold for more than three years in a row.

Actors

- Primary actor: User
- Secondary actor: Game System

Basic Flow

1. Game System monitors the pollution levels each year.
2. Game System checks if the pollution has exceeded the threshold.
3. Game System adjusts the pollution threshold based on the happiness of the city.
4. If the pollution threshold has been exceeded for more than three consecutive years:
 - Game System triggers the lose condition.
 - Game System displays a 'Game Over' message to the User.
 - Game System displays the User's final score and the history of their metrics.

Alternative Flows

No alternative flows, the only way to lose is by exceeding the pollution threshold for more than three consecutive years.

Preconditions

- The game is installed and functional on the user's device.
- The device meets the minimum hardware requirements for running the game.
- The User is actively making decisions (placing, repairing, and selling tiles) that affect the pollution levels.

Postconditions

- The user is informed that the game is over due to exceeding the pollution threshold.
- The user can view a summary of their performance and understand the reasons for losing the game.

Use Case Tests

Basic Flow Tests

- Monitor city status for lose condition
 - **Preconditions:** The game is running, and the user is actively making decisions that affect pollution levels.
 - **Action:** Pollution levels are changing in-game.
 - **Expected result:**
 1. Game system accurately monitors and records the pollution levels each year.

2. Game system accurately calculates the pollution threshold based on the happiness of the city.
 3. Game system correctly checks if the pollution has exceeded the threshold.
 4. Game system keeps a count of the number of years that the pollution limit has consecutively been exceeded for.
- Player loses the game:
 - **Preconditions:** The pollution threshold has been exceeded for more than three consecutive years.
 - **Action:** User has made decisions which have caused pollution to exceed the threshold for more than three consecutive years.
 - **Expected results:**
 1. The game system triggers the lose condition.
 2. Display 'Game Over' message.
- All basic flow tests passed.

Relationships

- This use case depends on [Dynamic in-game time](#), as the passage of time is required to track pollution.
- This use case is associated with [Display current statistics use case](#), as the user must be shown the pollution threshold.
- The use case is also associated with [Show current stats in pause menu](#), as the user is shown their sustainability score and metric history through a line-graph.

** This use case **PASSED** **

4.6.4.3 Buildings Degrade Over Time

This use case was used to fulfil user story [U4-3-1](#).

Goal

To simulate the degradation of buildings over time, affecting their values based on a multiplier.

Actors

- **Primary actor:** User
- **Secondary actor:** Game System

Basic Flow

1. Game System tracks the passing of time within the game.
2. Game System applies a degradation multiplier to each of the building's values. Positive building metrics decrease over time, and negative building metrics increase over time. For each value, a multiplier is applied every year.

3. Game system updates the buildings' values based on the multipliers.
4. User interacts with the buildings and observes changes over time.

Alternative Flows

Alternative Flow A: User pauses the game

When the User pauses the game, the game stops the passing of time.

Preconditions

- The game is installed and functional on the user's device.
- The device meets the minimum hardware requirements for running the game.
- The User has placed at least one building.

Postconditions

- The buildings' values degrade over time based on the specified multipliers.
- The user can see and interact with the changes in the buildings' values.

Buildings Degrade Over Time Tests

Basic Flow Tests

- Degradation multiplier is applied to buildings
 - **Preconditions:**
 - * User has placed at least one building.
 - * At least one year has passed since the player placed the building.
 - **Action:** Player places a building.
 - **Expected results:**
 1. Once a year has passed, degradation multipliers are applied to the building's metrics.
 2. These new values are updated in the building's metrics.
 3. The new values are applied in the game and the user observes these changes.
 4. This continues for every year a building is present.

All the basic flow tests passed. When a user places a building, the degradation multipliers are applied and updated for each building based on when they were built.

Alternative Flow A Tests

- Degradation multipliers aren't applied when user pauses
 - **Preconditions:** The user has started the game.
 - **Action:** The user pauses the game.

– **Expected results:**

1. Building degradation multipliers are not applied to buildings.

All the alternative flow tests passed as building degradation multipliers were not applied when the menu was paused.

Relationships

- This use case depends on [Placing tiles](#) and [Dynamic in-game time](#), as both placing tiles and the passage of time are required for buildings to degrade.
- The use case is associated with [Tooltip](#) as each tile's real-time pollution is shown on the tooltip as it changes.
- The use case is also associated with [Display current statistics](#) as the city's pollution is updated in real-time and displayed.

** This use case **PASSED** **

4.6.4.4 Use Case: Display Current Statistics V2

This use case was used to fulfil user story [U2-4-2](#). The first version of this use case is documented here: [Display current statistics](#). There is also a third version [here](#).

Goal

To provide the user with clear and accessible information about their city's current statistics to make informed decisions.

Actors

- **Primary actor:** User
- **Secondary actor:** Game System

Basic Flow

1. **User** starts the game
 - **UI:** The main game screen is displayed.
2. The **Game System** displays the current statistics in the top left-hand corner. The statistics include:
 - Current year
 - Current pollution / pollution limit
 - Amount of money
 - Yearly income.
3. The **Game System** displays health bars in the bottom left-hand corner of the screen representing:
 - Economic health of the city

- Happiness of the citizens
- Electricity generation
- Environmental health
- **UI:** The health bars are colour coded with percentage bars showing the value of the metric.

Preconditions

- The game is installed and functional on the user's device
- The device meets the minimum hardware requirements for displaying the UI elements.
- The game system has access to the variables storing the city's current pollution, economic health, happiness and electricity stats.

Postconditions

- The user can clearly see the current statistics of their city
- The user can access historical data on the statistics of their city. The user can make informed decisions based on the displayed statistics.

Display Current Statistics Tests

Basic Flow Tests

- Game system loads the base map
 - **Precondition:** Game system has access to the city's stats.
 - **Action:** User clicks 'Start Game'.
 - **Expected results:**
 1. The base map loads with the current year, pollution/pollution limit, money and income in the top left hand-corner and the 4 health bars in the bottom left of the screen.

The basic flow test failed. Although there was a health bar to show the electricity supply, there wasn't a label showing the pollution limit. This can be seen in Figure 5 which shows there is an electricity health bar.

Relationships

- This use case includes [Enhance game aesthetics](#) for screen resolution adjustments, and [Dynamic in-game time](#) for access to the changing metrics.
- This use case extends to [Exceed pollution threshold and lose game](#), when the check for the lose condition is conducted.
- The use case is associated with [Current stats in pause menu](#), as both display the user's stats.

** This use case **FAILED** **

4.6.4.5 Use Case: Place a Wide Range of Metric-Influencing Buildings

This use case was used to fulfil the user story [U4-4-1](#).

Goal:

To allow users to strategically influence city metrics (e.g., environment, economy, happiness, electricity) by selecting and placing a variety of buildings with unique effects.

Actors

- **Primary actor:** User
- **Secondary actor:** Game System

Basic Flow

1. The user opens the building menu.
2. The system displays a variety of buildings grouped by their cost:
 - **Power-generating:** Wind Farm, Coal Power Plant, Nuclear Power Plant
 - **Revenue-generating:** Office, Wheat Farm, Dairy Farm
 - **Happiness-generating:** Stadium, Park, Leisure Center
 - **Carbon-consuming:** Forest, Rubber Forest, Orange Forest, Palm Forest, Cocoa Forest
3. The user selects a building and reviews its cost and impact.
4. The user places the selected building on a valid grid cell.
5. The system dynamically updates the city metrics (for example, environment, money, happiness, electricity) based on the properties of the building.

Alternative Flows

- **Step 3 – Insufficient Funds:**
 - If the user attempts to place a building but lacks enough money, the system displays a message: "Not enough money to place this building."
 - The user can choose a different building or earn more money before proceeding.

Preconditions

- The building menu must display a variety of buildings grouped by their impact type.
- Each building must have a defined cost and metric effects.
- The grid must be interactive and allow placement at valid locations.

Postconditions

- The selected building is successfully placed on the grid.
- City metrics dynamically update to reflect the building's influence.
- The user gains knowledge about how different buildings affect metrics and learns to balance them for city improvement.

Use Case Test : Place and Interact with Metric-Influencing Buildings Tests

Basic Flow Tests

- **Open Building Menu**

- **Precondition:** The building menu is visible.
 - **Action:** The user clicks the building menu.
 - **Expected Result:** The menu expands, displaying buildings grouped by their effects. Each building option is interactable.

- **Select a Building and Review Cost**

- **Precondition:** The building menu is expanded, and buildings are displayed with details.
 - **Action:** The user selects a building and views its cost and effects.
 - **Expected Result:** The building is highlighted. Its cost and impact on metrics are displayed.

- **Place Building on Grid**

- **Precondition:** The grid is initialized, and the user has sufficient funds.
 - **Action:** The user places the selected building on a valid grid cell.
 - **Expected Result:** The building appears on the grid. Metrics (e.g., money, environment, happiness, electricity) update dynamically.

The basic flow failed the test since there were not a wide range of metric-influencing buildings to choose from

Alternative Flow Tests

- **Insufficient Funds**

- **Precondition:** The user does not have enough money to place the selected building.
 - **Action:** The user attempts to place a building.
 - **Expected Result:** A pop-up message appears: "Not enough money to place this building."

This alternative flow failed as there was no message which popped up when the user attempts to place a building with insufficient funds.

- **Occupied Grid Cell**

- **Precondition:** The grid cell is already occupied by another building.

- **Action:** The user attempts to place a building in the same cell.
- **Expected Result:** The system prevents the placement.

This alternative flow passed as occupied grid cells prevented any buildings being placed on them.

Performance Test

- **Precondition:** The grid already contains several buildings, and the user is adding more.
- **Action:** The user selects and places additional buildings on the grid.
- **Expected Result:** The game remains responsive, and metrics update without delay.

Relationships

- This use case depends on the [Building menu](#) as the user must be able to access the wide range of tiles.
- Similarly, the user must be able to place the tile, meaning it depends on the [Placing tiles](#) use case.
- The use case includes [Real-world data](#), as the new tile's are based on the real-world data.
- It is associated with [Display current stats \(V2\)](#), as each new tile will affect the city's metrics differently, and [Real-world data](#), as the new tiles must be based off real-world data.

** This use case **FAILED** **

4.6.5 Screenshots

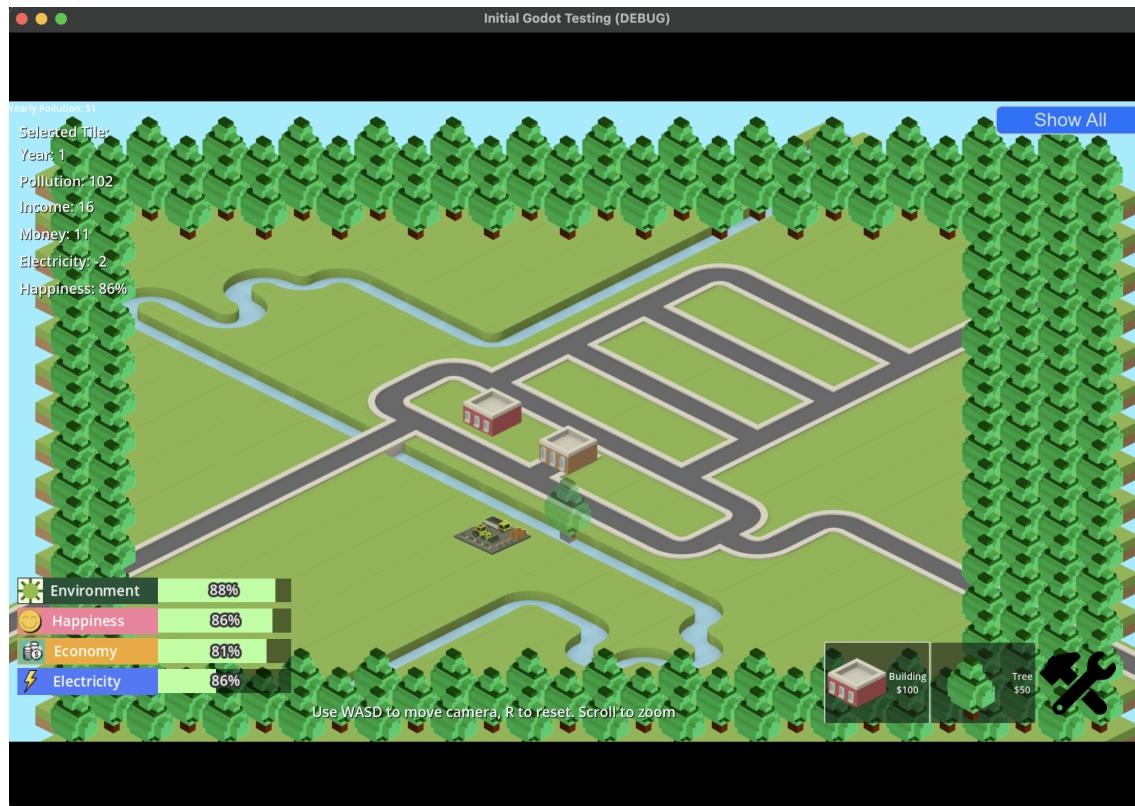


Figure 5: Screenshot of the product after sprint 4

5 Sprint 5: 27/11/2024 to 04/12/2024

5.1 Overview

Since we had collected the relevant data, from sprint 3 and 4, one of the main goals of the final sprint was to put the data into the game. The difficulty would be in addressing game balance whilst still basing the gameplay off of these relative values. When presenting our plans for this sprint in the [previous customer meeting](#), our customers seemed to be very keen on us implementing tooltips to show this data, giving the game further educational value, which we therefore prioritised. We also focused on tying up loose ends and putting the finishing touches to the game, of which there were many. We planned to conclude development after this sprint which was additional impetus for including so many items in this week's [sprint backlog](#).

Allocated roles: James was responsible for the documentation, Filippo was the product owner and Jake was the Scrum master. All other members were developers.

Table 35: Snapshot of the sprint backlog for sprint 5

Identifier	Task	Assignee	Epic	Story Points
U2-1-2	Link back-end functionality with UI to display informative and guiding Oracle advice via the twitter feed.	Anshu Singh and Calum Ogilvy	Decision-making and Educational Guidance (Oracle)	3
U4-3-2	Design a repair button for the air filter (of the dome in-game) and associated functionality. Design a repair button for individual buildings and link previously created functionality	Anshu Singh and Calum Ogilvy	Game Logic	4
U3-2-1	Make the game progressively harder by implementing an external pollution variable that increased exponentially over time. This user story was previously put back into the backlog since it failed to meet this criteria	Anshu Singh and Calum Ogilvy	Game Logic	7
T5-1	Add all new tiles and respective data into the the game, this included adding the tiles to the building menu. Test game balance once added. (This assimilated the user stories U3-1-1 and U4-4-1)	Filippo Santiano and Chris Seadon	Environmental Health and Sustainability	5
U5-1-1	Incorporate building stats and real life data into the tooltips for each building, including reference to the data source.	Filippo Santiano and Chris Seadon	Environmental Health and Sustainability	5
U5-2-1	Design a graph that plots the rate of change of variables over time (money, pollution, happiness, electricity) within the game which can be accessed by the user at the final screen and throughout via the pause menu.	Chih-Ting Chang and Jake Hulme	Decision-making and Educational Guidance (Oracle)	3
U5-3-1	Design a start screen and an end screen that describes the backstory for the game to the user. This includes how the variables interact, what the objective is and the lose condition.	Chih-Ting Chang and Jake Hulme	UI and Player Experience	3
U2-4-2	Complete the final acceptance criteria of this user story, which was creating labels to show in-game stats for the user, including current pollution and income	Chih-Ting Chang and Jake Hulme	UI and Player Experience	7

5.2 Review

- All user stories in this week's [sprint backlog](#) were completed and passed their respective user story tests.
- Task T5-1 grouped the user stories [U3-1-1](#) and [U4-4-1](#) since they depended on each

other closely. They both went on to pass their respective user story tests.

5.3 Meeting Minutes

5.3.1 Group Meeting 29/11/2024

Meeting attendees: All group members

Meeting aim: All members discuss progress, plans and raise any issues / ask questions

Meeting summary:

- **Anshu and Calum:** have refactored and added additional Oracle messages via the twitter feed. They have added a timer that delays how often messages are displayed, which is now essentially a throttled queue. They discussed the potential problem with this being that a critical message may be buried in the queue. A potential solution they highlighted was to periodically scan the queue and reorder it, based on priority, which would solve the issue. However, this would be complex and take time to implement.
- **Jake and Chih-Ting:** have split their tasks between the design of the start and end screen. They shared their work with the group to brainstorm further ideas and direction.
- **Filippo and Chris:** have added all the tiles and data to the game and have made a testable version which they are looking to test later on to address gameplay balancing.

Meeting review:

- This meeting was overall short and effective, lasting 18 minutes. We had extra time so we went into more detail discussing the twitter feed implementation. It was conducted online via Teams.
- A few members stayed behind after the initial meeting concluded to discuss technical issues.

5.3.2 Group Meeting 02/12/2024

Meeting attendees: All group members

Meeting aim: All members discuss progress, plans and raise any issues / ask questions

Meeting summary:

- **Anshu and Calum:** completed the external pollution back-end variable that was quite simple to implement. They then discussed their design choices on repairing the air filter. The air filter is related to the external pollution variable, which accumulates over time until it overwhelms the player. By repairing the air filter, the player can extend this duration, at a cost. They tested the new message features that they have added to the twitter feed, which now should come at the right time and not overload the player with information. They also completed the game over warning messages displaying in the twitter feed.
- **Jake and Chih-Ting:** have finished the start screen display. They are currently working on the end screen and plotting the graphs. The end screen only shows the score as of now. They plan to record the maximum of each variable in the game, to display percentages over time, plotted against that. We then discussed as a group having the option, as a player, to see these graphs and progression over time in the pause menu.
- **Filippo and Chris:** have sourced and referenced a few inconsistencies which were missing from the data set. Their testing for game balance is ongoing and they are tweaking

numbers where they feel it is absolutely necessary. A discussion about game balance and whether we should be concerned about edge cases of a few overpowered tiles followed.

Meeting review:

- This meeting lasted 30 minutes. It was productive and concise, a lot of material was discussed even though we went over the time limit, which we all thought was useful. We discussed as a group that it would be useful for all of us to test the game to get more perspectives on current and future game balance. We also discussed whether we should put limits on what the user can do at the start of the game and whether we should give users additional guidance. Lastly, since this was the penultimate sprint we discussed time management and what the team goals were as the deadline for the deliverables was approaching soon.

5.3.3 Group Meeting 04/12/2024

Meeting attendees: All members

Meeting aim: Plan the agenda for the customer meeting

Meeting summary:

- The team was in high spirits since there had been a big collaborative push among and between pairs to deliver the features required and a notable amount of progress on the game in only a week.
- Since the team had delivered everything that they had set out to achieve, following the [customer's guidance](#), and also since this was the penultimate week of the course, the team was in favour of proposing to the customers that they should focus their efforts on the remaining documentation deliverables.
- There were some small additions that the team proposed to work towards if there was enough time but the team was generally in agreement of concluding the majority of development operations.

5.3.4 Document Meeting 04/12/2024

Meeting attendees: All members

Meeting aim: Discuss the outstanding documentation deliverables with the TAs and ask them for feedback on the current documentation

Meeting summary:

- James showed the TAs the written example use cases that he had prepared which were not in the table format that they were expecting. The TAs showed a template that the team should ideally use and told the team to contact them further to confirm if they were unsure.
- The TAs also gave useful guidance and walked the team through examples of what—the user manual, installation guide and maintenance guide—should contain and how long each should be. This helped to clarify the focus going into the final week.

5.3.5 Sprint 5 Review 05/12/2024

Meeting attendees: All members

Meeting aim: Each member presented their completed work. As a team, we inspected the outcome of the sprint. We will determine what to do next based on the information gathered from this week's main meetings ([customer](#) and [document](#) meetings which happened before

this review).

Meeting summary:

- **Anshu and Calum:** had completed implementing the back-end external pollution variable that eventually overwhelms the user, therefore satisfying user story [U3-2-1](#). They had finished designing the repair button UI and functionality for the dome. They were also to complete a repair button included for tooltips. Together, these tasks jointly completed their assigned user story, [U4-3-2](#). Calum had also finished updating the map to be a larger playable area and also to be more natural-looking. The pair had also finished updating the Oracle to give more dynamic feedback which completed the second user story assigned to them, [U2-1-2](#). Chris collaborated with them to help when they got stuck or had technical issues.
- **Jake and Chih-Ting:** had completed their assigned user stories, [U5-2-1](#) and [U5-3-1](#). The start screen now included a guiding backstory and useful explanation of the in-game variables. The end screen now displayed a score and a line chart with plotted stats over the duration of the gameplay session, which was also accessible from the menu. They had also finished implementing displaying numerical in-game stats which included current pollution which, at last, completed user story [U2-4-2](#).
- **Filippo and Chris:** had completed adding all tiles and associated data into the game, which at last concluded [T5-1](#). They had tested the game balance incrementally and had tweaked some values for playability. They had given the tooltips a huge visual update and had updated the icons in the building menu. Finally, they had added data source references, accessible from the user menu, and "Did you know?" fun facts in the tooltips. This meant that, after the corresponding user story test had passed, they had completed assigned user story, [U5-1-1](#).

Meeting actions:

- Using the feedback from the [customer meeting](#), there were some small changes to implement for the product. However, overall the team was planning for the upcoming documentation deliverables in final week.
- We delegated out which item each person is responsible for delivering and scheduled meeting times. This was to allow frequent group review of deliverables and also to enable distributing the workload if necessary, for practicality and fairness.

5.3.6 Sprint 5 Retrospective 05/12

Meeting attendees: All members

Meeting aim: Reflect on group interactions, processes and tools used during the sprint.

Meeting summary:

- **Anshu and Calum:** rated their combined experience as a 4 out of 5. Since Anshu was preoccupied with interviews this week, she mentioned that Calum had given 200% effort to deliver their assigned features which was lovely to see. Calum summarised by saying that "they broke a lot of things, fixed a lot of things and asked Chris for help a lot".
- **Jake and Chih-Ting:** rated their pair experience a 5 out of 5. They split their work and successfully merged it when they reconvened. They commented that were quite a few issues but they overcame the challenges as a pair.

- **Filippo and Chris:** both enjoyed their experience working together, commenting that it was very productive, and rated it a 5 out of 5.

5.4 Product Backlog

Identifier	Details	Category	Epic	Story Points
U4-5-1	See user story for further details.	User story	Environmental Health and Sustainability	2
U2-5-1	See user story for further details.	User story	UI and Player Experience	2
U2-6-1	See user story for further details.	User story	UI and Player Experience	1
U2-7-1	See user story for further details.	User story	Environmental Health and Sustainability	2
U2-8-1	See user story for further details.	User story	City Building and Resource Management	2
U2-9-1	See user story for further details.	User story	City Building and Resource Management	1
U2-10-1	See user story for further details.	User story	Environmental Health and Sustainability	1
U2-11-1	See user story for further details.	User story	Game Logic	2
T1-16	Consider some luck element in the generation of income from businesses, could be based on real market data from a certain time	Task	Unassigned	1

Table 36: Snapshot of the product backlog after sprint 5

5.4.1 New Product Backlog Items

No items were added to the product backlog in sprint 5.

5.5 Exception Handling

Due to the large amount of development that went on during this sprint, there was a minor slowdown due to a few merge conflicts in version control, which were eventually resolved. Jake highlighted in our [sprint retrospective](#) that the communication, reviewing pull requests and letting others know when major updates had been added, was good during this sprint. This meant that each pair could develop on top of the most up to date version of the game throughout the week.

5.6 Product Documents

5.6.1 Customer Meeting 04/12/2024

Meeting attendees: All members

Meeting aim: Demo the product for the customer and propose plans for the final week

Meeting summary:

- We first displayed our development results from the week to the customer via the product demo. To recap, we showcased: our aesthetically updated building tooltips with new “Did you know?” fun facts referencing the data source; a building repair button that affects building efficiency with respect to its variables (e.g. carbon efficiency); a guiding backstory via the start screen; a map update that made the game more visually appealing and gave the user a larger play area; Oracle guidance being made more dynamic depending on variables and the game state (e.g. money, electricity, happiness, pollution, end game warning); data references accessible from the menu; in-game stats plotted in a graph accessible from the menu and at the end screen; all assets added into the game as tiles and data; and a repairable air filter for the external pollution variable (related to the dome backstory and end game condition).
- The customer suggested that we could add an asterisk to the data reference list which would inform the player that some game values have been edited, for gameplay reasons, in case they were using the game as a learning tool and believed the values to be fully accurate.
- The customer then asked us about our plans for the coming week. We responded with our plan which was to focus on documentation since the game was at a playable state. They agreed with our plans.
- The customer questioned further on whether playability was an issue, having seen the demo. The year timer was currently sped up for testing purposes which we planned to tweak downwards, since development was concluding. The customer made the point that the game should be slower paced, since it is a strategy game where the user should have enough time to plan their city.
- The group went on to discuss potential extension ideas that they had planned for such as: saving and loading progress; and a minigames feature, to make the game more actively engaging and boost production of associated buildings.
- Wrapping up the meeting, the customers were impressed with our product and gave us tips on our remaining documentation deliverables. They suggested that the maintenance guide could be a visual diagram showing how certain functions are interlinked.

Meeting actions:

- Integrate the suggestions of slowing down the in-game timer and having an asterisk in the data reference list to inform users that the game may not be fully accurate for playability reasons.
- Focus on our documentation deliverables for the final week.

5.6.2 New/Updated User Stories

No user stories were added or updated for this sprint.

5.6.3 User Story Tests

User story U2-4-2 Tests

The tests for this user story failed in sprint 4 but passed in this sprint.

User story U2-4-2 PASSED

User story U3-2-1 Tests

As shown in [Figure 6](#):

- There is a clear time element (year) in the top-left corner, which is updated at regular intervals if the game is running.
- There is an option to repair the air filter, and if it is not, the pollution increases exponentially making the game progressively harder

As shown in [Figure 6](#):

- The game assets are high-quality isometric images

This user story test did not pass in sprint 3, as the game did not get progressively harder at this stage of development, but passed in this sprint.

****User story U3-2-1 PASSED****

User story U4-4-1 Tests

The tests for this user story failed in [sprint 4](#) but passed in this sprint.

As shown in [Figure 6](#):

- The building menu now displays all the different types of tiles that the user can select and place.
- Placement functionality is identical to that of the original office and tree tiles.
- Each tile has a unique price and a different effect on the city when placed.

****User story U4-4-1 PASSED****

User story U2-1-2 Tests

As shown in [Figure 6](#):

- The tooltip now shows the selected tile's current pollution, income, electricity generation + usage and happiness.
- The twitter feed in the top-right corner now displays relevant and useful messages to advise the user on what needs attention.

As shown in [Figure 8](#):

- There is a help section with important information for when the user gets stuck.

****User story U2-1-2 PASSED****

User story U4-3-2 Tests

As shown in [Figure 6](#):

- The user can now press on the repair button to restore the tile to maximum capacity.
- There is a Repair Air Filter button in the bottom-right to repair the protective dome and reduce the external pollution.

****User story U4-3-2 PASSED****

User story U5-1-1 Tests

As shown in [Figure 6](#):

- In the tooltip, under the "Did you know?" section, there is a fun sustainability-related fact about the selected tile.

As shown in [Figure 7](#):

- A list of URLs for data sources can be found in the pause menu.

****User story U5-1-1 PASSED****

User story U3-1-1 Tests

****User story U3-1-1 PASSED****

User story U5-2-1 Tests

As shown in [Figure 6](#):

- The user's pollution, money, electricity and happiness since starting the game have been plotted.

As shown in [Figure 7](#):

- A list of URLs for data sources can be found in the pause menu.

****User story U5-2-1 PASSED****

User story U5-3-1 Tests

As shown in Figures: [11](#), [12](#) and [13](#):

- There are start screens displaying the game's backstory, how to play the game and the win/lose criteria.

****User story U5-3-1 PASSED****

5.6.4 Use Cases

5.6.4.1 Use Case: Dynamic In-Game Time (V2)

This use case is linked to user story [U3-2-1](#)

Goal

To ensure the game environment changes over time, making the gameplay experience dynamic and engaging

5.6.4.2 Actors

- **Primary actor:** User
- **Secondary actor:** Game system

Basic Flow

1. User starts the game.
2. Game System tracks the passing of time in-game, with years increasing one-by-one.
 { **Increment year** }
3. Game System updates the game environment based on the passing of time:
 - The score is updated for each year.
 - The income for the year is calculated and displayed.
 - The external pollution increases every year unless the air filter is repaired, in which case it resets to the original level. External pollution increases exponentially due to a yearly multiplier.
4. User interacts with the evolving game environment.
5. Game System ensures that time-based changes are applied and displayed to the User.

Alternative Flows

Alternative Flow A: User pauses the game

1. **User** starts the game.
- 2.1A User starts the game.
- 2.2A User pauses the game.
- 2.3A Game System stops tracking time.
- 2.4A User interacts with pause features.
- 2.5A User resumes the game.
- 2.6A Game System resumes tracking time.

Steps 3, 4, and 5 in the base flow are then executed.

Extension Points

- { **Increment year** }: The point at which the back-end game system increments the year

Preconditions

- The game is installed and functional on the user's device.
- The device meets the minimum hardware requirements for displaying the UI elements.

Postconditions

- The game environment changes over time, providing an engaging and evolving experience for the User.
- The User can see the changes in the game environment.

Dynamic In-Game Time (V2) Tests

Basic Flow Tests

- **Preconditions:** The game system loads correctly.
- **Action:** The player begins to play the game.
- **Expected results:**
 1. The years increase, one-by-one and are displayed to the user.
 2. The score is updated for each year, stored, and displayed on the 'Current Stats' screen in the pause menu.
 3. The total income is updated every year depending on the assets built in the map and displayed to the user.
 4. The health bars are updated multiple times within each year and stored and displayed on the 'Current Stats' screen in the pause menu.
 5. The external pollution becomes increasingly larger if the air filter is not repaired.

The basic flow test passed as the repair air filter feature was implemented in this sprint.

Alternative Flow A Tests

- Time stops passing when the game is paused.
 - **Preconditions:** The user has paused the game.
 - **Action:** User pauses the game.
 - **Expected results:**
 1. The pause menu is displayed.
 2. The years stop incrementing on the screen and within the back-end functionality.
 3. The score is frozen, and this value is displayed on the 'Current Stats' page in the pause menu.
 4. The total income is frozen and is not added to total money.
 5. The health bars are frozen, and are not updated.
- Time resumes passing when the game continues.
 - **Preconditions:** User paused the game.
 - **Action:** User resumes the game.
 - **Expected results:** The basic flow of this use case is resumed.

All tests in the alternative flow A passed. Nothing is updated when the game is paused, and everything resumes being updated when the game is resumed.

Relationships

- This user story is associated with the [Display current statistics \(V1\)](#) use case, as this is how the passage of time is shown to the user.

- This use case, responsible for the passage of time, is a key element in nearly every part of the game. The following use cases were chosen because they heavily rely on this mechanism: [Buildings degrading over time](#), [Repairing the air filter](#), [Viewing current stats in the pause menu](#), and [Displaying current statistics](#).

** This use case **PASSED** **

5.6.4.3 Use Case: Display Current Statistics V3

This use case was used to fulfil user story [U2-4-2](#). The first version of this use case is documented here: [Display current statistics](#) and the second version here: [Display current statistics V2](#)

Goal

To provide the user with clear and accessible information about their city's current statistics to make informed decisions.

Actors

- **Primary actor:** User
- **Secondary actor:** Game System

Basic Flow

1. **User** starts the game
 - **UI:** The main game screen is displayed.
2. The **Game System** displays the current statistics in the top left-hand corner. The statistics include:
 - Current year
 - Current pollution / pollution limit
 - Amount of money
 - Yearly income.
3. The **Game System** displays health bars in the bottom left-hand corner of the screen representing:
 - Economic health of the city
 - Happiness of the citizens
 - Electricity generation
 - Environmental health
 - **UI:** The health bars are colour coded with percentage bars showing the value of the metric.

Preconditions

- The game is installed and functional on the user's device
- The device meets the minimum hardware requirements for displaying the UI elements.
- The game system has access to the variables storing the city's current pollution, economic health, happiness and electricity stats.

Postconditions

- The user can clearly see the current statistics of their city.
- The user can access historical data on the statistics of their city. The user can make informed decisions based on the displayed statistics.

Display Current Statistics Tests

Basic Flow Tests

- Game system loads the base map
 - **Precondition:** Game system has access to the city's stats.
 - **Action:** User clicks 'Start Game'.
 - **Expected results:**
 1. The base map loads with the current year, pollution/pollution limit, money and income in the top left hand-corner and the 4 health bars in the bottom left of the screen.

The basic flow test passed. as there was now a label showing the pollution limit. This can be seen in [Figure 6](#) which shows the pollution limit value within the pollution label.

Relationships

- This use case includes [Enhance game aesthetics](#) for screen resolution adjustments, and [Dynamic in-game time](#) for access to the changing metrics.
- This use case extends to [Exceed pollution threshold and lose game](#) when the check for the lose condition is conducted.
- The use case is associated with [Current stats in pause menu](#) as both display the user's stats.

** This use case **PASSED** **

5.6.4.4 Building Menu (V3)

This use case was used to fulfil user story [U4-4-1](#). It also has [1st](#) and [2nd](#) versions.

Goal

To provide the user with access to a wide-range of placeable tiles in the building menu.

Actors

- **Primary actor:** User
- **Secondary actor:** Game system

Basic Flow

1. User starts the game.
2. Game system blocks User from being able to place tiles.
3. Game system displays a building menu in the bottom right of the screen with an icon that clearly conveys the button's purpose.
4. User clicks on the building button.
{Display Building Menu}
5. The Game system displays a building menu with the following tiles:
 - Revenue-generating Assets:
 - Office
 - Dairy Farm
 - Wheat Farm
 - Pollution-reducing Assets:
 - Forest
 - Cocoa Forest
 - Rubber Forest
 - Orange Forest
 - Palm Forest
 - Energy-generating Assets:
 - Coal Power Plant
 - Nuclear Power Plant
 - Wind Farm
 - Happiness-generating Assets:
 - Park
 - Leisure Centre
 - Stadium
6. User clicks on a tile from the menu.
{Update Cursor}
7. Game system displays selected tile under the User's cursor.
8. User clicks on a valid location to place a tile (See [placing a tile use case](#)).
{Check Place Tile}

9. Game system places the tile at the specified location and subtracts the cost of the tile from User's balance.
10. User clicks the building menu button.
{Hide Building Menu}
11. Game system hides building menu and blocks User from being able to place tiles.

Alternative Flows

- **Alternative Flow A: User cannot afford to place the selected tile**
 - At **{Check Place Tile}**, if User's balance is insufficient, the Game System does not place the tile.
 - The flow resumes at **{Update Cursor}**, allowing the User to select another action.
- **Alternative Flow B: User opens and closes building menu without selecting a tile**
 - At **{Hide Building Menu}**, if the User closes the menu without selecting a tile, no changes occur on the map or to the User's balance.
 - The Game System blocks tile placement until the menu is reopened.
- **Alternative Flow C: User clicks multiple tiles before placing one**
 - At **{Update Cursor}**, if the User selects multiple tiles consecutively, the cursor updates to reflect the last selected tile.
 - The flow resumes at **{Update Cursor}** until the User places a tile.

Extension Points

- **{Display Building Menu}**: The point at which Game system displays the building menu and puts the User into buildmode.
- **{Update Cursor}**: The point at which the Game system updates the selected tile and displays it under the user's cursor.
- **{Check Place Tile}**: The point at which the Game System checks if the cost of the tile can be taken from the User's balance and if the tile can be placed.
- **{Hide Building Menu}**: The point at which Game system hides the building menu and takes the User out of buildmode.

Preconditions

- The game system has successfully loaded and initialized all tile types, icons, and associated costs for display in the building menu.
- The game system can access the User's balance.
- The game system is set to block tile placement by default until a tile is selected from the building menu.

Postconditions

- If a tile is placed:
 - The selected tile is correctly displayed on the map at the specified location.
 - The tile's cost is deducted from the user's balance.
 - The map updates visually to reflect the placed tile.
- If no tile is placed:
 - The user's balance remains unchanged.
 - The map remains unaltered.
- The building menu state is correctly updated:
 - If closed, the system blocks tile placement.
 - If opened, the system allows tile selection and placement attempts.

Building Menu Tests

Basic Flow Tests

- **Opening the building menu**
 - **Precondition:** Game is running and building menu is not visible.
 - **Action:** User clicks the building button.
 - **Expected result:**
 - * The building menu appears at the bottom of the screen.
 - * Tile placement is enabled only after a tile is selected.
- **Selecting and placing a tile**
 - **Precondition:** The building menu is open, and the user has enough money to place the tile they will select.
 - **Action:**
 - * User selects the tile from the menu.
 - * User clicks a valid map location to place the tile.
 - **Expected result:**
 - * Before the tile is placed, it is shown under the cursor.
 - * The tile is placed at the location where the user clicks.
 - * The tile's cost is deducted from the user's balance.
 - * The map updates to show the new tile.
- **Closing the building menu**
 - **Precondition:** The building menu is open.
 - **Action:** User clicks the building button.

- **Expected result:**

- * The building menu is hidden.
 - * Tile placement is disabled until the building menu is re-opened.

All basic flow tests for this use case passed.

Alternative Flow Tests

- **Insufficient balance**

- **Precondition:** Building menu is open, the user has selected a tile and has insufficient funds for the tile.
 - **Action:** User goes to place the tile on the map.
 - **Expected result:**
 - * A tile is not placed.
 - * A warning or error message (e.g. "Not enough money") is displayed.
 - * The user's balance remains unchanged.

- **Closing menu without selecting a tile**

- **Precondition:** Building menu is open.
 - **Action:** User clicks on the building menu button.
 - **Expected result:**
 - * Building menu is hidden.
 - * Tile placement is disabled until building menu is re-opened.

- **Selecting multiple tiles**

- **Precondition:** Building menu is open.
 - **Action:**
 - * User selects a tile.
 - * Before placing that tile, user selects another tile.
 - **Expected result:**
 - * The cursor updates to show the most recently selected tile.
 - * Only the last selected tile can be placed.

All alternative flow tests for this use case passed.

Relationships

- This use case extends the [Interact with grid layout and track scores](#) use case as it builds on the tile-placing functionality, including tile costs.
- This use case is associated with the [Enhance game aesthetics](#) use case as the building menu must run smoothly and be visually-pleasing.

- This use case includes the [Metric-influencing buildings](#) use case as the building menu will eventually contain all of the new tiles.

** This use case **PASSED** **

5.6.4.5 Use Case: Live Message Feed (V2)

This use case was used to fulfil user story [U2-1-2](#). The first version of this use case can be found in [Sprint 2](#).

Goal

Provide the user with valuable information and advice that will better inform the decisions they make to positively impact their city's health.

Actors

- **Primary actor:** User
- **Secondary actor:** Game system

Basic Flow

1. User starts a new game.
2. Game system tracks and updates the city's health metrics (pollution, economic health, happiness, electricity usage) in real-time.
3. Game system displays a feed in the top-right corner, showing messages from the population about the city's status. The messages focus on the recent changes in the city's metrics:
{Update Message Feed}
 - The feed is updated each in-game year, and each message conveys important information about recent changes, such as rising pollution or increases in happiness.
4. User interacts with the game, making decisions such as placing, repairing, or selling tiles based on the information from the feed.
5. Game system continues tracking the city's status and updating the message feed.

Alternative Flows

- **Alternative Flow A: Pollution Threshold Warning**
 - At **{Update Message Feed}**, if current pollution is greater than acceptable pollution level:
 - * Game system detects that pollution has exceeded the threshold value.
 - * Game system provides a warning message in the feed, telling the user how much time they have left before they lose the game.
 - Resume basic flow.
- **Alternative Flow B: Multiple Metrics Change at Once**

- At **{Update Message Feed}**, if there are changes for more than one metric:
 - * Game system uses an array to store and display a message for each of the detected changes.
 - Resume basic flow.
- **Alternative Flow C: No Significant Changes in Metrics**
- At **{Update Message Feed}**, if there are no detected changes in any metrics:
 - * Game system displays a neutral message in the feed.
 - Resume basic flow.

Extension Points

- **{Update Message Feed}**: The point at which the game evaluates the recent changes in the city's stats and determines which message, if any, should be displayed.

Preconditions

- The game system tracks the city's metrics (pollution, economic health, happiness, electricity usage) in real-time.
- The user is actively making decisions (placing, repairing, or selling tiles) that affect these metrics.
- The message feed is set up to display relevant messages based on changes to these metrics.

Postconditions

- The game system provides real-time updates on the city's health through metrics and the message feed.
- The user receives advice based on their decisions, which helps them improve their city's health.
- The game system continuously updates city metrics and provides real-time feedback, guiding the user toward better decision-making.

Live Message Feed (V2) Tests

Basic Flow Tests

- **Display Messages Based on City Metrics**
 - **Precondition:** The game tracks city metrics in real time, and the user is actively interacting with the game.
 - **Action:** User starts the game, places tiles, and watches the message feed.
 - **Expected Result:** The message feed displays updates that are relevant to the recent changes in the city's infrastructure.
- **Show/Hide Message Feed**
 - **Precondition:** The message feed is visible, and the user is playing the game.

- **Action:** The user presses the “Show More” button followed by the “Show Less” button.
- **Expected Result:**
 - * “Show More” pressed – the message feed displays older messages alongside the new ones.
 - * “Show Less” pressed – the message feed hides the older messages and only shows the newest ones.

- **Notify User of New Messages**

- **Precondition:** An in-game year has passed since the last message, and new messages have been selected by the game system.
- **Action:** User waits for the most recent messages in the feed.
- **Expected Result:** At the end of each year, new messages are displayed in the feed.

All basic flow tests for this use case passed.

Alternative Flow Tests

- **Pollution Threshold Warning**

- **Precondition:** The city’s pollution exceeds the acceptable threshold.
- **Action:** User waits for the messages to update at the end of the year.
- **Expected Result:** A warning message appears in the feed showing how much time is left before the user loses the game.

- **Multiple Metric Changes**

- **Precondition:** The game detects changes in more than one metric during the in-game year.
- **Action:** Wait for the messages to update at the end of the year.
- **Expected Result:** At the end of the year, a message is displayed for each change.

- **No Significant Changes in Metrics**

- **Precondition:** The game detects no significant change in any of the metrics.
- **Action:** User waits for the messages to update at the end of the year.
- **Expected Result:** At the end of the year, the feed displays a neutral message indicating no significant changes.

All alternative flow tests for this use case passed.

Relationships

- This use case is associated with the [Help section in pause menu](#) use case as they are both related to how the Oracle guides the user.
- Given that the message feed is determined by the city’s pollution, this use case includes the [Interact with grid layout and track scores](#) use case.

- This use case also includes the [Exceed pollution threshold](#) use case as it includes functionality to warn the player if they are about to lose the game.

** This use case **PASSED** **

5.6.4.6 Use Case: Tooltip (V2)

This use case was used to fulfil user story [U2-1-2](#). The first version of this use case can be found in [Sprint 2](#). The third version is detailed [later](#) in this sprint's documentation .

Goal

To provide the user with real-time data on pollution, economy, happiness, and electricity for each tile, and allow them to reset the tile's values to their original state using the repair button.

Actors

- **Primary actor:** User
- **Secondary actor:** Game system

Basic Flow

1. Game system tracks pollution, income, happiness, and electricity (required and generated) for each placed tile.
2. User clicks on a placed tile (e.g., office, factory, park, or forest).
{Display Tooltip}
3. Game system displays a tooltip unique to that tile, containing:
 - Current yearly stats for:
 - Pollution output/uptake.
 - Income.
 - Happiness generation.
 - Electricity usage/generation.
 - A repair button that resets the tile's values to their original state.
4. User clicks the repair button.
{Repair Payment}
5. The game system subtracts the cost of the repair from the user's funds.
6. The game system resets the tile's stats to their original values.
{Display Updated Tooltip}
7. The tooltip updates to show the tile's current stats.
8. User clicks anywhere outside the tooltip to close it.

Alternative Flows

- **Alternative Flow A: No tooltip shown for invalid tiles.**
 - At {Display Tooltip}, if the user clicks on a non-interactive space (not a tile), the game system does not show a tooltip.
- **Alternative Flow B: Tile is already at original values and cannot be repaired.**
 - At {Repair Payment}, if the tile has just been built or repaired, do not accept payment from the user or change tile values.
 - Resume the basic flow at {Display Updated Tooltip}.
- **Alternative Flow C: User lacks sufficient funds to repair tile.**
 - At {Repair Payment}, if the user lacks the funds to repair the tile, do not accept payment or change tile values.
 - Resume the basic flow at {Display Updated Tooltip}.
- **Alternative Flow D: User reviews data but does not repair tile.**
 - Between {Display Tooltip} and {Display Updated Tooltip}, if the user does not click the repair button, resume the basic flow at {Display Updated Tooltip}.

Extension Points

- **{Display Tooltip}**: The point at which the game system gathers the tile's data and displays it.
- **{Repair Payment}**: The point at which the user clicks the repair button, and the game system processes the repair.
- **{Display Updated Tooltip}**: The point at which the game system updates the tooltip with the tile's live stats.

Preconditions

- The game system has access to each tile's yearly pollution, income, happiness, and electricity (generated and required).
- The game system has the repair functionality to reset tile statistics to their original values.
- The user has tiles placed on the map and can click on them.

Postconditions

- The user can see the yearly pollution, income, happiness, and electricity for any tile on their city's map.
- The user can improve the sustainability of a tile by clicking the repair button on the tooltip.
- The tooltip is hidden once the user clicks outside of it or navigates to another tile.

Tooltip (V2) Tests

Basic Flow Tests

- **Clicking a tile to display tooltip:**
 - **Precondition:** The map has at least one tile placed on it.
 - **Action:** User clicks on a tile.
 - **Expected Result:** A tooltip appears near the clicked tile, displaying:
 - * Current yearly stats for:
 - Pollution output/uptake.
 - Income.
 - Happiness generation.
 - Electricity usage/generation.
 - * A repair button.
- **Repairing a tile:**
 - **Precondition:** A tooltip is displayed for a tile whose sustainability has decreased since its construction, and the user has sufficient funds.
 - **Action:** User clicks the repair button.
 - **Expected Result:**
 - * The game system deducts the cost of the repair from the user's funds.
 - * The tile's stats reset to their original values.
 - * The tooltip updates immediately to reflect the repaired stats.
- **Closing the tooltip:**
 - **Precondition:** A tooltip is visible for the selected tile.
 - **Action:** User clicks anywhere outside the tooltip.
 - **Expected Result:** Tooltip is hidden. If another tile is clicked, a new tooltip appears.

All basic flow tests for this use case passed.

Alternative Flow Tests

- **Clicking a non-interactive area:**
 - **Precondition:** The game has been loaded.
 - **Action:** User clicks outside any placed tiles.
 - **Expected Result:** No tooltip appears. If a tooltip was previously visible, it disappears.
- **Tile cannot be repaired:**
 - **Precondition:** A tooltip is displayed for a tile already at its original values.

- **Action:** User clicks the repair button.
- **Expected Result:**
 - * No changes are made to the tile's stats or user funds. A message is displayed (e.g., "Insufficient funds to repair this tile").
 - * The tooltip remains visible.
- **Insufficient funds for repair:**
 - **Precondition:** A tooltip is displayed for a tile requiring repair, but the user lacks sufficient funds.
 - **Action:** User clicks the repair button.
 - **Expected Result:**
 - * No changes are made to the tile's stats or user funds. A message is displayed (e.g., "Insufficient funds to repair this tile").
 - * The tooltip remains visible.
- **Reviewing the data without repairing:**
 - **Precondition:** A tooltip is displayed for a selected tile.
 - **Action:** User does not click the repair button before closing the tooltip.
 - **Expected Result:** The tooltip disappears without any changes to the tile's stats or user funds.

All alternative flow tests for this use case passed.

Relationships

- This use case requires pollution to be tracked and therefore includes the use case [Interact with grid layout and track scores](#).
- The use case depends on the [Dynamic in-game time](#) use case as the tooltip must update its values.
- The use case is associated with the [Wide range of assets](#) and [Real-world data](#) use cases, as each tooltip will display the stats for each different tile.
- This use case was associated with the [Repair air filter](#) use case as both had repair functionality.

** This use case **PASSED** **

5.6.4.7 Use Case: Building Data is based off Real-world Data

This use case fulfilled user story [U3-1-1](#) since we had collected a full data set.

Goal

To incorporate the data from academic journals and government data into a unified unit system and apply it to in-game buildings.

Actors

- **Primary actor:** User
- **Secondary actor:** Game System

Basic Flow

1. **User** launches the game, selects a building from the building list, and places it on the map.
2. Real-world data from the established database is used to calculate in-game money, electricity, happiness, and other metrics.

Preconditions

- The game contains the appropriate buildings.
- The game includes corresponding functions to compute values derived from real-world data.

Postconditions

- Units have been converted for calculation purposes.
- Determine whether the game can still be played smoothly based on the real data.

Relationships

- The use case is associated with the [data sources use case](#) as this is where the data sources will be displayed.
- This use case is also associated with the [Metric-influencing buildings](#) use case, as the real-world data will determine the impact of each tile on the city.
- This use case extends to the [building menu](#) use case to select and place buildings.

Use Case Tests

Basic Flow Tests

- **Buildings use real-world data:**
 - **Precondition:** User successfully opens the game.
 - **Action:** User places a tile
 - **Expected results:**
 1. Game system uses real-world data values and applies them to relevant buildings
 2. These values are represented in game and affect the game dynamics.

** This use case **PASSED** **

5.6.4.8 Use Case: Data Sources Submenu

This use case was used to fulfil user story [U5-1-1](#). There is only one version of this use case.

Goal

To enhance the user's understanding of real-world sustainability by offering transparency about the data sources and directing them to educational resources.

Actors

- **Primary actor:** User
- **Secondary actor:** Game system

Basic Flow

1. User is playing the game.
 {**Pause Game**}
2. User pauses the game.
3. User clicks on and enters the extras menu.
4. User clicks on and enters the data sources page.
5. Game system displays a labelled list of URLs for all data sources used in the game.
 {**User Selects URL**}
6. User reads the list and clicks on the URL for the topic they want to explore.
 {**Open URL**}
7. Game system opens the URL in a separate window using the user's preferred browser.
8. User reads and learns more about the chosen data source.
 {**Show Data Menu**}
9. User returns to the game window and the data source page.
10. User clicks a back button to return to the pause menu.
11. User clicks a resume game button on the pause menu.
 {**Resume Game**}
12. Game system resumes the game.

Alternative Flows

- **Alternative Flow A: User Does Not Select a URL to Open**
 - At {**User Selects URL**}, if the user does not click on a URL before exiting the page:
 - * Resume basic flow at {**Show Data Menu**}.
- **Alternative Flow B: User Resumes Game by Pressing ESC**
 - Between {**Pause Game**} and {**Resume Game**}, if the user presses ESC:
 - * Resume basic flow at {**Resume Game**}.
- **Alternative Flow C: URL Cannot Be Opened**
 - At {**Open URL**}, if there is no internet connection or the URL is invalid:

- * User uses text labels to search for the data source manually.
- * Resume basic flow at **{Show Data Menu}**.
- **Alternative Flow D: User Selects More Than One URL to Open**
 - At **{Open URL}**, if the user clicks on multiple URLs:
 - * Each URL opens in a separate tab of the user's browser.
 - * Resume basic flow at **{Show Data Menu}**.

Extension Points

- **{Pause Game}**: The point at which the game system pauses the game and displays the pause menu.
- **{User Selects URL}**: The point at which the user finds the data source they are interested in and clicks on the URL.
- **{Open URL}**: The point at which the game system opens a new window in the user's browser and opens the selected URL.
- **{Show Data Menu}**: The point at which the user has returned to the data menu and now has the option to open another URL, return to the pause menu, or resume the game.
- **{Resume Game}**: The point at which the pause menu is closed and the game is resumed.

Preconditions

- The game system has access to the data sources and their corresponding URLs.
- The user has internet access to browse the external links.

Postconditions

- The user has accessed information about one or more data sources.
- The user can continue playing the game after exploring the data sources.

Data Sources Submenu Tests

Basic Flow Tests

- **Pausing the Game and Accessing the Data Sources Page**
 - **Precondition:** The game is running.
 - **Action:**
 - * User presses ESC to pause the game.
 - * User navigates to extras menu and selects data sources button.
 - **Expected Result:**
 - * The game pauses, displaying the pause menu.

- * The data sources page opens, showing a list of labels and URLs for each data source.

- **Opening a URL**

- **Precondition:** The data sources page is open, and the user has an active internet connection.
- **Action:** User selects a URL.
- **Expected Result:**
 - * A new browser tab or window opens, displaying the selected data source's page.
 - * The game stays paused.

- **Returning to the Pause Menu and Resuming the Game**

- **Precondition:** The data sources page is open.
- **Action:**
 - * The user clicks the back button to return to the pause menu.
 - * The user clicks the resume button.
- **Expected Result:**
 - * The pause menu reappears after clicking the back button.
 - * The game resumes from when it was paused when the resume button is clicked.

All basic flow tests for this use case passed.

Alternative Flow Tests

- **The User Does Not Select a URL**

- **Precondition:** The data sources page is open.
- **Action:**
 - * User views the list of URLs but does not click any.
 - * User clicks the back button to return to the pause menu.
- **Expected Result:**
 - * No browser windows or tabs open.
 - * The game remains paused, and the user is returned to the pause menu.

- **User Resumes Game Using ESC Key**

- **Precondition:** The data sources page is open.
- **Action:** User presses ESC.
- **Expected Result:**
 - * The pause menu closes immediately.
 - * The game resumes from where it was paused.

- **URL Cannot Be Opened**

- **Precondition:** The data sources page is open, and the user does not have an active internet connection or selects an invalid URL.
- **Action:** User selects a URL from the list.
- **Expected Result:**
 - * An error message is displayed.
 - * The user can still view the label text to manually search for the source.
 - * The data sources menu remains open.

• User Selects Multiple URLs

- **Precondition:** The data sources page is open.
- **Action:** User clicks on multiple URLs.
- **Expected Result:**
 - * Each URL opens in a separate tab in the user's browser.
 - * The game remains paused while the data source menu remains open.

All alternative flow tests for this use case passed.

Relationships

- This use case required access to the data sources, and therefore includes the use case [Use real-world data](#).
- The use case is associated with the [Wide range of assets](#) use case, as the data sources were used to determine the effect of each tile.

5.6.4.9 Use Case: Tooltip (V3)

This use case was used to fulfil user stories [U5-1-1](#), [U2-1-2](#) and [U4-3-2](#). This use case had 1st and 2nd versions before this.

Goal

To provide the user with real-time data on pollution, economy, happiness, and electricity for each tile, and allow them to reset the tile's values to their original state using the repair button. The tooltip now also serves to teach the user a fun fact about the selected tile.

Actors

- **Primary actor:** User
- **Secondary actor:** Game system

Basic Flow

1. Game system tracks pollution, income, happiness, and required and generated electricity for each tile.
2. Game system has access to an array of fun facts for each type of tile in the game.

3. User clicks on a placed tile (e.g., office, factory, park, or forest).
4. Game system randomly selects a fun fact to display.
{Display Tooltip}
5. Game system displays a tooltip, unique to that tile, containing the following:
 - Data for current yearly stats:
 - Pollution uptake/output
 - Income
 - Generated happiness
 - Electricity usage/generation
 - A repair button that resets the tile's values to what they were when they were first placed.
 - A random fun fact about that tile.
6. User reviews the information displayed in the tile.
7. User clicks the repair button.
{Repair Payment}
8. The game system subtracts the cost of repairing from the user's funds.
9. The game system resets the tile's values to their original state, improving its sustainability (repaired tiles have reduced pollution output, increased income, etc.).
{Display Updated Tooltip}
10. The tooltip updates to show the tile's current stats.
{Close Tooltip}
11. User clicks anywhere outside the tooltip to close it.

Alternative Flows

- **Alternative Flow A: No Tooltip is Shown if User Does Not Click on a Valid Tile**
 - At **{Display Tooltip}**, if the user clicked on a non-interactive space (not a tile):
 - * Game system does not show the tooltip.
- **Alternative Flow B: Tile is Already at Original Values and Cannot Be Repaired**
 - At **{Repair Payment}**, if the tile has just been built/repaired:
 - * Do not accept payment from the user or change tile values.
 - * Resume basic flow at **{Display Updated Tooltip}**.
- **Alternative Flow C: User Lacks Sufficient Funds to Repair Tile**
 - At **{Repair Payment}**, if the user lacks the funds to repair the tile:
 - * Do not accept payment from the user or change tile values.
 - * Resume basic flow at **{Display Updated Tooltip}**.

- **Alternative Flow D: User Reviews Data and Fun Fact but Does Not Repair Tile Before Closing**

- Between {Display Tooltip} and {Display Updated Tooltip}, if the user does not click the repair button:
 - * Resume basic flow at {Display Updated Tooltip}.

Extension Points

- **{Display Tooltip}**: The point at which the game system gathers the tile's data and displays it.
- **{Repair Payment}**: The point at which the user clicks the repair button and the game system either repairs the tile or not.
- **{Display Updated Tooltip}**: The point at which the game system updates the stats on the tooltip to display the most up-to-date numbers.

Preconditions

- The game system has access to each tile's yearly pollution, income, happiness, and electricity (generated and required).
- The game system has the repair functionality that will reset the tile's statistics to their original values.
- The user has tiles placed on the map and can click on them.
- The game system has access to several fun facts for each type of tile.

Postconditions

- The user can see the yearly pollution, income, happiness, and electricity (generated and required) for any tile on their city's map.
- The user can improve the sustainability of a tile by clicking the repair button on the tooltip.
- The user can see a fun fact about the sustainability of each tile.
- The tooltip is hidden once the user clicks outside of it, or if the user navigates to another tile.

Tooltip (V3) Tests

Basic Flow Tests

- **Clicking a Tile to Display Tooltip**

- **Precondition:** The map has at least one tile placed on it.
- **Action:** User clicks on a tile.
- **Expected Result:**

- * A tooltip appears near the clicked tile.
- * The tooltip displays:

- Data for current yearly stats.
- Pollution uptake/output.
- Income.
- Generated happiness.
- Electricity usage/generation.
- A repair button.
- A random fun fact about the selected tile.

- **Repairing a Tile**

- **Precondition:** A tooltip is displayed for a tile whose sustainability has decreased since its construction, and the user has sufficient funds.
- **Action:** User clicks the repair button on the tooltip.
- **Expected Result:**
 - * The game system removes the cost of the repair from the user's balance.
 - * The tile's stats (pollution, income, happiness, electricity) reset to their original values.
 - * The tooltip updates immediately to reflect the repaired stats.

- **Closing the Tooltip**

- **Precondition:** A tooltip is visible for the selected tile.
- **Action:** User clicks anywhere outside of the tooltip.
- **Expected Result:**
 - * Tooltip is now hidden.
 - * If the user clicks another tile, a new tooltip appears for the newly selected tile.

Alternative Flow Tests

- **Clicking a Non-Interactive Area**

- **Precondition:** The game has been loaded.
- **Action:** User clicks outside any placed tiles.
- **Expected Result:**
 - * No tooltip appears.
 - * If a tooltip was previously visible, it disappears.

- **Tile Cannot Be Repaired**

- **Precondition:** A tooltip is displayed for a tile that is already at the original values.
- **Action:** User clicks the repair button.
- **Expected Result:**
 - * No changes are made to the tile's stats.

- * No funds are deducted from the user's balance.
- * A message is displayed (e.g. "This tile does not need repairs").
- * The tooltip remains visible.

- **Insufficient Funds for Repair**

- **Precondition:** A tooltip is displayed for a tile that is not at original capacity, and the user does not have enough money to repair it.
- **Action:** User clicks the repair button.
- **Expected Result:**
 - * No changes are made to the tile's stats.
 - * No funds are deducted from the user's balance.
 - * A message is displayed (e.g. "Insufficient funds to repair this tile").
 - * The tooltip remains visible.

- **Reviewing Data without Repairing**

- **Precondition:** A tooltip is displayed for a selected tile.
- **Action:** User does not click the repair button before closing the tooltip.
- **Expected Result:**
 - * The tooltip disappears without any changes to the tile's stats.
 - * The user's money does not change.

Relationships

- This use case requires pollution to be tracked and therefore includes the use case [Interact with grid layout and track scores](#).
- The use case depends on the [Dynamic in-game time](#) use case as the tooltip must update its values.
- The use case is associated with the [Wide range of assets](#) and [Real-world data](#) use cases, as each tooltip will display the stats for each different tile.
- This use case was associated with the [Repair air filter](#) use case as both had repair functionality.
- This use case was also associated with the [Data sources menu](#) use case as they both provide the user with sustainability-related information.

5.6.4.10 Use Case: Repair Air Filter

This use case was used to fulfil user story [U4-3-2](#). There is only one version of this use case.

Goal

To allow the user to repair the air filter, reducing external pollution entering the city.

Actors

- **Primary actor:** User
- **Secondary actor:** Game system

Basic Flow

1. User has had the game running for at least one in-game year.
2. User clicks on a repair air filter button.
 {Repair Air Filter}
3. Game system deducts funds from user's money.
4. Game system repairs air filter, reducing the amount of external pollution entering the city.

Alternative Flows

- **Alternative Flow A: Insufficient funds**
 - At {Repair Air Filter}, if the user cannot afford to repair the air filter:
 - * Game system does not deduct funds or update the air filter.
- **Alternative Flow B: Air filter is already at maximum capacity**
 - At {Repair Air Filter}, if the air filter is already at maximum capacity:
 - * Game system does not deduct funds or update the air filter.

Extension Points

- {Repair Air Filter}: The point at which the game system deducts the funds from the user and repairs the air filter. This involves reducing the amount of external pollution that is being added to the city.

Preconditions

- The game system can track and change how much external pollution is entering the city.
- The game system has access to the user's in-game money.

Postconditions

- The air filter has been repaired, meaning the contribution of external pollution to the city's total pollution is now smaller.
- The air filter is not repairable until another year has passed.

Use Case Tests: Repair Air Filter

Basic Flow Tests

- **Test: Repair Air Filter Functionality**

- **Precondition:** The game has been running for at least one in-game year. The game tracks and updates the user's in-game money and external pollution levels.
- **Action:** The user clicks the “Repair Air Filter” button.
- **Expected Result:**
 - * The game deducts the repair cost from the user's funds.
 - * External pollution entering the city is reduced.

Alternative Flow Tests

- **Test: Insufficient Funds**
 - **Precondition:** The game has been running for at least one in-game year. The user's in-game money is insufficient to cover the repair cost.
 - **Action:** The user clicks the “Repair Air Filter” button.
 - **Expected Result:**
 - * No funds are deducted.
 - * The air filter is not repaired.
 - * A message is displayed indicating insufficient funds.
- **Test: Air Filter at Maximum Capacity**
 - **Precondition:** The game has been running for at least one in-game year. The air filter is already at maximum capacity (no further repairs needed).
 - **Action:** The user clicks the “Repair Air Filter” button.
 - **Expected Result:**
 - * No funds are deducted.
 - * The air filter is not repaired.
 - * A message is displayed indicating the air filter is already at maximum capacity.

Relationships

- This use case is associated with the [Tooltip \(V2\) repair button](#) use case as it also has a repair button.
- For the air filter to degrade, this use case requires the [passage of in-game time](#).
- It is also associated with the [Buildings degrade over time](#) use case. However, in this case, it is the air filter that is degrading.

5.6.4.11 Use Case: Add a "Current Stats" option in pause menu

This use case was used to fulfil user story [U5-2-1](#).

Goal

Add a menu option within the in-game pause menu that allows players to select "current stats", providing them with graphs showing annual changes in money, pollution, electricity, and other relevant metrics. By presenting this information through charts, players are encouraged to consider adjusting their strategies and to understand the consequences of their current approach.

Actors

- **Primary actor:** User
- **Secondary actor:** Game System

Basic Flow

1. The user presses the pause button during gameplay.
 {**Pause Game**}
2. The user selects and enters the "Extras" menu.
3. The user selects and enters the "Current Stats" page.
4. The game system displays a line chart that shows the yearly changes in various metrics from the start of the game to the current year.
5. The user clicks the "Back" button to return to the pause menu.
6. The user then selects the "Resume Game" button in the pause menu.
 {**Resume Game**}
7. The game system resumes the gameplay.

Alternative flows

- If the user resumes the game by pressing the "ESC" key.
- At the moment the game is paused, if the user presses "ESC," the game returns to active play.

Extension points

- Pause Game: The point at which the Game system pauses the game and displays the pause menu.
- Resume Game: The point at which the pause menu is closed and the game is resumed.

Preconditions

- The user must have played the game for at least two in-game years, in order for there to be sufficient data to plot the charts.
- If the user's position is occupied by any building, the chart will not be displayed.

Postconditions

- After viewing the current stats, the user can return and continue playing the game.

Use Case Tests: Add a "current stats" option in pause menu

Basic Flow Tests

- **Test: The game can enter the current stats screen**

- **Precondition:** The game has been on the main screen.
- **Action:** The user presses the “ESC” button into the pause menu and clicks “extra” and “current stats” into the current stats screen.
- **Expected Result:**

* The game creates one current stats line chart.

Alternative Flow Tests

- **Test: Press the “ESC” to go back to main screen**

- **Precondition:** The game has been on the pause screen.
- **Action:** The user presses “ESC”
- **Expected Result:**

* The screen go back to main screen.

Relationships

- Extends the functionality for adding submenus in the pause menu, which was done in the [Data sources menu](#) use case.
- This use case depends on the [passage of time](#) for the user's stats to be tracked over time.
- The use case is associated with the [Display current stats](#) and [Show current stats in pause menu](#) use cases as both are used to show the user live data about their city.

5.6.4.12 Use Case: Add Start Screens to introduce and explain the game

This use case was used to fulfil user story [U5-3-1](#)

Goal

Add three introductory start screens: These will introduce the game's background and objectives, explain how to play the game and achieve high scores, and the important details to pay attention to in the game.

Actors

- **Primary actor:** User
- **Secondary actor:** Game System

Basic Flow

1. The user launches the game and enters the Main Menu.
2. The user selects Start Game and enters Start Screen 1 (including the game background and objectives).
3. The user clicks the Continue button to proceed to Start Screen 2 (explaining how to play the game).
4. The user clicks the Continue button to proceed to Start Screen 3 (detailing goals and important in-game values).
5. The user clicks the Let's Play button to start the game.

Alternative flows

- If the player closes the game screen at any of the start screens, the game ends.

Extension points

- The Option and Exit Game buttons in the Main Menu.

Preconditions

- The game must be able to launch and display the Main Menu properly.

Postconditions

- The game's main interface must function correctly.

Use Case Tests: Add a Start Screen to introduce and explain the game

Basic Flow Tests

- **Test: The continue and let's play button functionality**
 - **Precondition:** The game has been in the start screen.
 - **Action:** The user clicks the “Continue” button and the “Let’s Play” button.
 - **Expected Result:**
 - * The game enters the successfully main screen.

Alternative Flow Tests

- **Test: Close the Window**
 - **Precondition:** The game has been on the start screen.
 - **Action:** The user closes the window.
 - **Expected Result:**
 - * The game window is closed

Relationships

- Extends to the [Help section use case](#) as the information from these screens is used for the help section.

5.6.4.13 Use Case: Help Section in Pause Menu

This use case was used to partially complete user story [U2-1-2](#).

Goal

Provide the user with assistance through a help section in the pause menu.

Actors

- **Primary actor:** User
- **Secondary actor:** Game system

Basic Flow

1. User has the game running.
2. User pauses the game and selects the help section.
3. Game system displays guidance and assistance to the user.

Alternative Flows

There are no alternative flows for this use case.

Preconditions

- There is a help section in the pause menu with information about the game's backstory, how to play the game, and how to win/lose.

Postconditions

- The user can access this information and find answers to their questions.

Use Case Tests: Help Section in Pause Menu

Basic Flow Tests

- **Test: User can access the help section**
 - **Precondition:** There is a help section in the pause menu.
 - **Action:** The user clicks the "Help" button.
 - **Expected Result:**
 - * The game displays useful information about the city that addresses the user's questions.

Relationships

- Includes the [Start screen](#) use case as the information for the help screen was obtained from the start screens.
- This use case is associated with the live message feed [Live message feed](#) use case as they both relate to guidance from the Oracle.

** This use case **PASSED** **

5.6.4.14 Use Case: Place a Wide Range of Metric-Influencing Buildings V2

This use case fulfilled user story [U4-4-1](#). The [1st version](#) of this use case failed as there was not a range of buildings to choose from, and a pop-up did not show upon a user attempting to place a building with insufficient funds, hence the use case V2.

Goal:

To allow users to strategically influence city metrics (e.g., environment, economy, happiness, electricity) by selecting and placing a variety of buildings with unique effects.

Actors

- **Primary actor:** User
- **Secondary actor:** Game System

Basic Flow

1. The user opens the building menu.
2. The system displays a variety of buildings grouped by their cost:
 - **Power-generating:** Wind Farm, Coal Power Plant, Nuclear Power Plant
 - **Revenue-generating:** Office, Wheat Farm, Dairy Farm
 - **Happiness-generating:** Stadium, Park, Leisure Center
 - **Carbon-consuming:** Forest, Rubber Forest, Orange Forest, Palm Forest, Cocoa Forest
3. The user selects a building and reviews its cost and impact.
4. The user places the selected building on a valid grid cell.
5. The system dynamically updates the city metrics (for example, environment, money, happiness, electricity) based on the properties of the building.

Alternative Flows

- **Step 3 – Insufficient Funds:**
 - If the user attempts to place a building but lacks enough money, the system displays a message: "Not enough money to place this building."
 - The user can choose a different building or earn more money before proceeding.

Preconditions

- The building menu must display a variety of buildings grouped by their impact type.
- Each building must have a defined cost and metric effects.
- The grid must be interactive and allow placement at valid locations.

Postconditions

- The selected building is successfully placed on the grid.
- City metrics dynamically update to reflect the building's influence.
- The user gains knowledge about how different buildings affect metrics and learns to balance them for city improvement.

Use Case Test : Place and Interact with Metric-Influencing Buildings Tests

Basic Flow Tests

- **Open Building Menu**
 - **Precondition:** The building menu is visible.
 - **Action:** The user clicks the building menu.
 - **Expected Result:** The menu expands, displaying buildings grouped by their effects. Each building option is interactable.
- **Select a Building and Review Cost**
 - **Precondition:** The building menu is expanded, and buildings are displayed with details.
 - **Action:** The user selects a building and views its cost and effects.
 - **Expected Result:** The building is highlighted. Its cost and impact on metrics are displayed.
- **Place Building on Grid**
 - **Precondition:** The grid is initialized, and the user has sufficient funds.
 - **Action:** The user places the selected building on a valid grid cell.
 - **Expected Result:** The building appears on the grid. Metrics (e.g., money, environment, happiness, electricity) update dynamically.

The basic flow passed the test as there were a wide range of metric-influencing buildings to choose from

Alternative Flow Tests

- **Insufficient Funds**
 - **Precondition:** The user does not have enough money to place the selected building.
 - **Action:** The user attempts to place a building.

- **Expected Result:** A pop-up message appears: "Not enough money to place this building."

This alternative flow passed as there was now a message which popped up when the user attempted to place a building with insufficient funds.

- **Occupied Grid Cell**

- **Precondition:** The grid cell is already occupied by another building.
- **Action:** The user attempts to place a building in the same cell.
- **Expected Result:** The system prevents the placement.

This alternative flow passed as occupied grid cells prevented any buildings being placed on them.

Performance Test

- **Precondition:** The grid already contains several buildings, and the user is adding more.
- **Action:** The user selects and places additional buildings on the grid.
- **Expected Result:** The game remains responsive, and metrics update without delay.

Relationships

- This use case depends on the [Building menu](#) as the user must be able to access the wide range of tiles.
- Similarly, the user must be able to place the tile, meaning it depends on the [Placing tiles](#) use case.
- The use case includes [Real-world data](#), as the new tile's are based on the real-world data.
- It is associated with [Display current stats \(V2\)](#), as each new tile will affect the city's metrics differently, and [Real-world data](#), as the new tiles must be based off real-world data.

** This use case **PASSED** **

5.6.5 Screenshots



Figure 6: Screenshot of the product after sprint 5

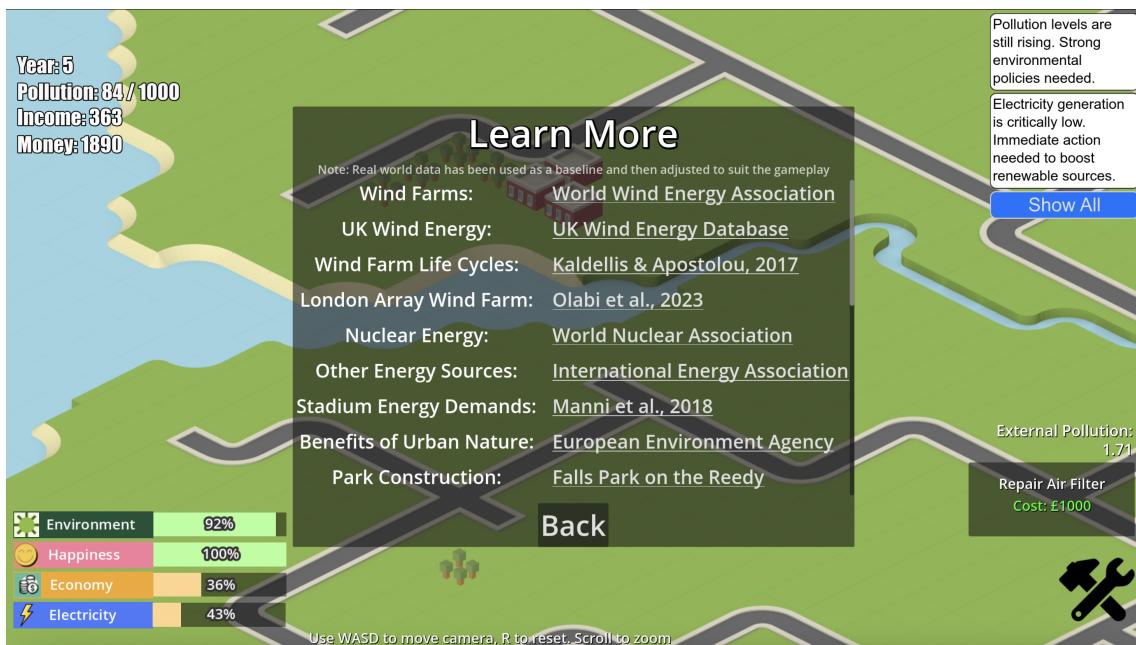


Figure 7: Screenshot of the final data sources menu

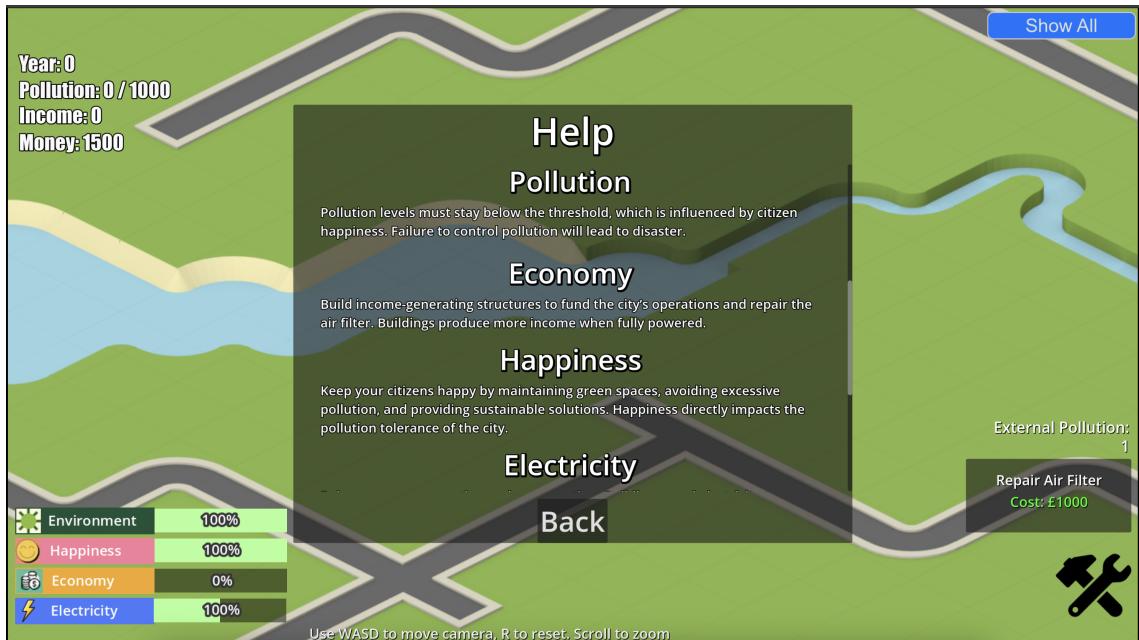


Figure 8: Screenshot of the help section

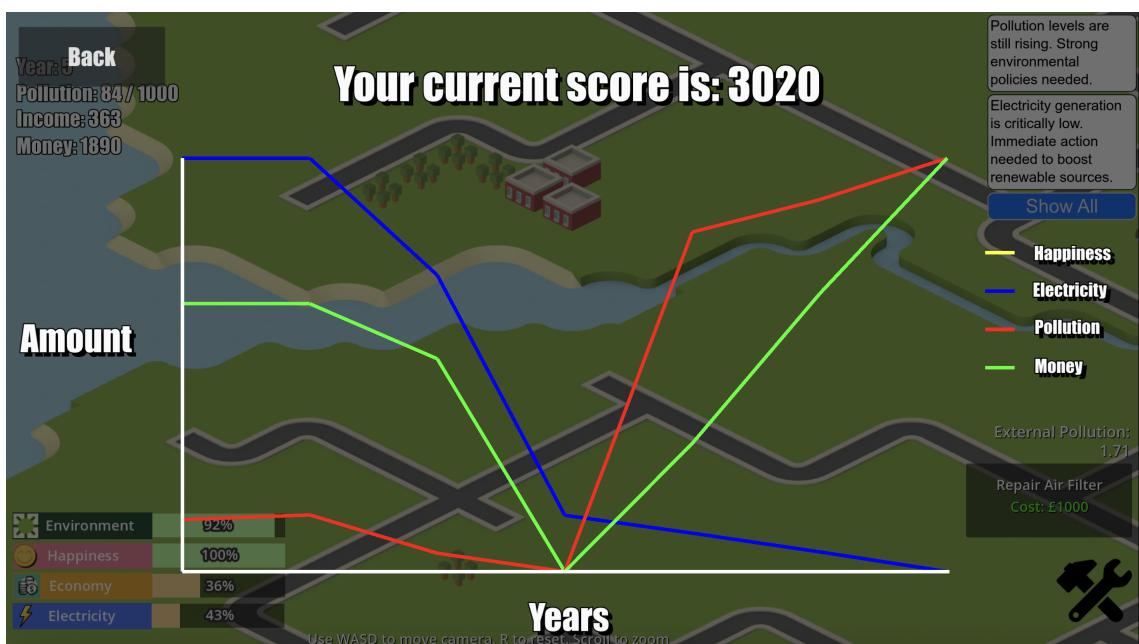


Figure 9: Screenshot of the final current stats screen

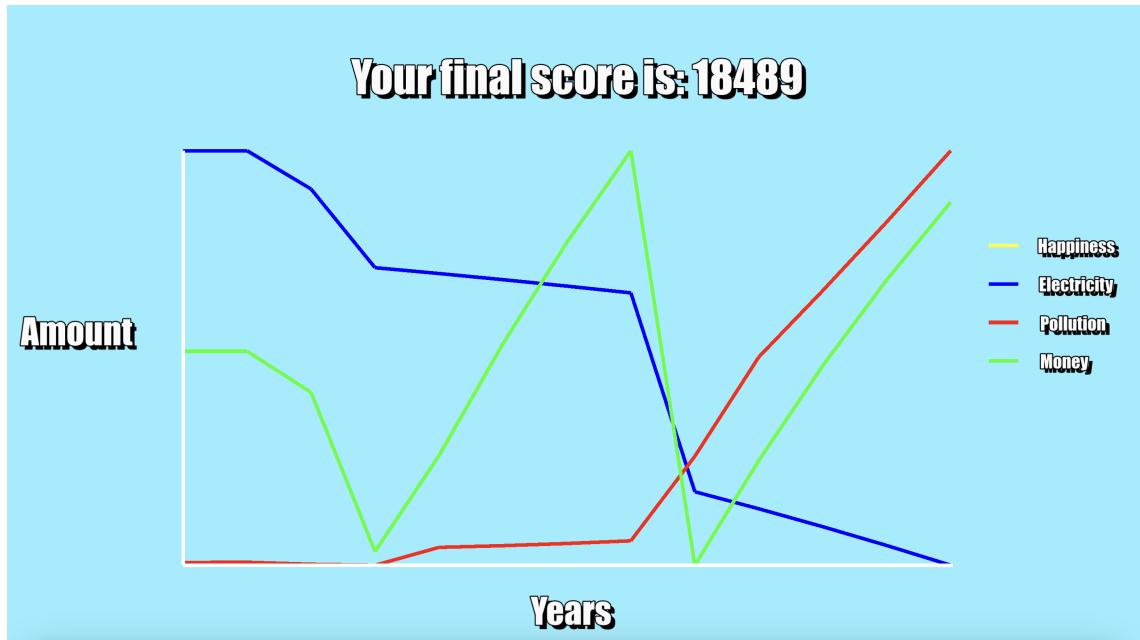


Figure 10: Screenshot of the final end screen

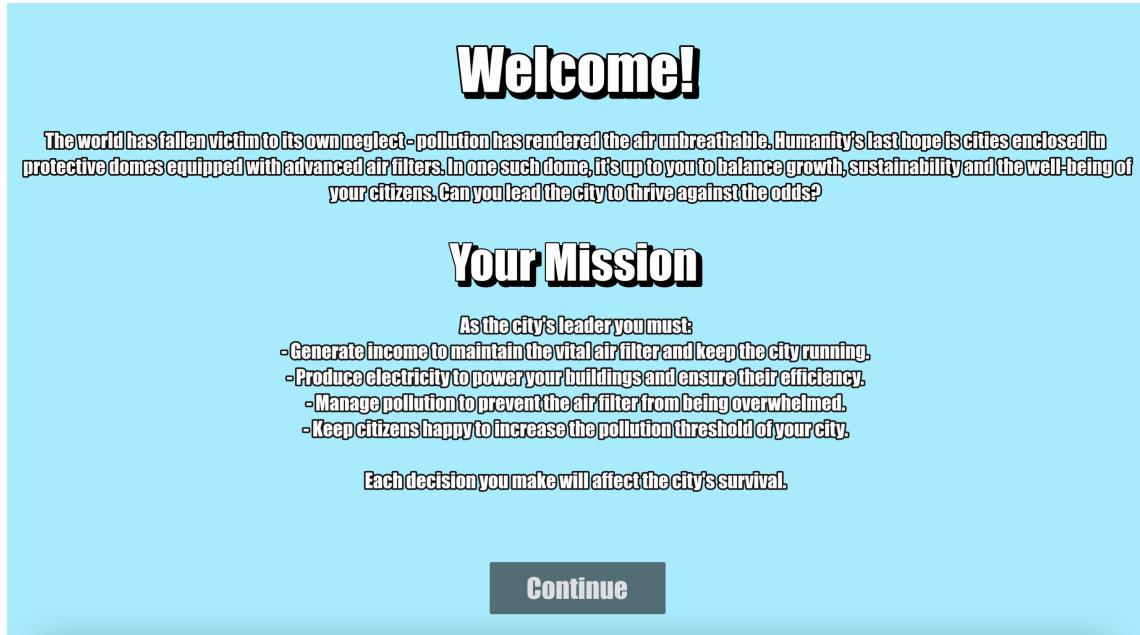


Figure 11: Screenshot of the first start screen

How To Play

Economy

Build income-generating structures to fund the city's operations and repair the air filter. Buildings produce more income when fully powered.

Electricity

Balance power generation and consumption. Buildings need electricity to function, but some power sources create pollution. Be strategic!

Pollution

Pollution levels must stay below the threshold, which is influenced by citizen happiness. Failure to control pollution will lead to disaster.

Happiness

Keep your citizens happy by maintaining green spaces, avoiding excessive pollution, and providing sustainable solutions. Happiness directly impacts the pollution tolerance of the city.

Continue

Figure 12: Screenshot of the second start screen

Your Goal

Survive as long as possible and score big by balancing sustainability and growth. Can you create a thriving, sustainable city in a dying world? Good luck!

Game Over Conditions

Pollution Crisis

Pollution exceeds the threshold for 3 years.

Bankruptcy

No money to repair the air filter.

Unhappy Citizens

Low happiness reduces the pollution threshold, making survival difficult.

Let's Play!

Figure 13: Screenshot of the third start screen

6 Future direction

As a group we had some ideas for the future development of our game that we were unable to complete in this project. These were the result of group discussion, brainstorming, customer feedback and what has been left in the product backlog. Below are some of the ideas that we came up with:

Mini-games

The mini-games would aim to teach players a variety of sustainability practises that they could use in their daily lives (it was left in the backlog since they were not a priority – see user story [U4-5-1](#)). As an incentive to complete these, players would be rewarded with money that they could use to improve their city. The higher the score they achieve in the mini-game, the higher the money reward. Another incentive discussed was temporary boosts to the efficiency of buildings (e.g. power production increases drastically). Some of the mini-game ideas were:

- **Recycling Tetris:** Similar to the game *Tetris*, but different types of rubbish will fall down from the top of the screen. Players will use the arrow keys to move the rubbish such that it falls into the correct recycling bin.
- **Ocean Clean-Up:** Players control a boat driving around the ocean picking up rubbish to increase their score. If the player drives into a shark or a rock they lose a life, with a total of 3 lives.
- **Whack-A-Mole:** The screen shows bad sustainable practises on a grid such as lights left on in a house or a water leak in a pipe, and the player has to keep clicking to turn the lights off or patch the leak.
- **Memory Matching Game:** Players will be presented with a grid of tiles. The tiles temporarily turn over showing a photo of an eco-friendly item, such as a solar panel, and then turn back so the player can't see the item. Players then have to match pairs of eco-friendly items, remembering their position.
- **Crossy Fish:** Players use arrow keys to control a fish navigating through the ocean by dodging the nets from trawlers, and plastic bags floating in the sea.
- **Park clean-up:** Players are presented with a park which is covered in litter. They have a time limit to drag and drop as much rubbish as possible into the correct bin (plastic, cardboard, general waste etc.)
- **Map clean-up:** Random pieces of trash appear on the map which the user needs to click several times to remove, this could have some animation that removes small bits on each click

We also discussed pairing minigames with specific buildings (e.g. **Park clean-up** and an actual Park building) that you could click to play the mini game at certain points during your game experience (random timer).

Levels

Players would be able to work their way through levels, having to achieve a certain score to progress to the next level. Each level would have a different setting, for example on Mars, in the jungle, in the desert, and would have increasing levels of difficulty. The difficulty could be increased by increasing the multiplier for external pollution and the multipliers for the building's

values. Additionally, more costly buildings could be brought in which allow you to survive for longer, but cost more to build.

Natural Disasters

As shown by user story [U2-10-1](#), which has been left in the backlog, another suggestion for future development is the inclusion of random events, such as earthquakes and tsunamis, which are triggered by the player managing the environmental health poorly. If one of these occurs, the economic health and happiness of the city would drastically decrease making it more difficult for the player to survive. This would encourage the player to balance all health bars, ensuring they do not dip too low.

Direct Oracle Guidance & Tutorial

In [customer meeting 2](#) of the sprint 1, the customer suggested not having a tutorial in the game by ensuring it was intuitive to play. This was so that the game was in-line with the scope of the project since a tutorial would take too long to implement. As a group, we thought that it would be beneficial for players if there was an Oracle guiding the player at the start by telling them what buildings to place first and why. This would allow them to get to grips with the game without too much trial and error. This feature is represented by user stories [U2-5-1](#) and [U2-7-1](#) which have been left in the product backlog.

Leaderboard

As well as showing the player a personal scoreboard, to encourage them to continue playing we thought it would be a good idea to include an online leaderboard where they could view their friends' high scores, with images of the cities they have built, and try to beat them.

Saving and Loading the game

Saving and loading the game was discussed, as shown in user story [U2-6-1](#). It would be challenging to implement since we would need to capture all of the game state, including time, variables (graph of rate over time included) and efficiencies of all current buildings in one save file (when they were built and when they were repaired). This was not in the scope of this project, therefore has been left in the backlog.

Automatic regenerating trees

We discussed having automatically regenerating trees (see user story [U2-8-1](#)) that would spread to nearby tiles as they grow over time. This was a very cool idea and perhaps would be an interesting game concept just on its own. There was a brainstorm regarding having biodiversity scores that would also affect happiness, depending on tile placement. Certain tile configurations would have differing effects on the city (such as forest next to park e.t.c.). For similar reasons as above, this was ultimately left in the product backlog.

Population growth

Having population as another in-game variable was also discussed. This could've been managed by building appropriate housing complexes and monitoring the capacity as they grew over time. It could have also had positive influences on income, as an example. Ultimately, this would

have made the game into a full city builder and thus was considered by the group to be outside of the project scope. The idea remains in the product backlog as user story [U2-9-1](#).

Transport requirements

The player would have greater customisation with their map and would be able to place road tiles. Each building would be required to be connected via a road before it was built. Based upon the number of roads and buildings attached, a congestion metric could be calculated, and the player educated on the carbon impact of transportation.

Building Upgrades

The player would be able to improve their buildings from a variety of relevant sustainable upgrades. For example, they could add double glazing to office tiles, adding loft insulation to a house or make the farms organic. This could educate the player on the impact that small changes can make to the environment.

Natural Resources

The map would load with a variety of natural resources on the map, that the player could extract. These resources would then be used in the construction of various buildings. For example, they could extract sand and gravel from the ground to make concrete, which could be used to build an office. Alternatively they could build their office from harvesting trees. However, whilst it could have a lower impact on the environment, it may degrade faster. If a player does not have a resource required, they could possibly import it at great expense both financially and environmentally. The carbon impact of each of these materials would be shown to further educate the player.

Government Policies

The player now has the option every 5/10 years to enact a new policy. These would be policies that target different potential issue within the city, so the player would have to be strategic depending on what tiles they have built. One example could be increased public transport that helps to lower a potential congestion score and reduces the pollution from transport. Another could be a city wide recycling scheme, that lowers the pollution created by offices and stadiums. Or the government could offer a form of subsidy that lowers the cost of renewable energy tiles such as wind farms.