Timmy’s Turbines

Game Design Report

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Introduction

Massive Open Online Courses have been touted as a revolutionary way to teach. They have become increasingly used by different universities around the world to teach off campus students. This is also the case at the TU Delft where MOOCs have been given on several topics. One of the most popular one is called introduction to aeronautical engineering. The TU Delft now has a dozen of these online courses that can be followed online from anywhere around the world. The university is also developing new courses, one of which is focused on an introduction to the concept of wind energy.

There is however a problem with MOOC: their retainment rates. Some MOOC can lose almost 90% of their audience by the second week of lectures. This can be blamed on different factors but the most recurrent one is the dullness of watching videos. Different ways have been explored to try to increase this retainment rate. One way is being explored at the TU Delft is serious gaming. Serious games are meant to make the courses more attractive and even addictive such that the retainment rate is increased while teaching the participants the same course material.

This report presents the design of a game, Timmy’s Turbines, that is meant to teach the wind energy MOOC for the TU Delft. The report is split in three main parts. In the first part the game purpose is presented, the second part the game goals are presented and the third part presents the omission and what could be the final game, beyond this course.

Game purpose and intent

This first chapter addresses the purpose and intent of the game in all their aspects. It then explains how these where achieved and through which specific methods.

Target audience

The main purpose of the game as discussed within the introduction is to teach players about wind energy. For this, it is important to know what the intended target audience is so as to tailor the game to this audience. The target audience of this game are people which are educated with an age ranging from late teens to retirement. This target audience is assumed to only have about thirty minutes of time per day to play the game. Furthermore, it can be assumed that the play time will occur at the end of the day where the mind is tired and not particularly concentrated.

Learning goals

Wind energy is a vast topic. Specific areas should therefore be selected for the purpose of the game. This in the interest of obtaining a finished and polished game within the provided time. Considering the target audience mentioned above, the material to be selected should be limited to the basics of wind energy. There is still a considerable amount of material related to the basics. Therefore, the following concepts were selected for the game to be developed over the period of the course:

- The relation between heights and wind turbine energy output.
- The relation between power loss and wind turbine energy output.
- The maintenance concept.
- The relation between blade length and wind turbine energy output.
- The relation between drivetrain, energy output and maintenance.
- The grid integration concept.
- The economics of wind turbines (note that this concept is not addressed in particular but is present throughout the other concepts as a background mechanic).

The first concept mentioned relates to heights. There is a physical relation that links both these elements. In general, and in a simplified manner, it can be assumed that the higher wind turbines are placed, the more output power they will produce. However, and this is where the economics of wind turbines interject, the higher the wind turbine are constructed, the higher the construction costs for this specific wind turbine will be.

The second relation touches upon the loss of power over distances. The electricity that is generated by a wind turbine has to get to its destination through wiring. However, over the distance it travels, electricity is lost. This is what is referred to when mentioning power loss. Wind turbines can be installed in very remote areas, and the electricity still has to be brought back to the city where it is consumed. There are ways to decrease these power losses through the use of different technologies that are only viable over long distance. This is an introduction of the grid integration concept.

Maintenance is another important learning goal for this MOOC. Wind turbines, like almost any mechanical object, require regular maintenance. This maintenance has a cost. Furthermore, the time between maintenance depends on different factors, one being the type of wind turbine that is being installed.

So far only concepts related to wind turbines have been mentioned. The wind turbine itself is also an important concept. There are dozens of different types of wind turbines that exist in the real world. To account for this, the concepts of wind turbine blade length and drivetrain are introduced. The blade lengths have an impact of the power output, the larger they are, the larger the power output is. They also have an impact on the costs, increasing as the blade length increases. The drivetrain has more impact. It affects the maintenance time, the costs and the power output. In the context of this game only two types of drivetrains are considered: the direct power train which has a higher cost, higher output and higher time between maintenance, and the indirect drivetrain which has a lower power, a lower cost and a lower time between maintenance. Furthermore, only three blade length are considered within the game: small, medium and large blades.

The last main aspect that is considered for this game relates to grid integration. In the real world, wind turbines tend to be remotely located, furthermore, they are not directly connected to the grid or to the consumer. This is done through different types of transformers. The distance between these transformers and the wind turbines is crucial. Adding to his, because the connection between the wind turbines and the transformers, and the connection between transformers are usually different. The voltages used on the cable to transport the electricity are very different. This leads to different power losses depending on what part of the electrical network is considered. The grid integration aspect of the game is therefore very connected to the power loss mechanic.

Implementation strategy

To implement all the mechanisms mentioned above and to make sure that the player will learn and understand what each mechanic is doing, two different methods are used. The main aspect of the learning experience is done through the visualization. The other method relates to experimentation with the construction and positioning of the wind turbines in a map.

The implementation of the heights within the game is done through the visualization of the terrain. The terrain onto which wind turbines can be placed has different shadings to represent different heights of the environment as shown below. The darker greens represent higher heights while brighter green represent the lower elevations. Additionally to this visualization technique, the player is provided with the elevation and the associated cost information mentioned earlier within the UI panel.

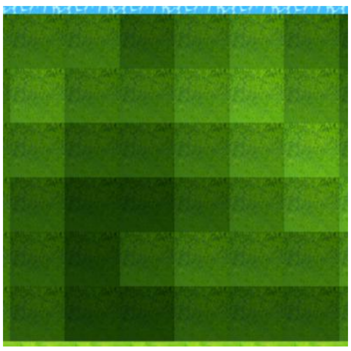

Figure 1 - Terrain tiles.

The power output is visualized above all objects represented within the game. It is shown in yellow, which is the color chosen for all power outputs. An example is shown below for two objects of the game. Note that the power output is only visible for one object at a time to avoid clutter of the UI.

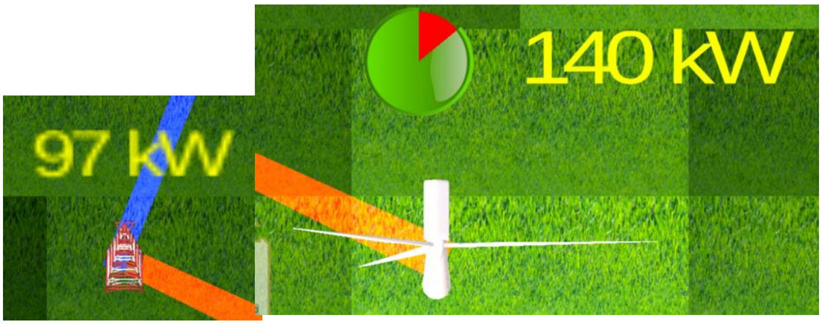

Figure 2 - Visualization of the power above a wind turbine and a transformer.

The implementation of power losses is also implemented through several visualization techniques. The first and most obvious visualization for the player is provided through the links connecting the wind turbines to the other elements of the game (in this case the transformers and the pumps). There are two visualizations that are visible through the links. The first one relates to the type of power loss. This is shown through the color. The orange illustrates a high power loss while the blue illustrates a very low power loss. The second aspect that can be observed through the links is the width of the links. This illustrates the power loss depending on the distance between two ends of a link. For example, when a wind turbine is located close to a transformer, the link will remain thick without tapering. However, when a wind turbine is placed further away, the link will taper representing the loss of power as the distance increases. These two types of visualization can help the player understand the power losses qualitatively.

The power loss can also be observed quantitatively. This is done upon the creation of a turbine. When a turbine is created, it is automatically connected to a transformer. The power losses occurring due to the specific wind turbine are shown below the normal output power of the wind turbine with a minus sign and in red. Upon creation, the actual power received by the transformer will also be displayed in green above the transformer for a few seconds. Once the quantitative visualization disappears, the player can find the power loss per turbine within the turbine information panel.

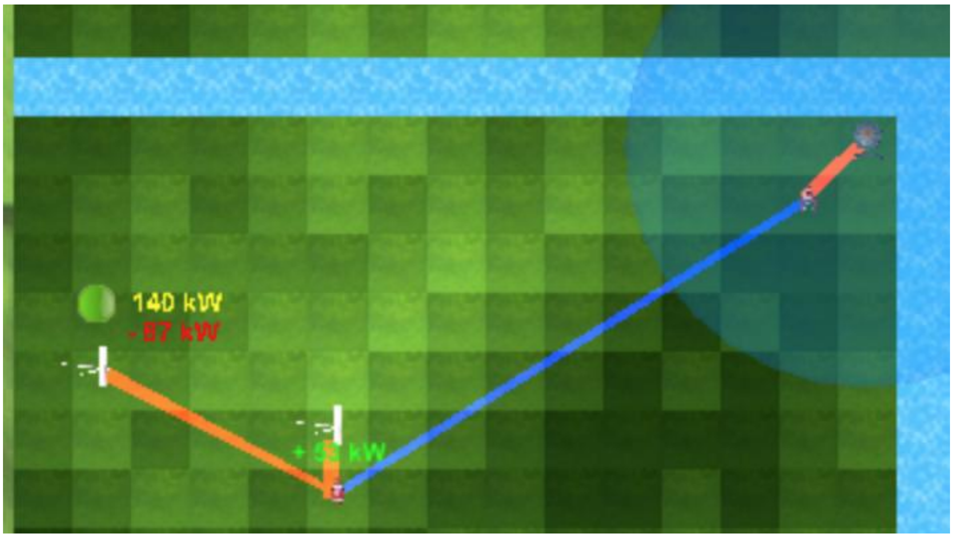

Figure 3 - Power loss visualization.

The implementation of the maintenance is also done through a visualization. This is done in the form of a small green pie. This illustrates the maintenance needs of the wind turbine. As time passes by, the maintenance needs of the wind turbine grows and the pie becomes red. This entire visualization is only visible by the player upon the creation of the wind turbine or when clicking on the wind turbine. It also appears on the screen when the player can (and should) repair the wind turbine as it nears the maximum maintenance need (full red pie). If the player does not repair the wind turbine, the pie becomes orange signifying the slow mechanical decay of the wind turbine. Additionally, once the pie is orange the wind turbine stops producing any power. This is further reinforced by a sound effect of power plant shutting down to alert the player of the situation. The same situation occurs with the orange pie. As the orange pie grows, the player can still repair the wind turbine. However, once the pie has become fully orange, the pie will turn black, the wind turbine dies and also turns black. At this point, the player can only renew or discard the wind turbine. To renew the player has to pay the full price of the wind turbine. Discarding is free of charge. These discard and renew introduces the player to the economics of wind turbines and what happens when a wind turbine has arrived at its end of life.

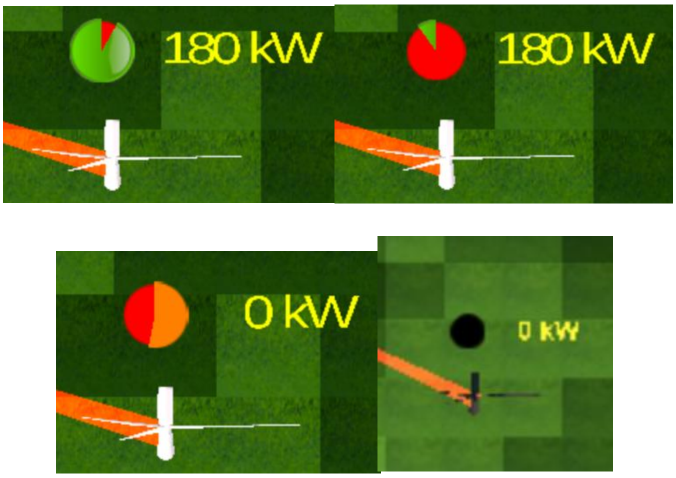

Figure 4 - Illustration of the visualization of the maintenance mechanic.

The last visualization that is implemented into the game relates to the construction of wind turbines. Within the game, it is possible to place two main types of wind turbines: a pre-designed wind turbine or custom wind turbines designed by the player. To illustrate the difference in wind turbine within the game setting, the custom wind turbines are painted in red. This can therefore help the player know which wind turbine is which when several are placed onto to the terrain

The visualization techniques are not the only way that the different mechanics are introduced within the game. The customization of the wind turbine which implements the blade length and the drivetrain are implemented through an interactive construction module. The player can design his own custom wind turbines. This is down in a UI panel on the right side of the game screen. The player can choose between three blade lengths and two drivetrain options. Each of these combinations lead to a wind turbine that will have a different cost, a different power output and a different time before maintenance. Upon creation, the new design is saved with the turbine pre-selection of the player so he can construct them easily at a later point in the game.

Game goal

Up to now, this report has only discussed the game purpose and the different methods that were used to attempt to achieve this purpose. However, the game has yet to be presented. This chapter introduces the game, its rules and its challenges

A tower defense game

The game designed is a tower defense game. During a tower defense game, small enemies progress along a pre-defined path. The aim is to get rid of these enemies before they reach the end of the path. Once all enemies have been cleared, the game is considered won. As this game is a wind energy game, an analogy is used. The path is a river onto which floods (the enemies) pass. The floods progress along the path toward a city. The aim is to pump the floods out of the river before they flood the city. For this, pumps are placed next to the river. These pumps are then powered by wind turbines which produce energy using the wind. The power that arrives to the pump is dependent on the positioning of the wind turbines and the transformers that are used to transfer the electricity. The pump's location is also crucial depending on the path the river takes. A better positioning will mean more pumping time for the pumps. A view of the entire game screen is shown below.

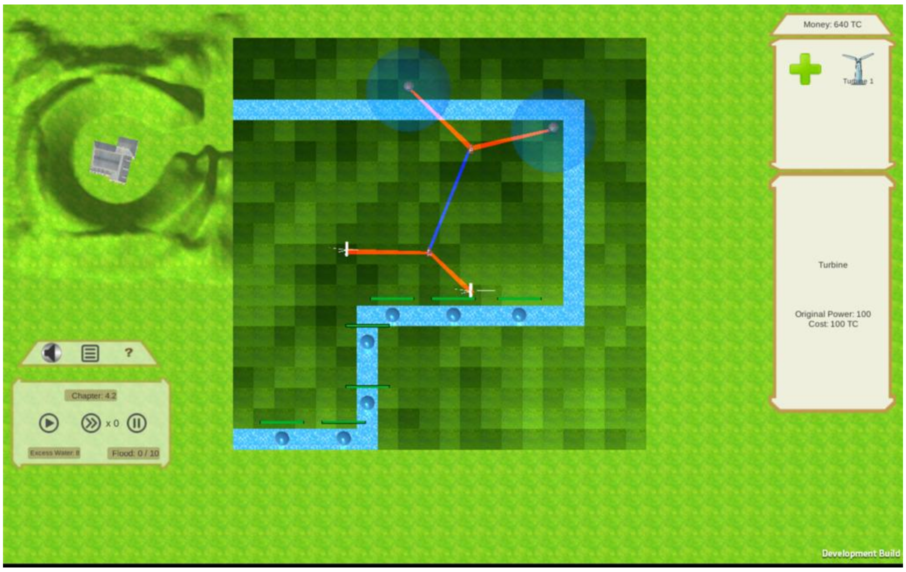

Figure 5 - Presentation of the main screen game.

There are some rules within this game which cannot be broken. The first rule is that the player cannot build wind turbines on the river or outside of the map. Furthermore, the player has a certain amount of money and cannot build wind turbines when he does not have enough money. The player can earn money by pumping out the floods. Each flood provides earnings of 10 TC to the player so he can pay for the maintenance of his turbines or the construction of new ones.

Feedback

The main feedback within the game is related to the visualization mentioned within the previous chapter. The player can see the effects of his actions on the system. No direct feedback is introduced in the game, the player has to find out the consequences of his choices. To give an indication of how well a player performed, the score is shown at the end of a map. Other feedbacks include the win or lose states and the interactive tutorial.

Challenges and dilemmas

The main challenge for the player is to manage to pump all the floods out of the river with limited monetary resources and while taking into account adverse factors such as power loss and maintenance. The player must be able to reason based on what he has learnt in previous levels. In each chapte (composed of two levels), the challenges for the player differ:

- For the first series of levels, the player must decide where to place his wind turbines considering that if his wind turbines are not placed appropriately, he will not be able to win the level as he will not have enough power to pump out the different floods.
- For the second series of levels, besides what the player has already learnt before, the player must place his wind turbine depending on the transformer location and on the power loss incurred by the distance to the transformer. Once again, a bad placement will not provide enough power for the player to win the level.
- For the third series of level, the player must be able to manage his money to maintain enough wind turbines to power his pumps. This is on top of the previously mentioned challenges.
- For the fourth level, the player must be able to design custom wind turbines to have enough power to win the level. The player will not be able to win the level with previously used pre-designed wind turbines.

Note that the difficulty of the game and the number of challenges increases through the game progression. The challenges from the first levels are however not big challenges as the player progresses within the game and gets an appropriate understanding of the different game mechanics.

The learning experience

Through the progression of the game, the player also learns about the different wind energy concepts. The first level series (level 1.1 and 1.2), for example, is designed with only the terrain heights included within the game. The levels are designed in such a way that the player must place all his wind turbines at a certain level to win the game. He must therefore understand the concept of heights and its impact on the maximum power output. A similar approach is used for the second level series (level 2.1 and 2.2) where the player is introduced to the power loss. In the third level (level 3.1 and 3.2), the player must get acquainted with the maintenance mechanic. To ease the understanding, the small pie representing the maintenance appear much earlier in game 3.1 when the mechanic is introduced so that the player can better discover it. Finally, a similar approach is used for the fourth level (level 4.1 and 4.2) where in level 4.1 the player can only build a custom wind turbine so he can discover the new mechanic before being able to apply it in the full game.

Note that in all these level series, the first level is always easier. It is made to introduce the player to the new concept and is also accompanied with a small tutorial. This is to help the player understand the new wind energy concept.

Game development

This chapter presents the different steps that were taken during the design of the game and the different mechanics that were not introduced within the game. It also discusses the potential requirements and development needs to get to the final game.

Process

The game was designed module by module. First, the tower defense aspect of the game was designed so as to make it possible to test the game's different mechanics upon development. Then the different mechanics that are mentioned throughout the report were introduced within the game. The height of the terrain was introduced first, followed by the power losses, the maintenance mechanic and the customization of the wind turbines.

The different visualizations were not all introduced at once. They were introduced following testing session and feedback sessions with the commissioners. They are the results of several iterations. The general game tutorial was introduced at the very end when the levels were completed to be tailored to each of the levels.

Discarded elements

Several mechanics did not make it into the final game due to time constraints. These are mechanics that relate to the grid integration that is mentioned at the beginning of the report. The aim of the game was originally to allow the player to place pumps and transformers are well as the wind turbines. He would also have been able to connect himself the different objects together. This would have helped the player discover the different power losses depending on the different connections he would make and allow for more flexibility within the game. This would have also approached more closely the general concept of tower defense where players have to place all the elements on the map themselves.

Other elements where not added to the game due to the scope. The game is potentially infinite in scope as it treats the very large subject of wind energy. The scope was therefore restrained from the beginning of the project to work on a manageable sized project. These elements are, for example, the addition of more than a dozen parameters for the customization of the wind turbine or the addition of a wind direction and a need for the player to control his wind turbines into the wind to provide the largest output possible.

Final game

Considering the potential scope of the game, it is hard to define exactly what the final game would look like and the time it would take to get there. As mentioned in the previous section the game could introduce the wind and additional customization. Another aspect of the game that could be included are the interaction of the wind with the terrain. With respect to the gameplay itself, it would be interesting to see in the final game different types of level where the waves of floods are not always the same size, with the same health and moving at the same speed. This would make the game more interactive with respect to the player, more challenging and therefore more addictive.

Other effects that are currently within the game could be modified. One of these is the panel that is used for the customization of the wind turbine. To include additional customization parameters, the panel would need a large redesign. Furthermore, it would be important to have a way to differentiate the different wind turbines created by the player beyond the single red color.

Conclusion

This report has presented the design approach that was used to design Timmy's turbine game. This game is aimed at teaching wind energy to an audience with a low amount of time. Initially, the different elements of interest from reality were selected based on the time available for the project. These are the impact of height on power output, the power losses stemming from electricity transportation, the maintenance of wind turbines, the grid integration of wind turbines and the customization of wind turbines. An explanation is then given on how these elements were tackled within the game through, in majority, the use of visualization elements but also through the tailored construction of wind turbines. The game for which these elements are used is a tower defense game where the aim is to power pumps using wind energy to pump flooding from a river. The approach used for the different level both from a point of view of game tuning and of learning objectives is presented. Finally, the different discarded elements are mentioned along with the elements that were not included to begin with. An overview of what a final game could look like is provided at the end of the report.