Net congestion explained

Designing a visual tool to explain the solutions
to prevent net congestion

17-07-2023

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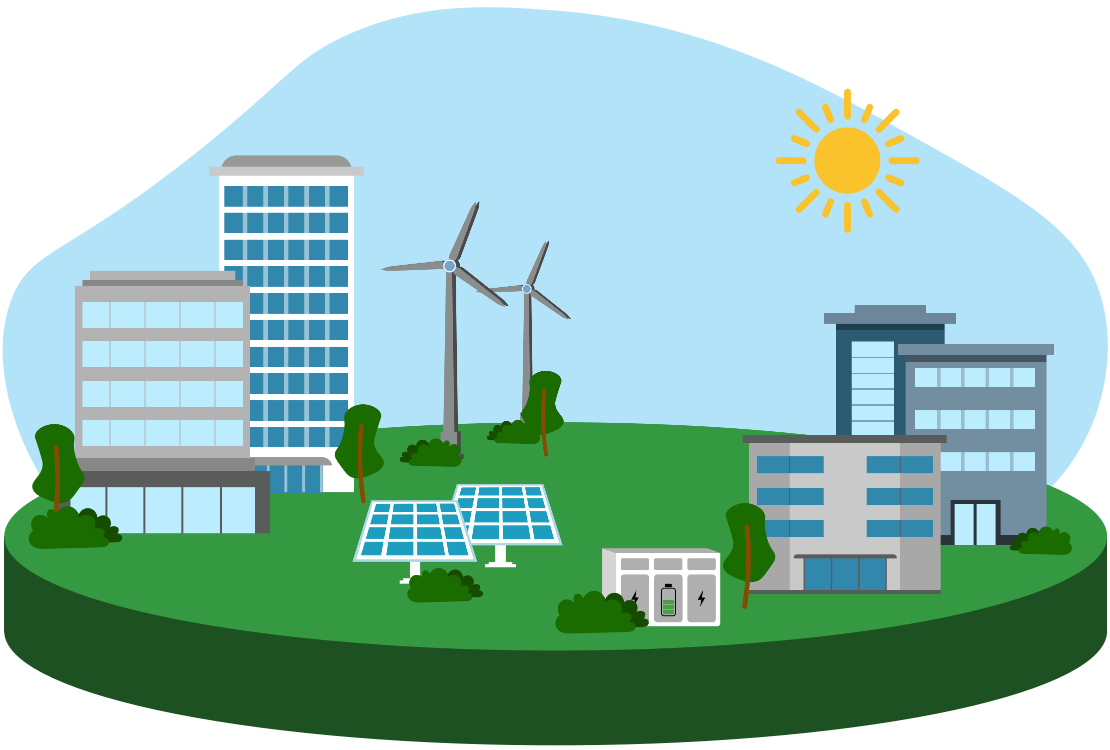

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Abstract

This research aims to investigate how to inform an audience about the use of energy hubs and smart grids in the energy transition on the Dutch energy grid to close the knowledge gap between Enodes and their clients through the use of a visual tool. It investigated the main functions of an energy hub: producing, storing and consuming electricity. Research showed that hierarchy, balance, simplifying, staying truthful and adding information are important when creating visuals. Furthermore, an audience can be defined by its characteristics. When communicating, these characteristics have to be kept in mind to create an engaging message.

To communicate the use of energy hubs in the energy transition, an interactive animation was created. The interactive video consists of three videos: an introduction video, a video targeted towards sustainability experts and a video targeted towards business owners. These are the two most important clients of Enodes. The introduction video explains the energy transition and the functions of energy hubs. The two other video provide specific information for the clients so that they have the important information about energy hubs.

The interactive animation was received positively by the client, Enodes, as well as the important stakeholders; a sustainability expert and a business owner on a business park. The video was perceived as a useful tool that is able to explain the need for energy hubs as well as the functions of an energy hub. It was recognised that the visuals were simple and fit with the animations. Furthermore, the voice-over was clear and understandable. The video is a promising prototype which will help to explain energy hubs in a quick and understandable way.

Acknowledgements

Doing research alone is never easy, but it can be made easier with a good support system. I want to thank my parents, brothers and boyfriend for listening to my stuggles about my life and project every weekend I came home. I want to thank all my housemates for doing the same, but during every dinner we had during the weeks. Many thanks to my friends who provided a safe space in which I could talk about my struggles and for providing support when I needed it the most.
I want to thank Sylvain van Ligtenberg for his enthusiasm and critical feedback every step during the project.
Lastly I want to thank Richard Bults and Erik Faber for their support and enthusiasm and their (very) critical feedback. While sometimes frustrating, they always pushed me to do better and improve whenever possible.

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Chapter 1: Introduction

The first chapter consists of the context analysis, the problem description, the research questions and the thesis outline.

1.1 Context Analysis

In the past ten years the amount of renewable energy produced by *renewable energy sources (RES)* in the Netherlands, such as solar panels and wind parks, has grown significantly [1] due to the rapid development of technologies in the field, grants from the government and the low costs of these energy sources [2]. This fits with the goal of the Dutch government of not being dependent on natural gas by 2050 [3]. With less use of natural gas, the demand for electricity is rising and will continue to rise in the future. On some places on the electricity grid the demand of the transport of electricity is already higher than the transport capacity of the energy grid, which can result in *net congestion* [4]. When this happens, energy producers cannot supply energy to the grid and consumers cannot take energy from the grid. When net congestion occurs, this might lead to power outages.

The Dutch energy grid was built to be robust and stable, with the energy production meeting the energy demands. It has a *central* energy production and from that point the energy is distributed [5]. With the rise of RES, there is a shift from centralised energy production to a *decentralised* energy production. In addition, the traditional consumers, such as households or businesses, have now become energy producers as well. While these groups would only consume electricity in the past, they are now able to produce energy themselves. This leads to a shift in the relationship between energy producers and consumers, as can be seen in figure 1.

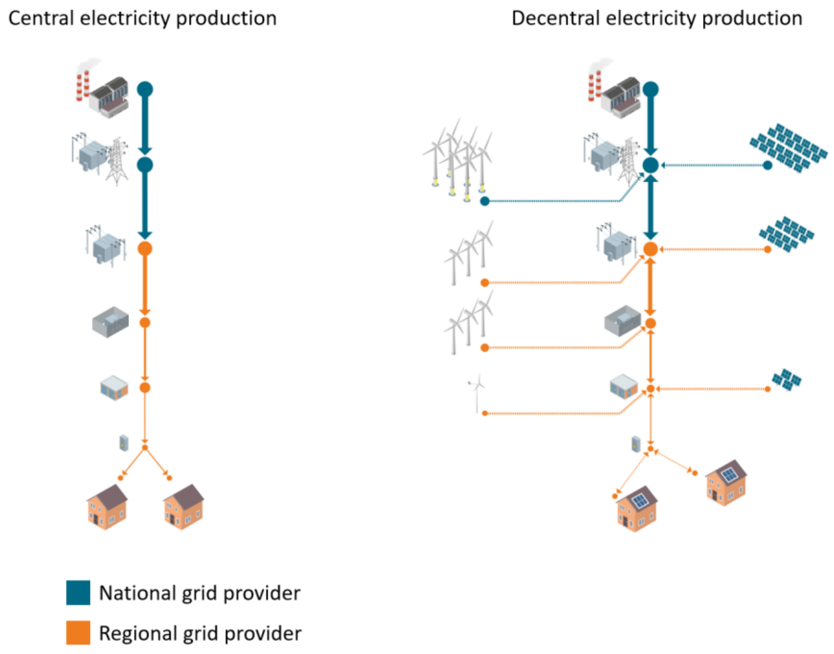


Figure 1. Central and decentral energy production

The Dutch electricity grid was not made with a steep rise of energy demand in mind. On top of that, the relationship shift between producers and consumers was not thought of as well. The new situation requires the grid to be flexible and adaptable. It should be able to transport more energy and allow for new consumers and producers to be added to the grid. One option to be able to transport more electricity is to strengthen the grid [5]. TenneT [6], the Transmission System Operator of the high voltage grid in the Netherlands, as well as other local grid operators, are already working on strengthening the electricity grid. This is a very time consuming operation and it can take up to 10 years to improve parts of the high voltage grid due to a shortage of qualified engineers and laws of the Dutch government [5]. However, strengthening the grid is not the only solution. The energy production of RES is not constant. The sun does not always shine, and the wind does not always blow, or both are happening at the same time. This use of RES leads to an unstable energy supply. To deal with the strong fluctuation of energy production the Dutch energy grid needs to be flexible.

Smart Grids (SG) and *Smart Energy Hubs (SEH)* can be used to create this needed flexibility on the grid. A SG is an electricity network based on digital technology that is used to supply electricity to consumers via two-way digital communication between the utility and its customers [7] [8]. A smart grid can be applied locally, regionally and nationwide. A SEH can be defined as local point in an integrated energy system, where the production, conversion, storage and consumption of different energy carriers takes place [9]. An important difference between a SG and a SEH is that the SG can be applied to the whole Dutch energy grid, while SEHs are decentralised energy systems where energy is produced, stored and used locally.

Implementing SGs and SEHs takes time and planning. The client of this graduation project is Enodes [10]. Enodes is a company that provides energy advice and make plans on how to make houses, businesses and business parks can become more sustainable. They do this with the use of different solutions, once of them being smart energy hubs.

1.2 Problem description

It is known that net congestion is a problem and that if nothing gets done, it might cause electricity problems. The energy transition is big and complex, which makes getting involved in the energy transition difficult. While grid operators such as TenneT are working hard to strengthen the grid, this energy transport problem can only be solved if key stakeholders get involved. Cooperation is needed, since these parties can be individual house owners, but also businesses or business parks.

For Enodes it is important that their clients know what the energy transition is about and which solutions are out there. The proposed challenge is to develop a visual tool that can help Enodes explain the energy transition with SEH and SG in the Netherlands. This is needed, since most of the clients of Enodes do not have the required knowledge to easily keep up with the conversation. To them net congestion is a known concept, the solutions (SGs and SEHs) however, are not. This makes the conversation difficult since Enodes has to explain these concepts first, before they can start the conversation about these solutions. The end product should inform the clients of Enodes truthfully, informing of possible advantages and disadvantages and complexities that come with implementing SEHs and SGs. The end product should close the gap of knowledge between Enodes and their clients. This can be in the area of transition of electricity production, energy storage or energy transportation.

1.3 Research questions

From this problem description the main research question follows:

"How to inform an audience about the use of energy hubs and smart grids in the energy transition on the Dutch energy grid to close the knowledge gap between Enodes and their clients through the use of a visual tool?"

To answer this main research question, the following sub-research questions have been formulated:

1. How do Smart Grids and Smart Energy Hubs work?
2. How can SGs and SEHs help with the energy transition on the Dutch electricity grid and at the same time provide more flexibility on the Dutch electricity grid?
3. What factors are important when creating an informative message about SEHs and SGs for an audience through the use of visualisations?

Since an informative visualisation will be created to inform the clients of Enodes, it is important to have a thorough understanding of what these topics entail. Sub-question one has been formulated to look into both concepts. After that, it is important to understand how both concepts can help create flexibility on the Dutch electricity grid. Sub-question two will answer this question. Lastly, communicating should be adapted to the target audience. It is important to understand what is needed to create an informative message that is well understood by its audience. Sub-question three will answer what factors need to be taken into account to create such a message.

1.4 Thesis outline

This thesis has nine chapters in which the main research question with the sub-research questions will be answered.

- **Chapter 2: Background research**
  This chapter consists of the following topics: Literature Research, State of the Art and a Conclusion of these two sections.

- **Chapter 3: Methods and Techniques**
  This chapter explains the chosen methods and techniques that were applied through the course of the thesis.

- **Chapter 4: Ideation**
  This chapter consists of two parts: One relating to the stakeholders. Here the stakeholder identification analysis will be done. Stakeholder needs will be identified as well. The second part of this chapter consists of the concept presentation and the chosen concept.

- **Chapter 5: Specification**
  This chapter describes the personas and the interaction scenarios that are used to set up the functional and non-functional requirements for this project. Storylines and the colour scheme are presented, which is translated into the final concept at the end of the chapter.

- **Chapter 6: Realisation**
  This chapter shows the development of the product that has been specified in chapter 5. Tools and techniques are described to get the desired outcome. Lastly, the functional

requirements are evaluated as well.

- **Chapter 7: Evaluation**
  This chapter focusses on the user evaluation of the product. The set up of the evaluation is describes, as well as the result of the evaluation. Evaluation is done with the target group and the company.

- **Chapter 8: Conclusion**
  This chapter will give an answer to the research questions that have been formulated in chapter 1.

- **Chapter 9: Future work**
  In this chapter, recommendations for future work are made to create better informative tools about Smart Energy Hubs.

Chapter 2: Background Information

This chapter consists of the literature research, consultations with experts, the state of the art and a conclusion of the previous three parts. The literature research will focus on the current and desired situation of the Dutch electricity grid, as well as the workings of smart energy hubs and smart grids. Next, consultations with experts and the target groups will be described. After that, the state of the art is looked into, to see what has already been done. Lastly, a conclusion will follow.

2.1 Literature Research

The first part of literature research focusses on the infrastructure of the Dutch electricity grid, followed by definitions and explanations of net congestion, smart grids and smart energy hubs. The second part focusses on effective communication with an audience and visual communication.

2.1.1 Dutch Electricity Grid Infrastructure

The Dutch government has four requirements the electricity grid must adhere to [11]. These four requirements are reliability, affordability, sustainability and safety. Reliability means that end consumers have guaranteed access to energy infrastructure, as well as that the government reduces dependability on energy streams from instable countries. Affordability means that the government strives to have the lowest possible relative costs for the end users, such as households, SMEs or the industry, and the government. Sustainability refers to the fact that the government strives for a sustainable energy supply in 2050. This means reducing CO_2 emissions as a result of energy usage from natural gas and coal and reducing the negative effects of energy systems on the direct natural living environment, such as nitrogen or noise. Lastly, safety refers to pursuit to keep the safety for the locals living near energy installations, the safety for employees in the energy sector, the safety of end users and the safety for vital systems of society, such as the electricity grid. These four requirements are uphold by the Dutch government and make sure that everyone has equal access to electricity.

As shown in figure 2, the Dutch electricity infrastructure was built with a *centralised* energy production in mind [5]. This means that the electricity goes from the power plant to the consumers. However, the electricity does not go directly from the producers to the consumers. When the electricity leaves the power plant, it gets pushed on the High Voltage grid. The high voltage grid transports electricity of 110 kV or more. This is too much for the consumers, as they would only need a connection of 0.23-0.4 kV [12]. The high voltage grid is managed nationally by TenneT [6].
To make sure that the consumer is able to use the electricity, the electricity has to be converted to the right voltages. The high voltage grid gets converted to the

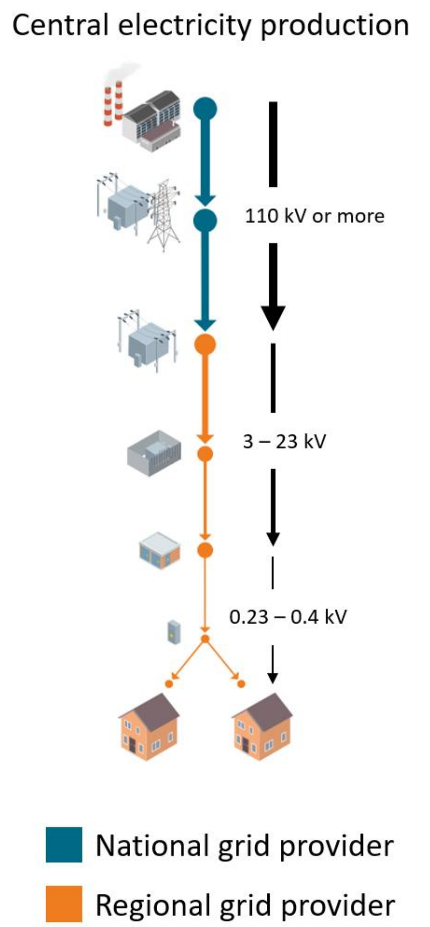


Figure 2. Centralised energy production and voltages

middle voltage grid (3-23 kV) and the middle voltage grids gets converted to the low voltage grid, until it can be consumed. The middle and low voltage grid are managed regionally by grid providers, such as Liander and Stedin [13].

The centralised production of energy makes it possible to adjust production according to the demand of energy, meaning that the energy production is equal to the energy demand. This makes the energy supply constant and the grid sturdy. However, when the demand for energy is bigger than the transport capacity of the electricity grid, this might lead to *net congestion*. When net congestion occurs, no produced electricity can be added on the grid [14], but consumers cannot use electricity either. It is however important to note that this two-way energy flow (consuming <-> producing) are separate of each other. It might be the case that produced energy cannot be added on the grid, but that there is still enough capacity for energy consumption [15]. Figure 3 shows two maps of the Netherlands, one for the production of energy and one for the consumption. The maps show where it is possible to get a large connection (>3x80A). It shows that it is still possible to get a connection for consumption in Groningen, but not one for production. Especially in the north and east of the Netherlands there is no possibility for an additional energy production connection. These areas are relatively thinly populated, the electricity grid that was build there did not have such a high consumption or production capacity. The rural areas have a lot of space to implement RES, and as a result the production capacity has been reached, while there is still enough room for large connections for consumption (in Groningen and Overijssel). This problem is less prevalent in the west of the Netherlands, since the electricity grid was build there to accommodate large production and consumption.

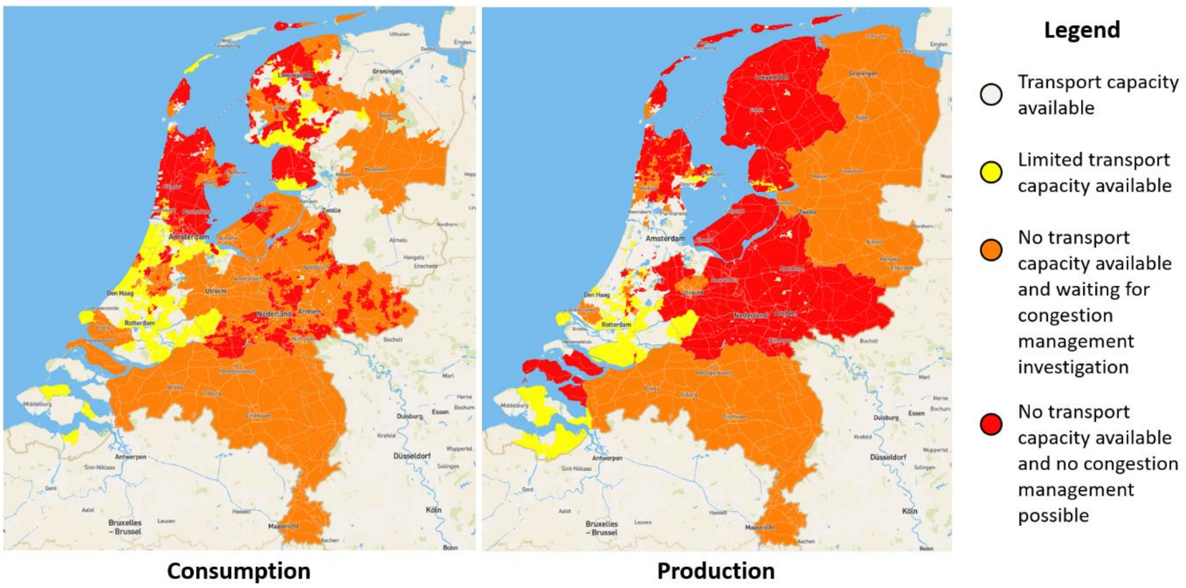


Figure 3. Capacity maps of the electricity grid in the Netherlands [16].

Currently TenneT and the regional grid providers are working on strengthening the electricity grid. As a result, more transport of electricity will be possible. Strengthening the grid takes a lot of time, money and expertise. A new high voltage connection can take 7 – 10 years to make [5]. This can take even longer, due to a shortage of qualified engineers and complex Dutch law. The demand for transport of energy grows faster than the grid providers can strengthen the grid as well [17]. These factors, complex law, shortage of qualified engineers and consequently long realisation times of expanding the grid, lead to long waiting times for new renewable energy sources or companies to be connected to the electricity grid.

Renewable energy sources (RES), such as solar and wind parks, are a growing source of energy in the Netherlands. RES can be connected to the high voltage grid as well as the middle and low voltage grid [5]. Not only is there a rise in RES parks in the Netherlands, consumers have now the option to produce their own energy as well, mainly by using solar panels. The classical relationship between producers and consumers switches to an infrastructure where consumers can be producers too. The use of more renewable energy sources leads to a *decentralised* energy production, as can been seen in figure 4 [5]. RES are important for the goals of the Dutch government, who strives the Netherlands to be independent of natural gas by 2050 [3]. But when new energy sources cannot be connected, the energy transition can take way longer.

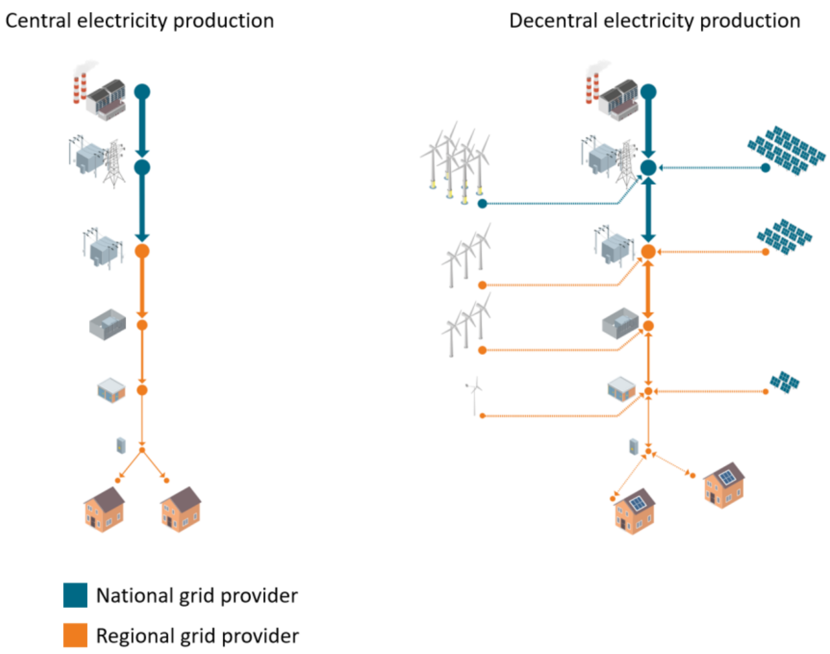


Figure 4. Central and decentral energy production [5].

While the sun and wind are excellent sources for energy, their supply is not constant and even. The sources depend on the weather; solar energy will only be provided during the day, if it is not cloudy and wind energy whenever there is wind. Use of renewable energy sources can cause large peaks in the energy production or even no energy production at all [18]. Furthermore, energy created by these sources cannot be stored on large scales yet [19]. It is already possible for consumers to store their self-produced energy, but this is not much implemented yet. The same goes for energy storage for big solar parks. This is mainly due to the fact that the costs of batteries is high, and no subsiding is available for it yet [20] [21]. Other than batteries, it is possible to store large amounts of energy in hydrogen (H_2) or heat storage, but these options are limited because of technical limitations or restrictions because of laws and regulations [22]. On top of that, when wind energy is not needed, the wind turbines get switched off, because the electricity cannot be stored yet.

Expanding the grid only will not solve net congestion. The demand for the transport of energy grows faster than the grid can be expanded. It is needed to look into other options that might help navigating the rise of the energy demand. These options include the use of *Smart Grids* and *Smart Energy Hubs*.

2.1.2 Smart Grids

As stated in chapter 1, a Smart Grid (SG) is an electricity network that incorporates digital technology that is used to supply electricity to consumers via two-way digital communication between the utility and its customers [7] [8]. A smart grid can be applied locally, regionally or even nationally. The goal of a smart grid is to increase, flexibility, efficiency and reliability of the grid, with the focus on [23] [24] [25]:

- Increase capacity of the transmission system;
- Increasing efficiency of energy transport;
- Integrating renewable energy sources;
- Ensuring reliability of energy transport;
- Reducing the carbon footprint.

There are many different kinds of smart grids, but going into details of the workings of every one of them, would be outside the scope of this project. Instead the workings of a SG will be explained from the basis.

2.1.2.1 Components of a Smart Grid

It is important to note that a SG is not one single device. A smart grid makes use of already existing communication technologies, which makes it possible to expand and evolve as new technologies will be developed. These technologies are placed along the electricity grid. The next technologies are considered to be key components of a SG [23]:

- *Sensing and measurement technologies*
  These technologies refer to the sensors that are places along the grid. They allow for stability, health and security. The most common form of sensing and measurement technology is the smart meter. Smart meters provide detailed data overviews and communication between the consumers and the providers. It gives consumers more insight in their energy usage and can help utility companies to detect failures of the grid more quickly.
- *Integrated two-way communication;*
  While different implementations of smart grids might use different technologies, they all require a network for data transport. This allows grid operators to detect and resolve problems on the grid, whereas they would rely on notifications from consumers if there was something wrong with the grid in the past. This is only possible if the components on the grid are capable of two-way communication abilities.
- *Advanced components*
  Advanced components can help both the producer and the consumer with better energy management. They determine the behaviour of the grid and include technologies such as smart devices, excess electricity storage and diagnostic equipment. For example, when there is an excess in energy production, a smart device might be turned on to use some of that excess electricity.
- *Advanced control methods*
  Advanced control methods refer to the utilization of the two-way communication components. They allow for easy management of different components on the smart grid. It allows for data collection, running diagnostics and some maintenance when needed.

2.1.2.2 Layers of a Smart Grid

As can be seen from the previous points, there are a lot of components involved in the use of smart grids. These components communicate with each other on different layers. Generally a smart grid consists of the following application layers [26]:

1. Power system layer: This mostly refers to the grid itself. It includes the power generation, the transport and the distribution.
2. Power control layer: This layer consist of the control, monitoring and management of the grid.
3. Communication layer: This layer makes the two-way communication possible.
4. Security layer: which provides data confidentiality, integrity, authentication and availability for all the parties that make use of the system.
5. Application layer: This layer builds on the already existing infrastructure. It provides smart grid applications to the customer.

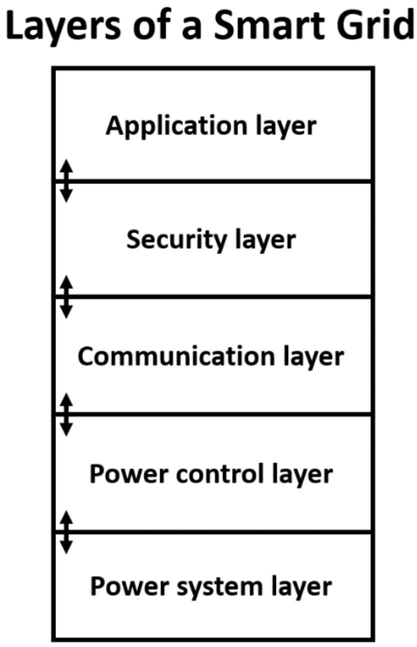


Figure 5. Layers of a smart grid

Figure 5 visualises these layers.

The most important layer is the communication layer. The communication layer can be divided into three network categories [26] [27]: The Wide Area Network (WAN), the Neighbourhood Area Network/Field Area Network (NAN/FAN) and the Premise Area Network (HAN, BAN or IAN). Figure 6 [26] illustrates this.

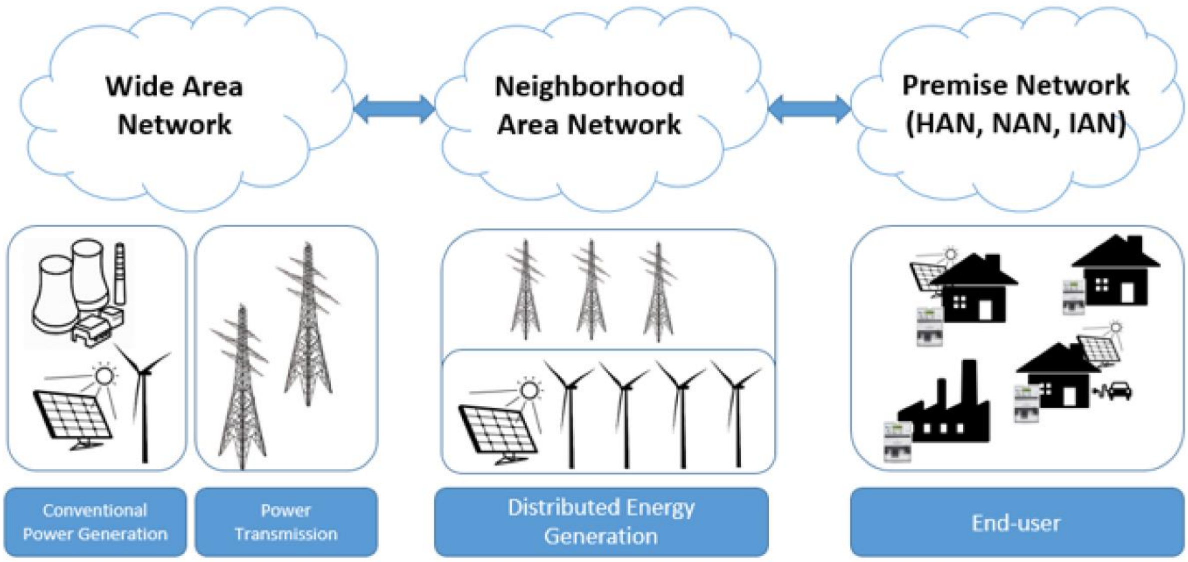


Figure 6. Communication between the network categories [26]

These categories each have different specifications and requirements related to data rate and coverage distance. Communication in these categories is done wired and wirelessly.
The Premise Area Network is mostly used for communication between the end-user and their home applications and appliances. This network has a small coverage and can be run with a low power supply. They also do not require a high data rate.

The Neighbourhood Area Network/Field Area Network makes the communication between the WAN and the HAN, BAN or IAN possible. This means that a NAN/FAN needs a bigger coverage and more power than a HAN/BAN/IAN. Furthermore, a NAN/FAN requires a high data rate.
The Wide Area Network is used to connect the NAN/FAN to control centres of utility companies. It requires an even higher data rate and cover area than a NAN/FAN.

2.1.2.3 Challenges of a Smart Grid

There are some considerations that need to be taken into account when implementing a smart grid. These challenges can be divided into three distinct groups: technical challenges, socio-economic challenges and miscellaneous [28].

- *Technical challenges* include issues such as cyber security [27], data management [28], reliable transmission [27]. The SG makes use of a lot of sensors and communication software. This number will only grow over time. This increases the risk of cyber-attacks. A secure communication network is of great importance, because information about the consumers (and net providers) should not be easily accessible.
  Data needs to be managed well. The sensors in the smart grid will generate an enormous amount of data that needs to be collected, stored and made readable, so that consumers, but also net providers, can easily understand this data.
  A smart grid makes use of a wide variety of technologies and these technologies each have their own limitations and advantages. Reliable communication is needed to make the SG work without any hiccups.
- *Socio-economic challenges* includes challenges such as lack of awareness [29] and fear of higher pricing [30]. Most of the general public is not aware of smart grids, and if they are, they might have wrong perceptions about the smart grid. This lack of awareness needs to be reduced, for example by education, to create a bigger acceptance for smart grids. This is needed, because the general public plays an important part in implementing smart grids; their houses might be part of the SG, if implemented. Research [30] also shows that consumers are afraid that the costs of investments will be their responsibility. This fear form a barrier as well.
  Lasty, installing a smart grid is a big operation with many stakeholders involved. Getting those stakeholders to agree on the goal of the implementation and have them understand how a SG works, can be a time consuming process.
- *Workforce challenges* include challenges such as an insufficient amount of engineers. There are not enough certified engineers that are allowed to implement SG components to the grid. This can slow down the SG implementation. Furthermore, interfaces for application connected to the smart grid need to be developed as well. There is also a shortage of software developers, which can cause a slow development.
- *Regulation challenges* are related to the laws and regulations that apply to certain countries. The Netherlands strives for accessible electricity for everyone, which has led to strict regulations regarding the electricity grid. Before the grid can be adapted or new components can be added, permits have to be given, which can take a long time.

A smart grid is a great option to create flexibility on the grid. Furthermore, it ensures reliability of energy transport and helps to reduce the carbon footprint. A SG is complex and consists of many different components and layers. It can be applied locally, regionally and nationally. While implementing brings many advantages, there are technical, socio-economic, workforce and regulation challenges that need to be taken into account.

2.1.3 Smart Energy Hubs

As mentioned in chapter 1, a Smart Energy Hub (SEH) can be defined as local point in an integrated energy system, where the production, conversion, storage and consumption of different energy carriers takes place [9]. In contrast to a smart grid, a SEH can only be applied locally. Locally means that neighbourhoods or business parks can be a SEH, but a house on its own can be a SEH as well. The goal of a SEH is to reach self-efficiency and has benefits such as [31] [32]:

- Reducing pollution;
- Minimizing energy consumption;
- Enhance reliability and resiliency;
- Reducing energy loss;
- Integration of RES.

Every SEH is unique. This is mainly due to the available possibilities a SEH can make use of in its area. These possibilities include possible energy sources, geographical locations [33] or in case of business parks; the types of businesses [34]. While every smart energy hub is different, they do have a few components in common.

2.1.3.1 Functions of a Smart Energy Hub

A SEH strives for self-sufficiency. However, there is still a connection to the 'backbone' of the electricity grid, in case of emergency, such as an excess or shortage of energy. But in an ideal scenario a SEH does not make use of the energy grid at all. This means that the following functions are important to consider when implementing a SEH [35].

- *Energy resources*
  A SEH tries to make use of RES as much as possible, but it can make use of natural gas as well [35]. Only in emergency it will make use of its connection to the grid. Renewable energy sources that a SEH will make use of are solar and wind power, but can also be energy generated by water, biomass or previously stored energy.
- *Storage of energy*
  To reach self-sufficiency it is needed to store energy, so that it can be used in times when there is a shortage. The storage of energy can be done in many different ways, such as batteries [36], heat in the ground [36] or as hydrogen (H_2) [37].
- *Consumption of energy*
  The distribution of energy makes use of various energy carriers. To meet the demand for energy consumption careful management of energy carriers, energy conversion and energy storage is needed, so that no energy gets lost.
- *Conversion of energy*
  Conversion of energy is an important function to consider in a SEH.
  Renewable energy sources, such as solar and wind power, generate energy in the form of electricity. However, the electricity generated may not be in the form required for a specific use, such as heating. Converting electricity is also needed, so that it can be stored, and used later when needed.

2.1.3.2 Examples of a Smart Energy Hub

These four functions of a SEH have to work seamlessly together to create a well-functioning smart energy hub. To make sure that these components work together, the SEHs is modelled first, to check the efficiency. Once the model meets the requirements the SEH gets implemented.

As stated before, a SEH can be implemented on different scales. Hubs on a small scale are called micro-energy hubs. These hubs can consist of just one house. Large scale hubs are called macro-energy hubs. A macro-energy hub can consist of multiple micro-energy hubs, but it can also be one SEH applied on a large scale [9].

Figure 7 [33] shows a micro-energy hub in the form of a household. Here energy is produced, stored, converted and consumed, just like the definition of a SEH states. Storage systems that would be logical to place in a house would include batteries. Own energy production would be done in the form of solar photovoltaic power, but there is still a connection to the electrical grid and to the gas network. Energy from the solar power is converted before it can be stored or used for house appliances, like a fridge or a washing machine. While not shown on figure 7, an electric car can be used to store energy for later use. Of course, the car is also a source for energy consumption.

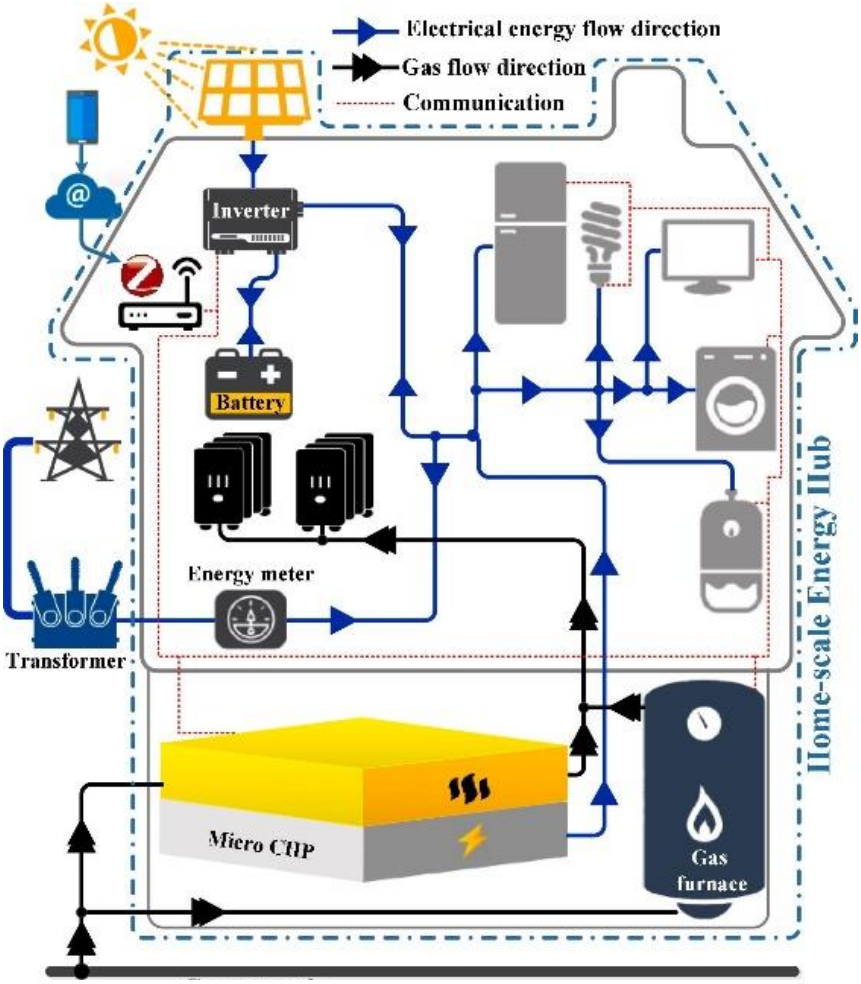


Figure 7. A house as a micro-energy hub

A macro-energy hub can be implemented in different ways, possible options for implementations are an offshore energy hub, industrial energy hub, energy hub in rural areas or a mobile energy hub. These SEH have a slightly different focus with a different implementation, but functions of the SEHs stay the same [9]. An example of an offshore energy hub is the North Sea Energy Hubs [38] project. This project aims to decarbonise industries in the north-western Europe, meaning that this project is a large collaboration between countries, industries and net providers. It strives to be fully realised in 2050; in line with the climate agreements made in Paris [39] and with the Klimaatakkoord [3]. Figure 8 [40] shows how such an offshore energy hub could be implemented. Here electricity is generated with the use of wind, but it could also be done with other technologies, such as offshore solar panels [41]. The electricity that is produced could either be pushed on the grid for consumption, get stored in batteries *or* it get converted to H_2 with can be stored to later convert back to electricity for consumption. It is important to note that in an offshore energy hub the consumption of energy takes place onshore.

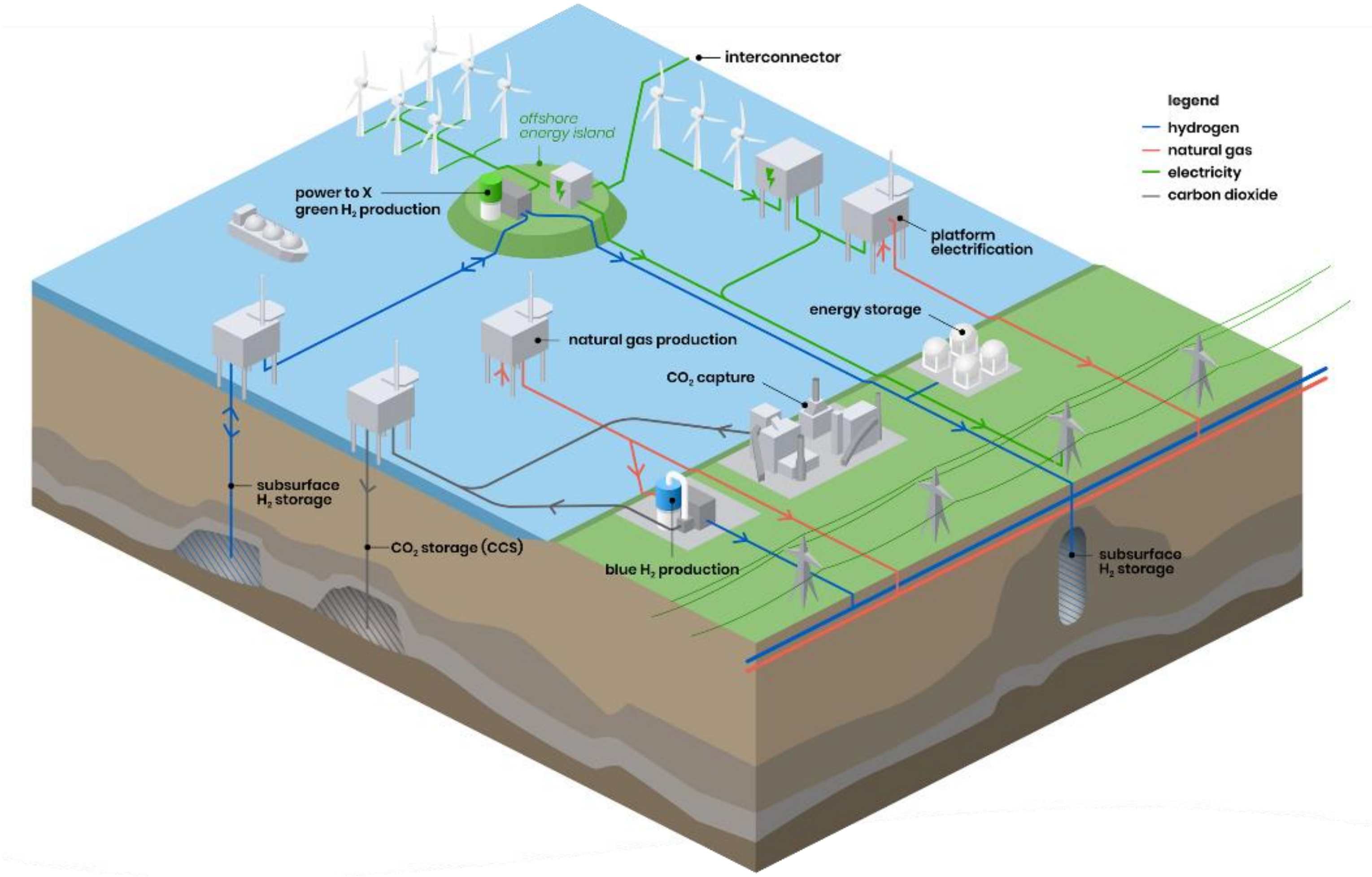


Figure 8. Possible implementation of the North Sea Energy Hub

2.1.3.3 Challenges of a Smart Energy Hub

Implementing a SEH has challenges, just like a SG. However, these challenges do differ a bit. The most important challenges of implementing a smart grid are summarised down below [33].

- *Use of space:* The available space is a limiting factor when implementing a SEH. First of all, there needs to be space for the RES. Solar and wind parks take up a lot of space, and it is not always possible to add huge parks to an energy hub. Furthermore, there needs to be space for energy storage and conversion as well. To store H_2 a lot of space is needed. Equipment to convert all the energy and transport the energy requires optimal use of space.
- *Stakeholders:* Multiple stakeholders are involved when implementing a SEH. In the case of the North Sea Energy Hub this would be: countries participating, municipalities, businesses and net providers. These stakeholders have different views on the implementation on what is important and what is needed. Getting stakeholders to understand each other and work together towards a shared goal is a massive undertaking that requires time and effort.
- *(Existing) energy infrastructure:* The electricity grid is almost everywhere in the Netherlands. When implementing a SEH it is possible to make use of the already existing energy infrastructure. However, a SEH makes use of multiple energy carriers. This means that in many cases new local energy infrastructure needs to be built before a SEH can be implemented.
- *Legalisations and laws:* The Netherlands has strict laws and legalisations regarding the energy grid. Adjustments to the grid cannot be made easily. Law processes can take 5 to 7

years before being realised. Especially laws regarding large energy storage places can make realising a SEH difficult.

Every SEH is unique, depending on the stakeholders, the space/area available and the already existing infrastructure. This also proposes great challenges, since there is no set standard for a SEH. However, every SEH is able to produce, store, convert and consume (own) electricity. While SEHs can only be applied locally, the scale can still vary. A SEH can be as big as just one house, or as big as a whole business park.

2.1.4 Relation between Smart Grid and Smart Energy Hub

On a first glance it might look like that the smart grid and the smart energy hub are two distinct options to manage the problem of net congestion, but the SG and SEH are closely related. As stated in section 2.1.2 the SG is designed to improve the efficiency, reliability, and sustainability of the electricity grid as a whole. The implementation of an SEH is an additional component that can be integrated with a Smart Grid to further optimise the management and integration of different energy sources and loads. While a SEH can be integrated with a SG to further optimize the energy system, it is not a requirement for a smart grid to function. A SG can operate without a SEH, but the implementation of a smart energy hub can bring additional benefits such as improving energy efficiency, integrating renewable energy sources, and increasing energy resilience and reliability.. Figure 7 shows how an energy hub within the electricity grid. Within the energy hub a SG is applied. The electricity grid might partially be a SG, however it is not part of the energy hub.

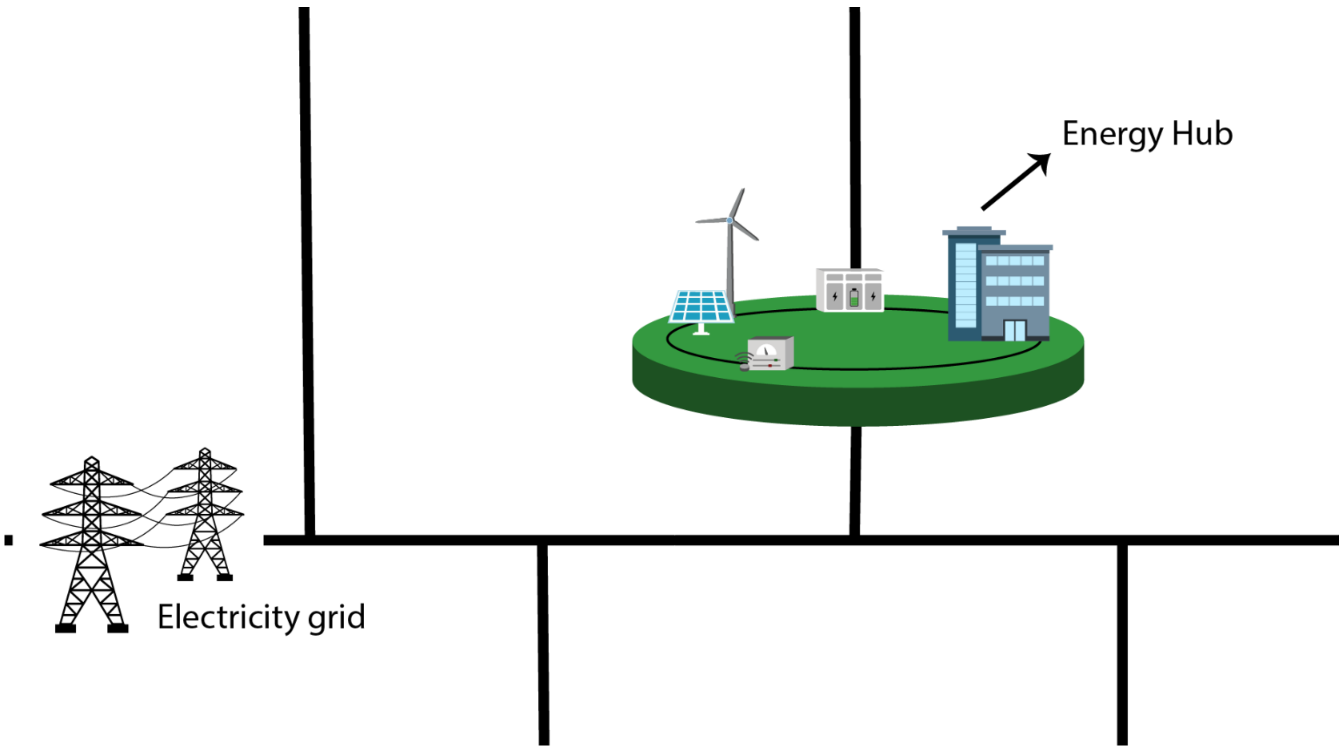


Figure 9. Energy hub within the electricity grid

2.1.5 Visual Communication

Visuals are all around us, and have an impact on how we perceive things [42]. By using the right visuals we can convey a message, but when visuals are used incorrectly, this message can get lost. To understand what practices are important to adhere to when creating visuals, it is important to identify guidelines that can help with this. This and the upcoming sub-chapters will focus on what practices work best to communicate to a non-expert audience, and thus will be answering sub-research question three.

First it is needed to have a clear definition of what 'visual communication' exactly is. For this graduation project the following definition is used: "Visual communication is the practise of using visual elements to convey a message, idea or emotion." Visual elements include, but are not limited to shapes, colours, typography and space. Visual communication can help to convey complex information in a clear and understandable way. Within the field of visual communication a distinction between graphic design and data visualisation can be made. The following sections explain the differences, the common areas and the key components we can take away from graphic design and data visualisations.

2.1.5.1 Graphic design

Graphic design is concerned with creating visual content for specific applications. This can be branding, advertising or packaging. Design elements are used to create a specific aesthetic or convey a particular message, while design principles are used to create a visual that is aesthetically pleasing and easy to navigate. This means that the design principles refer to the lay-out. Many sources [43] [44] [45] disagree how many design elements and principles there are within the field of graphic design. So for this project the four main elements and the five main principles are identified.

Graphic design elements:

1. *Shapes:* Shapes can be organic, geometric or even abstract. Shapes can influence how people perceive things. For example: A shape with sharp angles, might be associated with speed or with anger, while organic shapes can be associated with nature and peace.
2. *Colour:* Colour is of great importance to consider when creating visuals. Colours are associated with emotions. For example: green is associated with nature, but also with sickness. Red is associated with anger, but it is also the colour to communicate danger or a warning. Colours can show what is most important in a message; the brightest colours stand out and will get attention first.
3. *Typography:* Typography includes typefaces and fonts [46]. Typefaces are the 'looks' of the letter. This graduation project is written in the typeface Calibri. The font is the size and the weight of the letters. The main text of this graduation project is written in font 11. Titles are bigger and are **bold**. Typography can help with communication. Some typefaces are for example easier to read for people with dyslexia. Typefaces also communicate a message. Calibri can be perceived as a 'serious' font, while *Vladimir Script* could be perceived as 'elegant'
4. *Imagery:* Imagery includes everything that has an 'image'. This includes, but is not limited to photographs, icons, maps and drawings. Shapes can even be used to create images. The shown image should line up with what the message is about. If visualisation is about a bunny, it should show a bunny. Furthermore, images that are used should be of high quality and high resolution.

The elements of graphic design should confirm to graphic design principles [47]. Five import graphic design principles are:

1. *Hierarchy:* Hierarchy refers to showing what is important and what is less important in a visualisation. This can be done with the use of colour; a brighter colour grabs more attention than a dim colour. It can also be done with sizes of shapes and letters. The bigger the shape, the more attention it gets. Details are important as well. A picture with a lot of details can grab the attention, because there can be so much to see. With hierarchy one can emphasize what is of most importance in a visualisation. It is important to note that hierarchy can be created with the use of other principles, such as balance, contrast and repetition.
2. *Balance:* Balance provides structure and stability to a design. Balance in a design can be achieved by using symmetry and asymmetry. Design elements should be balanced along the design to create a visual that is 'easy' to see. If a visual is unbalanced it might feel cluttered to the viewer and information can get lost.
3. *Contrast:* Contrast is used to highlight certain aspects of the visualisation. This can be done by using colour (bright vs. dim), but also with the use of shapes (big vs. small). Using contrast can contribute to creating hierarchy within a visual.
4. *Repetition:* Repetition can help to create a sense of importance by repeating an object or pattern. It also creates a sense of familiarity and ease for the viewer. For example: a website with a new layout on each page would be very confusing to the user, repetition can help the viewer navigate the site.
5. *Alignment:* Alignment is about keeping the visual organised. Alignment applies to all the elements that are present in the visual; image, shape or text. Elements can be aligned to the edge (left or right) or in the centre.

In short, the graphic design elements should line up with the message that you want to conceive and they can help to convey a message more clearly. The graphical elements should be placed in a visual according to visual principles. This helps the viewer to go through the visual and to gather the information that is important.

2.1.5.2 Data Visualisation

The goal of data visualisations is to present complex information in a clear an understandable way. This allows the audience the quickly identify patterns, trends and insights that may not be apparent from raw data. Data visualisation makes use of key elements that are also used in graphic design. However, to create understandable visuals from data that a large audience can understand, some other principles are of more importance in data visualisation. Just as in the field of graphic design, there is not a main set amount of principles for data visualisation. For this project the four most important data visualisation principles are identified. These principles are as followed:

1. *Colour:* As stated in section 2.1.5.1 colours are associated with emotions and concepts. When creating a data visualisation, colours should be use according to these perceptions to not confuse the viewer [48]. For example: the colour blue is mostly associated with cold and red with warmth. When creating a heat map to show temperatures, the use of colours should line up with the expectations of the viewers. So cold areas should be more blue, while hot areas should be red.
2. *Stay truthful:* Staying truthful means that data should not be left out of the visualisation if it does not fit within the visualisation, it is important to show the outliers. Furthermore, the data shown should be proportional [49]. This means that all the data in a visual should be shown according to the scale used in the visual. Otherwise data can get misinterpret.
3. *Add information:* Data visualisations might sometimes be hard to grasp for viewers. To make sure that the viewer understands the visualisation it is needed to add axis with a clear meaning [50] [48], a legend to explain the data and if needed, a short explanation

underneath the visualisation itself. This makes that the information cannot be misunderstood.

4. *Keep it simple:* Simplification helps the viewer understand the data. This means that as much 'noise' (information that is not relevant) should be removed from the visualisation [51]. If a detail does not add something to the visualisation, it should be removed. On top that, to keep the visualisation readable, no more than two axis should be used. Only use 3D perspective when the 2D visual does not show all the information.

These four principles form a basis to create visualisations that are understandable to a large audience.

2.1.5.3 Key principles

As stated in the beginning of section 2.1.5, visual communication is a broad field. Graphic design and data visualisation are part of visual communication, but both have a different focus. While graphic design focusses more on creating visual content for specific applications, the goal of data visualisations is to present complex information in a clear an understandable way. Both fields have guidelines that can help to create the visuals that are needed. By combining these guidelines from graphic design and data visualisations the following key principles emerge:

- *Hierarchy:* To create emphasis, so that the viewer notices the important information first.
- *Balance:* To provide for structure and stability in the visual.
- *Simplify:* Keep the visual simple and do not add information that is not necessary.
- *Stay truthful:* Display information according to one scale and do not leave information out that does not fit the visual.
- *Add information:* Add information to the visual if needed. This can be done by adding a legend for example.

These principles will be used to create the visuals that will be used in this project and to analyse the available state of the art.

2.1.6 Communication to an Audience

When communicating to an audience, one should *know* the audience. Knowing the audience helps the presenter to tailor the message to the audience. Tailoring the message helps to keep the audience engaged and makes sure that the message is well understood. There a few factors that can help adapting your message to your target audience.

2.1.6.1 Knowing Your Audience

There is no set amount of characteristics you can define an audience by. For this project three characteristics are identified that can be taken into consideration when creating a message. These characteristics are:

1. *Demographics:* Demographics refer to the characteristics of a population categorised by a distinct criteria [52]. This can include, but is not limited to age, gender or income. Demographics can help to understand the viewer and to develop a message for this group. The data of demographics is quantitative.
2. *Psychographics:* Psychographics refer to the values, beliefs or opinions of a population [53]. The data from psychographics is qualitative and it difficult to catch into numbers, since values of people can change over time. Knowing the psychographics of your target group can help to identify when to play into the emotion of your target group, but it also helps to identify topics that should be avoided or approached carefully.

3. *Prior knowledge:* Knowing if your audience has prior knowledge on the topic of your message is of major influence [54]. This influences the complexity of the use of pictures and language. For example: if your audience has no prior knowledge of the topic, it is advised to keep the language simple, so that the audience is able to understand. An audience with no prior knowledge also benefits more if there are pictures added to the message. If the audience has prior knowledge of the topic, it allows for a more detailed message, with maybe more complexity or a deeper focus.

2.1.6.2 How to Communicate to Your Audience

To communicate with an audience, it is needed to have a general understanding of the characteristics of your audience. There a few practices that can help with delivering a clear message, even if the topic is complex. These practices are as followed:

- *Language:* The appropriate language in the message depends on the audience, mostly on the prior knowledge the audience has. When an audience does not have prior knowledge about a topic, it is not advised to use language that could be unknown to the audience [55]. This means to avoid jargon as much as possible and to explain difficult terms, if there are any. If an audience has prior knowledge on the topic, jargon can be used, but only if completely sure that the audience has the required knowledge.
- *Storytelling:* The way the message is told has a massive impact on how the information is received. Using narrative storytelling is especially successful when talking to a non-expert audience [56]. Using narrative storytelling helps with making the information accessible and is easier to process for an audience. Furthermore, narrative storytelling generates more attention and engagement.
- *Keep the attention:* Keeping the attention can be difficult, especially if the message is longer. If the message is presented in person, correct use of body language can help to convey the message [57]. Understanding how to build up a message is needed as well according to the attention curve of an audience can be used to keep the attention as well. Topics should not take longer than 20 minutes to discuss and intermediate conclusions should be added to increase the attention.

Identifying the target group and adapting the message to that group helps to convey a clear message. The characteristics and the principles will be used to create the appropriate message for this project. Furthermore the communication principles will be used to analyse the state of the art later in this chapter.

2.1.7 Conclusion Literature Research

From the literature research it can be concluded that smart grids are an integral part of smart energy hubs. While every energy hub needs a smart grid to function, a smart grid does not automatically include an energy hub.

An energy hub is an self-sustained area, where energy is produced, stored, converted and consumed. While a hub is still connected to the national electricity grid, it does not make use of it, when it is not needed. This lowers energy transport on the grid and thus the changes of net congestion occurring.

When creating a visual tool, visual communication principles can be applied to make an understandable visual. Visual communication can be divided into graphic design and data visualisation. Key principles that should be applied are hierarchy, balance, simplifying, staying truthful (do not leave out information) and adding information to graphs when needed.
On top of that, it is important to know the audience. This can be done by analysing the demographics, psychographics and prior knowledge of the audience. To make sure that the message

is understood by the audience, the language should be adapted to the demographics, psychographics and prior knowledge. Furthermore, narrative storytelling and knowing how to build a message can help with keeping the attention of the audience.

2.2 State of the Art

The state of the art is a review of the already existing visual material about net congestion, smart grids and smart energy hubs. The contents of the material, the type of visual material and the type of communication of the material will be reviewed. The last part of the state of the art consists of conclusion about the reviewed material.

2.2.1 Video Topsector Energie

Topsector Energy made an animation about the role of energy hubs in the energy transition [58]. The video introduces a few possible implementations of energy hubs and explains how these hubs could work.

2.2.1.1 Contents

The video starts with introducing the current Dutch electricity grid and explains its benefits. After that, the desired situation of the electricity grid is explained. To make this system work, energy hubs are introduced and explained. Various kinds of energy hubs are explained. After the explanation of the energy hubs, requirements for innovation and implementation to realise the hubs are named. The video takes four minutes to explain all these things. While disadvantages are not explicitly named, the video does touch upon the challenges when implementing an energy hub. The purpose of the video is to inform people about the possibilities of SEHs. Figure 10 shows an impression of what the animation looks like.

Figure 10. Fragment of video by Topsector Energie.

2.2.1.2 Analysis

The whole video is an animation. The voice-over is in Dutch and the video has Dutch subtitles as well. This makes the video accessible for those who are hard of hearing or do not have access to sound when watching the video. The video stays consistent with its colour usage; shades of green are used to represent the ground. The energy hubs shown in squares, which makes the concept of a 'hub' or something that is done locally, more tangible. The objects in the animation are simple, without too many details. This is good, since too many details would let the viewer to focus on the objects and not on what is being said. The focus of the animation is in the middle of the screen, and not balanced to one of the sides. Only the things that are mentioned in the voice-over are shown in the video, this makes understanding what is going on more easy. The animation has background music. The music is not overpowering the voice-over and it is slightly upbeat. Sound effects are added to strengthen the visuals and keep the audience engaged. Furthermore, the language that is used is simple, without using jargon that is common in the energy field. Narrative storytelling is used as well. This makes the video accessible to a non-expert audience.

2.2.2 Video TenneT

TenneT, the Dutch high voltage grid provider, made a video about congestion management [59]. It explains how the management would work.

2.2.2.1 Contents

The video starts with introducing the problem; the demand for energy transport is rising, because energy is used more in homes and businesses, but new renewable energy sources are added to the grid as well. The video goes on the explain that TenneT is already working on the grid, but that congestion management is needed to make sure that everyone has access to energy. After that, the workings of congestion management are explained. Lastly, it touches upon some advantages of congestion management. The video is informative and has a clear problem statement, which is followed with an understandable solution. Challenges of using congestion management is not named.

2.2.2.2 Analysis

The video starts with footage and after around twenty seconds the video switches to animation for the remaining part of the video. Figure 11 shows a fragment of the animated part of the video. The video takes around two minutes and 20 seconds. This video has a Dutch voice-over and Dutch subtitles as well. The footage in the beginning of the video matches with what is being said in the voice-over, which makes understanding what is being said easier. The animation does that as well. The animation part makes a consistent use of colours throughout the course of the video, which gives a sense of balance. However, many objects in the video are pictured quite detailed and some animations are rather small, which can make the focus of the viewer drift away to the details instead of what is being animated. The video makes use of background music, but not of sound effects. Sound effects could help the viewer focus on what is going on in the video and help point out the animations. The language used in the video is simple, which helps to engage the viewer. However, the video talks about ‘congestion management’, but the exact definition of congestion is never explained.

Figure 11. Fragment of video by TenneT

2.2.3 Video Energy Providers Coalition for Education

Common Craft [60] has made a video commissioned by Energy Providers Coalition for Education or EPCE for short. This video explains the working of a smart grid.

2.2.3.1 Contents

The video starts by explaining that there is a need for more efficient ways to manage the electricity grid. What follows is an explanation of how the electricity grid used to work, with a central electricity production point that uses fossil fuels for production. It goes on to explain the electricity grid and how it is outdated and needs updating. To meet the increasing energy demand, simply more power generators were build, but with renewable energy sources management of the electricity grid is needed. After that the smart grid is introduced and explained with examples. Later on the video lists a few advantages, such as more control over your energy bill and better incorporation of RES.

2.2.3.2 Analysis

The video is three minutes long and uses an unique way to visualise the story. No animations or video footage is used. Instead, multiple drawings are used to visualise the story. Sometimes there is a finger in the video that points to something important. To indicate that things change, variations of drawings are shown. This creates a unique ‘animation’, where everything is still, but due to the variations of drawings, motion is created. An impression of the video can be found in figure 12 The pictures are drawn very simple, without too much details. This makes sure that the attention of the viewer does not drift away from the story. The colour used in the video is coherent. The background is grey and the drawings are mostly white, white some colour added in the outline of the pictures. The colours used are dim, which results in nothing standing out too much. The video does not make use of background music or any sound-effects. It does have a voice-over. This voice-over uses different voice intonations and lays emphasis on words that are important. This helps the viewer understand what is important in the video. In contrast to the previous videos in this chapter, this video does not have subtitles.

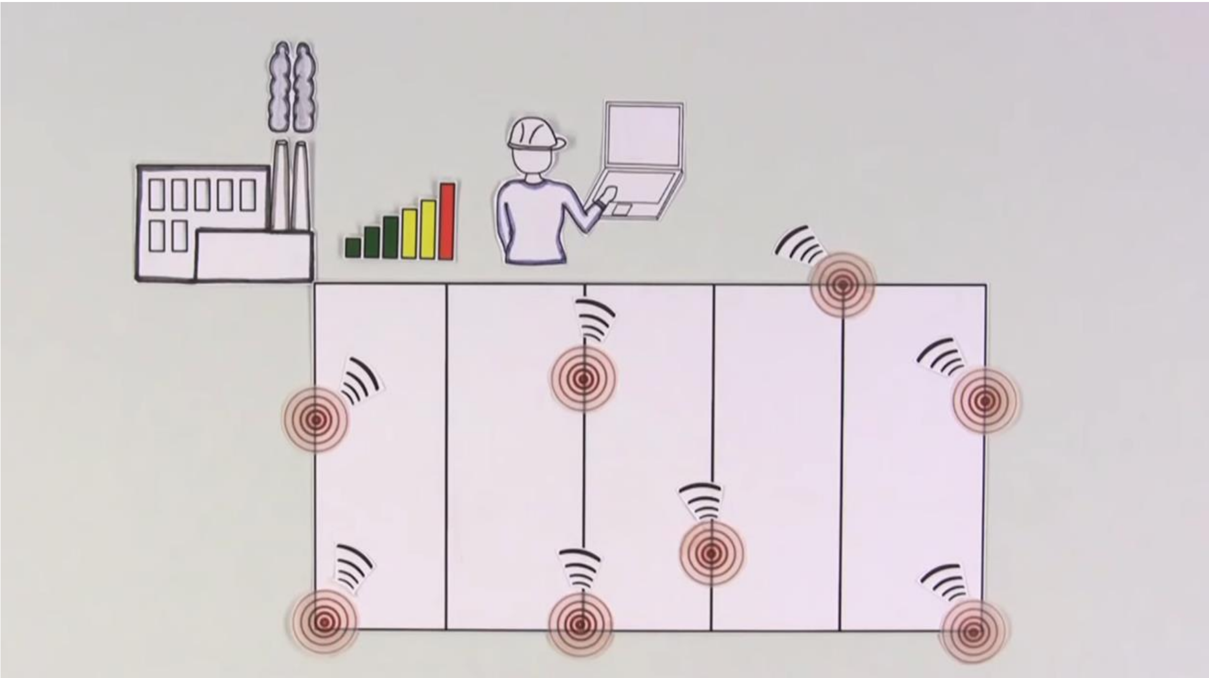


Figure 12. Fragment of video by Common Craft

2.2.4 Website North Sea Energy

North Sea Energy presents concepts to build a smart energy hub in the North Sea. The goal is to realise this by 2050. The site offers a great insight in how this SEH is being realised [61].

2.2.4.1 Contents

The site of North Sea Energy serves as a platform where all information related to the realisation of the energy hub can be found. The home page gives easy access to the executive summary, the introduction, the vision, the pathways, the challenges and the action agenda. The introduction is used to introduce the site and the concepts presented on the site. The vision talks about the goal of the energy hub and the ambitions and targets of the project. The pathways is a very detailed category that talks about how the energy hub will be realised. It talks about future trend lines for renewable energy sources: hydrogen, CO_2 storage and hydrocarbon extraction. The challenges highlight the difficulties when implementing a SEH, this includes stakeholders, uncertainty and use of space. The last point on the site is the action agenda. Here strategies to deal with the future challenges are presented. An impression of the site can be seen in figure 13.

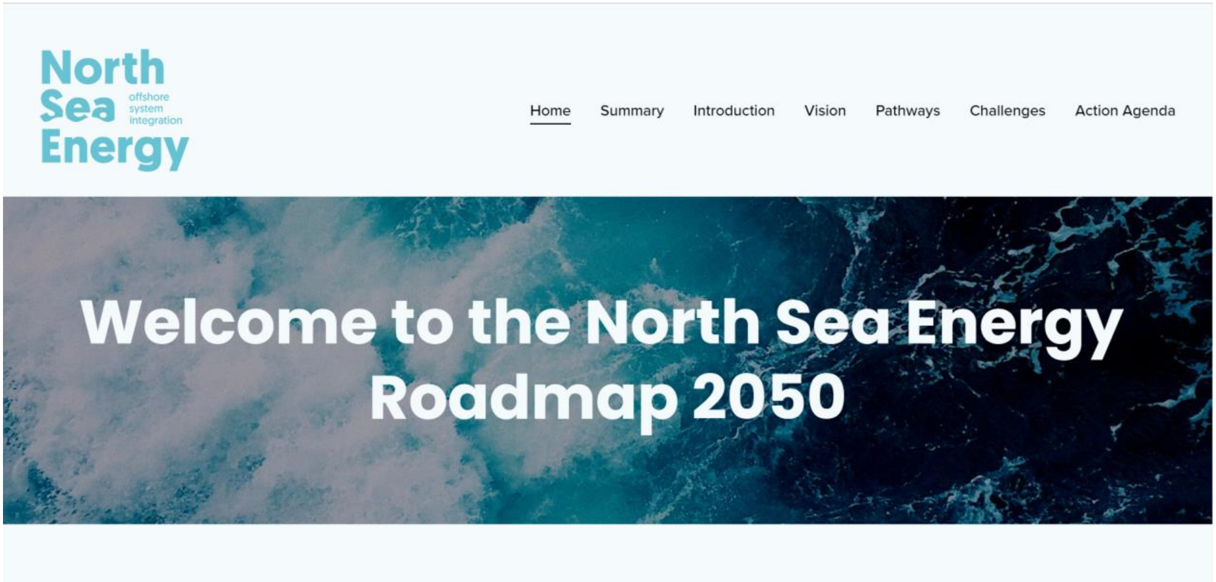


Figure 13. Home page of North Sea Energy

2.2.4.2 Analysis

The site of North Sea Energy consists of a quantity of pages. The home page gives an overview of what will be displayed on the rest of the site. At the bottom of each page there is a possibility to click a button which leads to the next page. This makes going through the site very easy. Furthermore, this presents all the information in a logical order for the viewer. The site stays consistent with its colour use, which gives a sense of coherence. The site mostly contains text, this to explain everything in as much details as possible. Some pages have visuals to explain the text, but the use of visuals is very limited. Since some of the text is very complex and difficult to understand, visuals would've helped to keep the viewer engaged. The site does not contain any other visual components, like videos or animations. There is also no sound integrated in the site. The site is accessible for everyone, but the language used on the site is (in some cases not). The main parts of the site, like the introduction, the pathways and the vision are written without any jargon or other difficult terms. But the further the viewer goes into the site and reads into the challenges and the action agenda, the more difficult the language gets. Not only does the language get more difficult, the text also gets longer. This makes it very hard for the viewer to stay focussed on the site.

2.2.5 Conclusion State of the Art

The previous sections give an insight in the state of the art. It needs to be noted that these sections do not include all the available state of the art, since there is just too material available. Instead these four pieces of material were chosen, since they provide an accurate and complete overview of the current state of the art.

In the videos, aminations are mostly used to visualise the story that is told. The visuals serve to support the story, but also to make the information more tangible, since some concepts can be confusing. The visuals are simple, without too many details and the colour use stays consistent throughout the videos. The site of North Sea Energy stays consistent with its use of colour as well, but does not have the same visual focus as the videos. Instead, the site uses text to explain how the North Sea Energy Hub will be realised. The amount of text is sometimes very large and does contain some jargon, this makes the site on some points very inaccessible. Furthermore, it does not make use of narrative storytelling. The videos however, make use of simple language and use narrative storytelling to explain the concepts. This makes it easy for the audience to understand. All in all, the videos are a good example of how complex topics could be explained. The site has a good message, but is complex due to the large amount of content, difficult language and lack of visuals.

From the contents of the state of the art, it can be concluded that there is material available that explains net congestion and net congestion management, smart grids and smart energy hubs through the use of videos/animations. However, there is no state of that art that explains the relation between net congestion, SGs and SEHs. Even in the videos and site from the analysed material no clear relation is made between SGs and net congestion or SEHs and net congestion. This shows that there is information on these topic available separately, but not yet in combination.

2.3 Discussion and Conclusion

The previous sections gave insights in the current state of the electricity grid, SGs and SEHs, but also in communication principles.

The Netherlands is going through an energy transition. Meaning that how and where the electricity is produced is changing. The electricity grid was built with a central electricity production point in mind. Here fossil fuels were mostly used to generate electricity. This situation is changing, more renewable energy sources are added to the grid, which leads to a decentral production of electricity. These sources are putting pressure on the electricity grid, which can lead to net congestion. Net congestion can be prevented by expanding the grid, but this can take up till 10 years. To make space on the electricity grid investing in technologies, such as SGs and SEHs, is needed.

A smart grid allows for communication about the situation on the electricity grid. It has advantages such as increasing efficiency of energy transport, integrating renewable energy sources and ensuring reliability of energy transport. Challenges of the smart grid are related to cyber security, lack of awareness of stakeholders, and laws and legalisations. Advantages of a smart energy hub are: reducing pollution, minimizing energy consumption and enhance reliability and resiliency. Furthermore, a SEH minimizes the use of the national electricity grid. Challenges that may arise when implementing a SEH can include law and legalisations, and available space on the existing electricity grid. It is important to note that a SEH always makes use of a SG, but that not every SG makes use of a SEH.

When designing a visual tool, it is important to keep the message that is being told in mind. Visual communication can be split into two parts: graphic design and data visualisation. Graphic design uses graphical elements, such as colour and shape, to convey a message. The graphical elements should be arranged according to graphic design principles. Data visualisation focuses on display complex data in an understandable way. This can be done by applying principles such as adding information when needed, correct use of colours and keeping the visual simple. For this project hierarchy, balance, simplifying, staying truthful and adding information are identified as most important principles that should be applied when creating a visual.

To communicate effectively with an audience, a few key principles can be applied. These principles include language (which should be adapted to the prior-knowledge of the anticipated audience), storytelling (narrative storytelling helps with processing the information) and keeping the attention.

Combining the literature research with the state of the art, shows that there is information available on each topic (net congestion, SGs and SEHs), but not combined. This can be due to the fact that each three of these topics are complex and difficult to explain. The videos that were available were easy of language, kept simple and used narrative storytelling. The website was more complex, since most communication was done through text, with little visuals to explain.

Chapter 3: Methods and Techniques

This chapter gives an overview and argumentation of the various methods and techniques that were used to throughout the project.

3.1 Design Method

For this project the Creative Technology Design method [62] is used. This method provides a guideline how to go through a project. The design method consists of four phases; ideation, specification, realisation and evaluation. A figure of the process can be found in appendix A. The method encourages an iterative process in which the designer can always come back to the previous stages. The iterative process is very useful when prototyping and implementing feedback from user testing.

The client of this graduation project was involved in the whole process of the product development, meaning that a participatory design process was used. This design process allows for active participation of the end user in shaping the product, as well as that it ensures that their needs and perspectives is incorporated in the end product [63]. Participatory design results in an end product that is aligned with the needs of the involved group. Furthermore, it fits perfectly with an iterative design approach, since the user feedback is constantly used to refine and improve the product where possible.

3.2 Stakeholder Identification and Analysis

The identification of the stakeholders was done through conversations with Enodes, as well as with the use of a brainstorm. Once the stakeholders were identified, they needed to be analysed. The analysis of the stakeholders was done with the use of an Influence vs. Interest matrix [64]. The influence vs. interest matrix helps to identify where the stakeholders stand in a project and if they have a high or low influence. In this case, power can be read as influence. Furthermore, this technique allows for stakeholder prioritising, since after the analysis is done, it is easy to see which stakeholders are most important for the project. Figure 14 shows what a influence vs. interest matrix looks like.

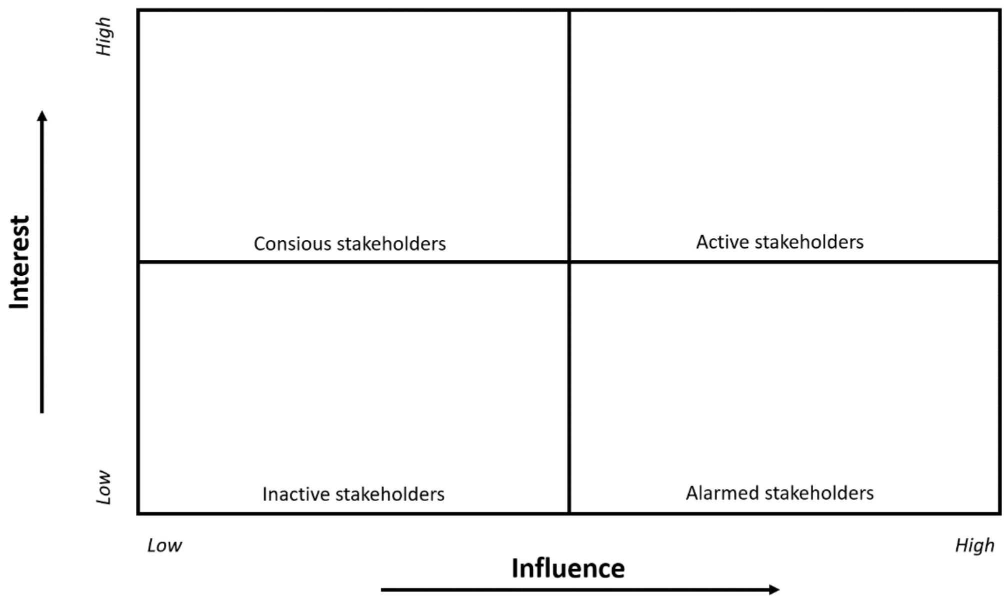


Figure 14. Influence vs. Interest matrix

The *crowd* has a low interest and a low influence on the project. They can also be called the 'inactive stakeholders. The *subjects* have a low influence, but a high interest in the project. They can be called 'conscious stakeholders'. The *context setters* have a high influence, but a low interest in the project. They can be called 'alarmed stakeholders'. Lastly, the *players* have a high interest and a high influence on the project. These can be called the 'active stakeholders'.

The influence vs. interest grid forces to determine how much interest, how much power, but also what influence the stakeholder has in the project. Stakeholders with a high interest and influence should be engaged in the process of developing a project, while stakeholders with a low interest and influence can be less engaged in the development process.

3.3 Requirements Elicitation and Prioritisation

Preliminary requirements for this project are based on the background research and on conversations with Enodes. The preliminary requirements are used to determine which concept developed in chapter 4 fits the best. The concept that is most in line with the preliminary requirements will be considered for the final concept.

In the specification phase functional and non-functional requirements are set up. These requirements are prioritised according to the MoSCoW method [65]. This method prioritises the requirements according to four categories: Must have, Should have, Could have and Will not have. Requirements in the Must have category *have* to be implemented in the final product to create the desired outcome of the project. Requirements labelled in the Should have category have a high priority, and if possible, should be included in the product. However, without the requirement included, the product is still able to function. The Could have category includes requirements that are desired, but not necessary. If they are to be included, it would increase the user experience for example. Lastly, requirements labelled as Won't have, are not to be included in the final project. They could be included when working on iterations of the product, but the goal of this category is to keep the expectations and realisations realistic.

3.4 Concept Ideation

As described in the in Creative Technology design method [62], the ideation phase first diverges. Here the user and the user needs are specified. Based on those needs, concepts are generated for an end product. After that, the ideation phase converges to a final concept.

The concept generation was done with the use of brainstorming, which was done individually. Brainstorming is used to generate ideas and can encourage creative thinking [66]. The technique that was used for this project is called brainstorming by associations. This technique allows to generate ideas by making spontaneous connections and associations that come to mind. Ideas can also be generated by looking at other ideas and things that are inspiring.

3.5 Product Specification

Specification is needed to get a better understanding of what is needed of the product. Specification can be done using various methods. For this project personas, interaction scenarios and specified requirements are used. Based on the personas, scenarios and requirements a storyline and a storyboard is developed.

Personas are used to describe a user's characteristics and their goals in life [67]. A persona serves as a valuable tool for designers to gain understanding, describe, focus on, and clarify the goals and behaviour patterns of users. For this project personas are used to get a better insight in the stakeholders and their concerns and goals.

The personas are used to create interaction scenarios. Interaction scenarios are small stories in which the interaction between the user and the product is described [68]. It is a great way to get insight in the needs of the users. In this project interaction scenarios are used to get an understanding how the product and the users interact with each other, as well as to understand the specific needs of each user (group).
The personas and interaction scenarios are used to set up functional and non-functional requirements. Functional requirements define what the product must do or what needs to be in the product. Non-functional requirements define the usability and the performance, but they also used to evaluate the visuals of the product. As mentioned in section 3.3, the requirements are prioritised according to the MoSCoW method. This helps to determine what is most important when creating the final product.

Storylines and storyboards were made after the requirements were set. Storylines can help the designer to get a feel for the story, while making sure that the important components are incorporated in the story [69]. It also helps to note down some ideas about the visualisations that can be made in the video.
The storyboard can be made, once the storylines are done and the script is written. Storyboards are a useful tool that can help the designer visualising what they want to show with the corresponding voice-over [70]. On top of that, storyboards can help in organising and planning the project, since the scenes can be mapped out in advance. Estimations of time can be made according to the complexity of a scene in the storyboard.

3.6 Product Realisation

In the realisation phase, the actual product is being realised. The functional and non-functional requirements are used and incorporated in the project. Since this project uses a participatory design approach the realisation phase is divided into two phases. For the first phase a very simple prototype is made. This prototype received feedback, which is incorporated in the second phase. The prototype is fully realised in the second phase. At the end of the realisation phase, the functional requirements are evaluated as well. Based on this evaluation, recommendations for future development are given.

3.7 User Evaluation Method

The user evaluation focusses on evaluating the non-functional requirements. The participants would receive an information letter with information about the evaluation and a consent form before the user testing. The user testing consisted of a questionnaire followed by a semi-structured interview. In both cases questions about the visuals and animations as well as the content were asked. Semi-structured interviews allows the research to prepare some questions, but if anything of interest comes up during the conversation it allows the researcher to ask questions about that more in depth.

Chapter 4: Ideation

The first part of this chapter gives an overview of the stakeholder needs and requirements. The second part of the chapter will show the preliminary concepts for the project. The last part shows the chosen concept for this graduation project.

4.1 Stakeholder Needs and Requirements Definition

4.1.1 Stakeholder Identification and Analysis

As stated in chapter 3, the stakeholders were identified through the interviews with Enodes and the background literature. The following stakeholders were identified:

- Enodes
- University of Twente
- The researcher
- Sustainability experts (of municipalities)
- Business owners
- (Local and national) grid operators

Figure 15 shows these stakeholders placed on a interest vs. influence grid. The reasoning of the placements and the analysis of the stakeholders can be found in table 1. It includes what interest and what influence each stakeholder has on the process of creating the final product.

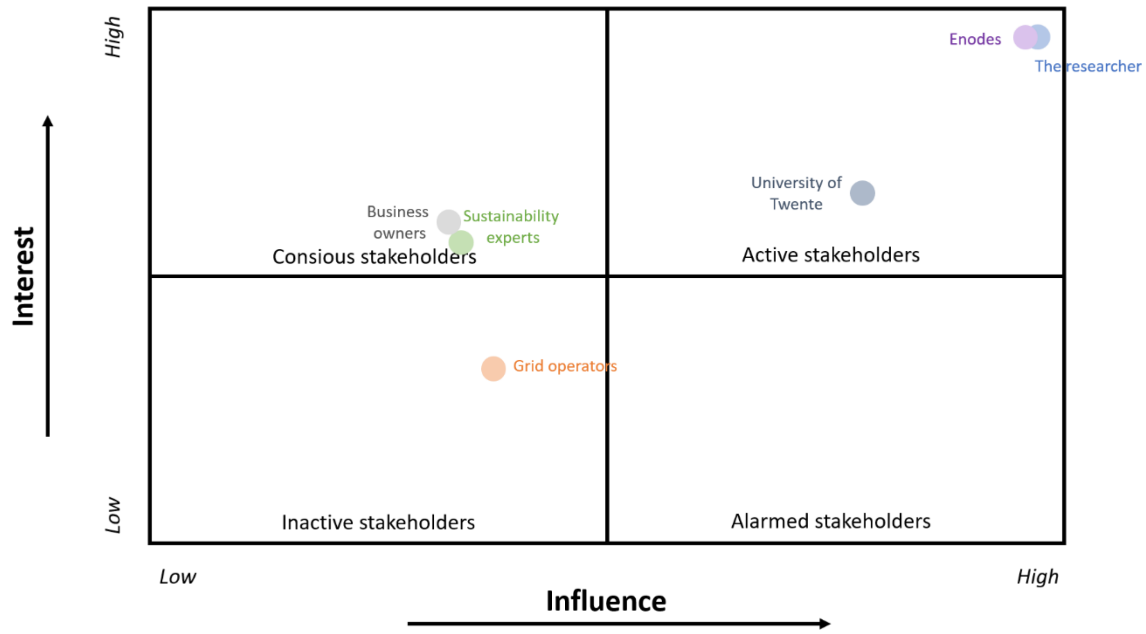


Figure 15. Interest vs. influence grid with stakeholders

Stakeholder	Analysis
Enodes	Enodes is the client of this project. They can use the outcome of this project to raise awareness about the relation between net congestion, SGs and SEHs. Furthermore, this tool can help to close the knowledge gap between Enodes and their clients, making sure that the conversation about the energy transition and about what Enodes does goes easier. In addition, this tool can be used for marketing purposes and it can strengthen the position of Enodes in the energy transition field. These factors combined, indicate that Enodes has a high *interest* in the end product. The *influence* of Enodes in the project is high as well. Company has a say in which concepts they like, and which ones not. Furthermore, the company provides suggestion what literature might be important to look into and what aspects are interesting to explorer further. The fact that Enodes has a say what the final product could be, gives them a high *influence*. The high level of influence and interest makes Enodes an active stakeholder.
University of Twente	The two supervisors for this project work for the University of Twente. The supervisors help guiding the process of the project. Feedback and tips are given to make sure that the project goes well. On top of that, they do the formal assessment of this graduation project. This means that they have a high *influence* on the project. They also have a high *interest* in the project. However, their interest would be lower than that of Enodes. Still, the high influence and interest makes them an active stakeholder.
The researcher	The researcher of this project, Marleen van Gerner, has the highest *interest* in this project, since her graduation is depending on it. It is a way to show everything that she has been learned in the past two years. The *influence* of the researcher is high as well. Relevant information needs to be obtained through literature and interviews. Analysis of this needs to be done. Concept generation, realisation and the evaluation are all done by her. The researcher decides how most of the project will be done, resulting in a high influence on the project and the process. The influence and interest of the are as higher than that of the University of Twente, but equal to that of Enodes, which can be seen on the grid. The researcher is an active stakeholder.
Sustainability experts (of municipalities)	Sustainability experts will have interest in the end product of the project. For them it is important to know what options are available to have a secure energy supply in a sustainable way. The end product will also help with the conversation with Enodes. This gives them a high *interest* in the product. However, sustainability experts will not have a large *influence* on the process and on the product development. Their perspective will be taken into mind when creating the product, but it does not have a high impact. The high interest, but low influence makes the sustainability experts a conscious stakeholder.
Business owners	Business owners, especially if they are located on a business area that could implement a SEH, will have a high *interest* in the outcome of the project. For them it is important to know what kind of technologies will be implemented and if it will affect their business. It will also help them in their conversation with Enodes. Business owners have a small *influence* on the process and the product development. Their perspectives and possible weariness about SGs and SEHs will be taken into consideration, but it will not directly influence the process. The

	high interest, but low influence makes the business owners a conscious stakeholder.
(Local and national) grid operators	Grid operators, like TenneT or Enexis, have a low *interest* in the project. They know about the energy transition and they know that new technologies can help with that. A tool that explains that to them would not be of interest. Grid operators have a low *influence* on the project as well. While they very much participate in the energy transition, they are not of great involvement of the development of the project. A low interest and influence makes grid providers an inactive stakeholder.

Table 1. Analysis of the stakeholders

4.1.2 Stakeholder Needs

Based on interviews with Enodes and on the literature research, preliminary stakeholder needs surfaced. Table 2 shows these preliminary requirements. These requirements will help to determine which concept is the best to choose.

No.	Requirement	Source
1.	The final product must be able to be distributed online.	Client
2.	The final product must include various perspectives of the involved stakeholders	Client
3.	The final product must has to be in Dutch	Client
4.	The final product must provide accurate information	Background research
5.	The final product must not contain jargon and use language that is accessible.	Background research
6.	The final product must give the possibility to be viewed alone	Client

Table 2. Preliminary requirements for an informative visual tool

4.2 Preliminary Concepts

In this part of the chapter the preliminary concepts will be explained. Pictures and brief descriptions are provided to illustrate the concepts further.

4.2.1 Concept 1: Animation

An animation can be used to explain the relation between net congestion, SGs and SEHs in a simplified way. Different perspectives can be incorporated into the animation with one coherent storyline. The animation length and the details of the animation are dependent on the target group and can be adapted if needed. Background music and sound effects can be used to strengthen the message in the animation. A voice-over will be needed as well.

4.2.2 Concept 2: Interactive Website

On a website everything about net congestion, smart grids and smart energy hubs can be explained. It allows for a very in-depth display of information, since large amounts of text can be displayed on websites. Pictures, animations and sounds can be added to grab the attention of the viewer and to strengthen the information displayed on the site. The website can be made interactive by implementing clickable links and images. Figure 16 shows a concept of how the site could look.

Figure 16. Concept set up of the interactive website

4.2.3 Concept 3: Interactive Image

An interactive image is an image that can be explored by clicking on different parts of the image. For example: An image displays a house with a powerline and a powerplant. The powerline goes into the house. The user can click on the point where the powerline goes into the house. When this point is clicked, new information appears. This information can be displayed in the form of text, an image, an animation or a combination of those. The interactive image allows the user to explore the concepts of net congestion, SGs and SEHs on their own. Figure 17 shows an example how an interactive image could look like, but instead of clicking on the powerlines, the wind turbines are clicked.

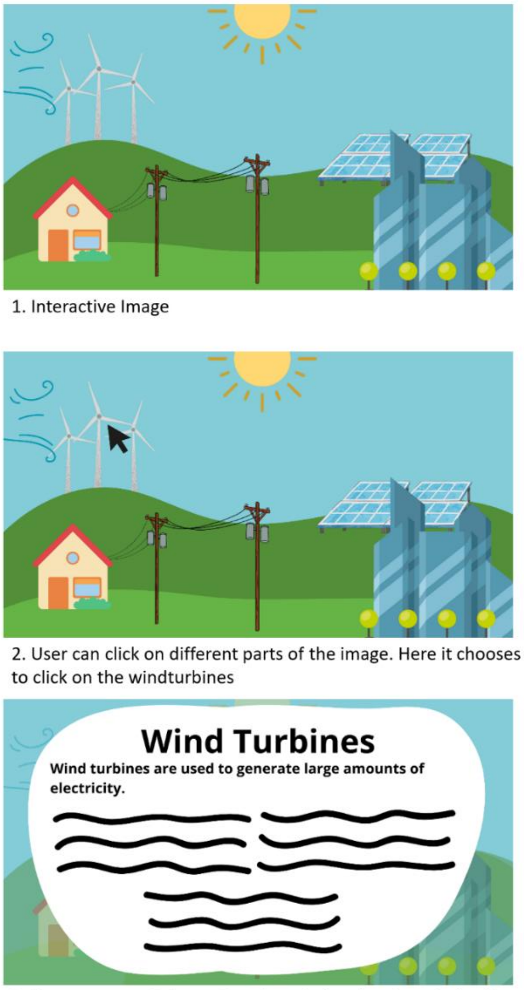


Figure 17. Concept of an interactive image

4.2.4 Concept 4: Interactive Video

An interactive video (or animation) can present the different perspectives of the stakeholders a bit more in-depth, since the perspectives are not put together into one video. The video can have a general introduction and at the end of the introduction the viewer can choose the path they are the most interested in or that applies to them. For example: After the introduction there is a possibility to choose what kind of stakeholder you are (business owner, sustainability expert, investor, etc.). When this has been chosen, the video goes on to show information that is applicable to the business owner. After each section of the video a new choice can be made. Figure 18 shows a flowchart of how one could go through the videos.

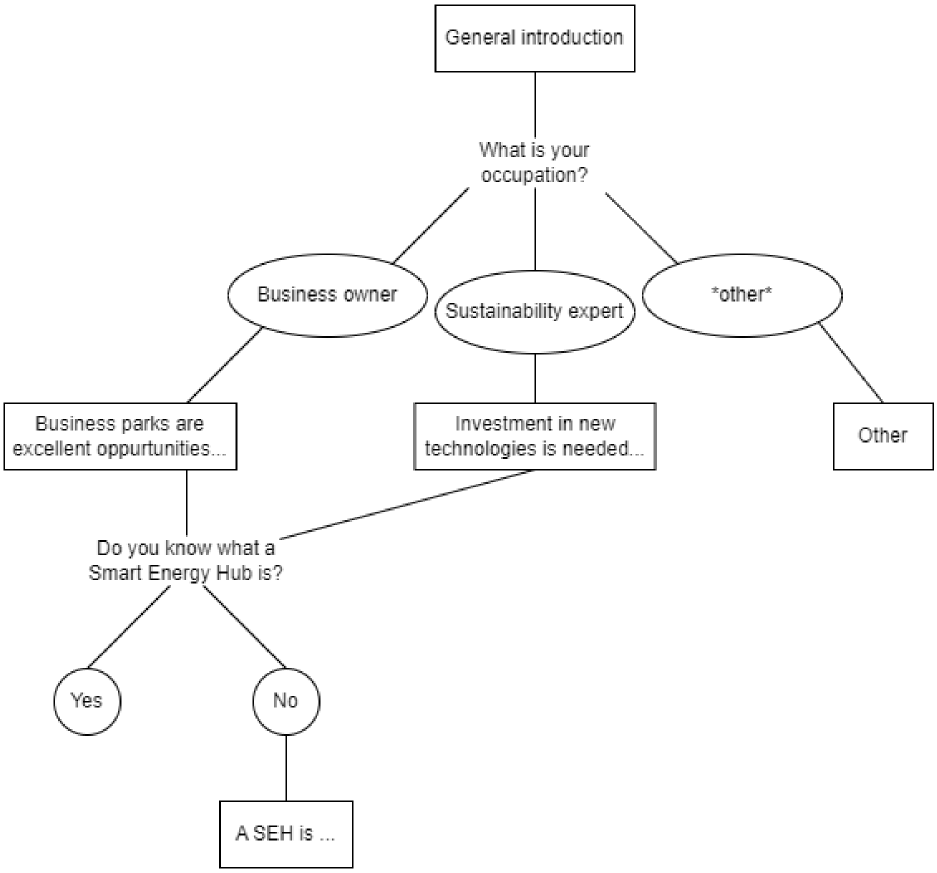


Figure 18. Possible flowchart of the interactive video

4.2.5 Concept 5: Radio Play

A radio play is able to tell the relation between net congestion, SGs and SEHs in a narrative way. Sound effects and music are added to keep the listener engaged in the story. This allows for an immersive experience even though no visuals are used. And example of a very well know radio play is 'The War of The Worlds' from 1938 [71]. A radio play about such a technical topic can be very interesting and challenging, but it would allow for a large audience, since the topic is made very accessible.

4.2.6 Concept 6: Board Game

A board game would allow people to discover net congestion, SGs and SEHs alone or in a group, depending on the medium and game type. A board game allows people to learn more about these concepts together. This could make for an interactive experience with the game, but it also provides interaction with the other players. Options for a board game could be to combine the game Ludo with a quiz element.

4.2.7 Concept 7: Posters

Posters can be a great way to grab the attention of people. They use graphical elements and principles to convey a message. A poster could be a stand-alone, just one poster with a lot of information, or they could be presented in series. When they are presented in series, each poster could display a different problem or solution. For this project one poster that explains net congestion, one that explains smart grids and one that explains smart energy hubs could be developed. The posters could also include infographics, or be infographics in itself.

4.2.8 Concept 8: Podcast

A podcast is a very good way to incorporate different perspectives into one concept. Podcasts are mostly used to tell stories or to broadcast discussions between people. In a podcast Enodes can discuss the energy transition as well as energy hubs with important parties that are involved when energy hubs are implemented. For example: grid providers and business owners. The podcast can be (partially) animated so that it can be viewed on a platform to reach a wider audience. The whole podcast could also be divided into small segments, so that the viewer does not get overwhelmed by all the content. Things such as why energy hubs are needed, who are responsible for them and consequences could be discussed in a podcast.

2.4.8 Requirements check

Table 3 shows the preliminary requirements compared to the initial concepts. From this, it can be concluded that concept 1 till 6 are all feasible and line up with all the requirements. Concept 7, the board game, does not line up with requirement 1 and 6, leading to this concept being unfit for the final concept.

No.	Requirement	Concepts
1.	The final product must be able to be distributed online.	C1, C2, C3, C4, C5, C7, C8
2.	The final product must include various perspectives of the involved stakeholders	C1, C2, C3, C4, C5, C6, C7, C8
3.	The final product must has to be in Dutch	C1, C2, C3, C4, C5, C6, C7, C8
4.	The final product must provide accurate information	C1, C2, C3, C4, C5, C6, C7, C8
5.	The final product must not contain jargon and use language that is accessible.	C1, C2, C3, C4, C5, C6, C7, C8
6.	The final product must give the possibility to be viewed alone	C1, C2, C3, C4, C5, C7, C8

Table 3. Preliminary requirements compared to initial concepts

4.3 Final Concept

4.3.1 First idea

The concepts were presented to Enodes, and the concept that sparked to most interest was the radio play. However, while the idea of listening was really appealing to Enodes, they did not want the playful elements of a radio play, since it would not fit with the company and the intended target group. From the radio play idea, the idea of a podcast emerged. This would suit with the image of Enodes and would be better target at the intended target group.

A podcast however, does not fit the requirements for a Creative Technology project, since a CreaTe project has to include some technical components. The idea was adapted to make the podcast a suitable CreaTe project.

To make a conversation in a podcast possible discussion material is needed. The discussion material will be provided through a short animation (not longer than a minute). This animation ends with a (pressing) statement to which the people in the podcast react. This will start a discussion. The people who are present in the podcast have a role in the energy transition. They could be sustainability experts, business owners or grid providers. The people will provide various perspectives on the statements, which will give an interesting discussion. The discussion will be led by Enodes themselves to make sure they are still connected to the project. Enodes could even be a participant in the discussion.

1. Korte uitleg van een concept of een probleem (max. 30 sec.)

2. In dit geval: wanneer er netcongestie optreedt, kan er geen energie meer geconsumeerd worden

3. Een stelling volgt. Aan de hand van deze stelling wordt een discussie gevoerd.

Figure 19. Concept of a short video with statement

The podcast still fits the requirements, since it can be easily distributed online, it involves various perspectives and it will be in Dutch. The animation will contain accurate information and will use accessible language. Furthermore, the whole podcast can be listened to in the users own time.

An example of such a video and statement could be a video that starts with a short explanation of what net congestion is and what happens when it occurs. This could be followed with a statement like: 'The only way to prevent net congestion is to expand the electricity grid'. Figure 19 shows how this could look like.

4.3.2 Second (final) idea

Upon further discussing the podcast idea with Enodes, it came to the light that it was not possible for them to gather equipment and get the people together who are needed for the podcast, due to the time constraints of this project and the fact that Enodes is really busy. They did however, really like the idea of making a podcast if they had the time and the resources for it. For this project it means that the podcast idea was not chosen to be the final concept, and that a new concept was developed.

This resulted in choosing a concept that would also fit Enodes and the requirements that were set up: An (interactive) video/animation. This video has to be in Dutch and has to show various perspectives of stakeholders that are important to consider. The video consists of one main part. Here the problem of net congestion is explained, and Smart Grids and Energy Hubs are explained as well. This will be followed with an interactive part, where the viewer can choose what kind of stakeholder they are. When clicked on the relevant part, a new video will start with only the information that is relevant for that stakeholder. Figure 20 shows the set-up of the video.

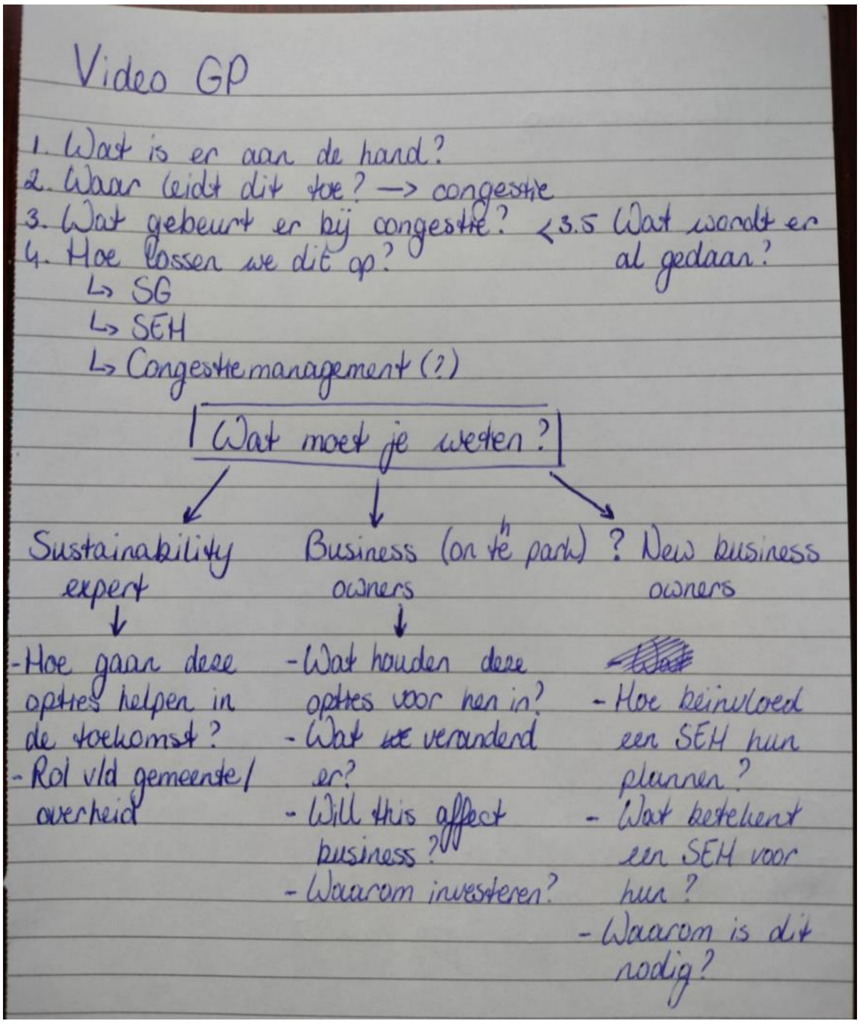


Figure 20. Set up of the interactive video

For the first part, a storyboard has been made. This can be seen in figure 21 and 22. The general part (the first part), introduces net congestion, what happens when net congestion occurs, what is currently being done to prevent net congestion and what Smart Grids and Energy Hubs are and how they can help with congestion. This storyboard will be refined in chapter 5; specification. Chapter 5 will help to define the main concerns of the stakeholders as well, to make sure that they will be addressed in the video.

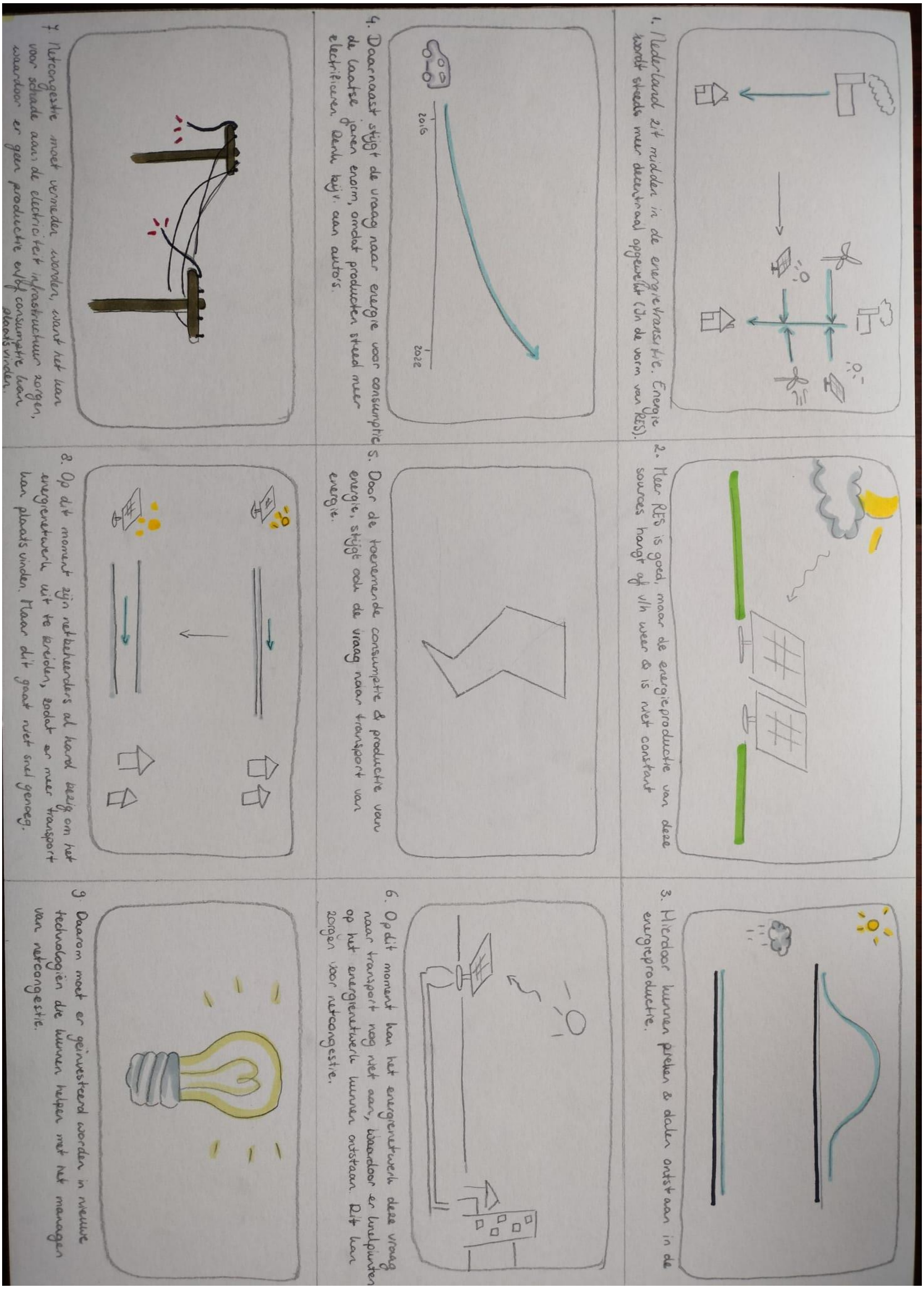


Figure 21. Storyboard of the general part of the interactive video (1)

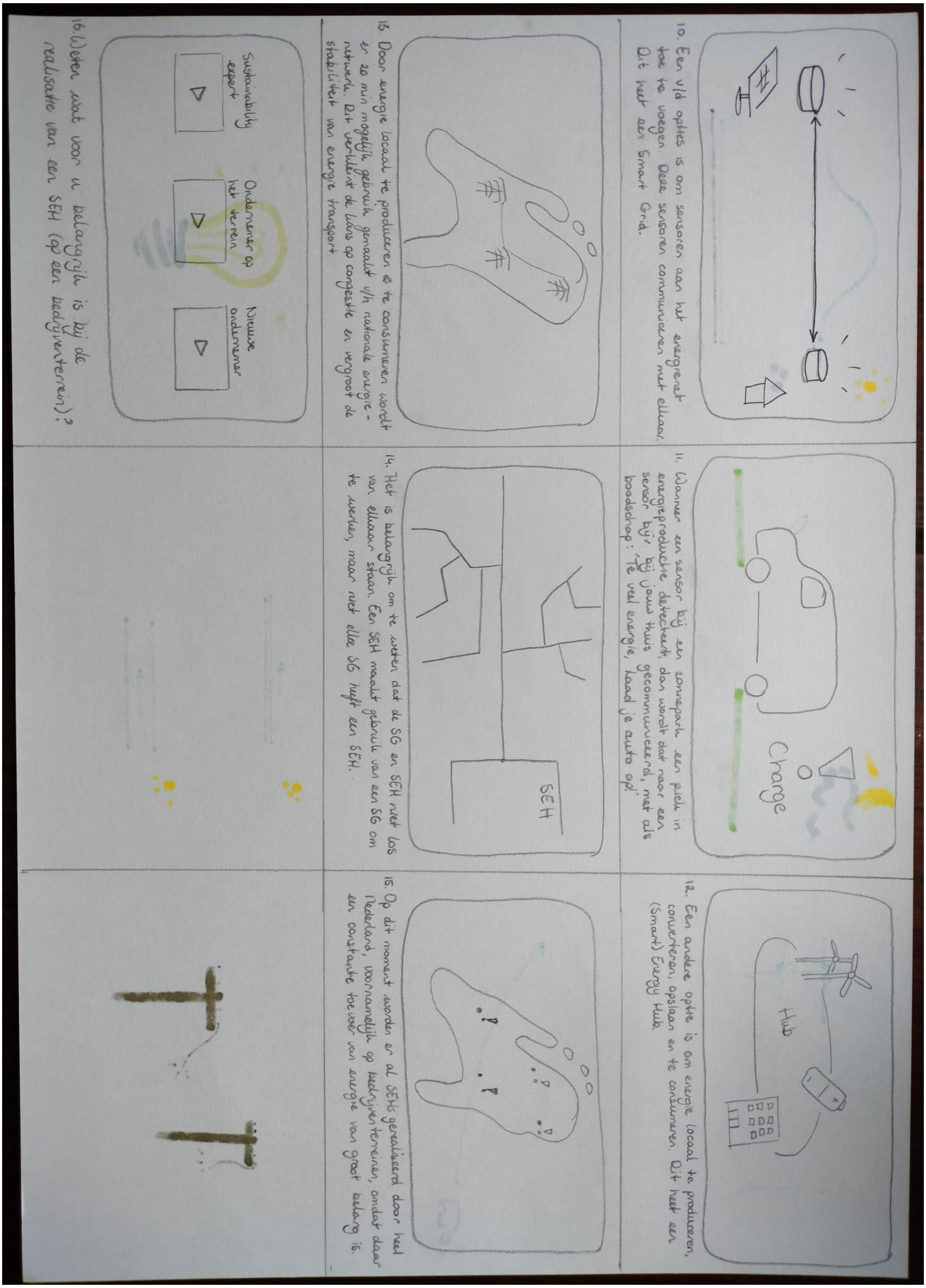


Figure 22. Storyboard of the general part of the interactive video (2)

Chapter 5: Specification

Chapter 5 is a continuation of chapter 4. The final concept that is presented in chapter 4 is specified further in this chapter. This is done with personas, scenarios and further specified requirements. Based on this, the final fully worked out concept is presented.

5.1 Evaluation of Concept with Enodes

The final concept, the interactive animation, was discussed and approved by Enodes. The main topics that were discussed in the meeting were regarding the storyline and the stakeholders. From this meeting it became clear that changes needed to be made to improve the storyboard and the structure of the video. The points of improvement are discussed in the following sections.

5.1.1 Improvement points video content

While some parts of the initial storyboard were well liked, such as the part about energy hubs, there were some points of improvement discussed in the meeting. These points are as followed:

- The introduction video should discuss the new and the old situation of the Dutch electricity grid (central production -> decentral production).
- The introduction video should mention that renewable energy sources are not flexible with energy production and that the grid gets loaded at the same time because of this. This causes bottlenecks (so net congestion).
- The introduction video should emphasise that net congestion is caused by the energy transition, due to decentral energy production and the electrification of appliances and energy sources.
- Net congestion does not cause damage, but it can cause black outs to prevent any damage to the electricity grid.
- If possible, mention in the introduction video that net congestion is mainly administrative.
- If possible, mention smart grids in the introduction video. If the introduction video gets too long, smart grids can be left out. It should however be mentioned that an energy hub makes use of smart systems. This can also be done in the videos targeted towards the sustainability expert and business owners.

These points have been added to the functional requirements that can be found in section 5.3.1.

5.1.2 Improvement points stakeholders

Another point of the conversation with Enodes were the stakeholders. From the conversation it became clear that some points should be mentioned in the storylines target towards the stakeholders. For the sustainability storyline the following points have been mentioned:

- Implementing an energy hub requires a form of organisation in a geographical area. Organisation is required on different levels.
    - A tight cooperation between the stakeholders is required.
    - A financial system is needed.
    - An automatic management system is needed.
- Furthermore, it would be nice, if it could be made clear that an energy hub means that the businesses are in one physical ‘branch’.

Points that should be mentioned in the business owner storyline are:

- When an energy hub is implemented business can still carry on with their activities and they can still grow.

- Solutions are developed. If possible some processes will be done during the night, since more energy will be available at those times.
- When an energy hub is implemented it means that a cooperation with other business is needed. Processes that need energy are all put together.
    - This requires a smart way of dividing energy over all of the business, in such a way that all the businesses still receive the energy that they need.
    - This means that processes will be prioritised according to importance and needs.

From this, it became clear that the already established business owners and new business owners have a lot in common. For this reason, it was decided that storylines of the established and new business owner would be fused. There is however one point for the new business owner that should be included in this storyline and that is the fact that new business owner cannot get a large energy connection at the moment on business parks, due to net congestion. If they would join a business park where an energy hub is being implemented, they will be able to get that connection.

5.2 Personas

As said in *chapter 3.5*, personas are used by designers to understand, describe, focus and clarify the user's goals and behaviour patterns. For this project two personas are identified. These personas represent the main stakeholders that are important to consider when creating the final product.

5.2.1 Persona 1: Business Owner on Business Park

The first persona that has been defined is the business owner on a business park. On this park a smart energy hub could be implemented. Henk-Jan has a business on a business park. One of his main goals is to grow his business by 50% in the upcoming 5 years. A bigger business, means more usage of electricity. To use more electricity, he needs a larger connection to the electricity grid and his energy supply needs to be secure, because otherwise his business cannot grow. Furthermore, he would like to have his business up to date with new technologies, so if investments are needed, he is willing to make them, even if it means investing in material to generate sustainable energy. He knows investment is needed, because the lack of capacity to transport electricity has been a new problem on the business park. Henk-Jan however does not really know what options there are to get a secure energy supply. While he has heard of smart grids, he does not really know what energy hubs are.

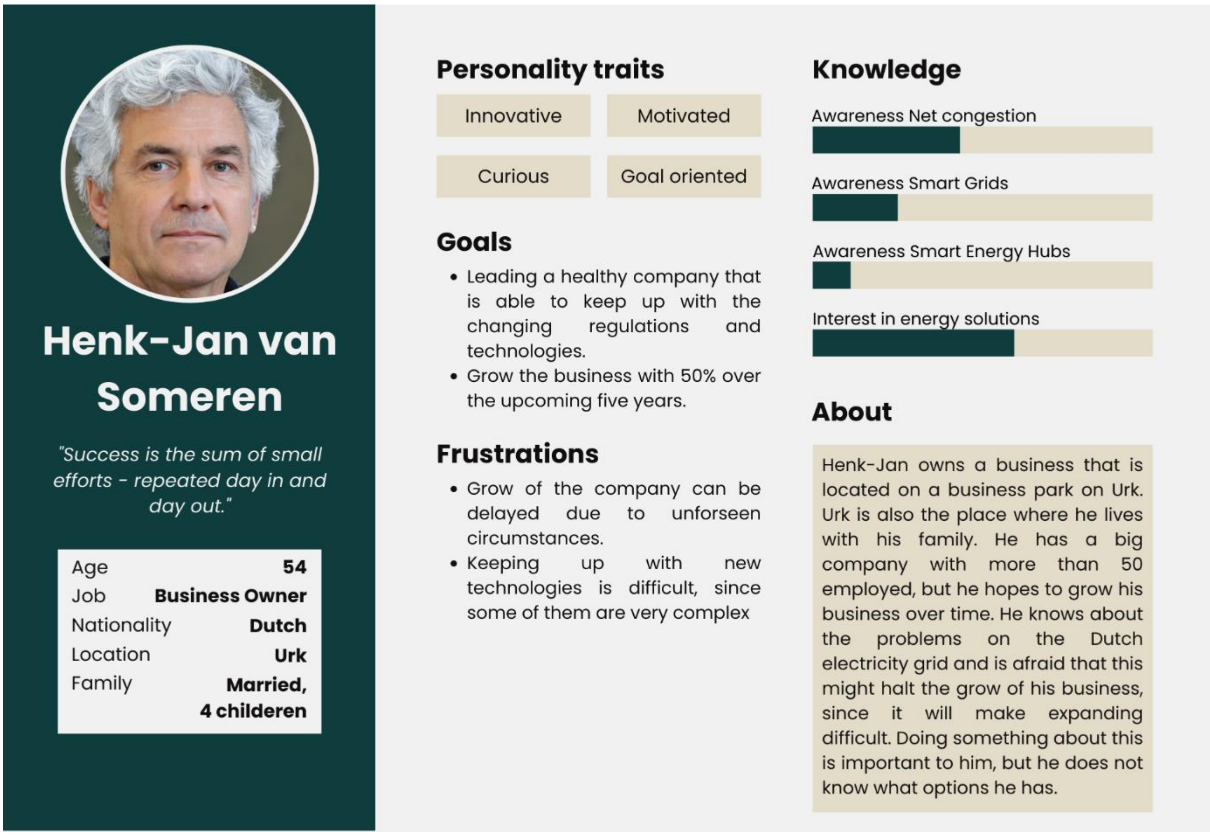


Figure 23. Persona Business Owner

5.2.2 Persona 2: Sustainability Expert of a Municipality

Anoushka Cohen is a sustainability expert of a Dutch municipality with a business park where a smart energy hub should be implemented. The sustainability expert has a lot knowledge about the options the municipality has to prevent net congestion and to foster sustainability. However, she does not know the specifics in regard of these technologies. This is needed for her job, since her job is to advice people on the possibilities regarding sustainability.

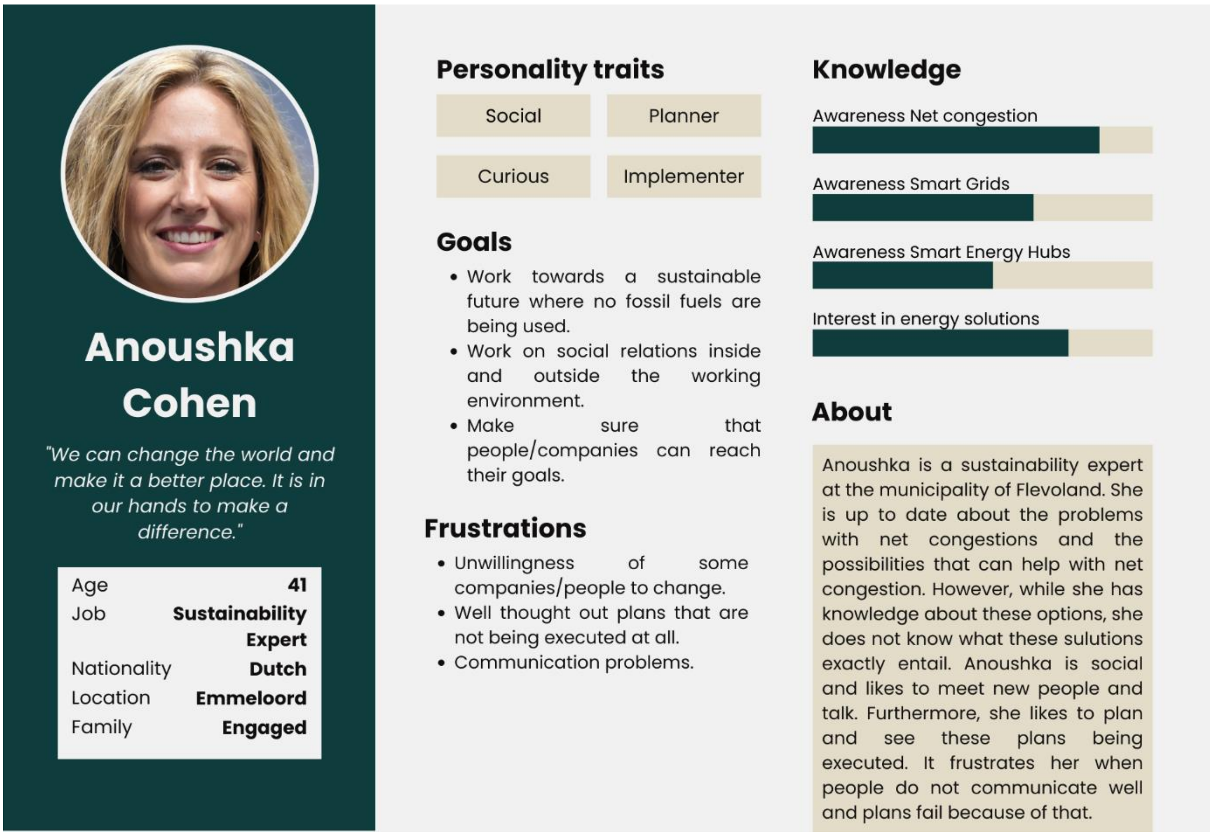


Figure 24. Persona Sustainability Expert

5.3 Interaction Scenarios

Interaction scenarios describe how the video can be used (by the stakeholders). Two interaction scenarios have been made for this project. The interaction scenarios can help to uncover what information is important to include in the specific parts of the interactive video. The scenarios also help to understand if the general part of the video is extensive enough or if it needs more explanation.

5.3.1 Interaction Scenario Business Owner

1. A business owner has a business that is located on a business park.
2. He wants to grow his business by 50% in 5 years. To expand the business he needs a bigger energy connection.
3. He also knows that new businesses will establish on the business park in the upcoming years, which means that he cannot get a bigger energy connection. This means his business cannot grow.
4. The business owner is willing to invest in new solutions, so he starts searching on the internet with the hope to find something.
5. He finds the video about net congestion and energy hubs. He watches the video.
6. He learns about energy hubs and the elements of an energy hub.
7. When presented with the option to watch a video that contains information that is specifically targeted to businesses owners, he clicks that option.
8. He is happy to learn more about the specifics of energy hubs. He knows what will change, why he should invest and work with the municipality, and what an energy hub means for him.

9. He contacts the other businesses on the business part to see if they are interested in joining an energy hub. He shows the other business owner the video as well, so that they understand the energy hub.
10. He contacts the municipality as well, to see if they are able to help with setting up an energy hub.
11. The business owner is happy to see that different parties are willing to talk and work out sustainable energy solutions.

5.3.2 Interaction Scenario Sustainability Expert

1. The municipality has the goal to invest in sustainable energy solutions.
2. The municipality gives the sustainability expert the task to look into possibilities to make the municipality more sustainable.
3. The sustainability expert thinks that the business park is a great place to implement new sustainable energy solutions.
4. They have heard about smart grids and smart energy hubs and know that they can be used to avoid net congestion and improve sustainability. However, the expert does not know how these options would work.
5. The expert goes on to search for information and finds a video about smart grids and smart energy hubs.
6. They watch the video and choose the option for ‘sustainability expert’, when the video gives the option to choose what stakeholder you are.
7. The expert watches the video and now knows what a smart grid and a smart energy hub entail. Furthermore, they know how these options can help the municipality reach their sustainability goals and which role they play when implementing a smart energy hub.
8. With this knowledge the sustainability expert recommends the municipality to implement an energy hub on the business park that is located in the area of the municipality.

5.3.3 Conclusion Personas and Interaction Scenario

The personas and interaction scenarios show that the stakeholders can have different reasons for the needs of a visual tool that explain smart grids and energy hubs. The personas help to understand the stakeholder needs, goals and behaviours, while the interaction scenarios focus on how the video might be used. From the personas and interaction scenarios it is clear that the sustainability expert needs a bit more explanation on the workings of an energy hub and how such an energy hub could be implemented. For the business owner it is important to mention what an energy hub means for his business and how it could affect his business.

5.4 Requirements

Based on the personas, interaction scenarios and the background literature, requirements can be defined in functional and non-functional requirements. Functional requirements refer to requirements on what the system should do. Non-functional requirements refer to how the ‘system’ should do it. The functional and non-functional requirements are prioritised with the MoSCoW method.

5.4.1 Functional Requirements

No.	Requirement	Must	Should	Could	Would not
1	The voice-over in the video speaks Dutch	X			
2	The videos have English subtitles	X			
3	When two videos are played after each other, they have a maximum length of five minutes	X			
4	The videos can be distributed online	X			
5	The videos can be distributed across different platforms on which Enodes is active	X			
6	The introduction video explains net congestion	X			
7	The video explains what the energy transition is	X			
8	The introduction video explains that net congestion is caused by renewable energy source that are not flexible with energy production	X			
9	The introduction video emphasises that net congestion is caused by the energy transition	X			
10	The introduction video explains the new and old situation of the Dutch electricity grid (central -> decentral production)	X			
11	The introduction video explains smart energy hubs	X			
12	There is a video directed towards sustainability experts	X			
13	The sustainability expert video explains that tight cooperation between stakeholders is required when implementing an energy hub	X			
14	The sustainability expert video explains that a financial system is needed for an energy hub	X			
15	The sustainability expert video explains that an automatic management system is needed in an energy hub	X			
16	There is a video directed towards business owners	X			
17	The business owner video explains that businesses can still carry out their activities when an energy hub is going to be implemented	X			
18	The business owner video explains that some processes will be done during the night	X			
19	The business owner video explains that businesses will need to cooperate with each other when an energy hub will be implemented	X			
20	The video has background music		X		
21	The introduction video explains that net congestion does not cause damage to the grid			X	
22	The introduction video explains that net congestion is mainly an administrative problem			X	
23	The introduction video explains smart grids			X	
24	The video has sound effects			X	

Table 4. Functional requirements

5.4.2 Non-functional Requirements

No.	Requirement	Must	Should	Could	Would not
1	The video explains terms that could be unknown to the audience	X			
2	The video is informative	X			
3	The video stays truthful	X			
4	It is clear to the viewer that there are two other videos they can watch after the introduction video	X			
5	Hierarchy is implemented to create visual emphasis		X		
6	Simple visuals are used		X		
7	Balance is used to create structure and stability in the visuals		X		
8	When graphs are used, they should be properly explained		X		
9	The language used throughout the video is appropriate for the target audience		X		
10	The video makes use of narrative storytelling		X		
11	The video is coherent		X		
12	The video looks 'neutral'		X		
13	The video invites the stakeholders to watch			X	

Table 5. Non-functional requirements

5.5 Storylines

The storylines are based on the personas, interaction scenarios and on a discussion about the final concept with Enodes. This resulted in three story lines: The main storyline, the business owner storyline and the sustainability expert storyline.

5.5.1 Introduction

This part is targeted at both the business owners and the sustainability experts.

5.5.1.1 Scene 1: Introduction

First, the voice-over mentions what is currently happening on the Dutch electricity grid: the energy transition. Then the voice over mentions that the Dutch grid is not build for this transition and that the transition leads to problems.
The video will show the Netherlands and how energy originally was produced. Then it will show the new methods to produce energy.

5.5.1.2 Scene 2: Problem description

The voice-over describes the problems the Dutch electricity grid is currently facing. It will mention that the energy production goes from central to decentral, and how this is causing congestion problems. On top of that, it will be mentioned that net providers are currently working on the problem.
The video will show how central and decentral energy production will look like. Furthermore, it will show what can happen when net congestion occurs and how net providers are strengthening the grid (by making the powerlines thicker).

5.5.1.3 Scene 3: Solutions

Here the voice-over will mention which solutions can be implemented to deal with net congestion. These solutions are Smart Grids and Energy Hubs. The voice-over will explain or give examples how

these solutions work.
The visuals will depict a smart grid and an energy hub. It will illustrate the examples that will be given in the voice-over.

5.5.1.4 Scene 4: Outro
The voice-over mentions how and where the solutions are currently implemented. It creates an ending of the video and it will ask which stakeholder is most applicable to the viewer.
The visuals show where the hubs are currently implemented. The visuals fade out and a black screen with the two choices will be shown.

5.5.2 Business Owner Part
This part is specifically targeted at business owners.

5.5.2.1 Scene 1: Introduction
A voice-over will shortly introduce the Energy Hub and mention the main functions again. It will highlight that business parks are excellent areas to implement energy hubs. It will be mentioned why the energy hub is a great option.
The video will show an energy hub with its functions. It will depict a business park where new business can be added or business can expand, due to the fact that they have enough energy.

5.5.2.2 Scene 2: Possibilities of an energy hub
The voice over will mention what will happen when an energy hub is implemented in a business park. To make it more clear, examples of how this could work are given. The voice over mentions that an energy hub helps to exchange energy among business and that priorities are made based on processes and their importance.
The visuals illustrate the examples that are given in the voice-over.

5.5.2.3 Scene 3: Outro
The voice-over rounds of the video. It mentions the advantages and the possibilities that an energy hub gives. It mentions that it will help creating a sustainable future.
The visuals show that more business can join the business park and that existing business can grow.

5.5.3 Sustainability Expert Part
This part is specifically targeted at sustainability experts.

5.5.3.1 Scene 1: Introduction
A voice-over will shortly introduce the Energy Hub and mention the main functions again. It will mention that energy hubs can be implemented in many different ways and that business parks are excellent places to implement an energy hub.
The video will show an energy hub with its functions. It will also show the different aspects that can influence the workings of the energy hub.

5.5.3.2 Scene 2: Organisation of an energy hub
The voice-over will mention the different levels of organisations that are needed when implementing an energy hub. This will be a management system and a financial system. It will also be mentioned that tight cooperation of all main stakeholders is needed when implementing an energy hub. If needed, examples will be given.
The visuals will illustrate how these system work and will show the main stakeholders.

5.5.3.3 Scene 3: Outro
The voice-over rounds of the video. It mentions that implementing an energy hub is a large operation that requires a lot of investment. It also states the advantages of an energy hub. It will mention that

this option will help with achieving a sustainable future.
The visuals will show all the things that are needed to implement an energy hub, to emphasize that implementing a hub is a lot of investment. It will show what the advantages are.

5.6 Colour Choices

To create unity throughout the videos, colours have been chosen. These colours will also help to create balance and hierarchy in the videos. Adobe Color [72] has been used to create a coherent colour palette for the video. The colours should also help to convey the feeling of 'neutrality'. Furthermore, the colours that will be used are chosen based on the message that should be conveyed. The colours that have been chosen can be found below, underneath the colours there is a short explanation why these colours have been chosen.

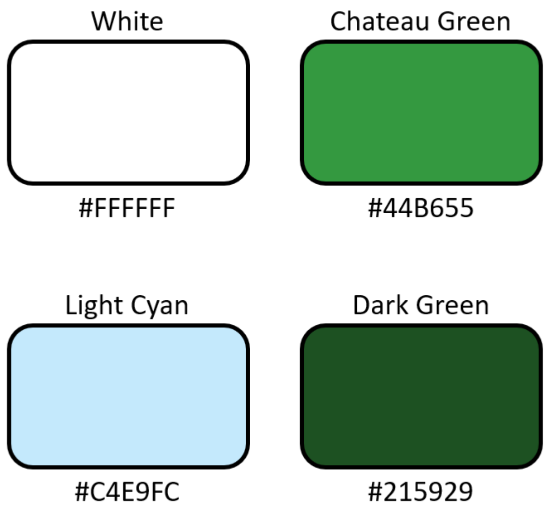


Figure 25. Colours, colour names and colour codes

The white and the light blue colour will be used mostly for the background of the video. White is mostly associated with calmness and it is also used to create contrast [73]. Furthermore, white is a neutral colour, meaning that it is very easy to combine with other colours. Blue is mostly associated with calmness and stability [74]. Pastel colours are often linked to neutrality and softness, which makes them great for background colours. This is why the light/pastel blue was chosen.
From the storyboard that was shown in chapter 4.3.2 it is clear that the ground/earth and the Netherlands will be shown a few times. For this the light green colour has been chosen, since green is associated with nature [75] and when countries are shown on maps, they are mostly coloured green. The darker green will be used to create shadows for the lighter green if necessary.

It is important to note that colours have different meanings and associations in different cultures. While blue is associated with reliability in Western European countries, in Latin Amerika it can be associated with mourning. The meanings that are explained in the section above are mostly connected to Western European cultures.

5.7 Final Storyboard

The final video will consist of a main part and two dedicated parts targeted at the two main stakeholders: business owners and sustainability experts. The structure of the interactive video can be seen in figure 26. The final script and storyboard are based on the evaluation of the concept with Enodes and on the storylines that were developed in chapter 5.5.

Based on the script, the duration of the videos were estimated. From this, it became clear that including smart grids in the introduction video, would increase the length of the introduction video by at least 30 seconds. This would mean that the introduction video + the video that the viewer chooses would become way longer than 5 minutes. On top of that, the two specific parts mention smart systems as a component of an energy hub. For this reason it was decided to not include smart grids in the introduction video.

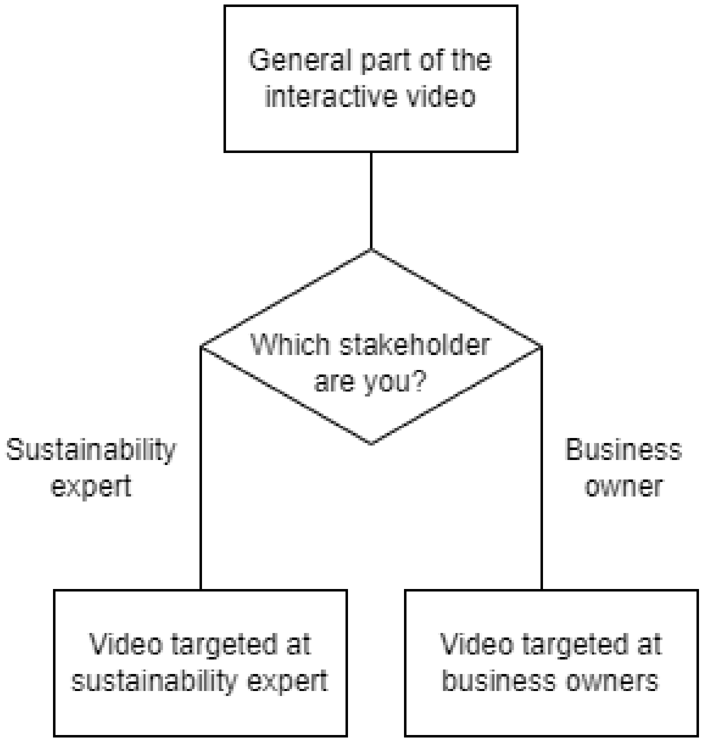


Figure 26. Stucture of the Interactive Video

5.7.1 Final Storyboard General Part

The storyboard of the general part of the video can be seen in figure 27. The numbers in the storyboard match the script that can be found in appendix B: Script General Part.

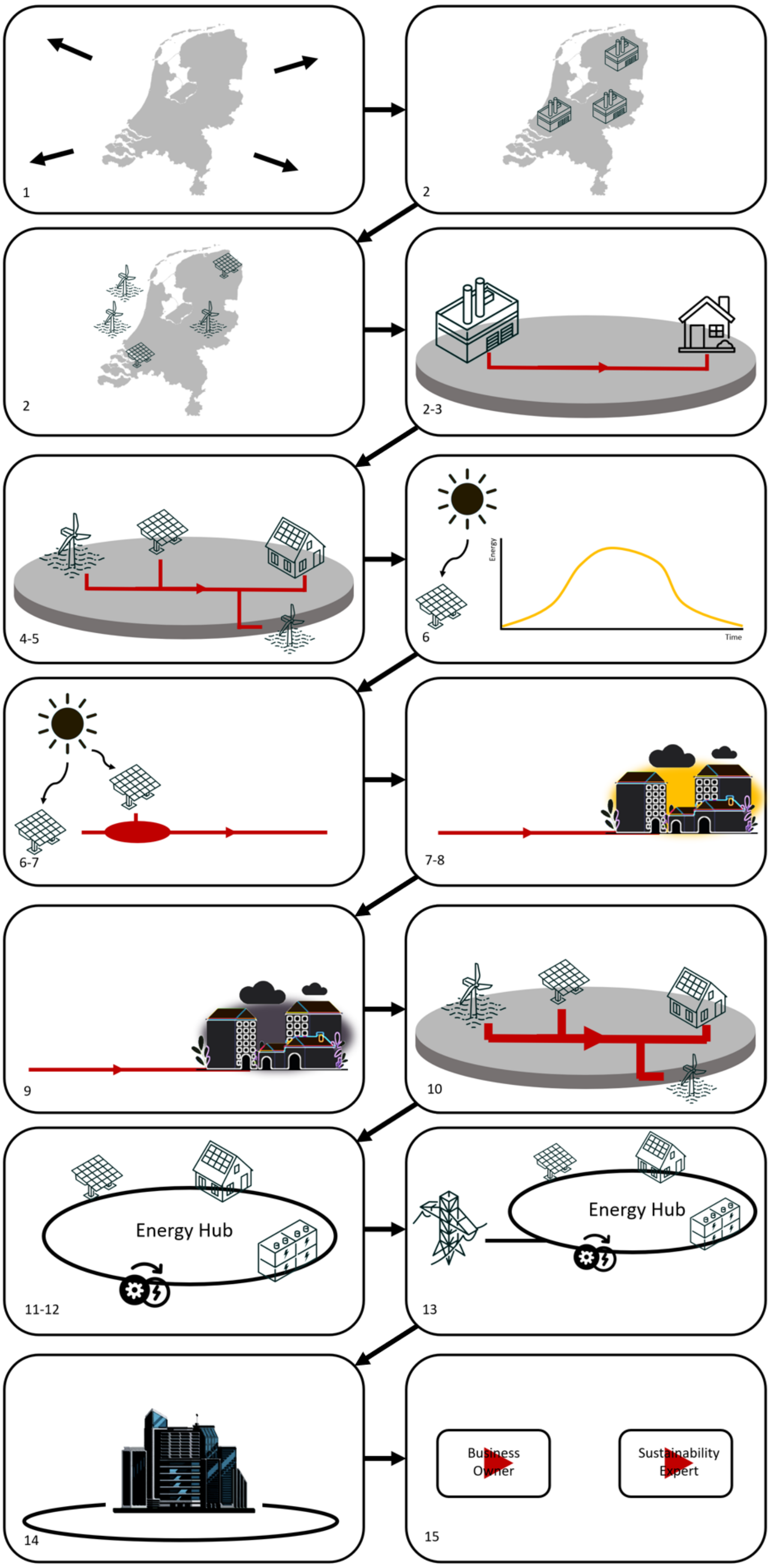


Figure 27. Final storyboard general part

5.7.2 Final Storyline Business Owner Part

The storyboard for the business owners can be seen in figure 28. The numbers in the storyboard match the script that can be found in appendix C: Script Business Owner Part.

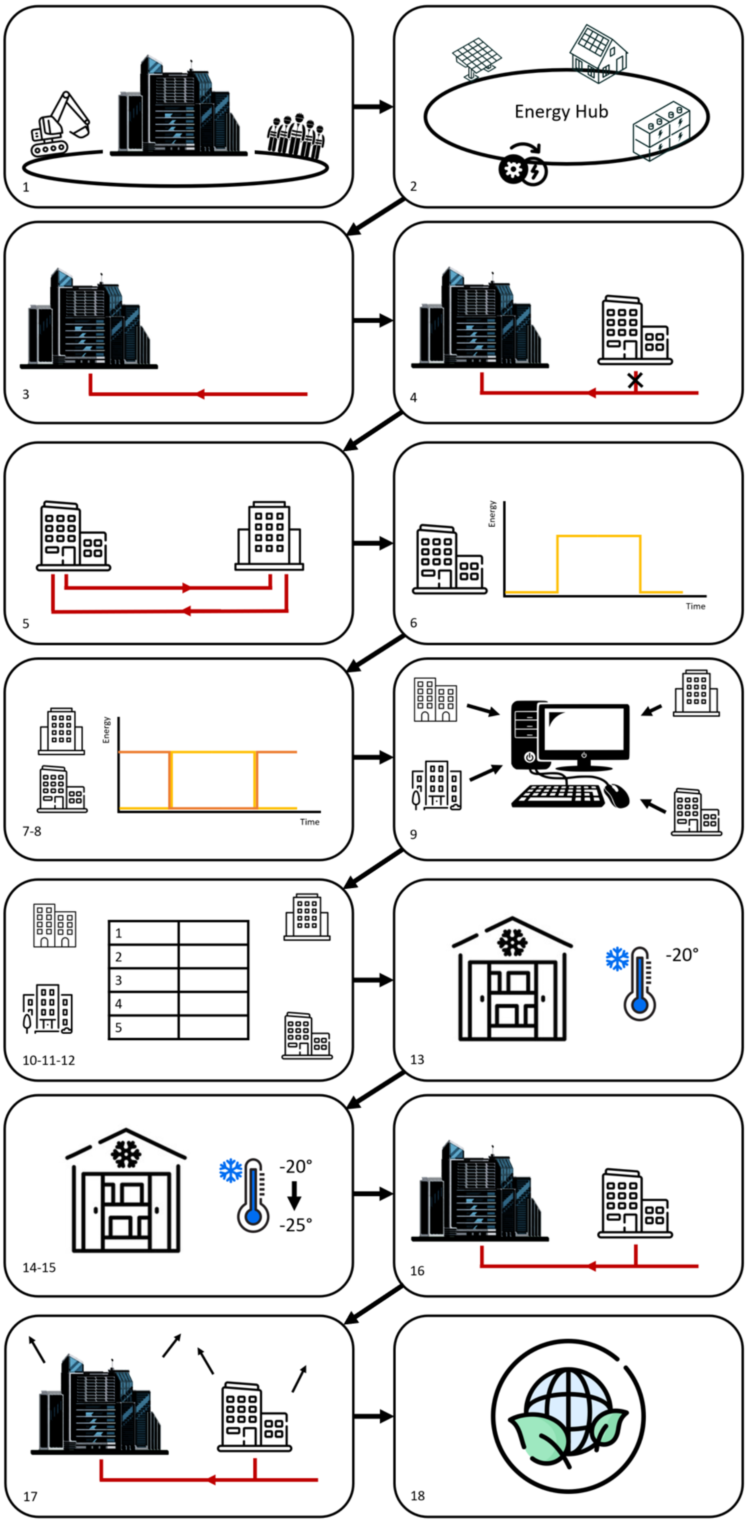


Figure 28. Final storyboard business owner part

5.7.3 Final Storyline Sustainability Expert Part

The storyboard for the sustainability experts can be seen in figure 29. The numbers in the storyboard match the script that can be found in appendix D: Script Sustainability Owner Part.

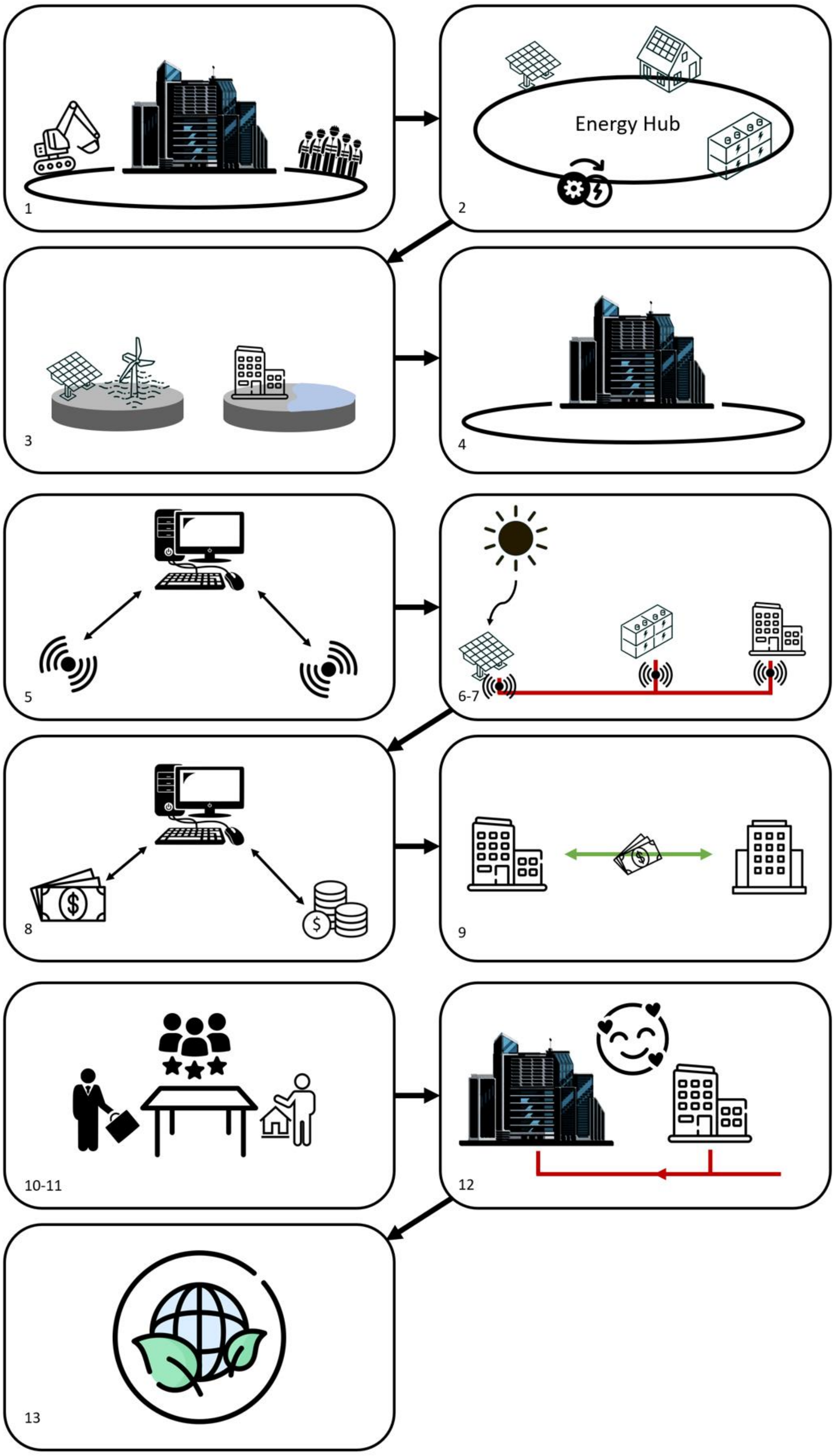


Figure 29. Final storyboard sustainability expert part

Chapter 6: Realisation

This chapter consists of three parts. First the workflow is described, then the tools that were used during the process are discussed. The third part describes how the illustrations and animations are made.

6.1 Workflow

This sub-chapter explains how the videos were made. First it is explained how to go from illustration to animation. Secondly, the two phases of the realisation are explained and what was done in these two phases.

6.1.1 From illustration to animation

The illustrations for the video are made in Adobe Illustrator 2022 [76]. As will be explained in section 6.3.1, the illustrations are very simple, without too many details. Once an illustration was done, all the individual elements of the illustration were grouped. Once grouped, they were exported from Illustrator into a library in the Adobe Creative Cloud [77]. When an illustration gets exported in a library, it is made into one graphical element, which means that the individual parts of the illustration cannot be changed anymore. Libraries can also be opened in Adobe After Effects [78], so graphical elements can easily be imported. The process can also be seen in figure 30.

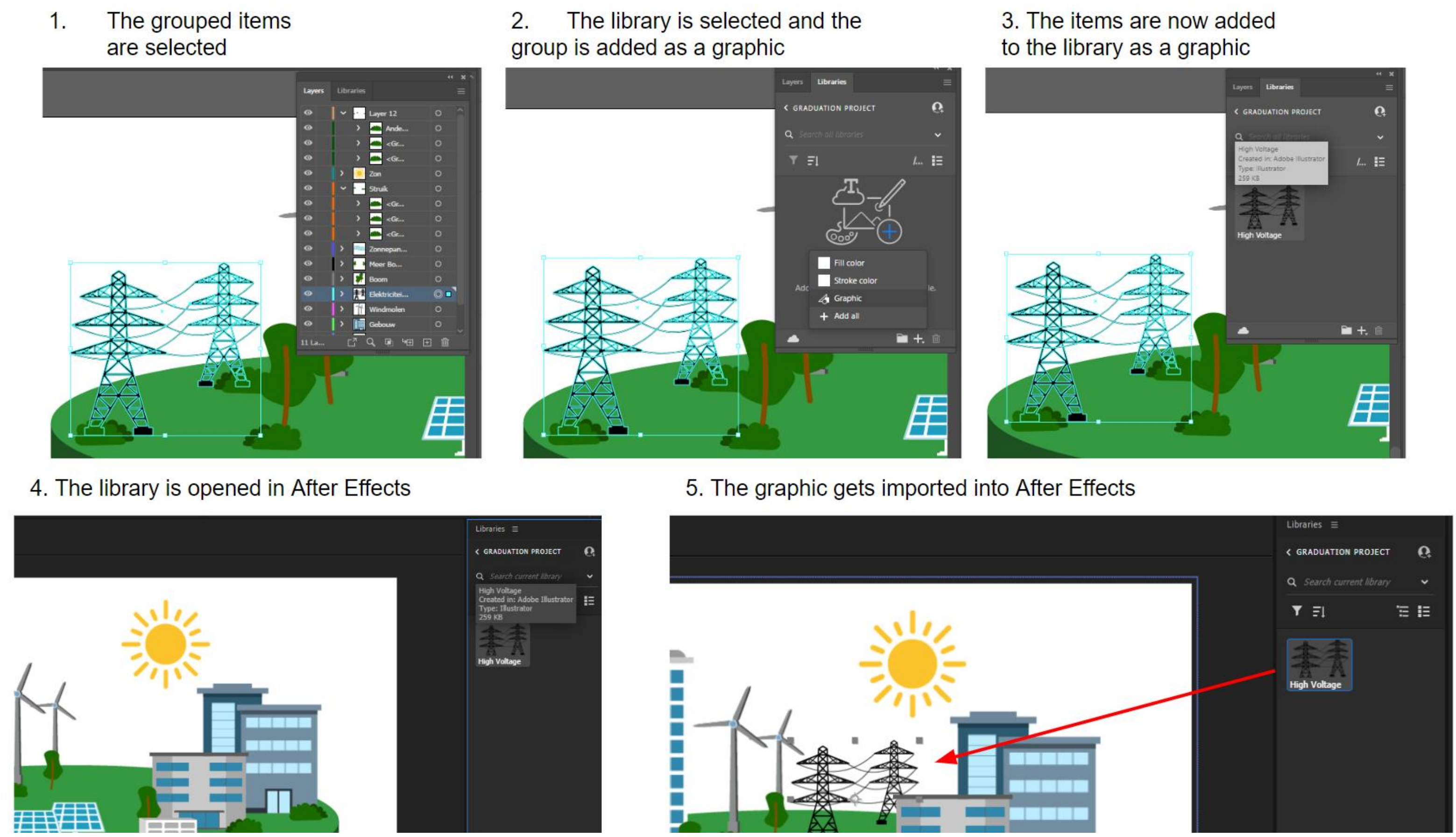


Figure 30. Process of adding graphics to After Effects

Before making any animations, the scripts that can be found in Appendix B, C and D were recorded. The script was recorded first, so that the animations could be timed with the voice-over easily. After the voice-over was recorded, it was uploaded into Adobe After Effects. The audio was cut and edited, to make sure that the volume and pacing was consistent throughout the video.

The voice-over is placed into different ‘compositions’. A composition is a scene with different elements that can be animated. Compositions can be placed into other compositions. This allows for a clean overview of the scenes that are in the video. This was also done for all the three videos that were made. Figure 31 gives an impression how that looks like. The elements that needed to be animated were imported into After Effects through the Creative Cloud.

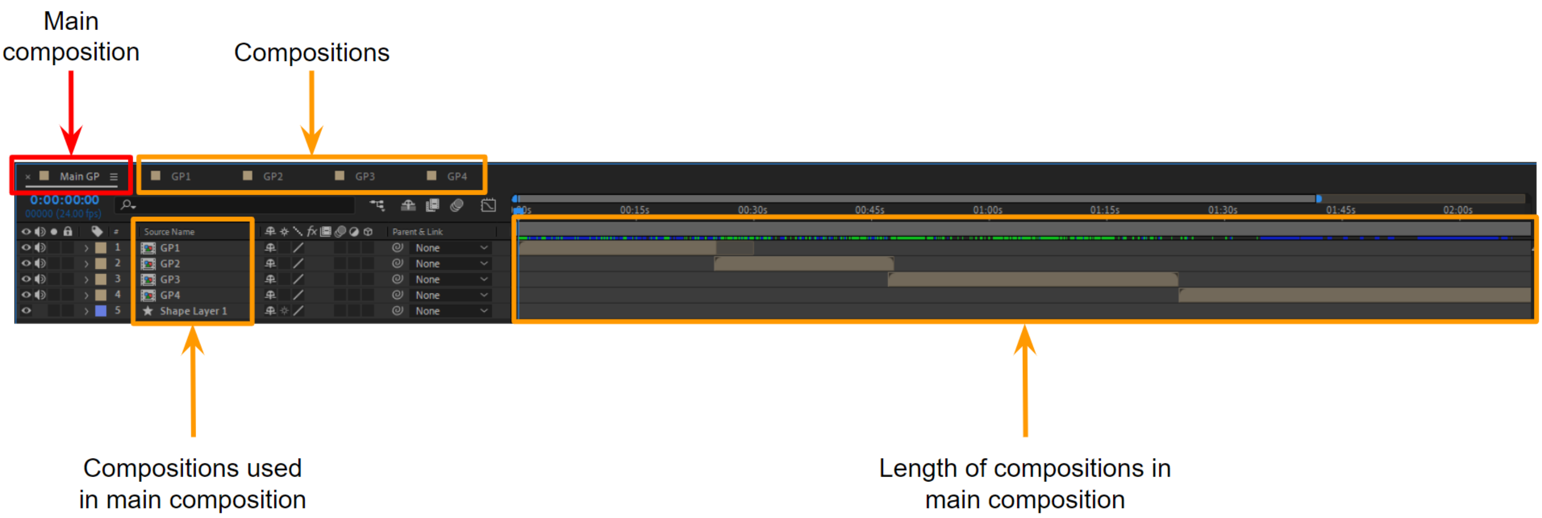


Figure 31. Main composition with other compositions

6.1.2 Phases

It was decided that the client, Enodes, would be involved in the development of the videos. Due to this participatory design approach, the development process was cut into two phases. Enodes would give feedback on the early prototypes of the videos. This would happen in the first phase. The second phase started right after, with processing and implementing the feedback. The second phase also includes adding finishing touches to the videos.

6.1.2.1 First Phase

The main focus of the first phase was to create a very basic prototype that could be shown to the client. This prototype would receive feedback and that feedback would be used in phase two to improve the videos. The animations for this prototype are simple, so that they could easily be changed in the second phase. Animations for this prototype mainly consisted of showing graphics at certain times and positioning graphics at different places throughout the video.

The first evaluation of the video was done at Enodes. The main focus of this evaluation was the coherence of the story and if the visuals fit the story.

The evaluation was done in person, with the use of a questionnaire and a semi-structured interview. The semi-structured interview served as a basis to discuss the answers that were given in the questionnaire.
The first impression of the video is that it is clear and concise. The sentences are well structured and fit the target group of the video. The story is coherent and the visuals are very fitting with the story.

The following points of improvement were given by Enodes in the evaluation. The points are ranked according to their priority. The first points are of high importance, while the later points are of lesser priority.

1. *Demotivating introductions*
   The introduction for the videos for sustainability experts and business owners mentions that implementing an energy hub can be difficult and takes a lot of time. This can be a demotivating introduction, because the first thing that the viewer hears is that it is going to be difficult. This is not inviting to watch the rest of the video and it is not the main message that you want to give to the viewer.
2. *Flexible with energy*
   The key to implementing an energy hub are businesses that are willing to use energy flexibly. This is important to know for sustainability experts and business owners. Currently the video targeted towards sustainability experts does not mention flexibility once, while this is a very important aspect that should be mentioned.
3. *Legalisation*
   Energy hubs are difficult to implement due to regulations in the Netherlands. The videos do not mention legalisation anywhere, while it is a very important aspect that should be mentioned.
4. *Expanding and electrifying*
   The video targeted towards business owners mentions that an energy hub makes it possible for new businesses to join a business park. While this is true, it is not something that is happening a lot. Something that happens more often is the fact that businesses can expand and electrify when they join an energy hub. This should be mentioned.
5. *Role of municipality*
   The video targeted towards sustainability experts does not mention the role that the municipality will have in the implementation of an energy hub. The video should mention what the role of the municipality will be.
6. *Constant energy supply*
   The video mentions that companies need a constant energy supply. However, companies should also be able to handle peaks in energy supply.
7. *Sending invoices*
   The video targeted towards sustainability experts suggests that businesses will send invoices to each other for the fact that they made their energy available. This is not the case. The system will send invoices to the businesses. This should be made clear.
8. *Nature organisations*
   The video targeted towards sustainability experts mentions that nature organisations have an impact on implementing an energy hub. While they might have an impact on the speed of the infrastructure being build, their influence in minimal and could be disregarded. They can be left out.
9. *Cold storage*
   The cold storage that is shown in the video for the business owners has an angled roof and it looks like it has large wooden doors. Cold storages have flat roofs and do not have large wooden doors, so that should be changed in such a way that that is included in the graphic.
10. *Introduction too long*
    One concern was that introduction might be too long. It explains the changing situation in energy supply and the results of this transition. The concern is that this is already known by the stakeholders and that it can be a turn-off to watch the rest of the video, since they already know the information.

11. *Different types of energy storage*
    Energy can be stored in different ways. The first prototype only shows energy storage in a large battery, but energy can also be stored as heat in the ground or in water or it can be converted to hydrogen and stored in tanks.

Based on this feedback the script and the video have been improved. Not all points have been implemented, due to their low priority of modification. Table 6 shows which changes have been implemented and which ones not. Changes to the script can be found in Appendix F.

No. of point of improvement	Implemented?
1.	Yes
2.	Yes
3.	Yes
4.	Yes
5.	Yes
6.	Yes

No. of point of improvement	Implemented?
7.	Yes
8.	Yes
9.	Yes
10.	No
11.	No

Table 6. Points of improvement

6.1.2.2 Second phase
As can be seen in table 6, most of the points have been implemented during the second phase. The script was edited and new part were added. The new scripts can be found in Appendix F: Improved Scripts based on Feedback with Enodes. The new parts were recorded and uploaded to After Effects. The voice-over got edited so that it fit seamlessly with the already existing parts.

Animations were improved in this phase as well. Pop-up, bouncing and trimpaths were added to create smooth animations and to create a more interesting video to watch. How these animations were made can be found in sub-chapter 6.3.2: Animations. All the animations were done, English subtitles were added, so that the video could reach a bigger audience. The last step was to add sound-effects and music. The music that is used is from the YouTube Audio Library [79]. This music is free to use as long as the video is placed on YouTube, which it is. The sound-effects are from zapsplat.com [80] and freesound.org [81] and are also free to use, as long as the site is credited. The music and sound-effects make the videos come more alive and nice to listen to.

The three videos are placed on YouTube. After the video is over, the videos target towards the sustainability experts and business owner pop-up. This is possible with the use of 'end screens' in YouTube.

6.2 Tools
To realise this project, different tools were used. These tools can be divided into three categories: visual tools, auditive tools and interaction.

6.2.1 Visual Tools
To create the visuals that are needed for the animation Adobe Illustrator 2022 has been used. Adobe Illustrator is a graphical design program that allows to create a wide variety of files. For this project it is important to create vector based images, since these kind of images can be scaled infinitely large without the image getting pixelated. Illustrator is able to do this.

The illustrations that were created with Illustrator were imported in Adobe After Effects. After Effects is a program that allows to create visual effects, animations and motion graphics.

Once the animation was finished, it was compiled in Adobe Media Encoder 2023 [82]. Media Encoder allows the user to select the right settings in which they want to have their video exported. For this project a .mp4 file format was chosen, since .mp4 is widely accepted on different platforms if it is shared.

6.2.2 Auditive Tools

The voice-over was recorded with the software Audacity [83] with the use of a Røde microphone [84]. The voice-over was recorded in snippets of 20 seconds, since this would allow for easier editing if changes are needed. The audio was uploaded in After Effects, so that it could be edited where needed to create one coherent voice-over.

6.2.3 Interaction

To make the video interactive, the platform YouTube [85] was used. YouTube allows to embed other videos at the end of a video. The user can click on the options that are presented, and once clicked the new video starts playing. YouTube was chosen since it is easy to use and is easily accessible. Furthermore, content from YouTube can be shared easily on different platforms, such as websites and LinkedIn. This fits with the requirement from Enodes: video can be distributed across different platforms.

6.3 Illustrations, Animations and Interaction

6.3.1 Illustrations

One of the requirements is that the visuals should not overload the viewer with details. For this reason a 'flat' illustration style was chosen. This means that there is not much perspective in the illustrations. Figure 32 shows a scene of the video and how such a flat illustration can look like.

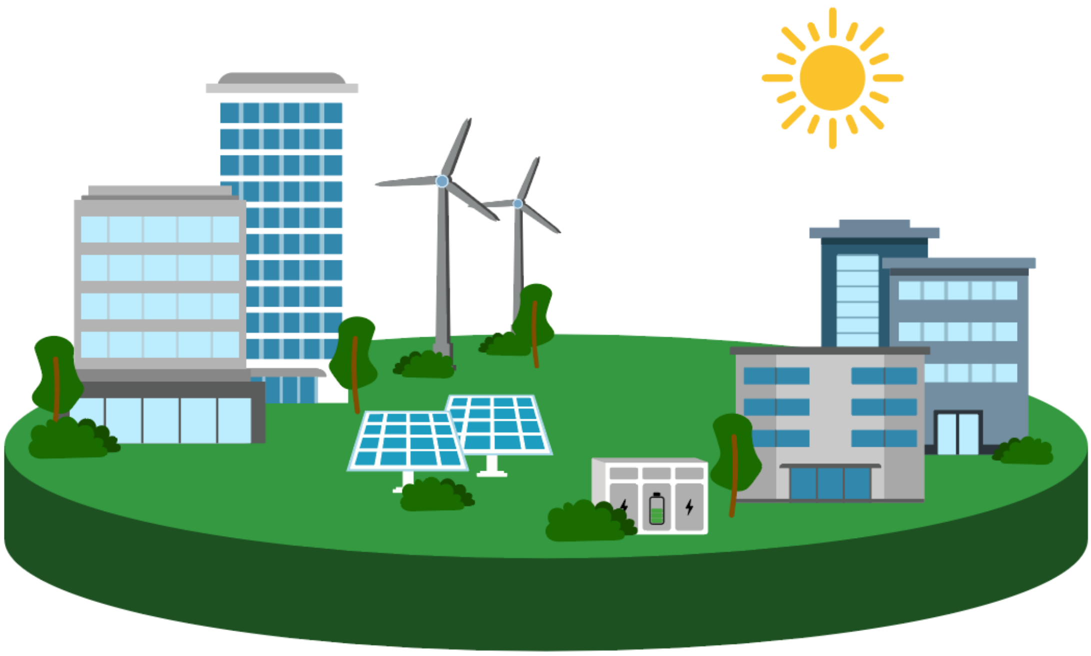


Figure 32. Scene with flat illustrations

Most of the illustrations, such as the buildings, the big energy storage and the solar panels, are made from simple geometric shapes. The shapes have been arranged in such a way that they form a flat illustration. Figure 33 shows one of the buildings that has been used throughout the videos. The left shows the whole illustration and the right shows how the illustration is build out of shapes.

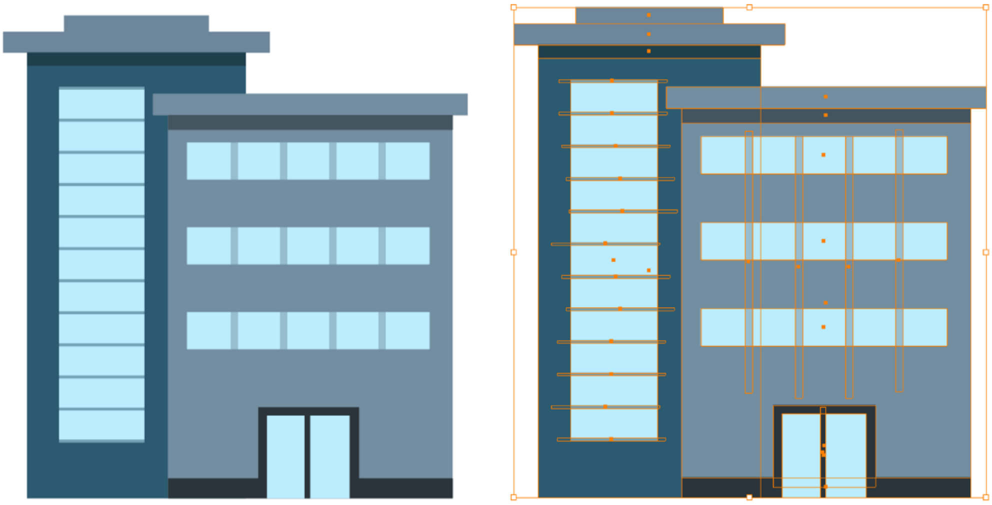


Figure 33. Illustrations of a building

The flat illustration style does not make use of outlines, so most of the illustrations do not have a distinctive outline. Outlines were only used in some cases to create a contrast between colours, for example between a yellow graphic and the white background as shown in figure 34. The outline of the coins and the lightning bolt are a darker shade of yellow to increase the contrast.

Figure 34. Coins and lightning bolt

Most of the illustrations are self-made, which was doable due to the simple graphics. However, for the more complicated illustrations, such as the money or the high voltage pylons, free images from sites such as Vecteezy [86] and Freepik [87] were used.

6.3.2 Animations

There are various kinds of animations throughout the video. These animations are keyframed. With keyframing parameters of objects are set to create transitions and movement. The three most used parameters that were used to create the animations in this video are scale, opacity and place. A few animations and the use of these parameters are explained down below.

6.3.2.1 Pop-up effect

The pop-up effect has been created with the use of the scale parameter. The scale parameter allows the user to scale the graphic as big or as small as they want. Since the illustrations are vector based, it means that they can scale endlessly big, without the image getting pixelated. The pop-up is key framed in five steps. The first step is to have the image scaled down, so it is not visible. Then, it scaled to a bigger size, bigger than the end of the animation. The third step is to scale the image down a tiny bit, then it should be scaled up again, but less big than in step two. Lastly, the illustrations should be scaled to the desired size. This is done in a few frames as shown in figure 35.

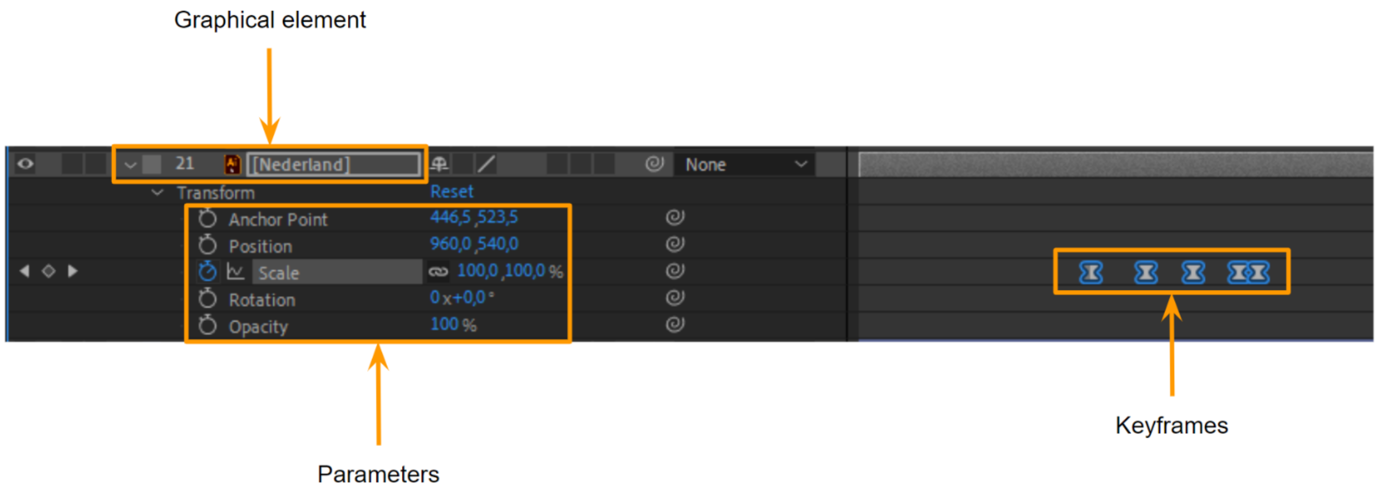


Figure 35. Keyframes to create pop-up effect

6.3.2.2 Bounce effect

There are a few moments in the animation where some of the objects fall into the screen and bounce on their place. For this the parameter 'place' has been used. This effect makes use of keyframes, but also uses an expression. Two keyframes need to be set for this animation; one at the begin position and one at the end position. Figure 36 shows what this looks like. An expression is added to the second key frame. The expression that has been used is created by Dan Ebberts from motionscript.com [88]. The expression is free to use and can be found in Appendix E.

Figure 36. Keyframes with expression to create bouncing effect

6.3.2.3 Blue background

The blue background in the video has not been illustrated, but it has been created in After Effects. For this a new shape layer was created. The shape is placed behind the other illustrations. After that, from 'Effects & Presets' the option 'Turbulence Displace' is applied to the shape. To make the background move, the parameter 'evolve' has been keyframed. This creates the effect of the slow moving blue background. Figure 37 shows a scene where this effect has been applied.

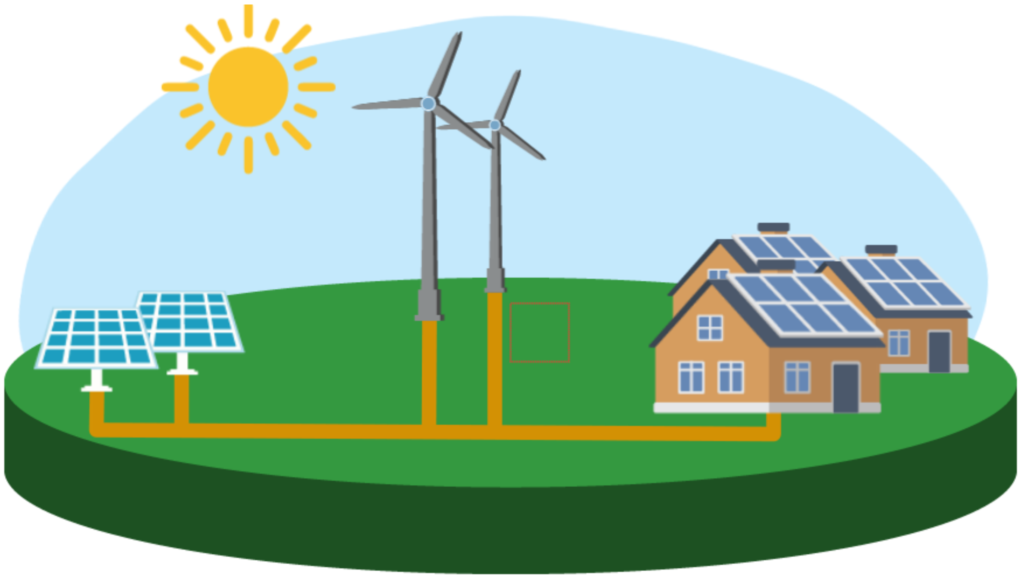


Figure 37. Scene in the video with moving blue background

6.3.2.4 Moving arrows

Throughout the video there are various moments were there are moving arrows. These arrows are mostly used to show energy flows. The moving arrows are made with the use of 'trim paths'. First a line is drawn and a trim path is added to this line. After that, keyframes are set, to indicate when a line should start moving and to indicate when it should stop moving. To create an arrow, a triangle has to be drawn. The path of the line is copied to the arrow, so that they have to follow the same path. Through settings the centre of the triangle follows the beginning of the line. This creates the moving arrows. Figure 38 shows a path that the line follows and how it would look like with an arrowhead.

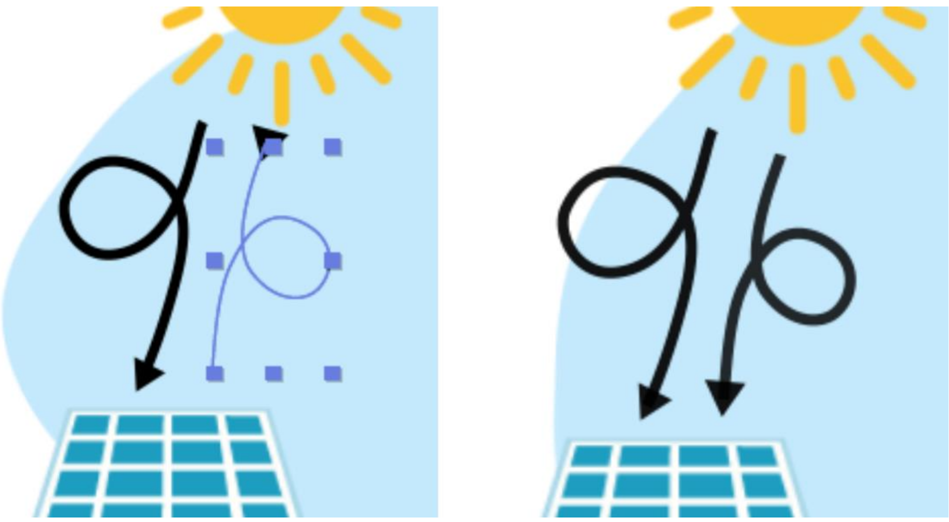


Figure 38. Path of moving arrow

6.3.3 Interaction

Interaction was achieved with the use of 'end screens' in YouTube. End screens can be added to the last 20 seconds of a video. The one that uploads the video can choose what they want to show to their viewer. This can be the latest video, but also whole playlists or a video in specific. To make sure that the viewer sees the right options, the 'recommend a specific video' option was chosen. Figure 39 shows how end screens can be added and how it looks in the video.

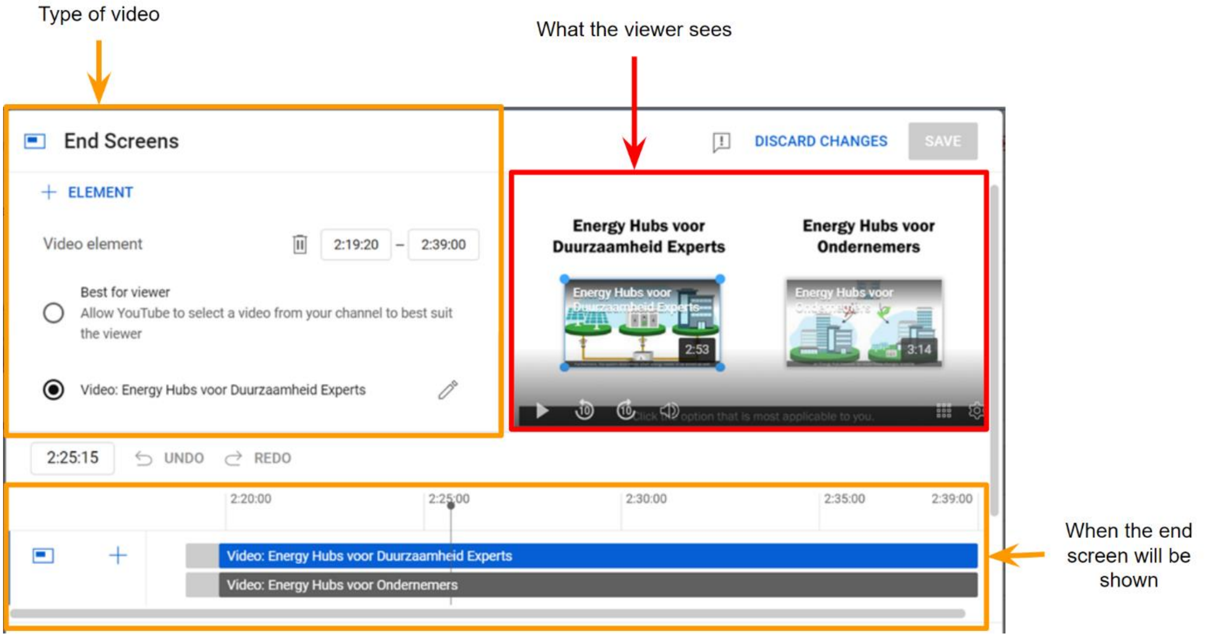


Figure 39. Adding end screens to a YouTube video

The end screens are also added to the videos targeted specifically at the sustainability experts and business owners, to navigate easily through the videos in case they want to watch the general part again or are interested in the other video.

6.4 Functional Requirement Evaluation

After the videos were completed, they were evaluated to see if they meet all the non-functional requirements that were set. Table 7 shows which requirements are met and which are not.

No.	Requirement	Priority	Implemented?
1	The voice-over in the video speaks Dutch	Must	Yes
2	The videos have English subtitles	Must	Yes
3	When two videos are played after each other, they have a maximum length of five minutes	Must	Partially yes
4	The videos can be distributed online	Must	Yes
5	The videos can be distributed across different platforms on which Enodes is active	Must	Yes
6	The introduction video explains net congestion	Must	Yes
7	The video explains what the energy transition is	Must	Yes
8	The introduction video explains that net congestion is caused by renewable energy source that are not flexible with energy production	Must	Yes
9	The introduction video emphasises that net congestion is caused by the energy transition	Must	Yes

10	The introduction video explains the new and old situation of the Dutch electricity grid (central -> decentral production)	Must	Yes
11	The introduction video explains smart energy hubs	Must	Yes
12	There is a video directed towards sustainability experts	Must	Yes
13	The sustainability expert video explains that tight cooperation between stakeholders is required when implementing an energy hub	Must	Yes
14	The sustainability expert video explains that a financial system is needed for an energy hub	Must	Yes
15	The sustainability expert video explains that an automatic management system is needed in an energy hub	Must	Yes
16	There is a video directed towards business owners	Must	Yes
17	The business owner video explains that businesses can still carry out their activities when an energy hub is going to be implemented	Must	Yes
18	The business owner video explains that some processes will be done during the night	Must	Yes
19	The business owner video explains that businesses will need to cooperate with each other when an energy hub will be implemented	Must	Yes
20	The video has background music	Should	Yes
21	The introduction video explains that net congestion does not cause damage to the grid	Could	No
22	The introduction video explains that net congestion is mainly an administrative problem	Could	No
23	The introduction video explains smart grids	Could	No
24	The video has sound effects	Could	Yes

Table 6. Evaluation of functional requirements

The table shows that all the requirements that had the highest priority have been fully or partially implemented. Requirement 3 is partially implemented. When two videos are played after each other, the total time is around 6 minutes. However, this time includes the credit scene and the time to make the choice which stakeholder the viewer is interested in. When these are excluded, the total watch time is around 5 minutes. Requirements with a lower priority, requirement 21, 22, and 23 have not been implemented in the project. These requirements were all related to the script and had a lower priority, since a coherent story could still be told if they were not included in the script. If the videos were not too long, these requirements could have been included to create a more complete story. Since all the requirements marked as ‘must’ have been implemented, it can be said that the realisation phase was successful.

6.4.1 Points of improvement

Based on the points in section 6.1.2.1 and the evaluation of the functional requirements, points of improvement be identified.

As stated in section 6.1.2.1, two suggestions have not been implemented. First, the introduction is quite long in regard of explaining the problem of the Dutch electricity grid, the energy transition and net congestion. The clients of Enodes are probably already aware of these problems, that is why they are a client of Enodes in the first place. To improve this, the introduction of the first video could be shortened. The energy transition and net congestion can be described in one sentence. This would also leave some more room to explain Energy Hubs in a bit more detail.

If the introduction of the first video is made shorter, there is room to explain requirement 21, 22 and 23. Based on conversations with Enodes, these requirements got a low priority, since a coherent story could still be formed without them. If the introduction is made shorter, it would be a perfect opportunity to implement at least one of these requirements. For this, it would be needed to edit the script and record the new script. On top of that, new illustrations and animations need to be made.

Another point of improvement mentioned in section 6.1.2.1, is to include other types of energy storage. Right now, only a large battery is shown, but energy can also be stored in heat or in H_2. These types of energy storage should be shown, since they are an important part in the energy transition. To improve this, the text should be edited, so it mentions other storage types as well. Furthermore, new illustrations should be made for the storages and animations would need to be added as well.

Chapter 7: User Evaluation

This chapter focuses on everything surrounding the user evaluation. First, the evaluation set-up is described. Then the results of the user evaluation are discussed. The user evaluation was done with a sustainability expert, a business owner and Enodes. Based on these evaluations the non-functional requirements are evaluated. The chapter is closed with a conclusion.

7.1 Evaluation Set-up

The evaluations were done online with the use of Microsoft Teams [89]. The sessions took around 15 to 30 minutes. Before the evaluations, the information letter was sent to the participants, so they knew what to expect. The evaluation sessions started with a short introduction, where the aim of the project and evaluation was explained. After that, the consent form was given.

The evaluation consisted of two parts: first, the three videos were shown, followed by a questionnaire. This questionnaire consisted of three parts which corresponded with the videos.

The questionnaire is divided into three parts, with each part dedicated to one of the videos. The questions and the answers can be found in Appendix G: Questionnaire Evaluation. The questions for the introduction video are mandatory, while the questions for the video for the sustainability expert or business owner are not. After each video there is an opportunity for the participant to fill in the questionnaire. The questions are answered with the use of a Likert scale, with the answers ranging from strongly disagree to strongly agree.

The aim of the semi-structured interview was to get additional insight into the answers that were given in the questionnaire. When some answers scored quite low, it was discussed why the video scored low for that question. After discussing the answers, other questions, such as first impressions and improvement points, were asked. The interviews were recorded with permission of the participants.

7.2 Evaluation Results

The user evaluation was conducted with a sustainability expert of a municipality, a business owner on a business park and Enodes, since they are the target group and the client of the videos. A summary of the results of the questionnaire and the semi-structured interview are discussed in section 7.2.1 and 7.2.2. It is important to note that all three participants already had prior knowledge about energy hubs and how they can be implemented.

7.2.1 Results Questionnaire

The questionnaire consisted of questions regarding the information provided, the visuals and animations, and the understandability of the videos. The questions and the answers can be found in Appendix G: Questionnaire Evaluation.

The sustainability expert did not fill in the whole questionnaire, because they thought they were not allowed to, even though nothing about that was stated in the information letter or consent form. All other questions have been filled in by all three the participants. While 3 participants are not enough to apply statistical analyses or to draw statistically significant conclusions, a questionnaire can still provide valuable insights and can be used to evaluate the user requirements.

The following points became apparent from the questionnaire:

- Generally, all three the participants filled in the questions quite similarly.
- The questions regarding the understandability and visuals and animations score generally a bit higher than the questions regarding the information provided in the videos. In section 7.2. it is explained why.
- The question about the explanation of the energy transition was answered with three different answers. While the business owner and the sustainability expert felt like it was explained pretty well, Enodes was neutral about the explanation
- The questions that asked if the introduction video was informative received three different answers as well. While Enodes and the business owner did feel like the video was informative, the sustainability expert was neutral about it.
- The sub-titles were perceived very differently. While the business owner and the sustainability expert did not feel like the sub-titles distracted from the video, Enodes did feel like they were.
- It became clear that Enodes did feel like advantages of an energy hub were clearly explained in the video targeted towards sustainability experts, while the business owner and the sustainability expert felt neutral about it.

7.2.2 Results Interviews

The interviews were conducted to get additional insight into the answers given in the questionnaire as well as to ask some other questions regarding the videos. Like the results of the questionnaire, the topics of the interview can be divided into the information provided, the visuals and animations, and the understandability of the videos. The feedback that was given is summarised per topic.

7.2.2.1 Clarity of the videos

The questionnaire already showed that the questions regarding the clarity of the videos scored high. The first thing that the sustainability expert pointed is that the language as well as the voice-over is very clear. The language fits the target audience: it is complex enough that the audience can understand it, but not too complex, since difficult terms such as energy hubs or net congestion, are still explained. The business expert mentioned that the voice-over was clear and calm and very easy to follow. Furthermore, it was mentioned that that the task that society has to face in the energy transition is clear.
The goal of the video however, was not perceived as very clear by the sustainability expert, because it was unclear who made the video. It could have been Enodes, the government or the net provider for example. Because this was unclear, the goal of the video became unclear. This raised the question if the video was supposed to be used for commercial purposes or just to provide information.

7.2.2.2 Visuals and animations

The first impression of the sustainability expert of the video was that it looked semi-professional and that the animations were nice and kept the attention. The business owner said that the visuals looked nice and that the style looked consistent throughout the videos. When asked why he did not give rate any of the questions about visuals higher than 4 four, it was said that 5 (strongly agree) is only meant for perfection, which is difficult to reach. They also mentioned that some parts of the video felt a bit static, meaning that there were little animations in some points of the videos.
Enodes also mentioned that the visuals looked nice and coherent and that the animations fit with the voice-over. It was also mentioned that the part about net congestion in the introduction video could be visualised with more urgency. Currently, the video shows energy accumulating in a ball when net congestion is mentioned. This could’ve been more exaggerated, for example with the use of the

colour red and with energy getting stuck in the ball, to show that the problem of net congestion is more urgent.

7.2.2.3 Information in the videos

All of the participants said that the story told in the videos is clear and well structured. The sustainability expert said that it is a short and concise way to explain energy hubs and net congestion in a fun approach. It is a good strategy to show this video to people who do not know about this topic, instead of trying to explain the concept in 15 minutes. They also pointed out that the second video was more informative than the first video. This also lines up with the answers that were given by the sustainability expert in the questionnaire. They said they felt that the introduction video was less informative, since they already knew about the energy transition and the cause of net congestion. That also resulted in them saying that the length of the introduction video was a bit too long.

The business owner however, said that the videos were informative, but that it really depends on the target group. They felt like it was not informative for them, since they already had knowledge about the topic, but that it could be very informative for viewers who do not have knowledge about energy hubs yet. The business owner also mentioned that they felt like the urgency was missing in the videos. It was said that the videos could use a bit more 'warning' incorporated in them, since it now feels like a solution that is just 'out there' and that there is not an urgent need for it.

While all of the participants that the videos were clear, they also all said that there is some information missing in some areas. The sustainability expert and Enodes pointed out that the introduction video only mentions net congestion as a cause of too much energy production, while net congestion can also be caused by a higher demand for energy consumption. Since both ways of net congestion are currently occurring and are an urgent matter, they should be mentioned both. It was suggested that this should also be mentioned in the video. Furthermore, they both pointed out that the current video only shows a large battery as an energy storage, while energy can be stored in many different ways. Lastly, Enodes and the business owner mentioned that the videos only show wind and solar power as renewable energy sources, while H_2 or biomass will play a big role in the future as well. They suggested that these other sources should be mentioned at least once somewhere in the videos.

7.2.3 Evaluation results overview

The results of the whole user evaluation is summarised in table 8.

Topic	Results
Clarity of the videos	The videos were thought to be very clear. The language fits the target audience; not too simple not too difficult. The voice-over is clear and understandable. The goal of the videos was for one of the stakeholders not very clear.
Visuals and animations	The visuals are clear and stay coherent throughout the videos. The animations fit with the voice-over and the story is clear. The urgency of the problem was missing in some places in the videos.
Information in the videos	All important information to tell a coherent and understandable story is included in the videos. It was thought that the information is more useful for an audience that does not have knowledge about energy hubs yet. Some information regarding net congestion, energy sources and energy storage was missing.

Table 8. Results overview

7.3 Evaluation of Non-functional Requirements

The non-functional requirements are evaluated based on the answers that were given in the questionnaire and the interviews. Table 9 shows which requirements are met based on the user evaluation.

No.	Requirement	Priority	Requirement met?
1	The video explains terms that could be unknown to the audience	Must	Yes
2	The video is informative	Must	Partially yes
3	The video stays truthful	Must	Partially yes
4	It is clear to the viewer that there are two other videos they can watch after the introduction video	Must	Yes
5	Hierarchy is implemented to create visual emphasis	Should	Yes
6	Simple visuals are used	Should	Yes
7	Balance is used to create structure and stability in the visuals	Should	Yes
8	When graphs are used, they should be properly explained	Should	Yes
9	The language used throughout the video is appropriate for the target audience	Should	Yes
10	The video makes use of narrative storytelling	Should	Yes
11	The video is coherent	Should	Yes
12	The video looks 'neutral'	Should	Yes
13	The video invites the stakeholders to watch	Could	Yes

Table 9. Evaluation of non-functional requirements

The table shows that all the requirements have been met, except for the requirements regarding the video being informative and truthful. From the evaluations it became clear that the information in the videos were informative and truthful, but that there was some information missing. As pointed out by the participants, different kinds of energy storage are missing, while they will be implemented more and more in the future. In addition to that, it was pointed out that energy can be produced in more ways than just with the use of solar and wind power. On top of that, it was mentioned that the video currently only shows net congestions as a result of too much energy production, while net congestion can also occur as a result of a higher demand for consumption. This means that the story told in the video is true, however part of the truth is missing, resulting in a partially yes for requirement nr. 3.

7.4 Conclusion User Evaluation

Overall, the videos were perceived as an useful tool to explain Energy Hubs and what is needed to implement a hub. The story is clear and the language that is used in the videos is appropriate for the target audience. The visuals and animations are coherent and clear and fit well with the voice-over. All the important elements that are needed to create a coherent story are implemented. The points of improvement mainly lie within the area of the information in the videos. All three of the stakeholders mentioned that the video only shows net congestion as a result of too much energy production, while it can also be a result of a too high of a demand for energy consumption. Furthermore, both Enodes and the business owner pointed out that other renewable energy sources, such as H_2 or biomass, will play a big role in the energy production in the future. The video mentions only solar and wind parks. In addition to that, both Enodes and the sustainability expert pointed out that the video only shows large batteries as storage options, while energy can also be stored in the ground or water. Furthermore, both Enodes and the business owner felt that the urgency of the situation was missing in the video. Lastly, it was mentioned by the business owner as well as the sustainability expert, that the videos did not feel very informative, especially the introduction video, since all the information was already known to them. However, the video is targeted to the clients of Enodes who do not have prior knowledge about energy hubs. The business owner mentioned that it could be a very useful tool to explain energy hubs to an audience without the prior knowledge, which is exactly the intention.

This makes that all the non-functional requirements have been fully met, except requirement 2 and 3 regarding the information and truthfulness of the videos.

Even with all these points, all stakeholders considered the video a good tool that informed the viewer about energy hubs.

Chapter 8: Conclusion

By commission of Enodes, this research aimed to answer the question: "How to inform an audience about the use of energy hubs and smart grids in the energy transition on the Dutch energy grid to close the knowledge gap between Enodes and their clients through the use of a visual tool?" Since energy hubs and smart grids are a very complex concepts to grasp, it is important that they explained quick and clear to the clients of Enodes.

To answer this question, three sub-research questions were formulated to get a better understanding of the problem.

"How do Smart Grids and Smart Energy Hubs work?"
A smart grid is an electricity network that incorporates digital technology that is used to supply electricity to consumers via two-way digital communication between the utility and its customers. It makes use of components such as sensors and communication systems to operate. A smart grid can be applied locally, regionally and nationally. A smart energy hub is a self-sustained energy area where energy is produced, converted, stored and consumed. An energy hub makes use of a smart grid to ensure that these processes work together seamlessly.

"How can SGs and SEHs help with the energy transition on the Dutch electricity grid and at the same time provide more flexibility on the Dutch electricity grid?"
As said before, a SEH makes use of a SG to function. This means that smart systems are integrated in an energy hub. While an energy hub is still connected to the national energy grid, it does not make use of this connection when it is not needed. This means less energy transport on the grid, which lowers the chances of net congestion occurring and leaves more room for new connections to the grid. This way more flexibility is created on the Dutch electricity grid.

"What factors are important when creating an informative message about SEHs and SGs for an audience through the use of visualisations?"
Research showed that many factors have a role in communicating a complex concept to an audience. Graphic design elements are used to create a certain aesthetic or to convey a message. While graphic design principles can be applied to create visually pleasing visuals that can easily be navigated. Data visualisation principles can be applied to make sure that complex data is understood. Applying graphical elements and principles as well as data visualisation principles help to create a message that is easily understood by an audience.
Next to visual communication principles, communication principles can be applied as well. It is important to know the audience that will be addressed. Getting to know an audience can be done by defining them with the use of characteristics, such as demographics, psychographics and prior knowledge. Effective communication is done with appropriate use of language, narrative storytelling and understanding how to keep the attention.

The Creative Technology Design Method was used in this project, to ensure that chances could be made throughout the whole development process. A participatory design approach was used by having conversations with Enodes throughout the whole development process. This made sure that all the wishes and concerns of the users are taken into account in every step of the process.

An interactive video was developed, that provides reasoning why energy hubs are needed, what energy hubs are and what is important to know for the main clients of Enodes. The interactive video consists of an introduction video, where smart hubs are explained. After the introduction video the viewer is able to choose which stakeholder they are; a sustainability expert or a business owner and click on the corresponding video. These videos explain what is important to know for the client of

Enodes if an energy hub will be implemented.
While research also focussed on smart grids, since they are a fundamental part of energy hubs, it was decided not to include smart grids in the introduction video, since the video would become too long. Instead, smart systems are mentioned in the two videos targeted towards sustainability experts and business owners.

The videos were evaluated with the three most important end users; Enodes, a sustainability expert and a business owner. From the evaluation it became clear that the videos are clear, understandable and use the appropriate language. The visuals are coherent and the animations fit well with the voice-over. The story is coherent and all the important information that the viewer should know are incorporated. In regard of the content of the video, improvements are suggested to make the story more informative and truthful.

From this it can be concluded that the interactive video is a useful tool to inform the clients of Enodes about energy hubs and how they can be implemented. This means that the videos can be used by Enodes to effectively inform they clients in a quick and easy way.

To answer the question: “How to inform an audience about the use of energy hubs and smart grids in the energy transition on the Dutch energy grid to close the knowledge gap between Enodes and their clients through the use of a visual tool?” With the use of an interactive video that provides a clear message about energy hubs and the energy transition by making use of communication principles and visual communication principles.

Chapter 9: Future Work

The interactive video is a promising tool that explains energy hubs and what is important to know for the clients of Enodes if they are to be implemented. The videos form a great basis that can be developed further in future research.

First of all, it would be really interesting to have an evaluation with stakeholders that do not have knowledge about energy hubs beforehand. The evaluation was done with stakeholders that already have knowledge about energy hubs and this had a large influence on how 'informative' they thought the introduction video was. Testing the interactive video with the stakeholders without prior knowledge can be done, if reached out on time to do the evaluation. On top of that, it would also add value if the group of participants is larger. This way, statistical analyses could be used to analyse the answers given in the questionnaire to get a clear interpretation on the answers that are given.

On top of that, the contents of the videos could be developed further. Currently, the videos contain all the content that is needed to tell a coherent story, but, as said in the evaluation, there is some information that can be added to make the story complete. For example, the video only mentions net congestion as a result of too much energy production, while it can also be a result of a high consumption demand. Another example could be the way energy is stored. Currently, the videos only show that energy can be stored in large batteries, but energy can also be stored in H_2 or as heat in the ground. Adding all this information, without making the videos much longer, so that they stay within the time limit, is an interesting area that could be researched further.

Furthermore, it would be interesting to look into other types of interaction that could be implemented in the video. Currently, the interaction is done with the use of 'end screens' in YouTube. This type of interaction is very limited, since only certain videos or playlists can be recommended. It would be interesting to see what other tools can be used to create interaction in videos and how these interactions could look like, with the restraints that were set in the requirements. Since the video should be able to be distributed online by Enodes.

Lastly, in chapter 4, two final concepts were presented: a podcast and the interactive video. The interactive video was chosen, because there simply were not enough time and resources to organise a podcast. Should in further research be chosen to make a podcast, a few things should be considered. First, it is important to know which groups are going to be involved in the podcast. People such as sustainability experts, business owners and representatives of grid providers should be contacted far in advance given their often full agendas. Second, a podcast requires space and a lot of equipment. It is important to consider where the podcast will be done and how to get all the equipment that is needed. It might be needed to reach out to external parties that have the space, equipment and expertise required for a podcast.

Sources

[1] Centraal Bureau Statistiek , “Hernieuwbare elektriciteit; productie en vermogen,” *https://opendata.cbs.nl/#/CBS/nl/*, Mar. 06, 2023. https://opendata.cbs.nl/#/CBS/nl/dataset/82610NED/table (accessed Mar. 19, 2023).

[2] J. C. C. M. Huijben and G. P. J. Verbong, “Breakthrough without subsidies? PV business model experiments in the Netherlands,” *Energy Policy*, vol. 56, pp. 362–370, May 2013, doi: https://doi.org/10.1016/j.enpol.2012.12.073.

[3] “Klimaatakkoord,” Jun. 2019. Available: https://www.klimaatakkoord.nl/documenten/publicaties/2019/06/28/klimaatakkoord

[4] Rijksdienst voor Ondernemend Nederland, “Netcapaciteit en netcongestie,” *RVO.nl*, Sep. 09, 2021. https://www.rvo.nl/onderwerpen/zonne-energie/netcapaciteit (accessed Mar. 19, 2023).

[5] Netbeheer Nederland, “Basisinformatie over energie-infrastructuur ,” Netbeer Nederland, https://www.netbeheernederland.nl/, May 2019. Available: https://www.netbeheernederland.nl/_upload/Files/Basisdocument_over_energie-infrastructuur_143.pdf

[6] “Homepage NL,” *TenneT*. https://www.tennet.eu/nl (accessed Mar. 19, 2023).

[7] U.S. Department of Energy, “What is the Smart Grid?,” *Smartgrid.gov*, 2019. https://www.smartgrid.gov/the_smart_grid/smart_grid.html

[8] “What is a Smart Grid?,” *Techopedia.com*, Jan. 26, 2017. https://www.techopedia.com/definition/692/smart-grid

[9] Topsector Energie, “Energy Hubs,” Topsector Energie, Dec. 2021. Available: https://www.topsectorenergie.nl/sites/default/files/uploads/Systeemintegratie/TSE_SI_Energy_Hubs_202112.pdf

[10] “Home Enodes,” *Enodes*. https://enodes.nl/

[11] Energie in Nederland, “2: Inrichting van het energiesysteem,” *Energie in Nederland*. https://www.energieinnederland.nl/zwe/energiesysteem/ (accessed Mar. 30, 2023).

[12] “1-faseaansluiting, 3-fasenaansluiting en krachtstroom | Enexis Netbeheer,” *www.enexis.nl*. https://www.enexis.nl/aansluitingen/wat-is-het-verschil-tussen-een-1-en-3-fase-aansluiting (accessed Mar. 30, 2023).

[13] Netbeheer Nederland, *2022 Electriciteit*. 2022. [Online Image]. Available: https://www.netbeheernederland.nl/_contentediting/files/files/EN_Elektriciteit-2022-Legenda.pdf

[14] D. Oosterveer, “Netcongestie: het stroomnet is vol en zonnepanelen vallen uit,” *Doe Duurzaam*, Nov. 09, 2022. https://doe-duurzaam.nl/2022/11/09/netcongestie/ (accessed Mar. 30, 2023).

[15] Nieuwe Energie Overijssel, “Netcongestie,” *Nieuwe Energie Overijssel*. https://www.nieuweenergieoverijssel.nl/Kennisplein-item/netcongestie/ (accessed Mar. 30, 2023).

[16] Netbeheer Nederland, “Capaciteitskaart elektriciteitsnet,” Netbeheer Nederland, Mar. 30, 2023. Available: https://capaciteitskaart.netbeheernederland.nl/

[17] Netbeheer Nederland, “Samen sneller het net op,” Netbeheer Nederland, Jan. 2022. Available: https://www.netbeheernederland.nl/_upload/Files/Samen_sneller_het_net_op_-_Actieteam_Netcapaciteit_28_01_2022_240.pdf

[18] S. Leavey, “Mitigating Power Fluctuations from Renewable Energy Sources,” Mar. 2012. Available: https://www.physics.gla.ac.uk/personal/shild/results/report_sean.pdf

[19] APG, “Wanneer kunnen we wind- en zonne-energie gaan opslaan?,” *APG*, Apr. 28, 2022. https://apg.nl/publicatie/wanneer-kunnen-we-wind-en-zonne-energie-gaan-opslaan/ (accessed Mar. 30, 2023).

[20] Solarfields, “Dynamische energieopslag zonnepark wordt werkelijkheid,” *Solarfields*, Oct. 28, 2022. https://www.solarfields.nl/nieuws/dynamische-energieopslag/ (accessed Mar. 30, 2023).

[21] Milieu Centraal, “Thuisbatterij: zonne-energie opslaan,” *www.milieucentraal.nl*. https://www.milieucentraal.nl/energie-besparen/zonnepanelen/thuisbatterij-zonne-energie-opslaan/#:~:text=Kun%20je%20zonne%2Denergie%20opslaan (accessed Mar. 30, 2023).

[22] M. van E. Z. en Klimaat, “Opslag energie: technisch veel mogelijk, maar regelgeving is barrière - Nieuwsbericht - Klimaatakkoord,” *www.klimaatakkoord.nl*, Apr. 01, 2022. https://www.klimaatakkoord.nl/actueel/nieuws/2022/04/01/webinar-opslag

[23] T. Flick and J. Morehouse, *Smart Grid: What Is It?* Syngress, 2010, pp. 1–18.

[24] “Smart Grid Grants,” *Energy.gov*. https://www.energy.gov/gdo/smart-grid-grants (accessed Mar. 30, 2023).

[25] International Energy Agency, “Technology Roadmap,” International Energy Agency, 2011. Available: https://iea.blob.core.windows.net/assets/fe14d871-ebcb-47d3-8582-b3a6be3662ba/smartgrids_roadmap.pdf

[26] M. Kuzlu, M. Pipattanasomporn, and S. Rahman, “Communication network requirements for major smart grid applications in HAN, NAN and WAN,” *Computer Networks*, vol. 67, pp. 74–88, Jul. 2014, doi: https://doi.org/10.1016/j.comnet.2014.03.029.

[27] F. E. Abrahamsen, Y. Ai, and M. Cheffena, “Communication Technologies for Smart Grid: A Comprehensive Survey,” *Sensors*, vol. 21, no. 23, p. 8087, Dec. 2021, doi: https://doi.org/10.3390/s21238087.

[28] R. Kappagantu and S. A. Daniel, “Challenges and issues of smart grid implementation: A case of Indian scenario,” *Journal of Electrical Systems and Information Technology*, vol. 5, no. 3, pp. 453–467, Dec. 2018, doi: https://doi.org/10.1016/j.jesit.2018.01.002.

[29] V. Gungor *et al.*, “Smart Grid and Smart Homes: Key Players and Pilot Projects,” *IEEE Industrial Electronics Magazine*, vol. 6, no. 4, pp. 18–34, Dec. 2012, doi: https://doi.org/10.1109/mie.2012.2207489.

[30] C. Milchram, R. Hillerbrand, G. van de Kaa, N. Doorn, and R. Künneke, “Energy Justice and Smart Grid Systems: Evidence from the Netherlands and the United Kingdom,” *Applied Energy*, vol. 229, pp. 1244–1259, Nov. 2018, doi: https://doi.org/10.1016/j.apenergy.2018.08.053.

[31] E. Mokaramian, H. Shayeghi, F. Sedaghati, and A. Safari, “Four-Objective Optimal Scheduling of Energy Hub Using a Novel Energy Storage, Considering Reliability and Risk Indices,” *Journal of Energy Storage*, vol. 40, p. 102731, Aug. 2021, doi: https://doi.org/10.1016/j.est.2021.102731.

[32] S. Walker, T. Labeodan, W. Maassen, and W. Zeiler, “A review study of the current research on energy hub for energy positive neighborhoods,” *Energy Procedia*, vol. 122, pp. 727–732, Sep. 2017, doi: https://doi.org/10.1016/j.egypro.2017.07.387.

[33] H. Sadeghi, M. Rashidinejad, M. Moeini-Aghtaie, and A. Abdollahi, “The energy hub: An extensive survey on the state-of-the-art,” *Applied Thermal Engineering*, vol. 161, p. 114071, Oct. 2019, doi: https://doi.org/10.1016/j.applthermaleng.2019.114071.

[34] Royal HaskoningDHV, “Meerwaarde Smart Energy Hubs voor Oost-Nederland,” Royal HaskoningDHV, Amersfoort, Oct. 2022. Available: https://oostnl.nl/sites/default/files/attachments/Meerwaarde%20SEH%20Oost%20NL%20-%20Eindrapport%20061022.pdf

[35] M. Mohammadi, Y. Noorollahi, B. Mohammadi-ivatloo, and H. Yousefi, “Energy hub: From a model to a concept – A review,” *Renewable and Sustainable Energy Reviews*, vol. 80, pp. 1512–1527, Dec. 2017, doi: https://doi.org/10.1016/j.rser.2017.07.030.

[36] P. Emrani-Rahaghi, H. Hashemi-Dezaki, and S. A. Hosseini, “Optimal operation and scheduling of residential energy hubs simultaneously considering optimal sizing of heat storage and battery storage systems,” *Journal of Energy Storage*, vol. 44, p. 103481, Dec. 2021, doi: https://doi.org/10.1016/j.est.2021.103481.

[37] H. Innovations, “InnovaHub English version,” *Vimeo*, Nov. 19, 2020. https://vimeo.com/481170012 (accessed Mar. 31, 2023).

[38] North Sea Energy, “Energy Hubs & Transport Infrastructure,” North Sea Energy , 2022. Available: https://north-sea-energy.eu/static/2fd1407691ef2b058666b7f5e5c93d05/NSE-2020-2022-1.1-Energy-Hubs-and-Transport-Infrastructure-v2.pdf

[39] De Europese Unie, “OVEREENKOMST VAN PARIJS,” Oct. 19, 2016. https://eur-lex.europa.eu/legal-content/NL/TXT/?uri=CELEX:22016A1019(01)

[40] North Sea Energy, “Opportunities System Integration,” *North Sea Energy*. https://northseaenergyroadmap.nl/opportunities-system-integration (accessed Apr. 04, 2023).

[41] North Sea Energy , “Roadmap to accelerate the transition to low carbon and renewable fuels.” Available: https://static1.squarespace.com/static/631717f22a89ee474abfdc55/t/639b51673554c854169cb2a0/1671123316072/North+Sea+Energy+-+Roadmap+2050+flyer.pdf

[42] S. Cole and E. Balcetis, “Motivated perception for self-regulation: How visual experience serves and is served by goals,” *Advances in Experimental Social Psychology*, vol. 64, pp. 129–186, 2021, doi: https://doi.org/10.1016/bs.aesp.2021.04.003.

[43] O. Ebenezer, “Graphic Design Principles and Theories Application in Rendering Aesthetic and Functional Installations for Improved Environmental Sustainability and Development,” *International Journal of Engineering and Manufacturing*, vol. 9, no. 1, pp. 21–37, Jan. 2019, doi: https://doi.org/10.5815/ijem.2019.01.03.

[44] D. Stewart, *GRAPHIC DESIGN SCHOOL : the principles and practice of graphic design.* S.L.: John Wiley & Sons, 2020.

[45] R. Poulin, *The language of graphic design : an illustrated handbook for understanding fundamental design principles*. Beverly, Ma: Rockport Publishers, 2018.

[46] K. J. Murchie and D. Diomede, “Fundamentals of graphic design—essential tools for effective visual science communication,” *FACETS*, vol. 5, no. 1, pp. 409–422, Jan. 2020, doi: https://doi.org/10.1139/facets-2018-0049.

[47] CorelDRAW, “CorelDRAW Graphics Suite | Free Trial,” *www.coreldraw.com*. https://www.coreldraw.com/en/tips/graphic-design-principles/index.html

[48] C. Kelleher and T. Wagener, “Ten guidelines for effective data visualization in scientific publications,” *Environmental Modelling & Software*, vol. 26, no. 6, pp. 822–827, Jun. 2011, doi: https://doi.org/10.1016/j.envsoft.2010.12.006.

[49] D. A. Szafir, “The good, the bad, and the biased,” *Interactions*, vol. 25, no. 4, pp. 26–33, Jun. 2018, doi: https://doi.org/10.1145/3231772.

[50] D. Nolan and J. Perrett, “Teaching and Learning Data Visualization: Ideas and Assignments,” *The American Statistician*, vol. 70, no. 3, pp. 260–269, Jul. 2016, doi: https://doi.org/10.1080/00031305.2015.1123651.

[51] S. Evergreen and C. Metzner, “Design Principles for Data Visualization in Evaluation,” *New Directions for Evaluation*, vol. 2013, no. 140, pp. 5–20, Dec. 2013, doi: https://doi.org/10.1002/ev.20071.

[52] Indeed Editorial Team, “Demographics: Definition and How It Is Used,” *Indeed Career Guide*, May 27, 2021. https://www.indeed.com/career-advice/career-development/demographics-definition

[53] W. D. Wells, “Life Style and Psychographics: Definitions, Uses and Problems,” in *Life Style and Psychographics*, Marketing Classic Press.

[54] R. E. Mayer and L. Fiorella, *The Cambridge Handbook of Multimedia Learning*. Cambridge University Press, 2021.

[55] S. Walker, “Effective antimicrobial resistance communication: the role of information design,” *Palgrave Communications*, vol. 5, no. 1, pp. 1–16, Feb. 2019, doi: https://doi.org/10.1057/s41599-019-0231-z.

[56] M. F. Dahlstrom, “Using narratives and storytelling to communicate science with nonexpert audiences,” *Proceedings of the National Academy of Sciences*, vol. 111, no. Supplement_4, pp. 13614–13620, Sep. 2014, doi: https://doi.org/10.1073/pnas.1320645111.

[57] B. Gaglioppa and F. Tabone, “Human behaviours: new paradigms of energy efficiency. Communication tools to deliver a technical message to non-experts,” *E3S Web of Conferences*, vol. 343, p. 05001, 2022, doi: https://doi.org/10.1051/e3sconf/202234305001.

[58] Topsector Energie, “Systeemintegratie - De rol van Energy Hubs in de energietransitie,” *www.youtube.com*, May 19, 2022. https://www.youtube.com/watch?v=lDohlzHg7zo (accessed Apr. 17, 2023).

[59] TenneT, “Congestiemanagement,” *www.youtube.com*, Sep. 08, 2021. https://www.youtube.com/watch?v=bZacvhRNLZ4 (accessed Apr. 17, 2023).

[60] EPCEenergyeducation, “The Smart Grid Explained - An Understanding for Everyone,” *YouTube*. Dec. 05, 2011. Accessed: Aug. 30, 2020. [Online]. Available: https://www.youtube.com/watch?v=4L31dHXP6i0

[61] "North Sea Energy," *North Sea Energy*. https://northseaenergyroadmap.nl/ (accessed Apr. 17, 2023).

[62] A. Mader and W. Eggink, "A DESIGN PROCESS FOR CREATIVE TECHNOLOGY," Sep. 2014. Available: https://ris.utwente.nl/ws/portalfiles/portal/5362930/140509_ADesignProcesForCT_EPDE14.pdf

[63] R. Luck, "What is it that makes participation in design participatory design?," *Design Studies*, vol. 59, pp. 1–8, Nov. 2018, doi: https://doi.org/10.1016/j.destud.2018.10.002.

[64] J. M. Bryson, "What to do when Stakeholders matter," *Public Management Review*, vol. 6, no. 1, pp. 21–53, 2004, doi: https://doi.org/10.1080/14719030410001675722.

[65] Agile Business, "Chapter 10: MoSCoW Prioririsation," *www.agilebusiness.org*, 2022. https://www.agilebusiness.org/dsdm-project-framework/moscow-prioririsation.html

[66] Lucid Content Team, "13 Effective Brainstorming Techniques," *Lucidchart*, Sep. 11, 2019. https://www.lucidchart.com/blog/effective-brainstorming-techniques

[67] Y. Chang, Y. Lim, and E. Stolterman, "Personas," *Proceedings of the 5th Nordic conference on Human-computer interaction building bridges - NordiCHI '08*, 2008, doi: https://doi.org/10.1145/1463160.1463214.

[68] R. Costa, "How to design user scenarios: best practices and examples," *www.justinmind.com*, Mar. 05, 2020. https://www.justinmind.com/blog/how-to-design-user-scenarios/

[69] Indeed Editorial Team, "How To Write a Storyline (With Tips)," *Indeed.com*, Jul. 22, 2022. https://www.indeed.com/career-advice/career-development/how-to-write-storyline

[70] K. N. Truong, G. R. Hayes, and G. D. Abowd, "Storyboarding," *Proceedings of the 6th ACM conference on Designing Interactive systems - DIS '06*, 2006, doi: https://doi.org/10.1145/1142405.1142410.

[71] D. Webb, "Orson Welles - War Of The Worlds - Radio Broadcast 1938 - Complete Broadcast.," *YouTube*. Dec. 16, 2010. [YouTube Video]. Available: https://www.youtube.com/watch?v=Xs0K4ApWl4g

[72] "Adobe Color," *Adobe.com*, 2023. https://color.adobe.com/nl/create/color-wheel

[73] K. Cherry, "How White Impact Moods, Feelings, and Behaviors," *Verywell Mind*, Apr. 24, 2021. https://www.verywellmind.com/color-psychology-white-2795822

[74] K. Cherry, "The Color Psychology of Blue," *Verywell Mind*, Nov. 22, 2022. https://www.verywellmind.com/the-color-psychology-of-blue-2795815

[75] K. Cherry, "How Does the Color Green Impact Mood and Behavior?," *Verywell Mind*, Jul. 17, 2022. https://www.verywellmind.com/color-psychology-green-2795817

[76] Adobe, "Buy Adobe Illustrator CC | Vector graphic design software," *Adobe.com*, 2019. https://www.adobe.com/products/illustrator.html

[77] Adobe, "Adobe Creative Cloud," *Adobe.com*, 2019. https://www.adobe.com/creativecloud.html

[78] Adobe, "VFX and motion graphics software | Adobe After Effects," *www.adobe.com*. https://www.adobe.com/products/aftereffects.html

[79] YouTube, “Audio Library — Music for content creators - YouTube,” *www.youtube.com*. https://www.youtube.com/c/audiolibrary-channel

[80] Zapsplat, “ZapSplat - Download Free Sound Effects & Royalty Free Music,” *ZapSplat - Download free sound effects*, 2018. https://www.zapsplat.com/

[81] Freesound, “Freesound,” *Freesound.org*, 2012. https://freesound.org/

[82] Adobe, “Free Media Encoder | Download free Adobe Media Encoder trial,” *www.adobe.com*. https://www.adobe.com/products/media-encoder.html

[83] Audacity, “Audacity ® | Free, open source, cross-platform audio software for multi-track recording and editing.,” *Audacityteam.org*, May 13, 2019. https://www.audacityteam.org/

[84] thomann, “🎤 Rode NT1-A Complete Vocal Recording,” *Musikhaus Thomann*. https://www.thomann.de/nl/rode_nt1a_complete_vocal_recording.htm?gclid=CjwKCAjwzJmlBhBBEiwAEJyLuzp8T8BZT1dZc5OE8ehukkdSTGlVuIXxlgazNaRfa1gqFl5YlZ8AlBoCk6QQAvD_BwE (accessed Jul. 10, 2023).

[85] “YouTube,” *YouTube*. Feb. 14, 2005. Available: https://www.youtube.com/

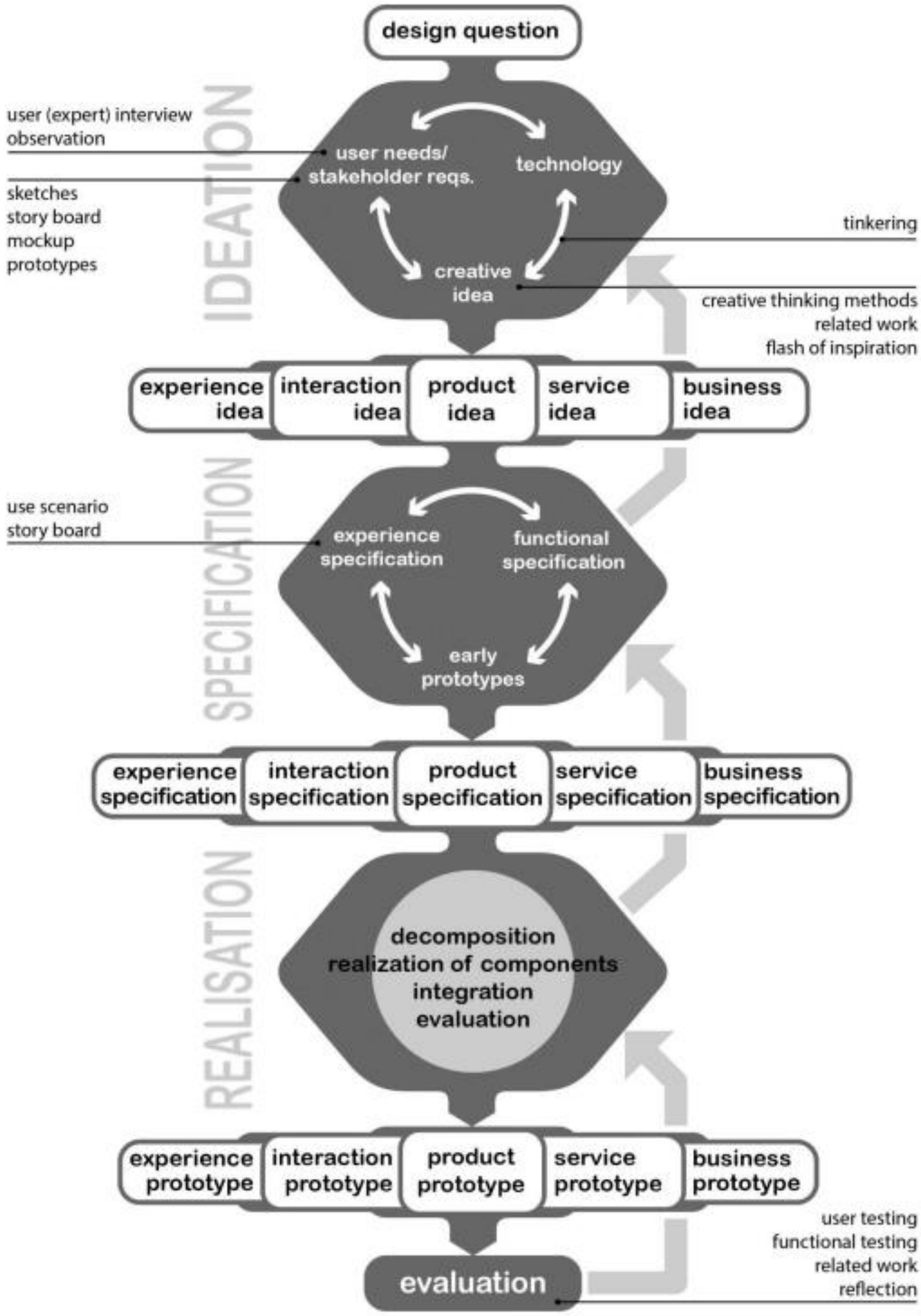
[86] Vecteezy, “vecteezy,” *Vecteezy*, 2019. https://www.vecteezy.com/

[87] Freepik, “Freepik - Free Graphic resources for everyone,” *Freepik*, 2019. https://www.freepik.com/

[88] D. Ebberts, “MotionScript.com - main page,” *motionscript.com*. https://motionscript.com/ (accessed Jul. 10, 2023).

[89] Microsoft, “Microsoft Teams,” *www.microsoft.com*. https://www.microsoft.com/nl-nl/microsoft-teams/log-in (accessed Jul. 10, 2023).

Appendix A: Creative Technology Design Method



Appendix B: Script General Part

1. Nederland zit midden in de energietransitie. We willen stoppen met het gebruik van gas en kolen om energie op te wekken om de klimaatdoelen te halen
2. Daarom maken we steeds meer gebruik van hernieuwbare energiebronnen, zoals wind- en zonneparken, om energie op te wekken.
3. Dit is nodig. Maar het huidige elektriciteitsnet is niet gebouwd op deze transitie.
4. Van origine is het Nederlandse energienetwerk gebouwd met een centraal productiepunt. Vanuit dit punt werd de energie naar de consument gebracht.
5. Deze situatie verandert. We wekken steeds meer zelf energie op en we zetten meer hernieuwbare bronnen in. We gaan nu over van een centrale naar een decentrale energieopwekking.
6. De nieuwe energiebronnen produceren energie op hetzelfde moment. De zonneparken produceren bijvoorbeeld alleen overdag en dit gaat in grote hoeveelheden.
7. Deze hoeveelheden kan het elektriciteitsnet nog niet aan, omdat er nog te weinig capaciteit om de elektriciteit te vervoeren vanaf deze decentrale plekken.
8. Wanneer er meer energie getransporteerd moet worden dan dat er capaciteit voor is, kan er netcongestie ontstaan.
9. Netcongestie moet zo veel mogelijk vermeden worden, omdat anders de stroom afgesloten kan worden om zo beschadigingen aan het net te voorkomen.
10. Op dit moment zijn netbeheerders al hard bezig om het energienetwerk uit te breiden, zodat er meer transport kan plaatsvinden. Maar dit gaat niet snel genoeg.
11. Daarom moet er geïnvesteerd worden in nieuwe technologieën die kunnen helpen met het managen van netcongestie.
12. Een van de opties is om energie lokaal te produceren, converteren, op te slaan en te consumeren. Dit heet een Energy hub.
13. Door energie lokaal te produceren en te consumeren wordt er zo min mogelijk gebruik gemaakt van het nationale energienetwerk. Dit verkleint de kans op congestie en vergroot de stabiliteit van energie transport.
14. Op dit moment worden er al energy hubs gerealiseerd door heel Nederland, voornamelijk op bedrijventerreinen, omdat daar een constante toevoer van energie van groot belang is.
15. Wilt u meer weten over wat voor u belangrijk is of hoe een energy hub gerealiseerd kan worden? Klik dan op een van de opties die het meest van toepassing is.

Appendix C: Script Business Owner Part

1. Het implementeren van een Energy Hub is een ingewikkeld proces, wat veel tijd kost en waar veel bij komt kijken.
2. Een Energy Hub heeft vier belangrijke functies. Dit zijn: energie produceren, converteren, opslaan en consumeren.
3. Bedrijventerreinen zijn uitstekende locaties voor het implementeren van een Energy Hub, omdat daar een stabiele en betaalbare energievoorziening van groot belang is.
4. Waar het nu vaak niet mogelijk is voor nieuwe bedrijven om zich te vestigen, wegens te weinig beschikbaar vermogen, maakt een Energy Hub een aansluiting wél mogelijk.
5. Een Energy Hub maakt het voor bedrijven mogelijk om onderling energie uit te wisselen.
6. Stel: een bedrijf heeft een gecontracteerd vermogen van 1 Mega Watt, maar dit wordt alleen gebruikt tussen 11:00 uur en 14:00 uur.
7. Dan blijft de rest van de dag die Mega Watt ongebruikt, omdat het bedrijf die niet nodig heeft.
8. Dit is zonde. Een Energy Hub maakt het mogelijk voor andere bedrijven om gebruik te maken van dit vermogen, bijvoorbeeld in de nacht.
9. Verder maakt een Hub gebruik van slimme systemen, waarbij het vermogen wordt verdeeld over de bedrijven die onderdeel zijn van de Energy Hub.
10. Vervolgens wordt er gekeken naar alle processen die energie nodig hebben. Aan de hand hiervan worden prioriteiten opgesteld.
11. De processen van het bedrijf waar het vermogen eerst aan was gecontracteerd staat bovenaan de prioriteitenlijst.
12. Maar processen die niet zomaar onderbroken kunnen worden zullen ook een hoge prioriteit hebben.
13. Denk bijvoorbeeld aan een koelcel. Deze koelcel moet altijd kouder zijn dan -20 graden. Dit koelen kost veel energie.
14. De koelcel kan worden doorgevroren tot -25 graden, waarna de temperatuur weer langzaam stijgt naar -20.
15. Hierdoor is er een tijdje geen energie nodig om te koelen en is er ruimte voor andere processen.
16. En wordt er ruimte op het elektriciteitsnet gecreëerd waardoor er nieuwe bedrijven zich kunnen vestigen.
17. Een Energy Hub maakt dus mogelijk dat nieuwe bedrijven zich kunnen vestigen. Verder kunnen huidige bedrijven blijven groeien, omdat er genoeg vermogen beschikbaar wordt gemaakt.
18. Zo zorgen Energy Hubs voor een stabiele energietoevoer en een duurzame toekomst.

Appendix D: Script Sustainability Expert Part

1. Het implementeren van een Energy Hub is een ingewikkeld proces, wat veel tijd kost en waar veel bij komt kijken.
2. Een Energy Hub heeft vier belangrijke functies. Dit zijn: energie produceren, converteren, opslaan en consumeren.
3. Hoe deze functies geïmplementeerd worden, kan verschillen per Hub. Dat kan bijvoorbeeld liggen aan de geografische ligging van het gebied of de al bestaande energie infrastructuur in het gebied.
4. Het organiseren van een Energy Hub vraagt verschillende vormen van afstemming binnen een geografisch gebied. Op een bedrijven terrein kan dat eruitzien als volgt.
5. Ten eerste moet er een management systeem worden opgezet. Dit systeem wordt opgezet door sensoren op het elektriciteitsnet te plaatsen.
6. Deze sensoren houden in de gaten hoeveel energie er geproduceerd en verbruikt wordt. Daarnaast bepaalt het systeem ook wanneer er energie opgeslagen of geconverteerd moet worden.
7. Dit gaat volledig automatisch.
8. Verder is een financieel systeem nodig. Dit systeem zal al het beschikbare vermogen bij elkaar nemen en aan de hand daarvan zullen prioriteiten van processen worden opgesteld en het vermogen worden verdeeld.
9. Dit systeem maakt het mogelijk voor bedrijven om elkaar te facturen voor het beschikbaar maken van hun vermogen.
10. Als laatste is een nauwe samenwerking tussen alle betrokken partijen nodig. Dit zijn onder andere de bedrijven zelf en de gemeente, maar ook de netbeheerder van het gebied.
11. Verder kan het nodig zijn om andere belanghebbenden, zoals omwonenden, natuurorganisaties en de overheid te betrekken in het proces om een Energy Hub op te zetten.
12. Investeren in een Energy Hub vraagt om veel organisatie op verschillende niveaus. Investeren in een Hub zal resulteren in het slimmer omgaan met energie en een stabiele energietoevoer voor de betrokken bedrijven.
13. Zo banen we een weg naar een duurzame toekomst.

Appendix E: Expression for Bounce Effect

Expression for bounce effect in After Effects created by Dan Ebberts from motionscript.com [88].

Bounce effect:

```
n = 0;
if (numKeys > 0){
n = nearestKey(time).index;
if (key(n).time > time){
n--;
}
}
if (n == 0){
t = 0;
}else{
t = time - key(n).time;
}

if (n > 0 && t < 1){
v = velocityAtTime(key(n).time - thisComp.frameDuration/10);
amp = .05;
freq = 4.0;
decay = 8.0;
value + v*amp*Math.sin(freq*t*2*Math.PI)/Math.exp(decay*t);
}else{
value;
}
```

Appendix F: Improved Scripts Based on Feedback with Enodes

Improved text General Part after evaluation with Enodes:

1. Nederland zit midden in de energietransitie. Om de klimaatdoelen te halen, willen we stoppen met het gebruik van gas en kolen om energie op te wekken
2. Daarom maken we steeds meer gebruik van hernieuwbare energiebronnen, zoals wind- en zonneparken, om energie op te wekken.
3. Dit is nodig. Maar het huidige elektriciteitsnet is niet gebouwd op deze transitie.
4. Van origine is het Nederlandse energienetwerk gebouwd vanuit centrale productiepunten. Vanaf deze punten werd de energie naar de consument gebracht.
5. Deze situatie verandert. We wekken steeds meer zelf energie op en we zetten meer hernieuwbare bronnen in. We gaan nu over van een centrale naar een decentrale energieopwekking.
6. De meeste nieuwe energiebronnen, zoals wind- en zonne-energie, produceren energie op hetzelfde moment. De zonneparken produceren bijvoorbeeld alleen overdag en dit gaat in grote hoeveelheden.
7. Deze hoeveelheden kan het elektriciteitsnet nog niet aan, omdat er nog te weinig capaciteit om de elektriciteit te vervoeren vanaf deze decentrale plekken.
8. Wanneer er meer energie getransporteerd moet worden dan dat er capaciteit voor is, kan er netcongestie ontstaan.
9. Netcongestie moet zo veel mogelijk vermeden worden, omdat ~~anders de stroom afgesloten kan worden om zo beschadigingen aan het net te voorkomen.~~ *het een rem op de energietransitie vormt.*
10. Op dit moment zijn netbeheerders al hard bezig om het energienetwerk uit te breiden, zodat er meer transport kan plaatsvinden. Maar dit gaat niet snel genoeg.
11. Daarom moet er geïnvesteerd worden in nieuwe technologieën die kunnen helpen met het managen van netcongestie.
12. Een van de opties is om energie lokaal te produceren, op te slaan en te consumeren. Dit heet een Energy hub.
13. Door energie lokaal te produceren en te consumeren wordt er zo min mogelijk gebruik gemaakt van het nationale energienetwerk. Dit verkleint de kans op congestie en vergroot de stabiliteit van energie transport binnen een Energy Hub.
14. Op dit moment worden er al energy hubs gerealiseerd door heel Nederland, voornamelijk op bedrijventerreinen, omdat daar een ~~constante toevoer van~~ *efficiënte omgang met* energie van groot belang is.
15. Wilt u meer weten over wat voor u belangrijk is of hoe een energy hub gerealiseerd kan worden? Klik dan op een van de opties die het meest van toepassing is.

Improved text Business Owner:

1. Het implementeren van een Energy Hub is een ~~ingewikkeld~~ *uitdagend* proces, ~~wat veel tijd kost en waar veel bij komt kijken.~~ *Waar veel regelgeving bij komt kijken.*
2. Een Energy Hub heeft drie belangrijke functies. Dit zijn: energie produceren, opslaan en consumeren.

3. Bedrijventerreinen zijn uitstekende locaties voor het implementeren van een Energy Hub, omdat daar een stabiele en betaalbare energievoorziening van groot belang is.
4. Waar het nu vaak niet mogelijk is voor nieuwe bedrijven om ~~zich te vestigen~~ *uit te breiden of te elektrificeren*, wegens te weinig beschikbaar vermogen, maakt een Energy Hub ~~een aansluiting~~ *dat* wél mogelijk.
5. Een Energy Hub maakt het voor bedrijven mogelijk om onderling energie uit te wisselen.
6. Stel: een bedrijf heeft een gecontracteerd vermogen van 1 Mega Watt, maar dit wordt alleen gebruikt tussen 11:00 uur en 14:00 uur.
7. Dan blijft de rest van de dag die Mega Watt ongebruikt, omdat het bedrijf die niet nodig heeft.
8. Dit is zonde. Een Energy Hub maakt het mogelijk voor andere bedrijven om gebruik te maken van dit vermogen, bijvoorbeeld in de nacht.
9. Verder maakt een Hub gebruik van slimme systemen, waarbij het vermogen wordt verdeeld over de bedrijven die onderdeel zijn van de Energy Hub.
10. Vervolgens wordt er gekeken naar alle processen die energie nodig hebben. Aan de hand hiervan worden prioriteiten opgesteld.
11. De processen van het bedrijf waar het vermogen eerst aan was gecontracteerd staat bovenaan de prioriteitenlijst.
12. Maar processen die niet zomaar onderbroken kunnen worden zullen ook een hoge prioriteit hebben.
13. Denk bijvoorbeeld aan een koelcel. Deze koelcel moet altijd kouder zijn dan -20 graden. Dit koelen kost veel energie.
14. De koelcel kan worden doorgevroren tot -25 graden, waarna de temperatuur weer langzaam stijgt naar -20.
15. Hierdoor is er een tijdje geen energie nodig om te koelen en is er ruimte voor andere processen.
16. En wordt er ruimte op het elektriciteitsnet gecreëerd waardoor er nieuwe bedrijven zich kunnen vestigen
17. Zo wordt er dus ook weer ruimte gecreëerd op het elektriciteitsnet waardoor ~~er nieuwe bedrijven zich kunnen vestigen~~. *Bedrijven kunnen elektrificeren.*
18. Een Energy Hub maakt het dus mogelijk dat huidige bedrijven kunnen blijven groeien, omdat er genoeg vermogen beschikbaar wordt gemaakt. Verder maakt een Hub het ook mogelijk dat nieuwe bedrijven zich kunnen vestigen.
19. Zo zorgen Energy Hubs voor een ~~stabiele~~ *efficiënte* energietoevoer. Zo werken we samen naar een duurzame toekomst.

Improved Text Sustainability Experts:

1. Het implementeren van een Energy Hub is een ~~ingewikkeld~~ *uitdagend* proces, ~~wat veel tijd kost en waar veel bij komt kijken.~~ *Waar veel regelgeving bij komt kijken.*
2. Een Energy Hub heeft drie belangrijke functies. Dit zijn: energie produceren, opslaan en consumeren.
3. Hoe deze functies geïmplementeerd worden, kan verschillen per Hub. Dat kan bijvoorbeeld liggen aan de geografische ligging of de al bestaande energie infrastructuur in het gebied.
4. *Daarnaast is het van groot belang dat de bedrijven die aangesloten zijn in een Hub, bereid zijn om flexibel om te gaan met hun energie verbruik.*
5. Het organiseren van een Energy Hub vraagt verschillende vormen van afstemming binnen een geografisch gebied. Op een bedrijven terrein kan dat eruitzien als volgt.

6. Ten eerste moet er een management systeem worden opgezet. Bij dit systeem worden er sensoren bij het elektriciteitsnet geplaatst.
7. Deze sensoren houden in de gaten hoeveel energie er geproduceerd en verbruikt wordt. Daarnaast bepaalt het systeem ook wanneer er energie opgeslagen moet worden.
8. Dit gaat volledig automatisch.
9. Verder is een financieel systeem nodig. Dit systeem zal al het beschikbare vermogen bij elkaar nemen en aan de hand daarvan zullen prioriteiten van processen worden opgesteld en het vermogen worden verdeeld.
10. ~~Dit systeem maakt het mogelijk voor bedrijven om elkaar te facturen~~ *Dit systeem zal de bedrijven ook factureren* voor het beschikbaar maken van hun vermogen.
11. Als laatste is een nauwe samenwerking tussen alle betrokken partijen nodig. Dit zijn onder andere de bedrijven zelf en ~~de gemeente, maar ook~~ de netbeheerder van het gebied.
12. Verder kan het nodig zijn om andere belanghebbenden, zoals omwonenden, ~~natuurorganisaties~~ en de overheid te betrekken in het proces om een Energy Hub op te zetten.
13. *De taak van de gemeente is om het gesprek tussen deze partijen te faciliteren (en om vergunningen te verlenen.)*
14. Investeren in een Energy Hub vraagt om veel organisatie op verschillende niveaus. Investeren in een Hub zal resulteren in het slimmer omgaan met energie en een stabiele energietoevoer voor de betrokken bedrijven.
15. Zo banen we een weg naar een duurzame toekomst.

Appendix G: Questionnaire Evaluation

Results of the user evaluation. A Likert scale was used, with a score from 1 (strongly disagree) to 5 (strongly agree).

	Sustainbility Expert	Business Owner	Enodes
Introduction Video			
De titel van de video past bij de video	4	3	4
De voice-over was goed te verstaan	5	4	5
Het doel van de video was duidelijk	3	4	4
De afbeeldingen en animaties passen bij de voice-over	5	4	5
De video legt duidelijk uit wat de energietransitie is	5	4	3
De video legt duidelijk uit wat netcongestie is	3	4	4
De video legt duidelijk uit wat de gevolgen van netcongestie zijn	4	4	4
De video legt duidelijk uit wat een Energy Hub is	5	4	5
De afbeeldingen in de video passen bij elkaar	5	4	5
De video was informatief	3	4	5
De video hield mijn aandacht vast	5	4	5
De ondertiteling lijdt af van de voice-over en de animaties.	1	2	4
De video was goed te begrijpen	5	4	5
Ik voel mij uitgenodigd om op een van de opties te klikken	4	4	5
Wat vind je van de duur van de video? (1: Too short – 5: Too long)	5	4	3
Video Sustainability Expert			
De voice-over was goed te verstaan	5	4	5
De afbeeldingen en animaties passen bij de voice-over	5	4	4
De afbeeldingen in de video passen bij elkaar	5	4	4
Het is duidelijk welke organisatie nodig is bij het opzetten van een Energy Hub	4	3	3
De rol van de gemeente bij het opzetten van een Energy Hub is duidelijk	4	3	4
Het is duidelijk welke voordelen een Energy Hub heeft	3	3	5
De video hield mijn aandacht vast	4	4	4
De video was goed te begrijpen	5	4	5
De video was informatief	5	4	4
Video Business Owner			
De voice-over was goed te verstaan		4	5
De afbeeldingen en animaties passen goed bij de voice-over		4	5
De afbeeldingen in de video passen bij elkaar		4	5
Het is duidelijk wat er van een bedrijf gevraagd wordt als ze meedoen aan een Energy Hub		3	4

Het is duidelijk hoe een Energy Hub een oplossing kan vormen om meer vermogen beschikbaar te maken		4	4
Het is duidelijk welke voordelen een Energy Hub heeft		4	4
De video hield mijn aandacht vast		4	5
De video was goed te begrijpen		4	
De video was informatief		4	5