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Bachelor Landscape Architecture & Spatial Planning  
Bachelor Thesis Landscape Architecture (LAR-81812)

# TURNING TIDES

Coastal Velsen-Noord as a source for hydropower land-art



Colophon

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27 October 2017

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Preface

This thesis report is the result of a Bachelor thesis in Landscape Architecture. The final result is a design that was developed through research by design, in which I have accumulated all the knowledge I have gained during my years as a Bachelor student at Wageningen University. My hope is that this thesis inspires designers that are involved in the production of energy landscapes to consider the importance of developing places with high landscape quality. I want to thank both my supervisors and all the peers that helped and supported me throughout the writing of this thesis.

Key Words

Landscape architecture, renewable energy, hydropower, visual landscape quality, land-art

Abstract

In order to accommodate for climate change and help steer the Netherlands towards an energy neutral tomorrow, the existing hydropower techniques need to be combined and redesigned to fit into the existing landscape. This thesis explores this statement within a comprehensive design at the coastal area of Velsen-Noord, in which hydropower techniques are combined with land-art and amenities to form multifunctional units that improve the quality of the existing landscape. It features research on different techniques of hydropower harvesting, an exploration of the current situation on location, and a search for land-art that will enhance the visual landscape quality. Key concepts that will be introduced include various hydropower techniques, land-art and visual landscape quality. Using a combination of qualitative and quantitative methods of data collection, using observational procedures, site analysis and secondary data, the area and possible interventions will be explored. This thesis aims to help to negate the notion that energy landscapes necessarily have to be places with low visual landscape quality, and tries and prove there is a way to transform energy landscapes into places with high aesthetic and cultural value.

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# 1. Introduction

In order to steer the Netherlands towards an energy neutral tomorrow, we need to start implementing renewable energy techniques on a large scale. Legislation and public aversion have so far prevented the large scale implementation of these devices (Provinciale Staten van Zuid-Holland, 2011, Verbong and Geels, 2007). This thesis proposes we change the image of renewable energy devices, starting with the ones that generate hydropower. The coastal area around the Noordzeekanaal in IJmuiden will house a comprehensive landscape design in which hydropower devices will provide a positive and proactive vision of how these new infrastructures can be enhancements to our most cherished places.

## 1.1 Problem context

We as a nation are in dire need of a transition towards renewable energy. Climate change and ongoing fossil fuel depletions call for a change in approach (Stremke et al., 2011, Jacobsson and Bergek, 2004). A large part of the energy consumed in the Netherlands is currently generated by burning imported fossil fuels, which add to the increase of greenhouse gases, and in turn global warming and climate change (Biesiot and Noorman, 1999, Jacobsson and Bergek, 2004/2004). This impending climate change will manifest itself in increased precipitation in winters, heavier rainfall and rising sea levels, both amounting to a higher risk of floods within the Netherlands (van den Hurk et al., 2014). Replacing fossil fuels with the use of renewable energy will reduce emissions of greenhouse gasses and help negate climate change.

## 1.2 Problem statement

Although a transition towards the use of renewable energy sounds resoundingly positive, there is growing resistance from citizens against the implementation of renewable energy technologies near their residential areas. This has hampered and even cancelled a lot of implementation projects (Wüstenhagen et al., 2007, Verbong and Geels, 2007). The NIMBY (Not In My Back Yard) Syndrome is thought to be the explanation for this public aversion to renewable energy development. NIMBY refers to the phenomenon in which developments in land-use may be accepted by an individual or community in principle, as long as they take place anywhere near to where they live (Dear, 1992).

The problem here is that even though renewable energy plants are usually smaller in size than

conventional power plants, the harvesting of renewable energy mainly takes place above the earth's surface. This means that unlike conventional power sources like fossil or nuclear energy, the harvesting of renewable energy is much more visible in the life of the everyday citizen. It also tends to take place closer to where these citizens live, thereby heightening the environmental impact near to the 'backyard'. As of now most renewable energy technologies aren't fit to compete with conventional technologies, therefore making the public's choice between acceptance and aversion a choice between short-term costs and long term benefits (Wüstenhagen et al., 2007, Stremke et al., 2017). Much of the opposition to renewable energy landscapes is based on aesthetic grounds (Layne, 2017). The opinion that energy landscapes will degrade the visual quality of the landscape is held by many. Combining energy landscapes with land-art may offer ways of solving this issue.

Although there is a variety of renewable energy sources available, such as geothermal, hydrothermal energy, hydropower, biogas, and biomass, the current market in renewable energy technologies is dominated by front-runners wind-energy and solar power (Marco Broekman, 2017). Although hydropower is currently only contributing 0,08% to the total renewable energy capacity installed globally, the potential for technically feasible hydropower installations is very large (Todeschini, 2017). At the moment the untapped potential for hydropower power is estimated at nearly 15 000 TW h/yr. Although filling this potential isn't feasible at the moment, it's evident from these numbers that hydropower can have a substantial role in the transition towards renewable energy (Bartle, 2002). Especially in a country like the Netherlands, with its highly institutionalized water sector, the development of hydropower landscapes could lead to high benefits (Manders et al., 2016).

## 1.3 Thesis Structure

This thesis begins by explaining the research set-up that was used. It will then go on to tell in detail what methods were used during this thesis. Chapter four begins by laying out the theoretical dimensions of the research, after which chapter five will deal with a structured analysis of the project area in Velsen-Noord. Conclusions are drawn from both these chapters, from which the design guidelines in chapter six are derived subsequently. All these guidelines are implemented in the design part of this thesis, in chapter seven. Finally, in chapter eight, conclusions are drawn and a reflection on the process and its outcomes are discussed.

# 2. Research Set-up

Through this thesis I aim to show the potential of how existing hydropower techniques should be combined and redesigned to fit into the existing landscape, in order to accommodate for climate change and help steer the Netherlands towards an energy neutral tomorrow. My objective here is to implement existing techniques of harvesting renewable hydropower in a way that combines multiple uses and improves the visual quality of the coastal landscape of Velsen-Noord. To provide a method of implementing this objective, I draw the following design question to be answered in this thesis:

*How can existing techniques of harvesting renewable hydropower be combined with land-art or amenities in order to produce multifunctional units that improve the visual quality of the landscape?*

In order to come to an answer to this question, the following research questions will need to be answered:

1. Which existing techniques of harvesting renewable hydropower are suitable to be implemented in the coastal landscape of Velsen-Noord?
2. What types of amenities are needed in the coastal landscape of Velsen-Noord that would help strengthen the existing landscape?
3. What land-art would tie in with the existing coastal landscape of Velsen-Noord and would help improve the visual quality of the existing landscape?

## 2.2 Motive

The municipality of Velsen has not yet come up with any plans for harvesting hydropower (Gemeente Velsen, 2016). The area around the mouth of the Noordzeekanaal houses untapped potential for harvesting renewable energy. The municipality is also looking for a new main location for their Techport, a place where innovation, entrepreneurship and education will go hand in hand. This thesis aims to address these two opportunities and combine them to benefit the Techport partners, as well as produce an energy landscape with high visual quality that strengthens the existing landscape.

## 2.3 Key Concepts

### 2.3.1 Renewable energy

Renewable energy is the energy harvested from non-fossil sources that are infinitely replenished, or from sources that are infinite in nature, such as the sun (Stremke et al., 2011). Examples of these sources are wind, sun, geothermal, hydrothermal energy, hydropower, biogas, and biomass (Marco Broekman, 2017).

When I mention the phrase 'energy neutral', I mean the situation in which the production of energy is equal to its total consumption (Marco Broekman, 2017). In this thesis energy usage as well as harvesting will be measured in petajoules (PJ). To give an idea of the amount it is helpful to know that 1 PJ is about equivalent to the yearly harvest of 38 wind turbines with a 3.3 MW capacity, 251 hectares of solar fields, or the power consumption of 81010 residences in the Netherlands (Marco Broekman, 2017).

### 2.3.2 Techniques of harvesting hydropower (MJ/km2):

- o Tidal energy:  
Tidal energy is harvested by generating electricity from tidal movements utilising either the height difference in water level or the current energy directly (Roberts et al., 2016).
- o Wave energy:  
Wave energy is harvested by absorbing energy from waves using different devices, depending on the water level and distance from the shore (Antonio, 2010).

### 2.3.3 Visual Landscape Quality

As shown in figure 1, there are three approaches to visual landscape quality assessment (Daniel, 2001), all of which are determined by the subjective judgement of observers that interact with physical landscape features (Daniel, 1990). Coastal visual landscape quality is often determined by a preference for undeveloped beaches with open vistas and high relative relief (Morgan, 1999).

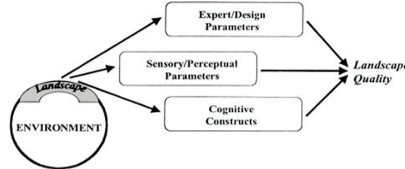


Figure 1: Visual Landscape Quality Assessment Diagram (Daniel, 2001)

2.3.4 Land-Art

Land art is an art movement that uses the physical landscape as a canvas. It enables aesthetic interaction with the environment, and contributes to the way beholders value the natural landscape (Brady, 2007). In some cases, such as the ones shown in figure 2, land art can be used to generate renewable energy.

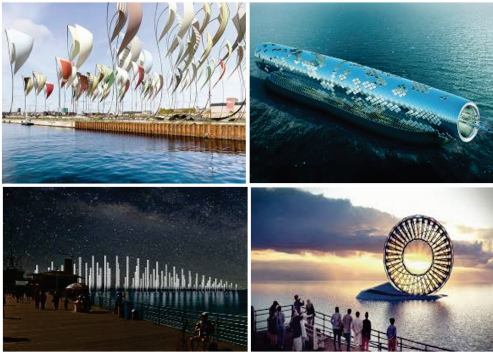


Figure 2: Land Art Generator Initiative Submissions - Land Art that harnesses renewable energy (LAGI, 2017)

3. Methods and Materials

I will employ the three cycle view of design science research, adapted to this particular case, as shown in figure 3 (Hevner, 2007).

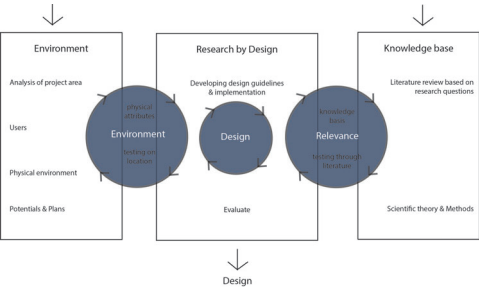


Figure 3: The Three Cycle View of Design Science Research adapted to this thesis

The research that is performed in order to answer the questions that were mentioned in chapter 2 (Research Set-up) consists of two parts, in between which I will switch back and forth to the design phase. A literature review is applied to find answers to research questions 1 & 3. The site analysis is applied to find answers to research question 2. The findings in the literature review and site analysis will function as the basis for the design in this thesis. The outcome of the design itself will provide the answer to the design question.

3.1 Literature Review

The purpose of this literature review is to get acquainted with the body of knowledge that is already available on energy transition in the Netherlands, hydropower and land-art preferences (Kumar, 2011). The results of the literature review will be an overview of suitable hydropower techniques, and conclusions on how to produce an energy landscape that will be embraced by the community of Velsen-Noord. Through this review an understanding of added the educational value an energy landscape may have

will be explored as well. This overview of information will function as a knowledge basis which can be integrated into design guidelines. The final design will reflect whether high visual landscape quality is actually realised by combining land-art and techniques that harvest renewable hydropower.

3.2 Search Strategy

The literature search was conducted in Scopus and Google Scholar using the following keywords: 'Land-art', 'energy landscape', 'landscape quality', 'hydropower', 'tidal energy', 'wave power', 'NIMBY', 'coastal landscape', 'public art', 'landscape preferences' and 'energy transition'. Documents that were related to the Scopus and Google Scholar findings were also consulted to make sure the best articles were used.

3.3 Selection of Studies

The studies had to meet the following criteria to be included in the literature review (Kumar, 2011):

- Highly cited
- The findings can be generalized to other situations
- Within the subject area of environmental sciences or landscape architecture
- Not outdated (except for when the literature is very heavily cited)

3.4 Site Analysis and Observations

The site analysis was conducted with secondary data and observations. A variety of data collection procedures is applied to collect data for the single case of Velsen-Noord. The findings of this analysis will be applied to draw conclusions on the amenities needed in the project area. The findings will lead to the selection of a project site and serve as guidelines for which multifunctional units can be constructed and where these may be implemented. The findings in the literature review are used in the site analysis to determine which hydropower techniques and types of land-art will need to be implemented in the area. Subsequently, three precedent studies will be explored to serve as possible examples of how to implement the suggested implementations. The three precedents will be selected from three subject areas: one a successful tidal power plant combined with recreational uses; one a Dutch energy landscape with educational value; and finally a design competition in which energy landscapes are combined with land-art.

3.5 Measures and Validity

A concern for the validity of this research is that the literature review concerning hydropower techniques somewhat lacks in reliability as there are many companies that produce such devices, and each of them differs slightly from the next. Furthermore, none of the specific ones listed have been tested on this specific site, so they may not function exactly like described. Furthermore, the observed data that has been discussed could have been more reliable if the study population would have been larger. Also, the observations were conducted on a limited two separate occasions within the same month, so more consecutive visits would have amounted to a higher reliability. As most of the information I have cited on the public acceptance of energy landscapes is about wind farms instead of hydropower landscapes, the validity of the statements in question may have suffered. In a couple of cases, such as with the hydropower devices, no peer reviewed articles could be found on the subject and websites had to be referred to, hampering the reliability. One of the reasons for this is because the peer review articles that were available on the subject were written by mechanical engineers and I could as such not decipher them. Another may be that as there are many manufacturers for these hydropower devices, hardly any share detailed and functional information on their devices for competitive reasons.

4. Literature Review

A transition from the use of fossil fuels to renewable energy is needed in order to steer the Netherlands towards a more sustainable future. To limit the global rise in temperature caused by climate change, saving energy and large-scale implementation of renewable energy technology is vital (Stremke et al., 2017, Biesiot and Noorman, 1999). Although there is a lot of public aversion to this right now, the Dutch population may learn to love these new landscapes if they are implemented in a suitable way (Verbong and Geels, 2007, Stremke et al., 2017). It's good to remember that some of the energy landscapes of the past are now viewed as World Heritage sites, such as the Dutch wind mills (Stremke et al., 2017).

As mentioned before, a lot of the required energy harvesting will take place above ground, and possibly also closer to residential areas. The fact that a lot will have to be implemented in a short amount of time is also a crucial factor. If we want this transition to be successful we will have to closely consider the spatial design of these new energy landscapes. Thankfully, now that the costs of renewable energy technology is diminishing there is more room for the development of the visual qualities of these devices (Stremke et al., 2017, Wüstenhagen et al., 2007).

Not only climate adaptation but also our economy will benefit from the implementation of renewable energy technology (Verbong and Geels, 2007). The transition towards a more sustainable society will cause an influx in the market for the development, manufacturing, maintenance and management of these technologies. Wind and solar power technologies are front runners in the race towards this energy transition, so far but hydropower seems to be a minor contender in the Netherlands (Stremke et al., 2017, Manders et al., 2016).

As mentioned before in the introduction, the Netherlands, with its intense relationship with water, houses great potential for extended development in hydropower sources (Manders et al., 2016). Although hydropower schemes require relatively high initial investments, they last longer than any other energy landscape, and have very minimal operating costs. They may also be implemented as multifunctional schemes, for instance when combined with irrigation or recreational facilities. There are many opportunities in the Netherlands to adapt existing hydraulic works to function as small hydropower facilities (Bartle, 2002).

There is already a large amount of (small-scale) techniques for harvesting of renewable energy available. Most of these techniques are still being experimented with and will still be improved upon. Following this imminent energy transition towards energy neutrality lots more investing and innovation is needed (Hoogerland, 2016, Verbong and Geels, 2007). For instance, as can be seen in figure 4 a & b, there has been some research into the possibilities of combining energy landscapes with other amenities such as nature development and the farming of fish, mussels and seaweed (Stremke et al., 2017).



Figure 4: a) Design for offshore wind park in combination with increased biodiversity. b) Design for a solar-island combined with Rana & fauna habitat (Stremke et al., 2017).

According to the 'MRA Verkenning Energietransitie' the aim for producing of the expected energy use in the MRA, which is 203.4 PJ by 2040 is one that cannot be met within the borders of the MRA using the techniques that have been used in the Netherlands up to this point. There is simply too big a growing demand and too little space to meet it (Marco Broekman, 2017).

Small-scale implementations of these techniques are relatively easy to implement, and are more flexible towards innovation. Through large-scale implementation of small-scale energy landscapes the energy transition may come to fruition. This implementation can be possible through the development of a 'smart grid'. Using this, electricity will be transported from producer straight to consumer, and vice versa. The existing infrastructure will have to be adapted to fit the combination of traffic and energy transport, preferably building upon the already existing network of routes. If we indeed choose the route of decentralising energy production, we will need a system in which local initiatives can be combined with collective management. These small-scale local initiatives will serve as icons for the energy landscape of the future (Hoogerland, 2016).

4.2 Hydropower technologies

4.2.1 Tidal energy

There is a large amount of tidal energy devices available. Some of these devices are listed in figure 5. The most common one, the axial flow turbine, will be explained in more detail below.

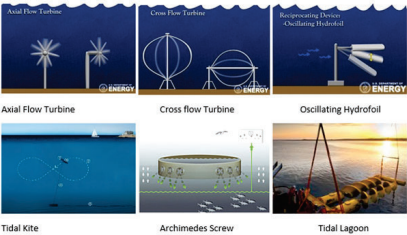


Figure 5: Different tidal energy installations (Tethys, 2017)

Axial flow turbines are turbines in which the flow of the working fluid is parallel to the shaft (Prandle, 1984). With their three blades with efficient hydrodynamic profile they are able to respond to local flow conditions. They are planted on the seafloor and include a cable that transports its harvest to the nearest collection hub or consumer (GE Renewable Energy, 2017).

Another way of implementing axial flow turbines is by creating a Tidal Lagoon, which is a structure similar to a hydroelectric dam. Essentially it consists of a large concrete structure containing sluices, separating one water feature from another, allowing eaves to move in and out of the dammed area. The sluices close at high tide, and are only opened when the tide has receded. The water flows through the axial flow turbines on its way out, generating energy, as shown in figure 6 (Green The Future, 2008).

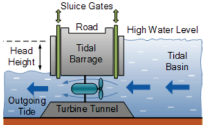


Figure 6: Tidal Lagoon diagram (Halliburton, 2016)

Placing two or more turbines in close proximity to each other doesn't affect their performance in any significant way (Bahaj et al., 2007). The energy generated through the use of a tidal lagoon can be calculated using the following equation (Hydropower-Tidalpower Blogspot, 2009, Xia et al., 2012, Green The Future, 2008):

$$E = \frac{1}{2} \times A \times \rho \times g \times h^3$$

where:  
h is the vertical tidal range,  
A is the horizontal area of the barrage basin,  
 $\rho$  is the density of water = 1025 kg per cubic meter and  
g is the acceleration due to the Earth's gravity = 9.81 meters per second squared.  
 $\frac{1}{2}$  is due to the reduction of hydraulic head as the basin flows empty

4.2.2 Wave energy

The amount of wave energy devices available are virtually endless. A couple of the most common varieties are listed in figure 6. A few of them will be explained in more detail further on.

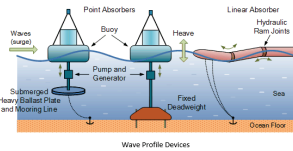


Figure 6: Wave energy devices (Alternative Energy Tutorials, 2017)

A wave buoy made by OPT can harvest energy in a range up to 15 kW. This average output power is deployment-site dependent (Ocean Power Technologies, 2017). It is fixed to the ocean floor and harvests energy using the rise and fall of swells to drive hydraulic pumps (Tethys, 2017).

A regular point absorber with a 4m diameter can absorb about 20 – 30 kW (De Backer et al., 2007). Theoretical physicist Joseph George, residing in Bangalore, India, had been doing research in which multiple point absorbers are fitted together to form a platform which can theoretically be used in a variety of ways. Figure 7 shows what this would look like. No further tests have been published as of now.

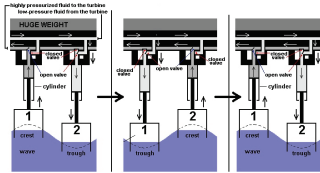


Figure 7: Diagram for a Multi-Point Absorber Floating Platform for Offshore Wave Energy (George, 2014)

4.3 Land-art preferences & energy landscapes

Land-art is an art movement that uses the physical landscape as a canvas. It enables aesthetic interaction with the environment, and contributes to the way beholders value the natural landscape (Brady, 2007). In bygone eras art and development had a very intimate relationship. This relationship has been disconnected in recent years, which has resulted in regions that are disconnected. They lack the finely crafted whole, creating a disappointing experience for those who dwell there. The reason for this is the pragmatism that rules most of project management, as well as time and budgetary constraints. Thinking of culture and thinking creatively at the start of a design process can help uncover the unique characteristics that make up a place's genius loci. Artists often have the ability and curiosity to uncover and investigate aspects of sites that the design team would never think to consider (Holding, 2008).

Cities have seen an increasing trend of wanting to develop culture-related uses in a particular area,

calling it a 'cultural quarter'. These cultural quarters are often stuffed with public art in order to raise the site image and identity. Often however, this works in a contradicting manner, as the projected image they try to develop doesn't reflect the community at all. Nevertheless, it is possible to enhance a site's image and identity with public art, by using historical associations to link to the existing image and identity. An 'art trail' can, for instance, help promote a site as a landmark and tourist attraction (McCarthy, 2006).

In many culture-led strategies signature architecture or scattergun implementation of public art are overused, instead of using creative, narrative trans-disciplinary design to truly enhance public space. The idea is that by implementing collaborative, participatory design using the narrative of the local environment, one can tell stories in and through the urban fabric (Austin, 2011).

Both energy landscapes and land-art installations draw a variety of reactions from the public, ranging from much-loved to much-hated. Both of them have a profound impact on the cultural landscape and as such visual integration into the environment is key when designing them. Much of the opposition to both are based on aesthetic grounds (Layne, 2017). When designing them one might consider people generally prefer round and curved objects over angular ones (Silvia and Barona, 2009).

Another key complaint the public has is that they are forced to experience the huge change in the physical landscape such large installations bring with it, rather than being invited to do so. The more open and participatory the planning and development process is, the more supporting the public will be. Re-imagining and re-presenting the energy landscape as distinct features in their own right will allow them to be extensions of the cultural landscape, becoming a valuable asset to the region, rather than an intrusion into it (Layne, 2017).

While land-art pieces are often open to the public, energy landscapes such as wind farms tend to keep closed borders, limiting communication and landscape development possibilities as well as the farm's incorporation in the landscape. If installations such as energy landscapes or land-art projects are made accessible, less attention will be given to the physical structures of the place, and more attention will be given to understanding the culture behind the installation. The public's acceptance levels will heighten when incorporating citizens into the installation, and allowing a level of engagement with it (Layne, 2017). The key features of engagement are 1) developing a continuity of or assimilation into the cultural experience, 2) perceptual integration of creating associations with the human experience, and 3) participation with, or recognising a societal function from, artistic works (Berleant, 1993, p. 46).

4.4 Precedent studies

In this section three precedent studies are introduced to illustrate how some of the concepts that have been introduced in the previous chapters are implemented in real life, and what benefits they bring. All of them have influenced the final design in a different way, and all are unique. Consequently each of them will be introduced in a different manner and different conclusions will be drawn from each project.

4.4.1 Sihwa Lake tidal power station

Lake Sihwa, in the Gyeonggi Province of South Korea, is an artificial lake that was constructed as a land reclamation project in 1994 (Kim, 2016, Patel, 2015, Bae et al., 2010). The lake, along with 172km<sup>2</sup> of reclaimed land, was created by constructing a large dike. The lake was supposed to function as a freshwater reservoir, but when waste water polluted the lake the decision was made to allow seawater exchange. The plan here was to gradually improve the water quality while providing a renewable energy source (Bae et al., 2010). Tidal energy is now generated twice a day at high tide using turbines and generators that harvest 552.7 GWh of electricity. The sluice gates close when the tide comes in, thus securing the water level of Lake Sihwa (Kim, 2016).

The power station, as seen in figure 8, has become a tourist attraction, as well as an educational centre where one can learn about ecosystems and the 146 species of bird that live in the area. The Sihwa embankment has been transformed into a popular location for sports and leisure. Around 1,5 million

people visit the power station each year (Kim, 2016).



Figure 8: Sihwa Lake tidal power plant (Patel, 2015)

4.4.2 Neeltje Jans

Neeltje Jans is the name of a sandbar, located in the middle of the Oosterscheldekering in the Province of Zeeland, part of the famous Deltaworks, turned into an artificial working island for Rijkswaterstaat (Cornelis, 1995). Fun park 'Deltapark Neeltje Jans', shown in figure 9, has since been constructed on the island, featuring attractions, a water park and various expositions (Watereducatie, 2017). Half a million people come to see Neeltje Jans each year, to learn about the Dutch history of living with water, as well as present day and future hydrological technology (Cornelis, 1995). Neeltje Jans has a variety of programmes on offer for all levels of education (Watereducatie, 2017). Environmental education is meant to help reduce the societal problem that the quality of the environment is degrading. Educating people about the environment will help them develop an environmentally friendly way of life (Vrieske et al., 2011). Places like Neeltje Jans provide a fun way learn about the environment, which will in turn help solve this societal issue. In 2015, 5 tidal turbines were installed in the Oosterscheldekering. It's the largest hydropower project in the Netherlands at the moment (Strukton, 2015).



Figure 9: Deltapark Neeltje Jans (Deltapark Neeltje Jans, 2017)

4.4.3 Land Art Generator Initiative

The Land Art Generator Initiative (LAGI) is a sustainable design event that inspires people the world over about the promise of a zero carbon future. Their goal is to provide new models of renewable energy technologies that add to the quality of landscapes; installations that inspire and educate. Though

innovation and interdisciplinary collaboration between art and technology they hope to accelerate the energy transition and provide renewable energy to homes all around the globe. One of the ways LAGI does this is by hosting a biennial design competition. Artists and engineers team up to design land-art installations that function as renewable energy landscapes simultaneously (LAGI, 2017).

The design brief as stated on LAGI's official website is as follows: "the artwork is to capture energy from nature, cleanly convert it into electricity, and transform and transmit the electrical power to a grid connection point to be supplied by the city. Consideration should be made for the safety of the viewing public and for the educational activities that may occur on site. The design should be constructible (rather than theoretical), and it must respect the natural ecosystem of the design sites" (LAGI, 2017). This thesis has been inspired by a lot of LAGI submissions, but the following two have been instrumental.

Algae scape (2010)



Figure 10: Algae scape, Poster 2 of 3 (LAGI, 2010)

The project shown in figure 10, situated at the shore of the Persian Gulf in the United Arab Emirates, featured a lagoon that created an island shelf separated from the main land. This shelf was cut to sea level, allowing water to flow in at high tide. Large floating platforms create a boardwalk over the water. Algae scape features multiple ways of harvesting renewable hydropower, and harvests energy from algae as well (LAGI, 2010).

Drawing Energy (2016)



Figure 11: Drawing Energy, Poster 1 of 3 (LAGI, 2016)

Drawing energy, as seen in figure 11, is a project set at the famous Santa Monica pier, which combined harvesting hydropower with converting seawater to fresh water. Rotating tidal turbines underneath a large platform drive the gears installed on the platform itself, filtering the sea water and creating a visual spectacle for the installation's visitors (LAGI, 2016).

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4.5 Conclusions

The large-scale implementation of renewable energy technology is vital, but if we want this implementation to be accepted by Dutch citizens, we will have to closely consider the spatial design of these new energy landscapes (Stremke et al., 2017). Hydropower seems to be a minor contender so far, but there is already a large amount of (small-scale) techniques for harvesting of renewable energy available, as the ones seen in section 4.2 (Hydropower technologies). As small-scale implementations of these techniques are relatively easy to implement, and are more flexible towards innovation, the design at the end of this thesis will consist of a small-scale energy landscape. The energy landscape will consist of a combination of the techniques mentioned in section 4.2. It will be connected to a Smart grid, and will serve as an icon for the energy landscape of the future (Hoogerland, 2016).

From my research on Land-art preferences I have concluded my design needs to be a vibrant hot spot for activity, inspired by the three precedent studies. In order to ensure it will be a success and will improve public perceptions of energy landscapes I plan to:

- o Involve artists and the community in the design process from the start and throughout (Holding, 2008).
- o Choose the artists by letting the community vote for their favourites (Austin, 2011).
- o Avoid adding public art in a scattergun fashion, and instead have it tap into the site history, creating a narrative (McCarthy, 2006).
- o Implement art that will change annually to keep interest (McCarthy, 2006).
- o Engage people from all ages in educational areas (Vreke et al., 2011, Berleant, 1993).
- o Turn the site into an open and distinctive landmark with round and curved features (Layne, 2017, Silvia and Barona, 2009).
- o Involve a tidal lagoon, moving objects to engage the public, and think of added benefits to the environment (LAGI, 2010, LAGI, 2016, Bae et al., 2010).

5. Site analysis

Velsen-Noord is situated in the province of North-Holland, in the municipality of Velsen. It's located in one of the eight regions of the Metropole Region of Amsterdam (MRA), shown in figure 13 (Provincie Noord-Holland, 2014). The project site is located at the coastal area of Velsen-Noord, to the North of the Noordzeekanaal, as shown in figure 12.



Figure 12: The eight regions of the MRA - North Sea Coast Region - Adapted from: (Provincie Noord-Holland, 2014)

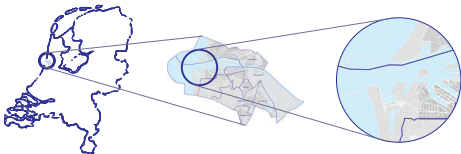


Figure 13: Location project site: The Netherlands - the Municipality of Velsen - Mouth of the Noordzeekanaal

5.2 Circulation

The MRA's aim for the North Sea Coast is to keep the existing amount of visitors coming. The shore needs to be accessible to fast as well as slow moving traffic. Each coastal site needs its own specific identity, creating an array of beaches fit for intensive recreation as well as ones for extensive recreation at beaches that are more difficult to reach. The idea is to create direct cycling and hiking routes through green corridors, making the beach accessible from the city (A. Bilek-de Jong, 2007).

The municipality of Velsen would like for recreational facilities and routing to be connected to cultural history such as de Stelling of Amsterdam, of which the Forteiland is a part (Gemeente Velsen, 2016). Furthermore, they would like to turn cycling routes into attractive ones and further develop public transport to reach inaccessible places.

One of these inaccessible places is the Forteiland, which will be made more accessible to allow for a more intensive recreational use. Although the public is able to reach the island by renting a boat, the local paid ferry only stops here every first Sunday of the new month. The free ferry service from Velsen-Zuid to Velsen-Noord does not stop on the way (Gemeente Velsen, 2017).

The project site is another one of these inaccessible places. The only free route from IJmuiden to the location in Velsen-Noord is to travel all the way around through Wijk aan Zee. The route is unattractive and rather smelly, due to the proximity to Tata Steel and its angry-looking fences. The fences, that are right alongside the cycling path, are fitted with spikes and big road signs that say "DANGER". There is no existing public transport connection. From this route there are three entrances to the coastal area: Golsurfpad, Kitesurfpad en Vliegerpad.

The other option is to pay for a €4,- return ticket on the paid ferry, which only goes 4 times a day (IJmuidense Rondvaart Maatschappij, 2017). The routes mentioned can be viewed in figure 14. To stimulate the access to both Forteiland, as well as the route to Beverwijk, the municipality would like to increase the amount of ferries as well as develop a long distance cycling route in a North-South direction along the coast (Gemeente Velsen, 2016).



Figure 14: Routes in Velsen

5.3 Utilities

The municipality of Velsen has joined hands with NOVA college ROC and Tata Steel in the development of a Techport Centre in the region of IJmond (Gemeente Velsen, 2016). Their first location has opened in the mouth of the Noorzeekanaal in SHIP (Techport, 2017). Techport Centre is still looking for its main location, but have decided it will be situated at or near the South of the Tata Steel location site, as shown in figure 15. It will house an Innovation Warehouse in which innovation and new technologies such as robotics, sensing, sustainability, renewable energy technologies and advanced analytics will be researched and developed (Gemeente Velsen, 2016, RTV Seaport, 2017). There will also be a place where starting and developing entrepreneurs can situate their companies. No definitive location has been chosen as of yet (RTV Seaport, 2017).



Figure 15: Proposed location Techportshown in IJlca (Gemeente Velsen, 2016, p. 28) p 28

5.4 Culture and Demographics

Plans made up by the municipality of Velsen for 2025, as shown in figures 16 a & b, include developing (holiday) housing near the beach and creating new recreational and public slow movement infrastructure. Also The municipality aims towards adding amenities to the project area (Witteveen, 2010, Gemeente Velsen, 2016, Provincie Noord-Holland, 2014).

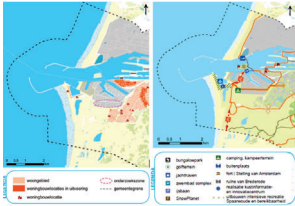


Figure 16: a) Housing - b) Recreation (Gemeente Velsen, 2016)  
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The beach to the North of the Noorzeekanaal is allocated as the 'tough' beach on which extreme sports such as surfing and kitesurfing can take place, right above a 'slow' beach, next to just to the North of the Noordpier, where people can sunbathe and have a swim (Gemeente Velsen, 2016).

Velsen also expresses a profound interest in art and culture that fits in with the Velser identity. According to them there is a need for art and culture in public spaces (Gemeente Velsen, 2016). A lot of the artworks in Velsen have a maritime theme, or are made of steel that was developed locally, at Dutch steel producer de Hoogovens (the current Tata Steel). Some of these artworks are shown in figure 17. There is an art trail situated along the fringes of Tata Steel, full of steel artworks, named 'de Zee van Staal' (the Sea of Steel) (Beelden van Velsen, 2017).



Figure 17: Examples of Art in Velsen (Beelden van Velsen, 2017)

5.5 Climate and Nature

The municipality and the MRA mean to strengthen the relation between the coast and the polder using ecological links. Their wish in the dune area is to enforce the dune meadow mosaic, and to stimulate sand-drift. Finally, they plan on connecting existing parks and estates and recreating the historical dune route (Witteveen, 2010, Gemeente Velsen, 2016, Provincie Noord-Holland, 2014). As you can clearly see in figure 18 the only remaining land that isn't part of either the city or a Natura-2000 reserve is a little stretch of coastline just to the North of the Noorzeekanaal.

The Velser municipality expresses a wish for all residences to be climate neutral in 2050. They facilitate as well as stimulate the harvest of wind- and solar energy, as long as the technologies don't hamper the quality of the landscape. Further possibilities are being researched, including the use of residual heat, geothermal energy and the harvest of tidal energy (Structuurvisie Velsen 2040).



Figure 18: Nature Areas - Scored: Natura 2000, Green: NEN Structures (Gemeente Velsen, 2016)

5.6 Geophysical processes

The Noorzeekanaal carries its own water, as well as that from the Amsterdam-Rijnkanaal and the Lekkanaal, to the North Sea through the Spuisluis and the pumping station at Umuiden. In order to keep large parts of the Netherlands from flooding, 3,000,000,000,000 litres of water, carrying sediment, are released to the sea each year (Arends, 2001). Waves at the mouth of the Noorzeekanaal carry a wave frequency between 20 and 500 mHz in cm, as seen in figure 19. Figure 20 shows an average of 2 meter astronomical tidal movement at the mouth of the Noorzeekanaal (Rijkswaterstaat, 2017).

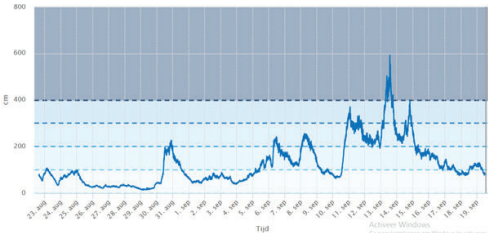


Figure 19: Wave heights predicted over 28 days (Rijkswaterstaat, 2017)

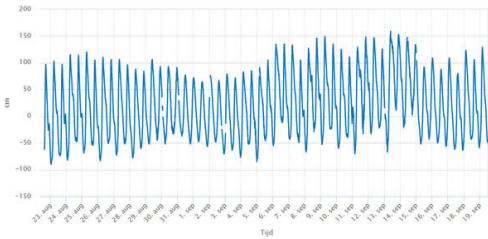


Figure 20: Water Heights predicted over 28 days (Rijkswaterstaat, 2017)

Sediment transport through waves will only take place in shallow waters. When the speeds of the waves' oscillations on the sea floor are larger than the stream flow of the sands' particles. This means finer particles are more easily transported than coarse ones. As waves near the coast they become smaller in size, and thus will release coarse particles, whilst still having the strength to take the finer ones with them. This finer material will eventually sink down in calmer water away from the shore. This process results in coarse beaches, turning finer and finer as one ventures out towards the sea (Pannekoek and Straaten, 1982). The in the area wind is predominantly from the South-West so waves will push sediment towards the shore (Windfinder, 2017). This direction is strengthened by a current perpendicular to the coast just to the North of the Noordpier at rising tide, as shown in figure 21.

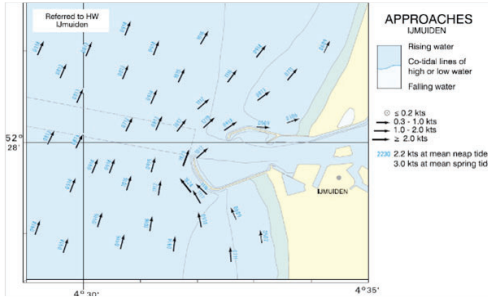


Figure 21: Flow direction at rising tide (Rijkswaterstaat, 2017)

## 5.7 Conclusions

From this site analysis I have concluded the only suitable place to place an energy landscape is to the North of the mouth of the Noordzeekanaal, as shown in figure 22 (Gemeente Velsen, 2016).

As this location is in the area where the Municipality of Velsen has proposed the development of the Techport should be, I will combine my energy landscape design with the development of the Techport centre (Gemeente Velsen, 2016).

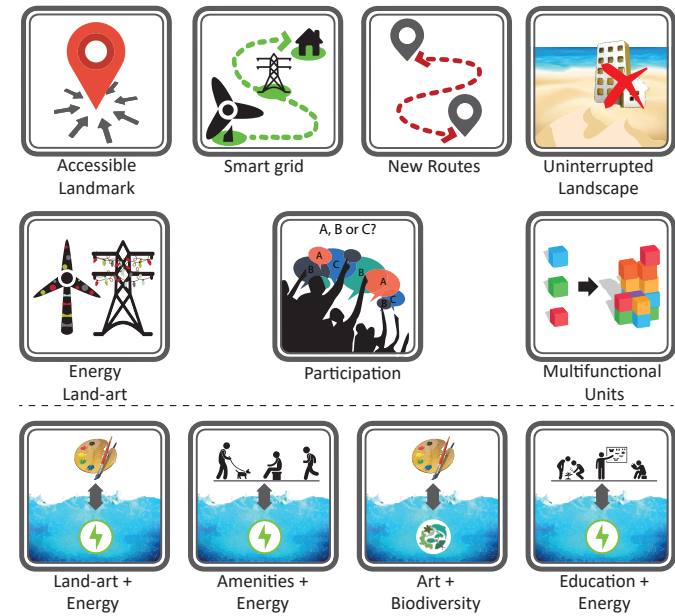
As per the wished of the municipality, the energy landscape and the surrounding area will be an accessible place, as I will enhance recreational slow movement infrastructure that is already in the area, and suggest new routes where they don't yet exist. This slow movement infrastructure will provide a barrier between the rough and slow beach, allowing both functions to be carried out without disturbance from the other side.

The wind is predominantly South-Western, causing waves to push sediment towards the shore, bringing the energy landscape in danger of silting over and becoming inoperable (Windfinder, 2017). This, as well as the prevalent tidal movement and the flow direction and are things that will be considered during the design process.

Figure 22: Aerial view final project site current situation (OpenTopo, 2017)



## 6. Design guidelines



7. The Design

The master plan can be viewed on the next page in figure 26.

As the Noordpier at the mouth of the Noordzeekanaal creates a current in a direction perpendicular to the beach, this design features a tidal lagoon that allows the current to keep flowing in this direction. The tidal lagoon is shaped and supported with the use of Filtrex Siltsoox, as seen below in Figure 23 (Filtrex International, 2017).



Figure 23: Filtrex Soxx (Filtrex International, 2017)

When the tide comes in, the entire lagoon is flooded, leaving an island visible in the middle of the design. When the tide recedes, water is caught in the lagoon. Once the tide has reached its lowest point, the sluice gates open and hydropower is harvested with the use of axial flow turbines. This sudden movement in the water makes the algae that grow in the lagoon glow in bloom. This tidal movement is depicted in figure 27.

The island in the middle of the design looks like a dune when seen from the beach, ensuring an uninterrupted and natural-looking coastal landscape, which ensures high visual landscape quality (Morgan, 1999). The dune houses a building that will serve as a show pony location for the Techport Centre. A floating platform with moving parts and an exhibition of kinetic artworks attracts visitors year-round, and harvests energy using multiple point absorbers.

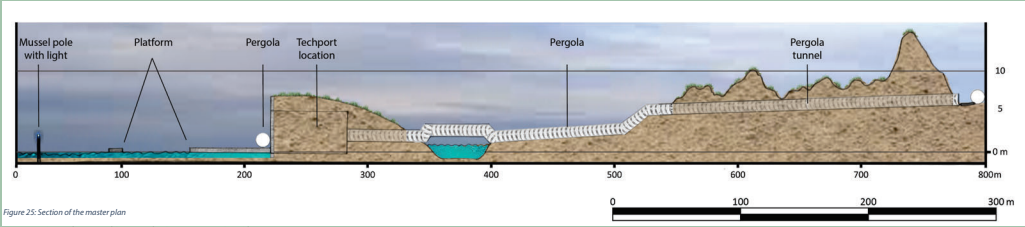


Figure 25: Section of the master plan

The circle is completed by a half-circle of Mussel Poles that vary in heights and pop up as the tide recedes, emitting an attractive light. Various wave buoy birds and a sediment dragon float nearby. The structure is accessible directly from Tata Steel and from the North by slow movement infrastructure in the shape of a circular pergola structure that serves as energy transport simultaneously.

Figure 24 shows a vignette of what location the section shown below in figure 25 was taken.



Figure 24: Vignette with section location in blue

Figure 26: Master plan

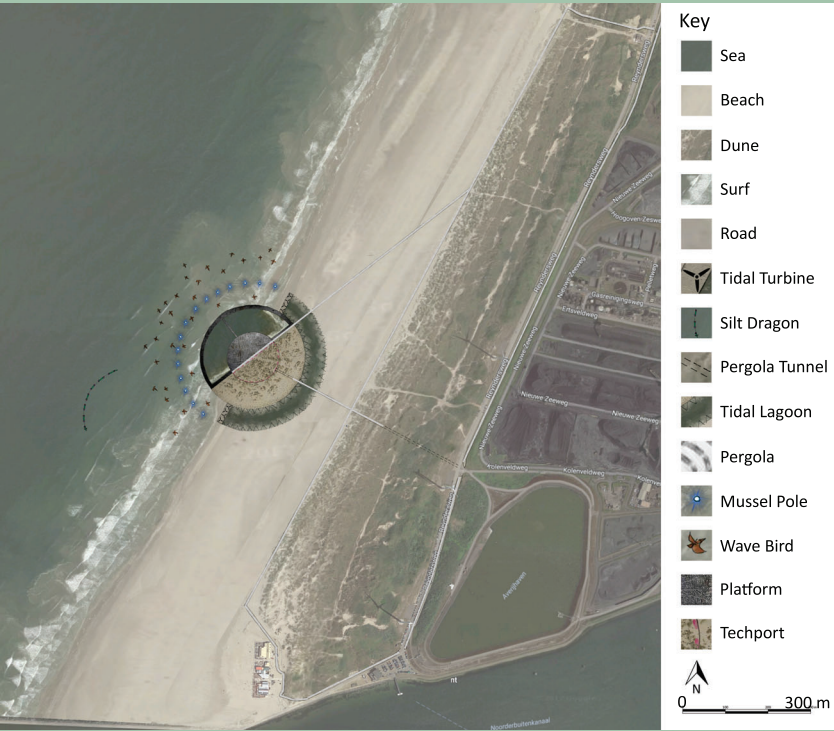
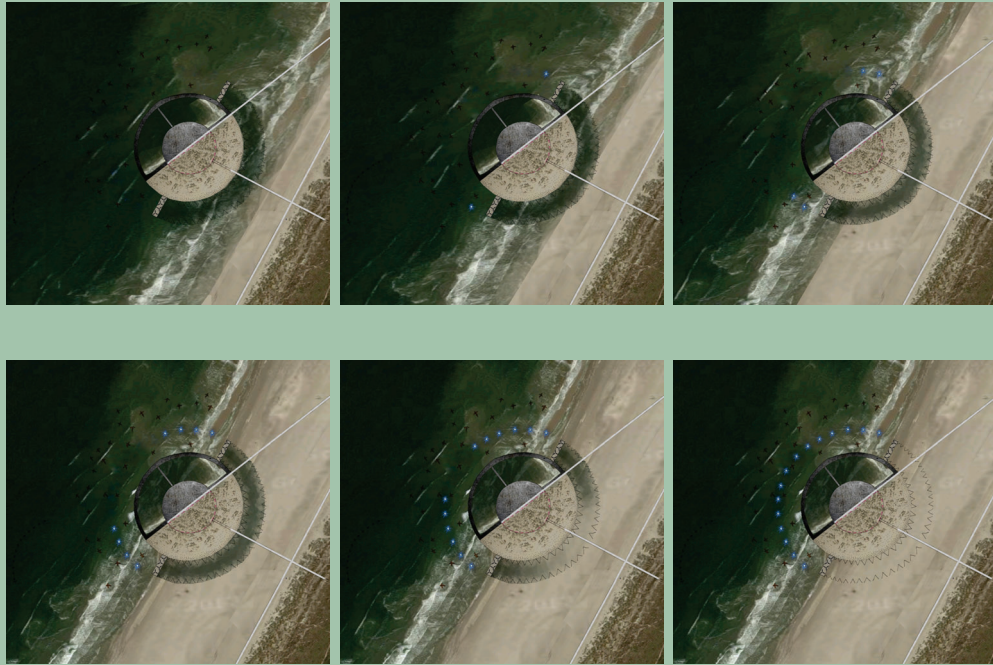


Figure 27: Tidal Movement



## 7.2 Details

### 7.2.1 Techport Location

The building will be situated inside an artificial dune, constructed with Filtrexx Soxx, allowing visual integration with its surroundings. From all sides but from the sea, uninterrupted coastal vistas will be maintained. A bird's-eye view is shown in figure 28.

Inside the artificial dune there is room for an information centre, a flexible exposition area, a café, and working spaces for small-entrepreneurship as well as for the studying ROC Nova College students. The generator that collects all the hydropower from the devices outside will also be housed inside, so the Techport location can run on the energy harvested, and consecutively transport it through the pergola system towards the nearest consumer.

Tata Steel and the municipality will be able to use the Techport location as their show-pony, using the building and its surroundings to host events such as scenario evaluations, art shows, and events in which they display their newest innovations to the public or their stakeholders. This will improve the image of the municipality as well as of Tata Steel; through placing the Techport location outside on the beach, it will be accessible to the public, where usually these events would take place behind closed doors.

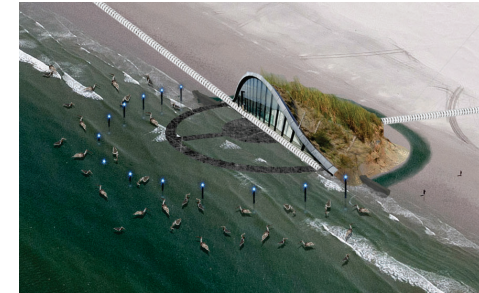


Figure 28: Bird's-eye view

### 7.2.2 Tidal Lagoon

Twice a day, as the tide comes in, the beach will flood up to the farthest reach of the Tidal Lagoon, fully engulfing it in water. At high water, the sluices fitted in the tidal wall will close, keeping the water level at its highest point inside the lagoon, while the tide recedes. When the tide is at its lowest, the sluices will open, allowing the water to rush out of the lagoon all at once. This causes the axial flow turbines fitted in the tidal wall to spin, thus generating energy.

Energy calculation:

$$E = 1/2 \times A \times \rho \times g \times h^2$$

where:

$h$  is the vertical tidal range,

$A$  is the horizontal area of the barrage basin,

$\rho$  is the density of water = 1025 kg per cubic meter and

$g$  is the acceleration due to the Earth's gravity = 9.81 meters per second squared.

$$E = 1/2 \times 17153,095 \times 1025 \times 9.81 \times 2^2 = 344957316.998 \text{ J}$$

Now we have 2 high tides and 2 low tides every day. At low tide the potential energy is zero. Therefore the total energy potential per day = Energy for a single high tide  $\times 2$

$$= 344957316.998 \text{ J} \times 2$$

$$= 689914633.995 \text{ J}$$

Therefore, the mean power generation potential = Energy generation potential / time in 1 hour

$$= 689914633.995 \text{ J} / 3600 \text{ s}$$

$$= 191642.953888 \text{ W}$$

$$= \text{approximately } 192 \text{ kW}$$

### 7.2.3 Platform

The platform nearest to the Techport location will serve as an outside gathering area, as well as a flexible exposition space. You can reach it at all times, by use of the pergola system, even when the Techport location has closed for the day. It's supported by poles that are safely secured to the seabed. The ring-shaped platform that protrudes out into the sea floats on the waves, supported by large floats. Underneath it, a ring of point absorbers is fitted to harvest energy as the waves flow underneath it. A diagram that visualises this is shown in figure 29. Both platforms are fitted with fencing, benches and signage filled with information on all of the ways hydropower is produced on site.

o Energy calculation:

As a regular point absorber with a 4m diameter can absorb about 20 – 30 kW, and the waves on site are on average only 2m in height, we will assume each will only absorb 20 kW (De Backer et al., 2007, Rijkswaterstaat, 2017).

The platform is 8m wide, and has a length of 326.7 m. Each point absorber has a 4 m diameter. Only one row of point absorbers would realistically fit within the 8m, allowing for a total amount of  $(326,7 / 4) = 81$  point absorbers. This amounts to:

$$81 \times 20 \text{ kW} = 1620 \text{ kW in total}$$

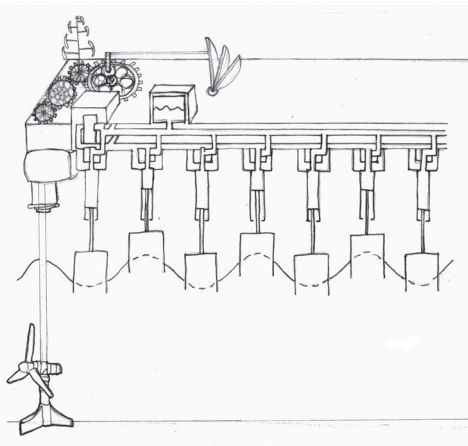


Figure 29: Platform devices diagram

### 7.2.4 Sea Dragon

To catch the sediment expelled by the Noordzeekanaal that is carried towards the lagoon by the waves pushed forwards by a predominantly South-Western wind, a silt curtain sea dragon, depicted in figure 30, is installed in a key location. The curtain is fixed to a number of wave buoy point absorbers, and fitted with dragon shaped PWC foam pieces. The dragon will excite young visitors to the site and will be a great conversation piece for all who see him.

- o Energy calculation:

A wave buoy made by OPT can harvest energy in a range up to 15 kW (Ocean Power Technologies, 2017). As the waves on site are on average only 2m in height, we will assume each will only absorb 10 kW. The dragon consists of 13 wave buoys, which amounts to a total of:

$$(13 \times 10 \text{ kW}) = 130 \text{ kW}$$



Figure 30: Sediment sea dragon

### 7.2.5 Wave buoy birds

The regular OPT wave buoys are fitted with foam seabirds that flock around the project site, allowing them to blend in with the landscape and create a floating spectacle, shown in figure 31. The birds will be coated with a steel-coloured lacquer, to tie in with the narrative created by Tata Steel.

- o Energy calculation:

Like the ones used in the sea dragon, these buoy point absorbers will absorb 10 kW each. There are a total of 31 birds distributed around the area, so all together they will harvest:

$$(31 \times 10 \text{ kW}) = 310 \text{ kW}$$

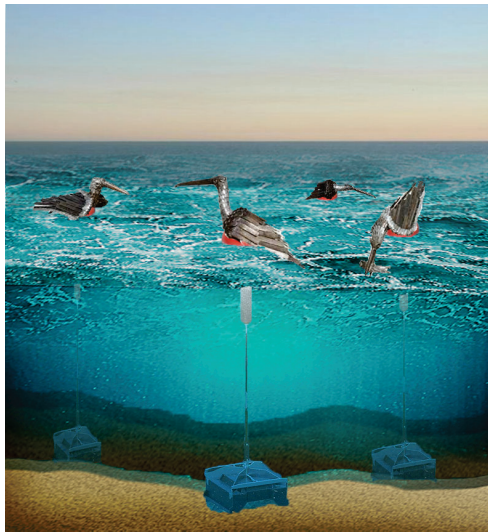


Figure 31: Wave buoy birds

### 7.2.6 Mussel Poles

To complete the circle created by the Tidal Lagoon, 15 mussel poles of varying heights are distributed in a half circle ranging out into the sea. All of them are fitted with a light that will activate as soon as it breaches the surface of the water. The outgoing tide will uncover these poles one by one, a process shown in figure 32. These mussel poles were chosen as they are commonly used along the Dutch shore and will thus create tie in with the narrative of the project area. Mussels are grown on these poles on the shoreline, where they are regularly exposed by the outgoing tide. Because the impact of implementing this energy landscape will have a large impact on the local ecosystem and biodiversity, the implementation of mussel poles in the design will serve as a method of compensation; encouraging wildlife to adhere to these poles and flourish around and among them. They will serve as a small-scale 'artificial reef', that may on the long-term resemble a natural reef (Burt et al., 2011).

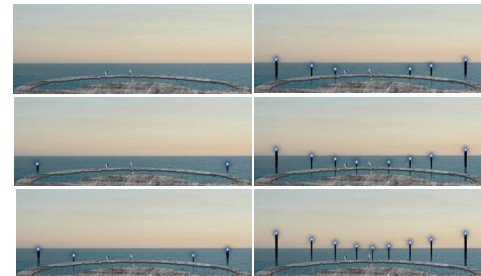


Figure 32: Mussel poles surfacing as the tide recedes

### 7.2.7 Energy transport

The pergola system shown in figure 33 is circular in shape, to add to the cohesiveness of the overall design. It's fitted with cables along the roof that transports the energy harvested at the project site. It is donned with light fittings, as well as plexiglass on top and on one of the sides, to shelter travelers from the elements. The closed side is facing Tata steel on the road leading to the beach, to shade passengers from the smell as well as the noise. Along this road, fragrant herbs, such as Lavender, will be planted inside the pergola, to mask the smell of fumes emitted from the Tata Steel plant. From the Tata Steel site, the pergola will tunnel in a straight line, underneath the row of dunes, to avoid disturbing the NEN area above. On the beach the closed side will face the shore, as the predominant wind will come from this direction. It will provide the beach with a soft barrier between the slow beach in the South and the 'rough' beach in the North.



Figure 33: Pergola energy transport

7.2.8 Algae Bloom

A type of algae, Noctiluca scintillans, also known as Sea Spark, will be farmed inside the Tidal Lagoon. The Noctiluca scintillans algae has been chosen for its ability to emit a bright blue light when moved vigorously, as shown in figure 34 and 35. Each time the turbines open, the algae will shift and illuminate the Tidal Lagoon, creating a colourful spectacle that will dazzle nightly visitors. Noctiluca scintillans produce and store oil, making them suitable for harvest and the subsequent subtraction of biofuels. When farmed in suitable conditions, they may yield up to 6 litres of biofuel per square meter (Pagnoni and Roche, 2015). As more testing in the field will need to be done to determine whether these conditions will sustain the growth of these algae, this output will be left out of the energy calculations.



Figure 34: Sea Spark in bloom (Peraðjögætt Magazine, 2017)

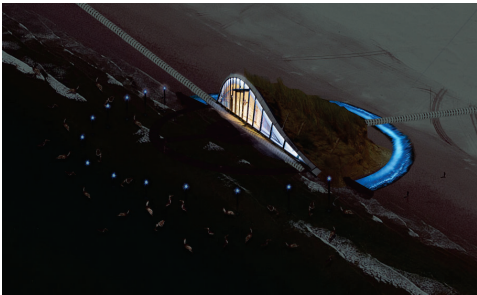


Figure 35: Bird's-eye view at night

7.2.9 Total energy Output

The tidal lagoon makes 192 kW.  
The platform makes up to 1620 kW.  
All the wave buoy point absorbers together make up to 440 kW.

Together his makes for a total of 2252 kW, and because  $E(kWh) = P(kW) \times t(hr)$  a total of  $(2068 \times 8784 =) 19781568$  kWh/year

Assuming the power conversion efficiency to be 33% (Xia et al., 2012): the yearly-average power generated =  $19781568 \text{ kWh/year} \times 33\% / 100\%$

The annual electricity consumption in the Netherlands is 6713 kWh/ year per capita, so this design could cater to the yearly energy consumption of 2946 Dutch citizens. Velsen-Noord has a total population of 5205, so using a smart grid this design could cater to the energy consumption of 56,6% of Velsen-Noord (The World Bank, 2017, Trading Economics, 2017).

As the Dutch electricity consumption is believed to have gone down 30% by 2050 this energy landscape will by then be able to cater to a total of 9822 Dutch citizens, which is 14,5% of the current population of the municipality of Velsen (Sijmons, 2017, Oozo, 2017).

7.3 Detail Plan

The detail plan is shown on the following page in figure 40. Figure 36 displays a vignette with the detail's location in the master plan. Figure 38 shows a vignette of where the section in figure 39 was taken.

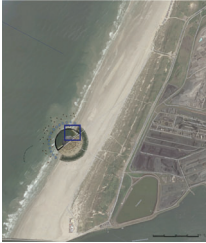


Figure 36: Vignette with detail plan location in blue

The platform nearest to the Techport location, shown in figure 37, will feature high-tech looking cogs that are imbedded in the floor behind plexiglass. They are rotated using axial turbines on the seabed beneath the platform. The material steel was chosen for the platform, to use the narrative of the local environment and tell a story through the design. Kinetic art is suggested to be mounted on the cogs to emphasize the hydropower collected by the turbines on the seabed as they turn. This motion is designed to engage visitors, by making something that happens below the surface visible and obvious. The works of art can be changed over the years on

a rotational bases, and picked from local artists or ROC Nova College students, during a participatory event that will involve all the stakeholders. Representatives from the municipality of Velsen, Tata Steel as well as students from NOVA ROC College will have a say on which artworks are chosen. Repeating this participatory voting process on a yearly will keep the public invested, will keep the project looking up to date and will provide an influx in visitors after every rotation. The ones on display in images .... and .... are merely suggestions that might fit the 22<sup>nd</sup> century image this energy landscape tries to portray.

The platform itself is donned with tables, chairs and umbrellas, on which visitors can lounge after they have had a look around the place. To engage visitors in education, events may be held on location such as workshops, scenario evaluations, or art shows. The platforms themselves offer educational value through signage, and visitors are invited to take a stroll onto the tidal wall and have a look through a plexiglass plate at the axial flow turbine below.



Figure 37: Bird's-eye view of platform and Techport Location

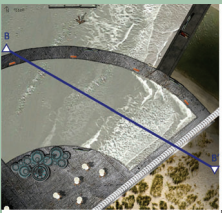


Figure 38: Vignette with section location in blue

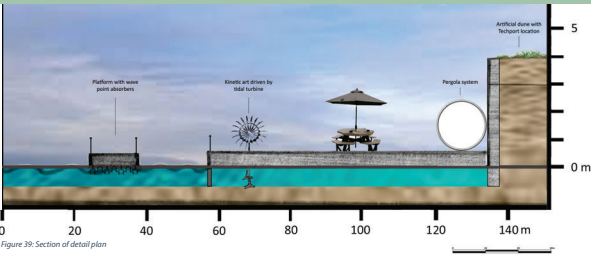
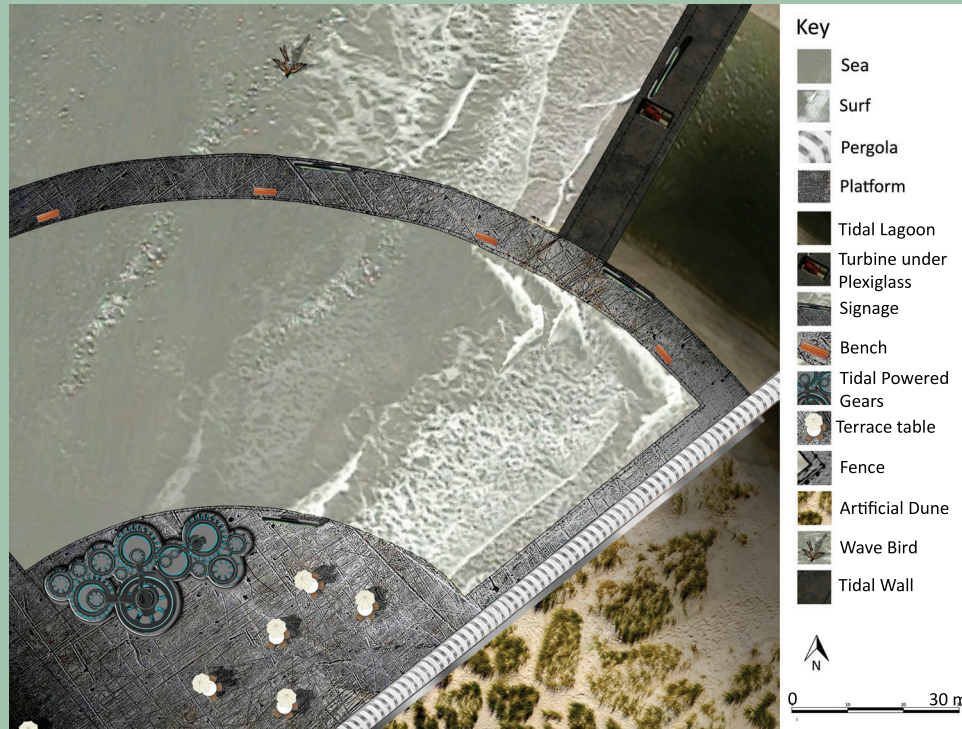


Figure 39: Section of detail plan

Figure 46:  
Detail Plan

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## 8. General Discussion

The design wasn't able to cater to the municipality's wish for increased accessibility from Umuidein and Velsen-Zuid. It leaves me to instead advise the municipality to implement a higher frequency in ferries, allowing more citizens to reach not only Forteiland, but the project site as well. As Forteiland is known for drawing visitors, the improved connection will also improve the amount of visitors to the project site due to its close proximity to Forteiland.

This design will very obviously cost a lot of money to complete. It will be a large investment, and the amount of energy harvested will most likely not make up for the cost. However, it will be a work of art, and as such the benefits are unable to be described in monetary terms.

Combining art with an energy landscape has its drawbacks. On the one hand, it's difficult to have to design an art piece with high aesthetic value when you need to incorporate very static technology that hasn't been designed to look attractive. On the other hand this energy landscape could potentially be a lot more productive in terms of energy output if it hadn't needed to have a high visual quality. Over all I cannot guarantee this design will indeed add high visual quality to the landscape as this quality is inherently subjective and as such subject to opinion.

Even though the artificial dune hides the large structure of the Techport location, and keeps the coastal landscape looking natural to a degree, the large tidal walls and pergola platform are still visible from all sides and may diminish the visual landscape quality.

The multiple point absorber floating platform, conceived by Joseph George, has never been tested in real life and as such there is no way of guaranteeing its functionality. As this design functions as a place for innovation and experimentation, this would however be a suitable location to start experimenting with this concept to determine whether it is indeed feasible.

As I haven't been educated as a physicist or mechanical engineer I would have to consult professionals before implementing any of the multifunctional units suggested in this thesis. Many of the adaptations to seem -to me- to work in theory, but would have to be tested and adapted in the field under supervision.

Although the concept of marrying this energy landscape with the Techport development is feasible in theory, there has so far been no response to my queries from any of the partners of the Techport Centre, and I can as such not guarantee their cooperation in the execution of this project.

Although small-scale hydropower landscapes are currently globally viewed as clean, green and socially just, there are people who argue that the per kilowatt impact of the environment is still similar to those of large hydropower schemes (Manders et al., 2016).

Finally, it must be noted that my final design won't be applicable anywhere else in the world, as I have to designed something that is particular for this particular area.

### 8.2 Conclusions

To conclude this thesis, the answer is given to the design question that was formulated in the chapter research set-up; *How can existing techniques of harvesting renewable hydropower be combined with land-art or amenities in order to produce multifunctional units that improve the visual quality of the landscape?*

As all approaches to visual landscape quality assessment are determined by the subjective judgement of observers that interact with physical landscape features (Daniel, 2001, Daniel, 1990), all designers can do is turn the observer's association with the given landscape into a favourable one. According to definitions proposed by Berleant and Layne, the design will generate acceptance from potential visitors and onlookers.

By Berleant's definition the project needs to cater to the three key features of engagement if people are to accept it as an addition to the quality of the landscape (Layne, 2017, Berleant, 1993). I believe the design does:

- 1) Create a continuity with the cultural experience of the area, assimilating various aspects of its heritage in its land-art installations and chosen materials. The site creates discourse and action between the local area and the Dutch energy transition, while assimilating recreational and cultural priorities into the energy landscape.
- 2) Integrate notions of the Velsler identity into visual objects, whilst creating associations with the human experience by educating visitors on the applied techniques and inviting them to participate in several aspects of the design. The flexible exhibition space encourages associations between hydropower devices and renewable energy, and integrates the energy landscape into the global picture of renewable energy discourse.
- 3) Allow participation with the artistic works and creates a recognition of a societal function in the energy landscape's addition to the Dutch transition towards renewable energy, while serving the dual function of providing education as well as serving as a recreational area.

As coastal visual landscape quality is often determined by a preference for undeveloped beaches with open vistas and high relative relief, this design is successful in the regard that the coastal vista has remained open, and elements of high relative relief have been added in the shape of the artificial dune and the tidal lagoon (Morgan, 1999).

Future visitors to this energy landscape will form a collective social discourse that will reflect their opinion of the project area. This discourse may potentially influence the opinions of the region on this energy landscape, which may in turn influence people's perceptions of other, as well as future energy landscapes (Layne, 2017).

Of course, not all energy landscapes have to be turned into a land-art installation or landmark in order to succeed in the public eye. This won't be possible, especially when in our energy transition towards renewable energy use, energy landscapes will claim more and more of the space available. This is why educating the public on renewable energy techniques and implementing landmarks such as the one proposed in this thesis is important. By engaging citizens and consumers with the process of this energy transition people may grow to accept the future implementation of large-scale energy landscapes, and we may turn the tide on the public's aversion (Stremke et al., 2017).

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8.3 Reflection

I had quite a lot of difficulty with the chosen subject during this thesis. I may have bitten off more than I could chew considering the last time I had to calculate using physics equations and formulas was back in 2009 when I was in high school. Also, as I quickly realised, I had no prior knowledge of hardly anything to do with the Dutch coast and the maritime environment involved. It took a lot of research and even more missteps, that were thankfully caught by my coordinator Sven Stremke and Roel Dijkma, Hydrologist at Wageningen University, to come to this final design.

One of my personal learning objectives was to keep my stress levels down. This turned out to be difficult, due to the time constraint caused by the unfortunate situation attending the Summer school (which was thankfully a very good experience in its own right) had put us in. Me and my peers were set back a week, but managed to work extra hard and catch up. After this I kept to a tight schedule, which allowed for set-backs and the struggles that are inherent in doing research by designing.

My final presentation unfortunately didn't go as planned. Although I am usually fairly competent when presenting, this time I let the stress get to me and I reverted to the inexperienced and stuttering girl I used to be when I first started this Bachelor programme. Although I did manage to bring across most of the information I intended to I wasn't able to sell my ideas and convey that I stand behind the design I made. Fortunately everyone present was very kind and the criticism I got was helpful and well received. I will definitely remember to practice more often the next time around, and not to rely on unfounded notions of my competence when it comes to presenting.

I do believe that I learned a great deal from writing this thesis. For example, I believe that my academic writing skills have increased significantly, and I now know more about hydropower techniques than I at first thought possible. I wish I could spend more time diving into the fascinating world of energy landscapes, as I obviously have much more to learn on this regard, and I am eager to. Perhaps my Master thesis will allow me to continue where I have to leave off now.

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