Energy dashboard on Vlieland

A dashboard to provide insight in the energy situation of Vlieland

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LABVlieland

Master Energy Science
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Commissioner

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FOREWORD

The research on the development of an energy dashboard on the Dutch Wadden island of Vlieland has led to this consultancy report. The process has been carried out in order to provide LABVlieland with essential information for the development of an energy dashboard. This is part of their next step in accompanying the process towards the non-autarkic energy neutrality of the island in the year 2020. Firstly, we would like to acknowledge that we are pleased with the end result and we hope the written document will be very useful for LABVlieland and other concerned parties!

Since April we have worked dedicated to become familiar with the island of Vlieland, the municipality, tourists and other stakeholders. In order to achieve this, we visited the island twice. During the first visitation we attended a lecture and discussion evening led by Søren Hermansen. He is the director of the Energy Academy of Samsø, a Danish energy neutral island that can be considered as an expiring example for Vlieland. This event provided a realistic insight in the desires, struggles and opportunities for Vlieland's ambitions to become energy neutral. On the second visit, a wide range of tourists, inhabitants and stakeholders have been interviewed and surveyed. This created a more in-depth analysis of the situation.

Because of our involvement in the process we honestly hope that the upcoming years steps will be taken in order to reach Vlieland's energy neutrality ambitions. As energy science students we believe these kind of achievements could inspire many other villages, cities and countries to set up energy neutrality goals and other initiatives that bring energy consumers closer to their energy consumption. We think involvement of the public in energy related topics might be the key of the sustainable development of the energy sector. Therefore, we wish LABVlieland success in assisting Vlieland in the process and we hope the municipality will finds a solution that satisfies all stakeholders! Thereby, we hope that a pleasing energy dashboard will be set up the upcoming years, which will fulfill an important role in reaching the 2020 ambitions.

Besides the search for the appropriate answers on the research question and delivering the desired advice, the learning process was an important purpose of this project. Our effort in order to deliver an appropriate report is performed in the context of the course ''consultancy project'' of the master study ''Energy Science'', taught at Utrecht University. Fortunately, a lot of supervision and feedback was offered. Therefore, we specifically would like to note these persons. Firstly, we would like to thank Govert Reeskamp for all supervision from the side of LABVlieland, using his network and for his positive attitude towards our project. Secondly, we would like to thank Geert Litjens, Floor van der Hilst and the students of the Ecofys consultancy group for all their time spent in order to deliver plenty of feedback and supervision during the course.

As last, we would like to thank all stakeholders on Vlieland for the collaboration, their time and the enthusiasm! Specifically, we thank Lammert de Graaf for his hospitality and the tasteful coffee.

Introductie

De gemeente Vlieland heeft in 2007 samen met de provincie Friesland en de andere Waddeneilanden de ambitie geformuleerd om energieneutraal te zijn in 2020. Om dit op Vlieland te bereiken moet er duurzame energie worden opgewekt op het eiland. Tijdens de eerste periode (2007-2014) na het vastleggen van dit doel is er nauwelijks progressie geboekt. LABVlieland denkt dat meer betrokkenheid onder de bewoners, toeristen en bedrijven zal leiden tot meer vooruitgang op dit gebied. Door het maken van een energie dashboard speciaal voor Vlieland, hoopt LABVlieland deze betrokkenheid te creëren. Om deze reden zijn vijf studenten van de Universiteit van Utrecht gevraagd om inzicht te geven in de datastromen die relevant zijn voor het maken van een energie dashboard en hoe deze datastromen kunnen worden verkregen.
De hoofdvraag van dit onderzoek luidt:

"Welke data betreffende energiegebruik en -productie is relevant voor de ontwikkeling van een energiedashboard voor Vlieland en hoe kan deze data verkregen worden?"

Deze studie is gericht op het landoppervlak van de gemeente Vlieland en de bijbehorende fysieke grenzen. Het energieverbruik van de veerdienst tussen Harlingen en Vlieland is buiten beschouwing gelaten.

Methoden

De hoofdvraag van dit onderzoek is opgesplitst in verschillende deelvragen. Voor de beantwoording daarvan zijn verschillende onderzoeksmethoden gebruikt. Er is een duidelijk onderscheid tussen het eerste gedeelte van het onderzoek waarin de meningen en voorkeuren van de verschillende belanghebbenden zijn onderzocht, het tweede gedeelte waarin er vooral gekeken is naar de beschikbare (statische) data en ten slotte het verkrijgen van de benodigde (dynamische) data voor het dashboard.

De verschillende belanghebbenden zijn opgedeeld in een aantal groepen. Twee grote groepen worden gevormd door de inwoners van het eiland en de bezoekers. Om een indicatie te krijgen van de mening van deze belanghebbenden, is er een kwantitatief onderzoek uitgevoerd onder de inwoners en bezoekers. Kwantitatief onderzoek houdt in dat er gebruik is gemaakt van een gestandaardiseerde vragenlijst die door 211 inwoners ofwel bezoekers is ingevuld. De resultaten zijn vervolgens verwerkt door middel van beschrijvende statistiek en toetsing. Daarnaast zijn er verschillende afzonderlijke belanghebbenden zoals de camping, de haven of Staatsbosbeheer. Bij dit soort specifieke belanghebbenden zijn semigestructureerd kwalitatieve interviews afgenomen.

Zoals gezegd staat in het tweede gedeelte van het onderzoek het verkrijgen van data centraal. Deze data kan weer worden onderverdeeld in data die beschikbaar is en data die nog verzameld dient te worden. Beschikbare data bestaat uit jaarlijkse cijfers over de huidige netto gas- en elektriciteitsconsumptie, de huidige productie van duurzame energie en het geschatte opwekpotentieel van zonne- en windenergie per jaar voor het hele eiland. Consumptiedata is afkomstig van Energie in Beeld. De huidige opwek bestaat uit zonnepanelen, zonnecollectoren en biomassa. De data is verkregen uit interviews en het productie installatie register. Het opwekpotentieel is bepaald aan de hand van weergegevens over 2014 (KNMI, 2015) en bestaande fabrieksspecificaties van zowel zonnepanelen als windturbines.

Naast de beschikbare data is er ook data die nog verzameld moet worden. Dit is de data die benodigd is om een actueel beeld te kunnen geven van de energieconsumptie- en productie op het eiland. Verschillende manieren, zogenoemde “data tools”, om delen van deze data te verkrijgen zijn omschreven. Uiteindelijk is een combinatie van deze verschillende datatools nodig om een beeld te geven van de energie situatie van Vlieland. Om te bepalen welke combinatie van data tools het meest geschikt is, is er een Multi-Criteria Analyse (MCA) uitgevoerd. Een MCA is een methode om voor- en nadelen van verschillende opties tegen elkaar af te wegen. Uiteindelijk is de hoogst scorende optie het meest geschikt als de gestelde criteria in acht worden genomen. In dit onderzoek zijn de verschillende combinaties van manieren om de data te verzamelen, beoordeeld op een aantal verschillende criteria. Deze criteria zijn: kosten, sociale impact, complexiteit, dynamische representatie, nauwkeurigheid en gedetailleerdheid. In samenwerking met LABVlieland zijn aan deze criteria weegfactoren gekoppeld. De weegfactoren weerspiegelen in hoeverre een bepaald criterium effect heeft op de kwaliteit van een bepaald scenario.

Resultaten

De mening van belanghebbenden

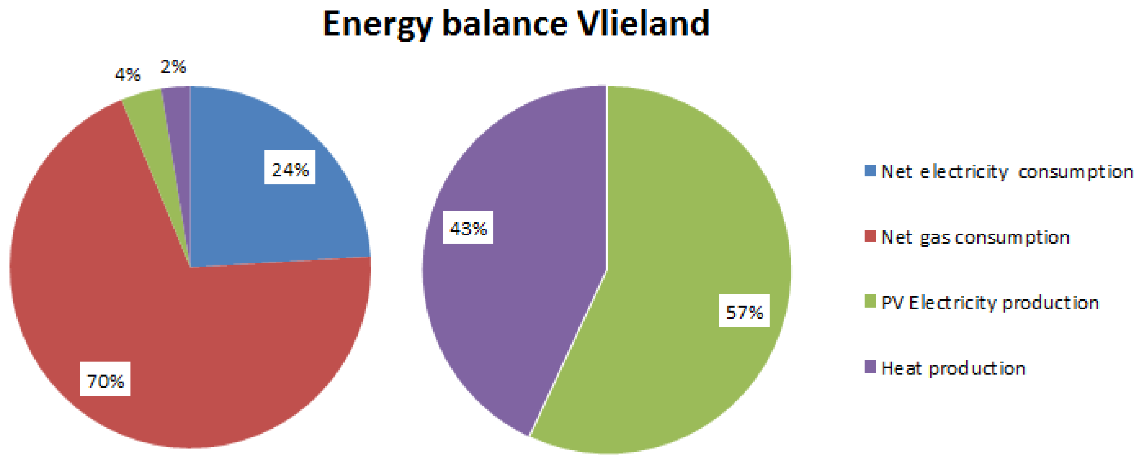
Op basis van de interviews kan worden vastgesteld dat alle geïnterviewde positief staan tegenover de ontwikkeling van een energie dashboard voor Vlieland. Privacy is geen grote zorg als het aankomt op het delen van informatie over energiegebruik en -productie. Er is ook benadrukt dat de informatie op het dashboard vooral simpel en overzichtelijk dient te zijn. Er heerst verdeeldheid over het al dan niet real-time maken van de data en het tonen van het opwekpotentieel. Uit de vragenlijst van de twee grote groepen belanghebbenden blijkt dat er geen significante verschillen zijn tussen de antwoorden van toeristen en inwoners en dat de meerderheid een dashboard interessant zou vinden. Ook hier heeft een simpel dashboard de voorkeur. Verder willen inwoners hun consumptie en productie graag zien en vergelijken met de gemiddelden. Voor duurzame horeca kan een dashboard voordelig uitpakken, omdat veel bezoekers aangeven dat ze hun keuze zouden laten beïnvloeden door informatie over de energetische prestaties van een bepaalde horecagelegenheid.

Welke data is relevant voor op het dashboard?

Uit de resultaten van het onderzoek onder de belanghebbenden en de literatuurstudie is bepaald dat de actuele energieconsumptie en de actuele energieproductie interessant zijn om weer te geven op het dashboard. Ook is er interesse in het weergeven van het actuele verbruik en de productie van de haven, de school, camping en het zwembad. Daarnaast volgt uit de vragenlijst dat men graag inzicht zou willen hebben in het verbruik van hun eigen huishouden. Wat betreft het weergeven van de potentiële productie waren de meningen verdeeld. Sommige zagen dit als opdringerig, terwijl anderen het interessant vinden om te zien wat er mogelijk aan hernieuwbare energie geproduceerd kan worden op Vlieland met zonne- en windenergie. In de interviews werd aangegeven dat de data zo simpel mogelijk zou moeten worden weergegeven.

Huidig beschikbare data

In figuur I.1 wordt een overzicht gegeven van de huidige totale consumptie (linker diagram) en productie (rechter diagram) op Vlieland.



Figuur I.1 - De energiebalans van Vlieland, betreffende consumptie en duurzame productie. Het linkerdiagram weergeeft de bruto consumptie bestaande uit de netto consumptie (rood en blauw) en de productie (groen en paars). De rechter diagram weergeeft de productie op Vlieland, onderverdeeld in de productie van warmte (paars) en elektriciteit (groen).

Buiten de consumptie en productie zijn ook de hernieuwbare opwekpotentiëlen voor wind- en zonne-energie van het eiland berekend. Hier is berekend dat een zonneweide 1.6 GWh kan opwekken, een grote windturbine 6.8 GWh en een kleine windturbine 0.43 GWh kan opwekken.

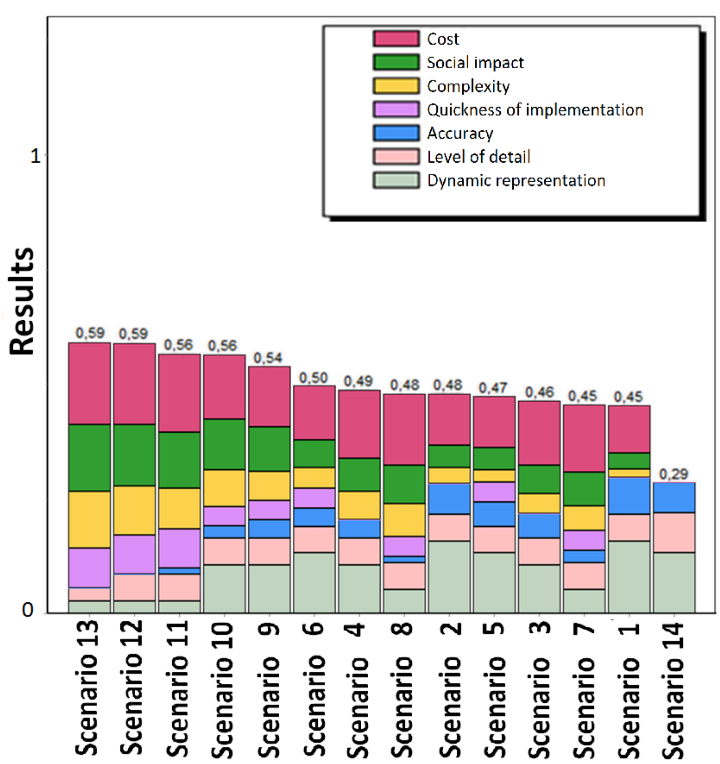
Actuele data

Omdat de huidig beschikbare data niet voldoende is om een actueel energiedashboard te maken, is er nog additionele data nodig. Daarnaast heeft LABVlieland de voorkeur om het dashboard actueel te maken. Voor het verzamelen van de additionele data zijn verschillende methoden (data tools) bepaald. Met behulp van deze data tools kan er actuele data op het energie dashboard worden weergegeven. Er zijn verschillende data tools nodig voor het verzamelen van data voor de volgende verschillende groepen: het gehele eiland, huishoudens, grootverbruikers en de productie.

Een methode voor het verkrijgen van het actuele netto energieverbruik van Vlieland, is het plaatsen van een meter op de elektriciteitskabel en de gasleiding tussen het vasteland en Vlieland. De netto energieconsumptie van huishoudens kan uitgelezen worden met behulp van slimme meters die in de toekomst geplaatst gaan worden. Dit kan via de P1-poort van de slimme meter, die de actuele data per 10 seconden geeft. Het kan ook via de P4-poort, waarbij de data elk kwartier wordt uitgelezen en de data beschikbaar is met een dag vertraging. Als derde optie voor huishoudens kunnen gebruiksprofielen van een gemiddeld huishouden in Nederland gebruikt worden om de data te schatten. Deze laatste optie is goedkoper en eenvoudiger, maar wel minder nauwkeurig. Bij grootverbruikers wordt al kwartierdata gemeten, en dit wordt aan het einde van de dag gecommuniceerd. Op aanvraag plaatst het meetbedrijf een gprs logger, die de data elk kwartier kan doorgeven. De grootverbruikersdata kunnen ook geschat worden door middel van de verbruiksgegevens van het voorgaande jaar. In dit geval hoeft er geen ingewikkelde software geïnstalleerd te worden. Echter, is het wel minder nauwkeurig.

Ook de productie van duurzame energie kan geschat of gemeten worden. Voor het actueel meten van de productie zijn productiemeters bij alle grootverbruikers nodig. De productie van zonnecellen en zonnecollectoren kan ook geschat worden door het extrapoleren van één productiemeter op een bepaald systeem naar het totaal geïnstalleerd vermogen, of door gebruik te maken van jaarlijkse productiedata in combinatie met actuele zonnestralingsintensiteit. Er geldt opnieuw dat meten preciezer, maar wel ingewikkelder en duurder is dan schatten. Tot slot is er nog een data tool om de potentiële productie van hernieuwbare energie te schatten. Voor zonne-energie gebeurt dit op basis van het beschikbare oppervlakte voor zonnepanelen en op basis van actuele zonnestralingsintensiteit. Voor windenergie gebeurt dit op basis van actuele winddata en gegevens van een grote en/of kleine windturbine.

Uit combinaties van deze data tools zijn in totaal 14 mogelijke scenario's gevormd. Voor al deze scenario's zijn scores bepaald voor de verschillende criteria beschreven in de methode. Uit de analyse bleek dat scenario 12 en 13 de hoogste scores krijgen (zie figuur I.2). In deze scenario's zitten de volgende data tools verwerkt: een meter op de kabel en de gasleiding voor het netto consumptie van Vlieland en het schatten van de consumptie, -productie en potentiële productie voor zowel huishoudens als grootverbruikers.



Figuur I.2 - Resultaten van de MCA

Vervolgens is er een onzekerheidsanalyse uitgevoerd om te bepalen in hoeverre het kiezen van andere weegfactoren en/of het toekennen van andere scores effect heeft op de uitkomsten. Hieruit bleek onder andere dat zodra nauwkeurigheid een stuk belangrijker zou worden gevonden, scenario 1 als beste zou scoren. In dit scenario wordt het energiegebruik en de energieproductie van klein- en grootverbruikers niet geschat, maar gemeten.

Advies

Wat betreft het energy dashboard wordt geadviseerd om een fysiek dashboard te maken voor het gehele eiland waarop de energie productie en consumptie wordt weergeven. Daarnaast wordt geadviseerd om voor volgende grootverbruikers een fysiek dashboard te maken: camping Stortemelk, haven, zwembad Flidunen en de nieuwe middelbare school. Ook de huishoudens zouden graag inzicht willen hebben in hun eigen verbruik. Echter, zijn hier al meerdere gratis online dashboard voor beschikbaar, zoals www.slimmemeteruitlezen.nl. Om deze reden wordt hen geadviseerd een slimme meter te installeren en gebruik te maken van reeds bestaande online dashboards. Verder wordt er geadviseerd om de belangrijkste output op het dashboard heel eenvoudig te houden. Aanvullende en meer gedetailleerde data kan dan op een online website worden gepresenteerd voor de geïnteresseerden. Ook wordt aangeraden de potentiële productie op dit online dashboard weer te geven.

Wat betreft het verkrijgen van de data, wordt geadviseerd om scenario 12 als uitgangspunt te nemen, aangezien in dit scenario ook het grootverbruik wordt geschat, terwijl dit in scenario 13 achterwege wordt gelaten. Scenario 12 is gemakkelijk en goedkoop om te implementeren en het heeft een lage sociale impact. Echter is de data niet nauwkeurig. Zodra scenario 12 is geïmplementeerd, kan het dashboard verbeterd worden door de data nauwkeuriger te maken. In dit geval wordt geadviseerd om stapsgewijs naar scenario 1 te werken, waarin meer data worden gemeten in plaats van geschat. Dit brengt wel hogere kosten en complexiteit met zich mee. In figuur I.3 staan de stappen uitgewerkt die moeten worden gedaan om scenario 12 en scenario 1 te implementeren.

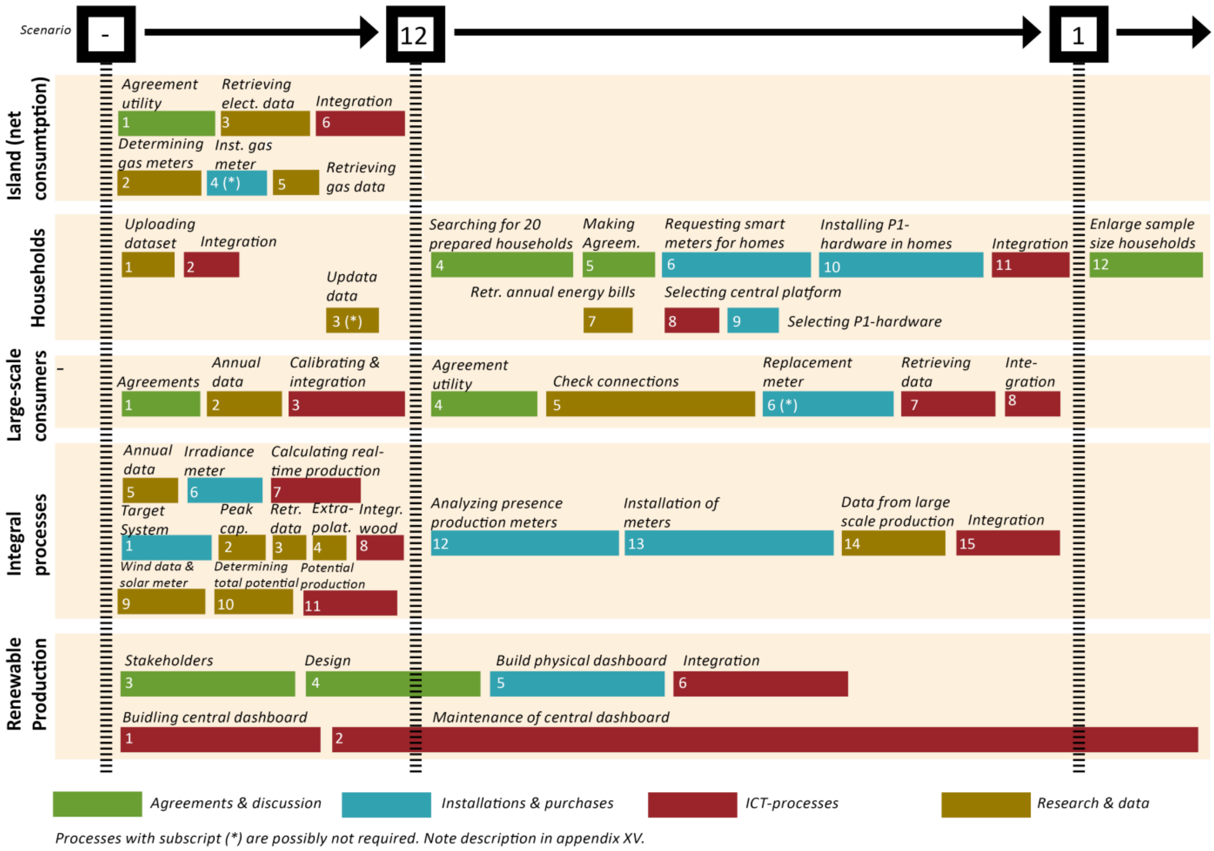


Figure I.3 - Visualization of the required steps for the different data tools in order to create a dashboard, in which scenario 12 is implemented first followed by scenario 1.

Tot slot, is een IT team nodig om de data te verzamelen van de verschillende meters en om het online dashboard te ontwikkelen. Daarnaast wordt geadviseerd een gespecialiseerd team in te schakelen om het dashboard te ontwerpen, zodat het zo duidelijk mogelijk wordt.

GLOSSARY

Energy specific jargons & other technical terms

kWh (kiloWatthour)	Absolute energy unit, equal to cumulative consumption of one kilowatt during one hour
GJ (Gigajoule)	Absolute energy unit. 1 kWh is equal to 3600 GJ
3x80A	Electrical capacity of power connection. Connections smaller than 3x80A are indicative for small-scale consumers.
DSMR P1-port	Data port for personal use on smart meter.
DMSR P4-port	Data port for utility data collection on smart meter.
Synthetic Load Profile (SLP)	Average consumer profile for estimating the electricity and/or gas consumption

Vlieland specific jargon

Gas and electricity connection between island and mainland	The single electricity and gas grid connection from mainland to Vlieland

Research specific jargon

Data tool	Description of a possible method to collect a certain set of real-time data.
Production Installation Register (PIR)	
Multi-Criteria Analysis (MCA)	*"A* method to compare various alternatives accounting for a wide range of criteria that are not all expressed in monetary terms" (Nieuwlaar, 2015)
Scenario	Certain combination of data tools
Gross energy consumption	Total energy consumption on the island
Net energy consumption	Total energy consumption minus renewable energy production on the island
Net energy import	Energy imported from the mainland to the island minus the energy exported from the island to the mainland. When the average net import over a certain period of time is zero or negative , the island is energy neutral.
Selected large-scale consumers	Large-scale consumers that are interested in a dashboard for their own location and from which the annual data on consumption and production is acquired.

Non-autarkic energy neutrality	The production of energy on the island is higher than or equal to the net consumption of energy on the island over a whole year, irrespective of the energy carrier. This means that the island is still dependent on the mainland for real-time delivery of energy.
Final energy	The energy directly delivered to end users.
Primary energy	All energy needed to produce the energy directly delivered to end users. The difference between primary and final energy lies in the energy cost of production, transformation, conversion and/or transportation.

EXECUTIVE SUMMARY

In 2007 an ambition manifest is signed by the municipality of the Dutch Wadden island Vlieland. This manifest includes a non-autarkic energy neutrality target for the year 2020. Non-autarkic energy neutrality means that the production of energy on the island is higher than or equal to the net consumption of energy on the island over a whole year, irrespective of the energy carrier. In the first period (2007-2014) after the manifest was signed, almost no progress in the direction of energy neutrally has been achieved (Hanssen et al., 2014). The foundation LABVlieland tries to accelerate this process. LABVlieland suggests that increased awareness about energy consumption would lead to a more positive attitude towards renewable energy and energy efficiency. For this reason, LABVlieland aims to give insight in the energy situation on Vlieland. In order to reach this, LABVlieland would like to create a real-time updated energy dashboard for the island.

In the first part of this research, it is investigated which data on energy consumption and renewable production is relevant to show on an energy dashboard. In the second part of the research, the focus is on the currently available data. In the third part of the research, methods to obtain the additional required data are treated.

First, the relevant data to display on an energy dashboard is investigated. This is determined by doing literature research and by conducting interviews and a survey amongst visitors and inhabitants. Results from interviews and the survey show that most organizations, inhabitants and visitors are rather positive towards the concept of an energy dashboard and are willing to participate. Furthermore, it was frequently mentioned that it is important to keep the dashboard simple and palpable. The interviews resulted in a variety of opinions on the relevance of showing the energy potential of wind energy and PV panels. However, the results of the survey indicated that showing the potential would be interesting. Therefore, energy potential is considered to be relevant data in this research. Although a preference for a real-time or dynamic representation is not clear from the survey, during the interviews the reactions on real-time or dynamic representation were rather positive. Moreover, a real-time dashboard is preferred by LABVLieland. For this reasons, this research focused on acquiring the relevant data as real-time as possible.

In the second part of the research, the focus is on obtaining currently available data. The currently available data is determined for the consumption, renewable production and potential renewable production. The method to obtain the net energy consumption of Vlieland is acquiring data from 'Energie in Beeld'. The method to obtain the renewable production, is using results from the interviews and information provided in the production installation register (PIR). Annual production potential of solar energy can be estimated by combining the available solar irradiation data with the available area on the island and system efficiencies of PV panels. The potential production of wind energy can be estimated based on available wind speed data. The resulting final gross energy consumption of Vlieland is 128.7 TJ. The majority (72%) of the final gross energy consumption is in the form of heat, 28% is in the form of electricity consumption. The total renewable production is 8 TJ. This amount includes the energy production from a solar field of 1 ha that is in development. Together with the combustion of wood, this upcoming solar field accounts for the major part (92%) of the renewable energy production on Vlieland. The total potential for renewable energy using PV panels is estimated to be 12.7 TJ per year. The total annual energy production potential for a big wind turbine is about 24.5 TJ electricity per year, for a small wind turbine about 1.5 TJ electricity per year.

Since the currently available data is static, real-time data has to be acquired in order to be able to update the dashboard frequently. Real-time data can be acquired using data tools. Data tools are methods to obtain real-time data on the energy consumption, production and the production potential of Vlieland. The data tools were defined using conversations with stakeholders, conversations with LABVlieland and by performing literature research. Nine data tools were created:

Data tools to obtain real-time consumption data:

1. Meter on gas and electricity connection between the island and mainland
2. Reading P1 of smart meters in households
3. Reading P4 of smart meters in households
4. Consumption profiles for households
5. Reading meter of selected large-scale consumers via web service
6. Using last year's data of large-scale consumers

Data tools to obtain real-time production data:

7. Measuring production
8. Estimating production

Data tools to obtain real-time production potential data:

9. Estimating real-time renewable energy production potential

Several combinations of these data tools are made. In this manner, fourteen different scenarios are composed. The first twelve scenarios are selected using the following constraints: gross consumption and production of the whole island must be shown, data of the households and the selected stakeholders must be acquired and the output must be updated hourly or more frequently. Furthermore, two additional scenarios are created: one scenario excluding large-scale consumers' consumption and one scenario without a meter on the gas- and electricity connection of the island. Based on a multi-criteria analysis, the most desirable scenarios were determined. Two scenarios were selected, namely one for the first and one for the second implementation phase. In the first implementation phase the following criteria are important: high speed of implementation, low social impact and low costs. As a result, scenario 12 is the most favorable scenario. In this scenario everything is estimated, except for the net energy consumption Vlieland. From the described data tools above, the numbers 1, 4, 6, 8, and 9 are used. In the second implementation phase a higher accuracy will probably become desirable. As a result, scenario 1 becomes the most interesting scenario. In this scenario all estimated consumption- and production data is substituted by measured data. From the described data tools above, the numbers 1, 2, 5, 7 and 9 are used.

Overall, it is recommended to create one main physical dashboard for the whole island. It is important that this dashboard is simple. Therefore, it is suggested to only show the gross energy consumption and the renewable energy production on this dashboard. Further, several large-scale consumers indicated that they would like to have a physical energy dashboard at their own location as well. From the survey it resulted that visitors would be interested in this as well. So, next to the main energy dashboard for the whole island, it is recommended to consider developing additional physical energy dashboards for the following large-scale consumers: harbor, swimming pool, school and campsite Stortemelk. In order to provide more detailed information on the energy situation of Vlieland and to show the renewable production potential, it is recommended to develop an online energy dashboard for Vlieland as well. As a result, the detailed information is accessible for users who are interested while the physical dashboards remain easy to interpret.

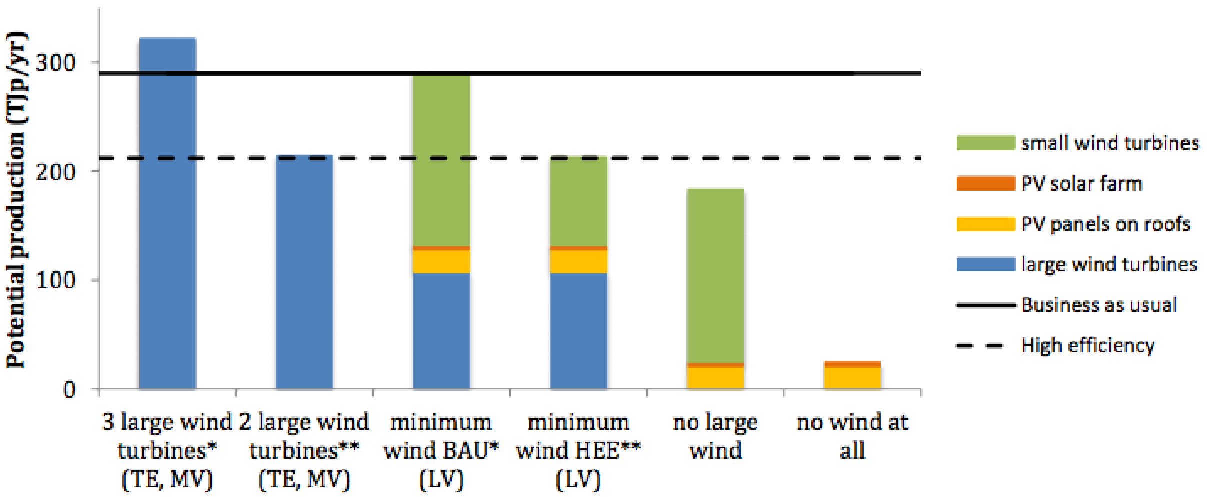
Contents

1. Introduction

1.1 Problem definition

Vlieland is one of the Dutch Wadden Islands, located between the Wadden Sea and the North Sea. With approximately 1,110 inhabitants it forms its own municipality covered by the Dutch province Friesland (CBS, 2014). Together with the four remaining populated Dutch Wadden Islands, an 'Ambitiemanifest Waddeneilanden' was set up. This manifest is designed to aspire a non-autarkic energy neutrality per island in the year 2020. Non-autarkic means that the production of energy is more than or equal to the consumption of energy over a whole year on the island. This means that the island is still dependent on the mainland for real-time delivery of energy. The neutrality covers the final energy consumption related to electricity, heat, heated tap water and transport fuel consumption (Gemeenten Waddeneilanden, 2007). LABVlieland is a foundation has set a target to develop and share knowledge about the development of the island. LABVlieland has got the command for researching and shaping the energy neutrality ambition of Vlieland. This research is commissioned by LABVlieland.

In the first period (2007-2014) after the takeoff of the manifest, almost no progress in the direction of energy neutrally has been achieved (Hanssen et al., 2014). In 2014, Utrecht University students of the master program Energy Science set up a consultancy report, in order to map the possibilities for Vlieland to reach energy neutrality in 2020. The report concluded that achieving the ambitions could hardly be achieved without wind energy installations, as shown in figure 1.4. First of all, the space that could be assigned to PV panels does not meet the energy demand of the island, while wind energy requires a much smaller surface. In economic terms, large-scale wind energy is more favorable than the PV panels on roofs. Supported by a multi-criteria analysis, the research of Hanssen et al. (2014) suggested that installations in wind energy are required for reaching the 2020 ambitions of Vlieland. However, also energy saving measures and solar energy could contribute to some extent.



*Assuming a business-as-usual (BAU) estimate of energy demand in 2020; ** assuming a high energy efficiency (HEE) estimate of energy demand in 2020; TE: based on techno-economically weighted MCA; MV: municipality of Vlieland-weighted MCA; LV: Lab Vlieland-weighted MCA.

Figure 1.4 - Seven Proposed (combinations of) renewable energy options to meet Vlieland's energy demand in 2020 (Hanssen et al., 2014).

Since LABVlieland is a consulting and connecting party, it does not have the mandate to decide for the energy policies of Vlieland. Therefore, the support of the inhabitants and the local authorities is required. Also visitors play an important role, because the visitors provide the main source of income for the inhabitants and the municipality. Visitors on the island, including visitors, represent an important share of the total amount of people present on Vlieland (CBS, 2014).

LABVlieland suggests that more awareness on the energy situation on Vlieland has a positive effect on the attitude towards renewable energy and energy efficiency. For this reason LABVlieland wants to give insight in the energy situation on Vlieland to the inhabitants, the visitors and other involved stakeholders.

LABVlieland wants to achieve this by developing an energy dashboard. The main purpose of the energy dashboard is to visualize the progress towards the 2020 target on Vlieland. This way LABVlieland hopes to create awareness and therewith gain support for the deployment of renewable energy and trigger energy savings.

In order to develop an energy dashboard, the interests of the visitors and inhabitants need to be surveyed. It needs to be determined which data is relevant for an energy dashboard. Based on the opinion of the inhabitants, visitors and literature research, it can be determined which data is relevant for an energy dashboard. Data is relevant if the data provides an increased insight in the energy situation on Vlieland and thereby create support for the deployment of renewable energy and trigger energy savings.

The next step is to obtain this data. First, it should be determined which data is currently available. Currently, static data is available about the production, potential renewable energy production and consumption of Vlieland. However, LABVlieland prefers to display real-time data instead of static data, so additional data is required. In order to gain a real-time data source for an energy dashboard, several possibilities for data tools are researched. Data tools are methods to obtain real-time data on the energy consumption and production on Vlieland. These data tools are not necessarily technical tools, because data can also be estimated. Different data tools should be used for different categories, namely the whole island, the households, large-scale consumers and production. Therefore, a combination of these tools is necessary to obtain the required data.

1.2 Research questions

This research will focus on the following main question, supported by 3 sub-questions with underlying questions.

Main question:
Which data on energy consumption and production is relevant for developing an energy dashboard for Vlieland and how can this data be obtained?

Sub-questions:
1. Which data is relevant for an energy dashboard?
   1.1. Which data is relevant for different stakeholders on Vlieland?
   1.2. Which data is relevant to display on the energy dashboard?
2. Which relevant data can be obtained currently?
   2.1 What is the currently registered gas and electricity consumption on Vlieland, based on existing data?
   2.2 What is the renewable energy production per technology, based on existing data?
   2.3 How can the potential production of different renewable energy technologies be estimated?
3. What are feasible possibilities for obtaining the additional required data, regarding technical, social and economic aspects?
   3.1 Which different data tools can be used to obtain additional required data on energy consumption and production?
   3.2 What is the best combination of data tools to obtain the additional required data?

1.3 Research scope and boundaries

The geographical boundary of the research was limited to the island Vlieland. The municipality of Vlieland comprises a total area of 315.8 km^2, of which 36.1 km^2 island and the remainder area consists of water, namely the Wadden Sea (CBS, 2014). In this research, only the land area of Vlieland was included in the geographical boundaries.

The electricity and gas usage on the island and Vlieland's energy production was evaluated. The usage and possible production of fuels was not taken into account. Consequently, the energy consumption of the ferry of Rederij Doeksen, the fuel bought by private boats, and the fuel used by the vehicles on the island were not within this research scope. The main reason for this was that the inhabitants and visitors have almost no influence on the usage of these fuels, since decisions on them are made by the firm Doeksen, which is located in Harlingen. Furthermore, there are no fuel stations present on Vlieland. Furthermore, since the gas and electricity use of Vlieland's military base is classified and is not included in the statistics of the distribution system operator, it was not dealt with separately in this research.

Concerning the renewable energy production already present on the island, electricity production by PV systems and solar collectors was measured or estimated. A share of the PV systems of the inhabitants is not registered and therefore data on this type of production was not known. Amongst the small-scale consumer, 17 connections have been registered (Energie in Beeld, 2015). Based on observations on the island, it was expected that not many more small-scale consumers connections have renewable energy production. Many of the roofs cannot be used for PV systems due to monumental protection of the houses in the center of the village. Moreover, the large-scale consumers provide the largest share of renewable energy production. For this reason, these non-registered panels will not be taken into account for calculating the energy production on the island.

The amount of energy production from other sources than PV systems, solar collectors and biomass, is not taken into account. The island is small and surveyable. For this reason it is assumed that any significant renewable energy production from any other sources than the abovementioned would have been known.

Since wind energy and electricity production by PV systems are viable options for the production of renewable energy on the island in the future, the real-time potential of these techniques was estimated. Offshore wind energy potential was not assessed, since offshore energy production is not within the scope of this research.

1.4 Report structure

In this section, a short description is given of the following chapters. In chapter two the research background is given. In the research background the client's assumption that increased insight leads to an increased awareness and support towards renewables, is checked. In the third chapter the research methods are outlined. The method section is divided into three parts. First, the methods for the interviews and a survey are given. Second, the method to acquire the currently available data is given. Third, a method is created to get the additional required data needed to create a real-time data input for an energy dashboard. This chapter is followed by chapter four in which the results of each method are described. Next, the data quality and assumptions are discussed in chapter five and recommendations for further research are given. Finally, a conclusion is given in chapter six. The report ends which an advice for LABVlieland on which data is relevant for an energy dashboard and how to obtain this data.

In figure 1.5 below a graphical image of the report structure is shown.

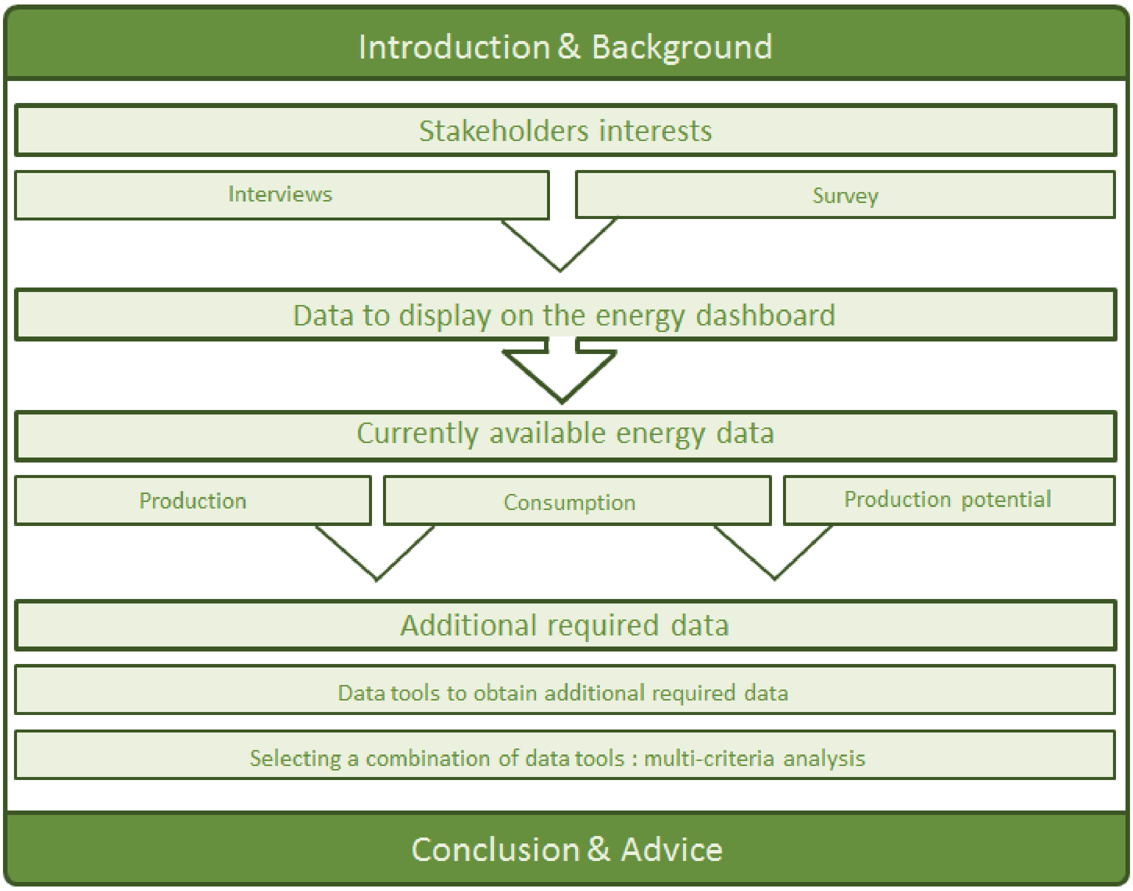


Figure 1.5 - Report structure

2. Research Background

As described in the introduction, the essence of developing an energy dashboard is based on the theorem that insight in the energy situation leads to more support achieving the energy-neutrality ambition. Firstly, this chapter focusses on the underlying scientific principles of this theorem and the three pathways via this pretended effect can occur. Furthermore, this background is focused on the state-of-the-art of the concept of energy dashboards. A summary of already existing energy dashboards and comparable initiatives is given. Different frequently appearing aspects of these energy dashboards are evaluated and compared. Examples of evaluated aspects are the dynamics of the dashboard (updating frequency) or showing the potential of renewable energy production.

2.1 The effect of increased insight

Exposing inhabitants to information on the energy situation of Vlieland will assumably lead to more insight in and knowledge (awareness) on the energy situation (see effect 1 in figure 2.1). More insight could contribute to achieving the 2020 ambitions via the three important pathways described below. In the rest of this section relevant literature is evaluated in order to underpin this effect of awareness on the attitude of people.

- Firstly, awareness of the topic can lead to more energy saving measures (efficiency) and energy saving behavior by visitors and inhabitants (see effect 4a in figure 2.1). This is the case, since people are more aware of the consequences of the effects of their energy consumption. Also getting around energy consumption (sufficiency) by choosing energy low alternatives (e.g. travelling by bike instead of by car) is included. If less energy is consumed, less renewable energy installations have to be installed in order to achieve the 2020 ambitions of Vlieland (see effect 4b).
- Secondly, knowledge and insight can lead to more support for renewable energy installations on the island (see effect 2a and 2b in figure 2.1) and thus to less resistance to top down initiatives in the near area (often described as the NIMBY-effect (Miller, 2008)). This enlarges the changes for external parties to successfully install renewable energy (see effect 2c).
- Furthermore, awareness also stimulates inhabitants and other Vlieland based organisations to realize renewable energy installations (see effect 3a and 3c in figure 2.1). This could be done individually by installing domestic solar energy systems, but also by cooperation in large-scale energy projects. An additional benefit of this process is the fact that these locals assumably will gain knowledge on the topic, if they set up renewable energy initiatives themselves (see effect 3b).

Firstly, research on the effect of increased insight in energy consumption on energy saving behaviour has been going on since the 70s. It was stated that feedback on domestic energy consumption through a display monitor has measurable energy-saving effects (Seligman *et al.,* 1977; Socolow *et al.,* 1977; Darby, 2006). Feedback on energy consumption became a self-learning tool for consumers: they could learn to use fuels more efficiently through experimentation, so-called learning-by-doing. To function as a learning-tool, it is important that the feedback is given frequently or even continuously. Therefore, to stimulate energy savings it is important that the consumer can experiment with the system and is able to determine the effects of their behaviour (Darby, 2006).

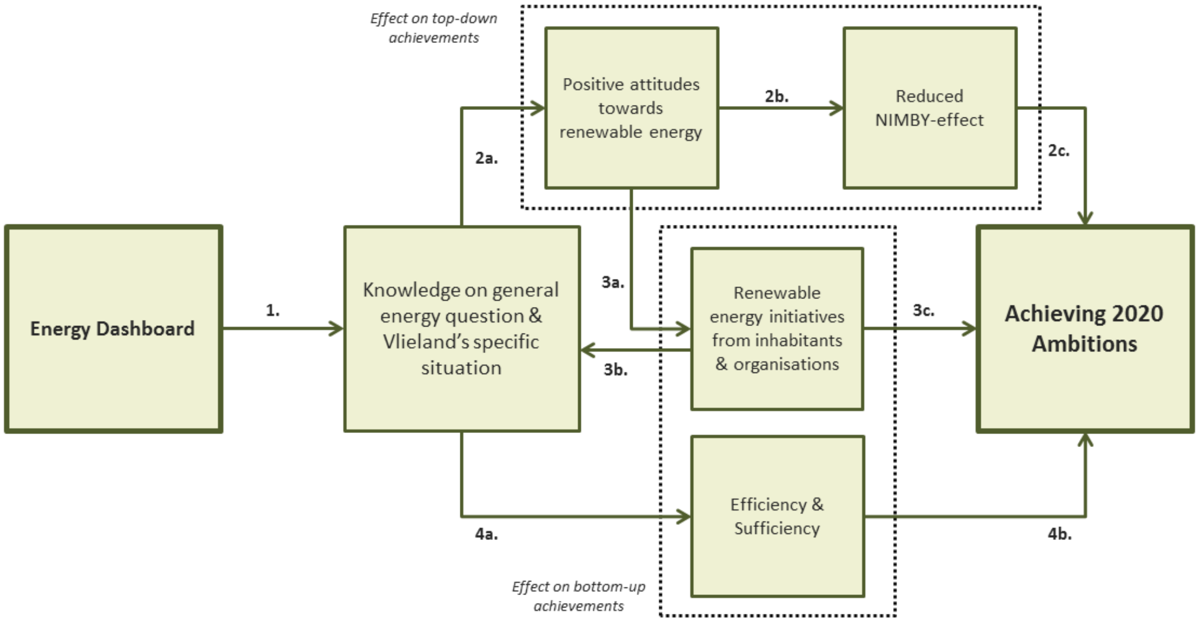


Figure 2.1 - Effect chain of energy dashboard on achieving the 2020 ambitions. Note that the figure is a simplification of reality and that it could be extended with more effect arrows

In line with this, literature states that feedback is more useful when it is user-specific: a one-size-fits all approach is less effective (He, 2010). When providing information on a larger scale, like in an energy dashboard for a community, this is more difficult. Effects of individual behaviour are not directly shown and the provided information might not be relevant for the people's situation (Darby, 2006). However, Darby (2006) notes that information on a community scale can still contribute to energy savings, as long as information is expressed in a common, easily understandable language. For example, a website that provided simplified information on load in combination with system capacity, was very popular during a Californian energy crisis in 2001 (Darby, 1006). It seemed that many people adjusted their behaviour to the current energy situation on the grid. This underpins the theory of the effect of awareness on energy saving (see effect 4a. in figure 2.1).

It seems that there has not been done much research specific on the contribution of awareness on sustainable energy topics and sustainability to a positive attitude towards (the implementation of) renewable or wind energy. However, one research on attitudes towards wind power quotes for the Danish village Sydthy the following: ''People with a high degree of knowledge about energy generation and renewables tend to be more positive about wind power than people with little knowledge'' (Krohn et al., 1999). Also in other disciplines, the effect of a higher degree of knowledge on a certain topic on the attitudes and behavior of people has been studied. It has been demonstrated that knowledge about organ donation improves the attitude towards being an organ donor (Morgan, 2002). In a research on taxation it has been pointed out that knowledge of tax laws increases the compliance to pay taxes (Hofman et al., 2012).

Also in sustainability related disciplines evidence could be found for comparable effects. It is shown that environmental awareness and knowledge could have a significant stimulating effect on green product purchasing behavior (Lizawati Aman et al., 2012). Together with the previously mentioned examples, there is literature underpinning the effect of awareness on a better attitude towards renewable energy (see effect 2a and 2b in figure 2.1). This will reduce the resistance and improve the possibilities for renewable energy investment installations.

An important remaining question is if awareness also leads to more assertiveness among the locals. Beside financial aspects often mentioned as motivations, also environmental and ethical aspects seem to be important inducements for personal renewable energy investments (Walker, 2008). As described in the research of Walker (2008), this effect will become even more important when it concerns organizations with a high level of social and environmental responsibility. Vlieland is a small community and different bodies are indirectly governed by the municipality. Therefore, it is assumable that more awareness about the manifest and the renewable energy discussion could lead to private renewable energy investments. Further, an additional benefit is the fact that community based renewables lead to a better attitude towards renewables (Warren et al., 2010). This could be considered as a positive feedback loop, which possibly occurs due to the fact that public renewables initiatives lead to more knowledge and insight (see effect 3b in figure 2.1).

Regarding the underlying principles of the insight created by the dashboard, it is assumable that it will result in energy saving measures. Furthermore, in the available literature is stated that it is likely that insight will lead to a more positive attitude towards renewable energy. This is the basis for reducing the possible resistance towards renewables and triggering bottom-up renewable energy initiatives. Therefore, an energy dashboard is a useful tool for LABVlieland in order to help Vlieland realize it's energy ambitions.

2.2 Comparable projects

Many initiatives to create insight in the energy situation of municipalities or institutes have been set up (see table 2.2). Especially municipal governments, cities, utilities and universities use energy dashboards to create insight in the energy consumption of the institution. In most of the cases found on the internet the goal of the dashboard is related to climate or energy saving targets. In many dashboards it seems that governments or institutional boards tend to give insight in their energy saving efforts, probably trying to improve the public opinion on the topic (note: used sources are given in the description of Table 2.2). Creating insight insight in order to improve the attitudes towards energy savings and renewable energy is mentioned as main purpose of a few of the dashboard. This is for instance stated in the description of the energy dashboard of the dashboard of Berkeley (Berkeley University of California, 2015).

Table 2.1 - An overview of comparable projects. Information of examples from top to bottom.

Case / location	Year	Physical / digital	Sub-sections within dashboard	Dynamics	Relative perform. incl.	CO2-footprint Incl.	Number of users incl.	Focus on renewables
City of Bloomington (US)	2010	Digital	Yes (3 buildings)	1 hour	Yes, from history	Yes	Yes, non-up-to-date	No
City of Reno (US)	-	Digital	Yes (>10 buildings)	1 hour	Yes	Yes	-	Yes
City of Oberlin (US)	-	Digital	Yes (different sections)	1 min.	Yes	Yes	Yes, non-up-to-date	Yes (PV-monitor)
City of Tempe (US)	-	Digital	Yes (10 buildings)	1 hour	No	Yes	No	No
City of Surrey (US)	2010	Digital	No (Only total)	1 year	Yes	Yes	No	No
City of Amsterdam	2015	Digital	Yes (clusters of households)	1 year	No	Yes	No	Yes, indiv. dashb.
TU Delft	2005	Digital	Yes (66 buildings)	1 year	Yes, from history	Yes	Yes (partially)	Yes
Province of Gelderland	-	Digital	Yes	1 year	-	-	-	Yes, indiv. Dashb.
City of Washington D.C.	-	Digital	Yes (365 buildings)	15 min.	Yes	Yes	No	-
Denmark / Energinet	-	Digital	Yes (power plants and connections)	1 min.	No	No	No	Yes
Berkeley University of California (US)	-	Digital	Yes (140 buildings)	1 min.	Yes, real-time	Yes	No	No
Wilfrid Laurier University (CA)	2014	Digital	Yes (40 buildings)	1 hour	Yes, from history	Yes	Yes, non-up-to- date	No

Sources: Building Dashboards (2015a), Green Energy Reno (2015), Oberlin Dashboard (2015), My Energy Pro (2015), Sustainability Dashboard (2015), Gemeente Amsterdam (2012), TU Delft (2013), Provincie Gelderland (2015), City of Washington D.C. (2015), Energinet.dk (2015), Berkely University of California (2015), Building Dashboard (2015b).

Most of the dashboards that can be found are described as fully digital. Municipal governments of cities located in the USA set up most of the available energy dashboards. In most of the cases, sub-sections are created by showing the energy consumption of different buildings or separated sections, like households or industrial buildings. The level of detail of the dashboards varies from a small number of buildings or sections towards the complete set of buildings of an institute.

Underlying tactics behind the design of the dashboard are poorly described. Scientific evidence about the effectiveness of different communication methods on the support of renewable energy seems to be absent in the strategies of the observed dashboards. However, patterns could be observed in the communication strategies. Most universities use dynamic dashboards which are updated often. Also, a comparison of the current performances with the average or previous performances has been made in most of the cases, for instance by showing a graph including the historic trends. When applicable, renewable energy production has been included to the dashboard. In a few cases the energy consumption is related to the number of users of the buildings or sections, in order to make the presented information more tangible.

The following other communication tactics used in the observed energy dashboards (note: used sources are given in the description of Table 2.2) have been noticed:

- A financial focus is included, which shows how much money is spent on energy purchases or how much is saved by renewable production.
- A competition element is implemented: how are the performances compared to other buildings or other communities?
- Comparison of magnitudes with clear units are used to make the communication more tangible. In the dashboard of Berkeley the number of hours of lighting the Eiffel towers is used (Berkely University of California, 2015). Also the energy consumption of one household is used as unit. The dashboard of University of Oberlin points out how much a typical office desk uses in a certain situation (Oberlin Dashboard, 2015).
- In some dashboards, targets are involved. Graphs show how the energy consumption of a certain building is relativized to the targets set by the institution.

3. Research methods

3.1 Methodology outline

In the last section of the previous chapter different versions of dashboards were compared. However, the question which content is the most appropriate choice for a certain dashboard can be answered differently for each case. Every dashboard has its own purpose and not all data is available by default. Therefore, the aim of this research was answering the following main question:

'Which data on energy consumption and production is relevant for developing an energy dashboard for Vlieland and how can this data be obtained?'

In order to answer the main question, several sub-questions were answered. To answer these different sub-questions, different research methods were used.

First, the opinion on Vlieland was assessed by doing qualitative research (interviews). Next to this, quantitative research (questionnaire) was done amongst inhabitants and visitors. The outcomes were taken into account in order to decide which data to display on the energy dashboard.

The second part of the research is about obtaining this data. A distinction was made between data that was currently available and additional required data. The available current data is static data. The current data could be improved by making it real-time (more frequently updated data) and/or more detailed (more sub-divisions among users). Therefore, additional required data is needed. To acquire this additional required data, several data tools should be implemented. These data tools are methods to obtain real-time data on the energy consumption and production of Vlieland. First, a list of optional data tools is created. From combinations of these data tools, different scenarios are formed. These scenarios are evaluated by doing a multi-criteria analysis (MCA) to define which scenario is the most desirable at the moment and possibly in the future, regarding different criteria.

3.2 Investigating stakeholders' interests

In order to get insight on what should be displayed on an energy dashboard, qualitative and quantitative research was conducted. Several people were interviewed (table 3.1) and a survey was conducted amongst visitors and inhabitants. In the qualitative interviews, information about the availability of data concerning the energy consumption and production was obtained. Furthermore, an indication of the general opinion on the possibility of receiving more insight in energy consumption and production was determined. By doing a questionnaire amongst inhabitants and visitors, an overall opinion on different forms of energy dashboards and on possible measures to collect data was surveyed. The questionnaire formed the quantitative part of the research.

By investigating the stakeholders' interests, the following sub-question was answered:

1.1) Which data is relevant for different stakeholders on Vlieland?

3.2.1 Stakeholder analysis

In order to get an overview of the different stakeholders and their relevance for this research, a stakeholder analysis has been conducted. A stakeholder analysis (see figure 3.1) helps to identify the most important stakeholders by classifying each stakeholder by their interest in the project and their power to influence the result (Mindtools, 2015). This leaves 4 different categories: Monitor (low power, low interest), Keep informed (low power, high interest), Keep Satisfied (high power, low interest) and Manage Closely (high power, high interest).

In figure 3.1, three different types of stakeholders are distinguished:

- The visitors and the inhabitants (green, quantitative research).
- Specialists that are active on the island and are interviewed (red, qualitative research).
- Specialists that are not directly involved with the island and are interviewed (orange, qualitative research).

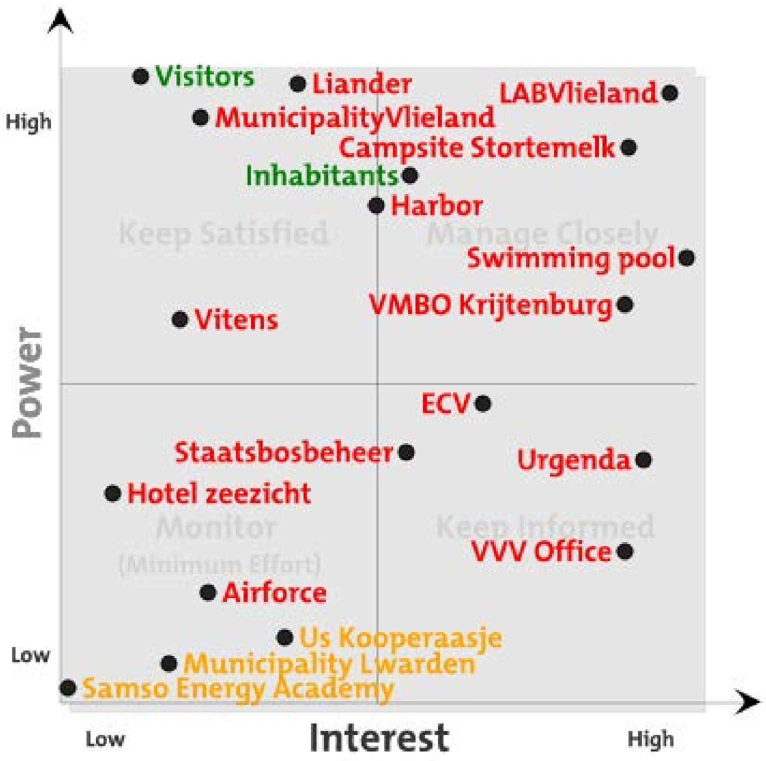


Figure 3.1 - Stakeholder analysis based on power and interest. The exact position of the symbols within the graph is based on estimation.

3.2.2 Qualitative research

Qualitative research is a concept which stands for different types and methods of research, each with the emphasis on gathering profound extended data for describing processes (Boeije et al., 2009, 264-265). Qualitative data is not suitable for generalizations but can be useful when the researcher wants to describe opinions accurately and when sensitive or complex topics are discussed.

The qualitative research was conducted with semi-structured interviews conform the book "Analyseren in kwalitatief onderzoek; Denken en doen" (Boeije et al., 2005, pp. 266-268), which describes analysis in this type of research. One of the reasons for conducting semi-structured interviews is the fact that each interviewee has a different story, opinion and level of expertise on the subject. This means that the interviewer has to match his line of thought and style of communication with the interviewee. In that case, it is desirable that questions are adapted to the specific interviewee rather than standardized. The semi-structured interviews used are given in appendix I. The interviews were executed in Dutch, except for the one with Søren Hermansen.

The interviewees are shown in table 3.1. The selection of the interviewees is influenced by the preferences and suggestions of LABVlieland.

Table 3.1 – Stakeholders interviewed according to qualitative research method, with semi-structured interviews.

Stakeholder	Contact person	Description stakeholder
	Tourism sector	
Campsite Stortemelk	Jan van der Veen & Lammert de Graaf	Major campsite on Vlieland. With max of 3500 visitors biggest accommodator. Produces large share of renewable energy.
Hotel Zeezicht	Erik Houter	One of the large hotels on Vlieland. Opinion on energy dashboard could be important and representative for hotels.
VVV office	Annie Beiboer	Dutch based tourism cooperation agency. Has information about tourist streams.
Waddenhaven Vlieland	Jan Lever & Cornelis de Jong	Vlieland based harbor. Important accommodator. Produce large share of renewable energy and could have important data on tourist numbers.
	Energy and water sector	
Energie Coöporatie Vlieland (ECV)	Jan den Ouden & Erik Houter	A Vlieland based small-scale energy cooperation.
Liander	Tjalling Ypma	Dutch utility which provides energy connection of Vlieland. Data on energy transmission is decisive for dashboard.
Samsø Energy Academy	Soren Hermansen	Advices islands and municipalities on transition strategies. Could provide information on dashboard strategies.
Us Koöperaasje	Bouwe de Boer	A Province of Friesland based overarching energy cooperation. Could provide information on energy dashboards.
Vitens	Cees Potiek	Dutch water company that operates on Vlieland. Has energy consumption and renewable production.
	Other sectors	
VMBO Krijtenburg	Hessel Brandsen	Only secondary school on Vlieland. Also provides facilities to other organizations
Zwembad Fldunen	Gerard List	Swimming pool on Vlieland. Major energy consumer and biggest renewable producer. Data is probably relevant for dashboard.
	Governmental organizations	
Gemeente Leeuwarden	Bouwe de Boer	Municipality of Leeuwarden, capital of the province of Friesland. Could have more information on energy dashboards.
Gemeente Vlieland	Joke Weeda & Henk Visser	Municipal board of Vlieland. Could provide information on tourist numbers and different energy data streams.
Staatsbosbeheer	Anke Bruin	Governmental nature organization, which manages a major part of the island. Have more information on wood production.
	Non-governmental organizations	
LABVlieland	Govert Reeskamp	Amsterdam based NGO focusing on energy neutrality developments of Vlieland, is the client of this consultancy project. Opinion on weighting variables MCA is important.
Urgenda	Antoine Maartens	Dutch NGO that tends to accelerate sustainable development in whole country. Tests sustainable house on Vlieland.

3.2.3 Quantitative Research

In general, quantitative research is used when large groups of respondents have to be reached. This was the case for the inhabitants and the visitors that needed to be addressed. The respondents answered standardized questions and these questions are tested and analyzed. In our research, a paper questionnaire was used (appendix II).

Target group

Two groups were approached to fill in the questionnaire. The groups were defined according to the following definition:

- Inhabitants of Vlieland: persons who are registered as an inhabitant of the municipality of Vlieland and who live on Vlieland during the majority of the year.
- Visitors: persons who do not live on Vlieland for the majority of the year and are on Vlieland for leisure or other purposes like work or family visits.

Sample size

To acquire a representative opinion of these two target groups, a specific sample size for the survey has to be set. Every conclusion based on the surveys has to be tested and this can only be done if the distribution of the survey is assumed to be a normal distribution. A rule of thumb for a normal distribution is that the amount of cases must be larger than 30: $n \geq 30$ (de Vocht, 2011, p. 67). For example, when testing whether people under 20 years old have a more positive attitude towards renewable energy, this means there should be at least 30 respondents younger than 20. If the results of the survey need to be generalized for the different population groups, in this case all inhabitants and the total amount of visitors, there is a certain threshold value. The total amount of inhabitants on Vlieland is 1,110 (CBS, 2014) and the amount of visitors entering the island is 181,000 (Harlingen-online.nl, 2013). When calculating the sample size threshold based on these numbers, this means that at least 669 surveys have to be done; 285 for the inhabitants and 384 for the visitors (Surveymonkey, 2015).

Because of limited time and because LABVlieland has asked to limit the amount of questionnaires amongst inhabitants, the sample size threshold was not met in this case. The main reason for LABVlieland's request was that the inhabitants of Vlieland are the topic of several other energy researches as well. Even though the survey was not representative for the total population due to the relatively small sample size, it can still be of value. If the samples are normally distributed, they can still give indications of the opinions of the target groups.

Methods

The questionnaires were distributed on the boat to and from Vlieland. Respondents younger than 18 years were left out of the survey.

The survey was conducted on:

- 19-05-2015 Harlingen --> Vlieland between 19:00 and 20:30
- 21-05-2015 Vlieland --> Harlingen between 17:00 and 18:30
- 22-05-2015 Vlieland --> Harlingen between 12:00 and 13:30
- 22-05-2015 Vlieland --> Harlingen between 17:00 and 18:30

A few surveys were taken on the street in the village of Oost-Vlieland.

Analysis

The resulting data was processed and analyzed by the software IBM SPSS Statistics 20.0. Student's T-tests for independent samples (as explained in Vocht, de, 2011) were conducted to compare the answers of both groups. For the majority of the questions in this survey, a Likert scale is used. This scale goes from 1 (totally disagree) to 5 (totally agree). Likert-scale values are ordinal, with a degree of hierarchy (Likert, 1932). On the contrary, questions like "do you generate renewable energy at home?" are nominal. There are no ratio variables in the survey. Questions on age and income were categorized to lower the privacy barrier of answering those questions. A p-value (probability) of 0.05 was used. It means that each conclusion based on tests has a reliability of 95%.

The first step in analyzing the survey was reporting the descriptive statistics of each question. Secondly, the item non-response was given, to gain insight in avoided questions. Finally the student's T-tests were conducted. Together with the descriptive statistics, these methods give sufficient insight in the opinions of both the inhabitants and the visitors.

3.3 OBTAINING CURRENTLY AVAILABLE DATA

When the interest of the stakeholders is determined and it is determined what to display on the energy dashboard, the data must be obtained. First the currently available data was obtained. By acquiring currently available data, the following sub-questions were answered:

2.1) What is the currently registered gas and electricity consumption on Vlieland, based on existing data?

2.2) What is the renewable energy production per technology, based on existing data?

First the consumption is discussed and then the production. The production is divided in production by PV panels, solar collectors and biomass extraction.

All measured consumption data is net consumption. Net energy consumption is defined as the total energy consumption minus renewable energy production on the island. In order to be able to calculate the gross energy consumption, that is the total energy consumption on the island, the total energy production on the island is needed.

3.3.1 Currently available consumption data

In 2011, Grontmij has published a report on the energy consumption and production of Vlieland (Weerdhof, 2011). The sources used in the report of Grontmij were used to obtain the currently available data about gas and electricity consumption of Vlieland as a whole and per sector. For retrieving the energy consumption, data from 'Energie in Beeld' is used.

3.3.2 Currently available production data

To obtain the amount of renewable energy production on Vlieland, the data from the different interviewed people were used. Also the information is used given in the PIR register. The following energy production sources present on Vlieland are discussed below: PV panels, solar collectors and biomass.

Currently available data of production by PV panels

To obtain the amount of energy production from PV panels on Vlieland, data on energy production from the different interviewees based on Vlieland was used. For electricity from PV panels, the largest energy producers are:

- Swimming pool
- Campsite Stortemelk
- The harbor
- Vitens

In the near future, the secondary school will also install PV panels on their roof. They will become one of the larger solar energy producers as well. Also, an area of 1 hectare at the Vliehors is destined for the placement of PV panels.

Furthermore, several inhabitants of Vlieland have PV panels on their roof. The production data of these small-scale consumer connections were obtained from Energie in Beeld (2014). However, some of the PV panels are not registered in the Production Installation Register (PIR). These unregistered panels are excluded and data about these systems is unknown. As mentioned in the research scope and boundaries (section 1.3), only the registered systems were taken into account.

Currently available data on production by solar collectors

Some of the interviewed people have solar collectors, but not all production is included of the solar collectors. The swimming pool is the only collector that is taken into account in the currently available production. The swimming pool has a production meter (GJ) on the solar collector, but the yearly production is not yet available. Only the estimation of gas savings is known, of which the unit can be converted to MJ. The caloric value (HHV) of Groninger gas is used with a caloric higher heating value of 35.17 MJ/m^3 (Gasunie, 2015).

Currently available data on production from biomass

In this report wood is considered to be a clean source of energy. Therefore, the production of heat through the combustion of wood is considered to be renewable energy production. Inhabitants of Vlieland use wood from the island's vegetation to produce warmth in their houses. This way they reduce their gas consumption. Therefore, the wood was seen as a source of renewable energy. The amount of energy produced from wood was calculated using equation 3.1:

$$Q_e\ [MJ] = V\ [m^3] * \rho \left[\frac{kg}{m^3}\right] * H \left[\frac{MJ}{kg}\right] * \eta \tag{3.1}$$

In which:
Q_e = effective heat [MJ]
V = volume [m^3]
ρ = density of wood [kg/m^3]
H = caloric value [MJ/kg]
η = calculated average efficiency wood stove in the Netherlands (unitless)

The caloric value used is 21.3 MJ/kg (Toossi, 2008). The wood density used is 550 kg/m^3 (Cutnell, 2009). According to Sonja Vrijenhoek of Staatsbosbeheer, this wood consists for about 90% of pine wood. In the calculation it is assumed that 100% of the wood is pine wood.

In order to calculate the effective heat production, an assumption had to be made on the efficiency of the average wood stove. While an air tight wood stove may have an efficiency of up to 80%, a fireplace may only have an efficiency of 10% (Koppejan, I. J. 2010). In order to estimate the efficiency of a woodstove on Vlieland, the average efficiency of a wood stove in the Netherlands was calculated. This was done by combining the data on the efficiency of the different types of wood stoves, number of wood stoves per type in the Netherlands and average usage hours per year (see appendix III).

3.3.3 Estimating renewable energy production potential

By estimating the renewable energy production potential, the following sub-question will be answered:

2.3) How can the potential production of different renewable energy technologies be estimated?

In the report of Utrecht University (Hanssen et al., 2014), it was concluded that PV and wind energy are the most realistic renewable energy technologies to implement on Vlieland. For this reason the renewable energy production potential was estimated for PV and wind energy.

The potential production of PV systems that can be installed on the Vliehors and on all the available roof space was estimated. Since the space for solar collectors panels is in competition with the space for PV panels, the potential production for solar collectors is not taken into account. It is chosen to calculate the potential for PV panels instead of solar collectors since it is certain that PV systems are going to be installed on the Vliehors. The potential production for biomass is not estimated, since during the interview with Staatsbosbeheer it was mentioned that the maximum amount of wood which the forest can produce in a sustainable manner, is already used at the moment.

Potential production PV panels

The potential production of PV systems can be estimated based on the total yearly solar irradiance on Vlieland and the amount of available area on the island on which PV panels can be placed. This total area comprises rooftops and land on the Vliehors available to build a solar field on. When estimating the potential, systems on rooftops are assumed to have a lower efficiency than systems in a solar field. The PV-potential of the useful power output for Vlieland was calculated using the following equations (Twidell & Weir, 2015, p. 80):

$$P_r\,[W] = G\,\left[\frac{W}{m^2}\right] * n * A_r\,[m^2] \tag{3.2}$$

$$P_f\,[W] = G\,\left[\frac{W}{m^2}\right] * n * A_f\,[m^2] \tag{3.3}$$

In which:

P_r = Potential power of rooftops [W]
P_f = Potential power of solar field [W]
G = Solar irradiance [W/m^2]
n_r = Rooftop system efficiency [unitless]
n_f = Solar field system efficiency [unitless]
A_r = potential available roof surface [m^2]
A_f = solar field surface [m^2]

Since there is no available solar irradiance data available for Vlieland, hourly irradiance data of Leeuwarden is used (KNMI, 2015). The suitable roof surface on Vlieland was estimated to be 14,000 m^2 by Hanssen et al. (2014) and the projected solar field area is 10,000 m^2 (LABVlieland, 2015). Because of the optimal positioning of panels in a solar field and fewer losses due to the shade compared to systems placed on rooftops, it is assumed that the efficiency of the solar field system is slightly higher than a comparable rooftop system. The efficiencies are estimated to be 13% for rooftops and 15% for the solar field, based on an range of efficiencies mentioned in Twidell & Weir (2015, p. 181).

Potential production wind energy

The potential of the useful power output from wind energy was calculated using the following formula (Twidell & Weir, 2015, p. 271):

$$P\ [W] = \frac{1}{2} * C_p * \rho \left[\frac{kg}{m^3}\right] * A\ [m^2] * u^3 \left[\frac{m}{s}\right] \quad (3.4)$$

In which $A\ [m^2] = \frac{1}{4} * \pi * D^2\ [m]$ (3.5)

And $C_p = \frac{P_{max}\ [W]}{\frac{1}{2} * \rho \left[\frac{kg}{m^3}\right] * A\ [m^2] * u_{rated}^3 \left[\frac{m}{s}\right]}$ (3.6)

Where:
P = Power of wind turbine [W]
ρ = Density of air [kg/m^3]
A = Area of rotor plane [m^2]
D = Diameter of rotor plane [m]
u = Wind speed [m/s]
P_{max} = Rated power [W]
C_p = Performance coefficient [unitless]

The density of air (at 15 °C) is 1.225 kg/m^3. The potential is calculated for a small and a large turbine as described in the report of Utrecht University (Hanssen et al., 2014). The hub height of the small turbine is 18 meter and the hub height of the large turbine is 80 meter. A rotor plane diameter of 17.9 meter for the small wind turbine and 80 meter for the large wind turbine was used (Hanssen et al., 2014). The technical specifications P_{max}, u_{rated}, cut-in and cut-out speed for the large turbine are derived from Twidell & Weir, 2015 and for the small turbine from WES, 2015.

The hourly average wind speed was measured at a wind station on Vlieland at 10 m height and the data can be acquired from the KNMI (2015). In equation 3.7, the meteorological measurements of the hourly average wind speed were converted to the hourly average wind speed at hub height (Twidell & Weir, 2015, p. 248):

$$u_z \left[\frac{m}{s}\right] = u_s \left[\frac{m}{s}\right] * \left(\frac{z\ [m]}{10\ [m]}\right)^{b'} \quad (3.7)$$

In which:
u_z = wind speed at height z [m/s]
u_s = standard meteorological wind speed measurements [m/s]
z = hub height of wind turbine [m]
b' = 1/7 for open sites in even areas [unitless]

3.4 Obtaining additional required data

The next step is to obtain the additional required data. By obtaining additional required data, the current data is made more detailed and real-time. There are several data tools for obtaining additional required data (section 3.4.1). By combining these data tools, different scenarios have been made. By performing a MCA the most desired scenario can be selected (section 3.4.2).

3.4.1 Data tools to obtain additional required data

Data tools are methods to obtain a certain set of real-time data on the energy consumption and production of Vlieland. These data tools are not necessarily technical tools, because data can also be estimated. Different sets of data can be acquired by the data tools. These sets are data on net energy consumption for the whole island, data on net energy consumption for households, data on net energy consumption of large-scale consumers and data on energy production.

The data tools were defined by using conversations with stakeholders, conversations with LABVlieland and by performing literature research. By defining the data tools, the following sub-question was answered:

3.1) Which different data tools can be used to obtain additional required data on energy consumption and production?

Each tool was given a substantiated score on each of the criteria related to implementation and operation, as listed in table 3.2.

3.4.2 Method to select a combination of data tools

By combining the different data tools described in section 3.4.1, different scenarios have been made. To determine which scenario would be most suited for Vlieland's situation, a multi-criteria analysis (MCA) was performed. 'A multi-criteria analysis is a method to compare various alternatives accounting for a wide range of criteria that are not all expressed in monetary terms' (Nieuwlaar, 2015). By performing the MCA, the following sub-question was answered:

3.2) What is the best combination of data tools to obtain the additional required data?

The method for setting up the MCA is described in this section. Each scenario was given a score on each of the seven criteria given in table 3.2. The scores on the criteria related to implementation and operation are based on the scores of the data tools involved in the scenario. The scores related to data output are not based on the scores of the data tools, but are determined for the scenario as a whole.

Finally, the MCA was performed with the software programme DEFINITE by using the weighted summation method and maximum standardization. Each scenario receives one overall main score based on the scoring on the different criteria and their weighting factors. The weighting factors are defined in collaboration with LABVlieland. This way, the MCA was able to place the different scenarios in order of desirability.

Criteria

The criteria used in the MCA are given in table 3.2.

Table 3.2 – The criteria used in performing the MCA. The measurement scale is given per criteria. A cost means that a high score represents a negative effect and a benefits means that high score represents a positive effect.

Criteria	Measurement scale	Benefit or cost
CRITERIA RELATED TO IMPLEMENTATION AND OPERATION		
Costs	Ratio scale	Cost
Social impact	Ratio scale	Cost
Complexity	Ratio scale	Cost
Quickness of implementation	--/++	Benefit
CRITERIA RELATED TO DATA OUTPUT		
Accuracy	---/+++	Benefit
Level of detail	0/+++	Benefit
Dynamic representation	---/+++	Benefit

The different criteria given in table 3.2 are discussed separately. For every criteria a definition is given, the relevance for the criteria is explained and it is explained how the information for assigning a score on this criteria was obtained.

- **Criteria related to implementation and operation**

Costs – This is the sum of the initial investment costs of a data tool and the estimated costs of operation of a tool. The latter include costs for normal operation and reparation costs. The total costs were estimated for the first five years of the project. The costs will be expressed in euros. As in all projects, the budget to make the dashboard operational is limited: the cheaper the better. There is no (fixed) amount of money available for the project yet, therefore LABVlieland suggested that no fixed constraint is applied for maximum costs. Information on costs was found in (mostly non-scientific) literature and partly obtained from parties related to measurement of energy data (e.g. Liander, Enexis).

Social impact - Impact or possible resistance on social level, including mainly privacy issues and annoyance because of activities necessary for the implementation. It is important that stakeholders on the island are not going to be annoyed by the implementation of the dashboard. After all, the dashboard is meant as an attractive device. If the community has negative experiences with it, that would undermine its function. The scoring for the social impact was estimated for each tool.

Complexity - Difficulty of implementation and operation. This can be due to involvement of multiple stakeholders and/or juridical, political or technical complexity. This criteria is important since complexity implies vulnerability. For instance, when a lot of stakeholders are involved in providing data, the system will be more susceptible to interferences. The same counts for a system that is technologically highly advanced. Also data which are difficult to process, for example multiple different types of files from different parties, contribute to the complexity. The complexity was estimated. The number of stakeholders involved and technological needs were the most important factors.

Quickness of implementation – The rapidity at which a tool or combination of data tools can be implemented. Since the ambition for Vlieland is to be energy neutral by 2020, time is limited. Therefore, data tools that can be implemented in a very short time from now are preferred. The quickness of implementation was estimated.

- **Criteria related to data output**

Accuracy - The quality of the data, in terms of being correct or precise. When all the data is measured, maximum accuracy is reached. When estimations are made or approximate values are used, the data is less accurate. Accuracy is desirable because it makes the dashboard more reliable and therefore more persuasive. The accuracy-score is estimated based on the share of the data that is measured and the share of the data that is extrapolated.

Level of detail - Degree of subdivision within the energy consumption and/or production data. As mentioned in the background, energy feedback data is more effective when the feedback is detailed (He, 2010). This is necessary to avoid that users do not feel addressed by the dashboard because it is too general. Feedback on the individual level works best in reaching behavioral change, but a subdivision of data, for example in households, hotels and a rest group, is also preferred above information restricted to general data only. The score on level of detail is based on the amount of different groups on which data are provided separately.

Dynamic representation - This is the frequency of the data updates, and in how far this is real-time. With frequency, the time interval between two data points is meant. With real-time, the interval between measuring and exposing the data is meant. These two together determine to what degree the data represents the current situation. This is important in order to use the dashboard as a learning tool, since seeing the effect of behaviour of a change in circumstances within a short time span is necessary for learning. Therefore, a more dynamic data representation option is preferred over a more static option.

Weighting factors MCA

The weighting factors were determined by taking the average of the weighting factors set by our team (50%) and the weighting factors set by different employees of LABVlieland (50%). The weighting factors set by our team are based on literature, survey results and common sense. The resulting weighting factors and the corresponding arguments for assigning them are given in chapter 4: results.

Scoring of Tools and Scenarios

- **Criteria related to implementation and operation**

The scorings of a scenario on the criteria related to implementation and operation were based on the scoring on the different tools that are involved in the scenario.

Costs – To derive the costs for the scenario, the costs for the different tools involved in the scenarios were added. The MCA on the different scenarios was carried out using 0 to 5 scale, proportional to the estimated costs.

Social impact - Social impact will be expressed for each tool separately on a 0 to 5 scale. For determining the score for the whole scenario, the scores for the social impact of the tools were added up. The reason for this is that the different social impacts of the tools are cumulative. Social impact is a cost in the MCA, so a high score means a high negative impact. Adding up the tool scores will result in a ratio scale.

Complexity - Complexity will be expressed for each tool on a 0 to 5 scale. For determining the score for the whole scenario, the scores for the complexity of the tools were added up. Complexity is a cumulative effect as well, since two complex tools are twice as complex as one. Complexity is a cost in the MCA, so a high score means a high negative impact. Adding up the tool scores will result in a ratio scale.

Quickness of implementation - A --/++ scale was used for the tools. A positive score (++) on a certain tool means that very quick implementation is possible. On the contrary, a negative score indicates a long implementation period. For scoring the scenario, the most negative score out of the involved tools is used. After all, the implementation time of a scenario fully depends on the tool with the longest implementation time. Therefore, for the scenarios a --/++ scale on quickness of implementation was used as well.

- **Criteria related to data output**

The scorings of a scenario on the criteria related to data output were determined for the scenario as a whole. It was decided to do so since all tools together determine the data output, and therefore 'calculating' an overall scenario score based on separate tool-scores would not be meaningful.

Accuracy - A ---/+++ scale was used. A more positive score means a higher accuracy of the provided data.

Level of detail **-** A 0/+++ scale was used. A more positive score means a higher level of detail of the provided data.

Dynamic representation - A ---/+++ scale was used. A more positive score means a higher frequency of updates of (a part of) the provided data and/or a small time interval between measuring and exposing the data.

Detailed argumentation for allocating these output related scores to the scenarios is given in the results.

Sensitivity and uncertainty analysis

A sensitivity analysis was carried out to give insight in the effects of variations in the weighting factors. A sensitivity analysis is done for each of the criteria separately.

An uncertainty analysis was used in order to give insight in both the effect of variation in weighting factors and in the scoring of the different scenarios. The weighting factors are varied with 50% of their original value. The uncertainty analysis shows how likely it is that a certain scenario will receive another position in the ranking. The scoring values are varied with 75% for costs, 30% for social impact, 50% for complexity, 30% for accuracy, 30% for level of detail and 30% for dynamic representation.

4. RESULTS

In this section the results of the research are presented. First, the interest of several stakeholders on the island is determined by the results of the interviews and the survey. From these results, it is determined which data is relevant to display on the energy dashboard (section 4.2). Then, the currently available data is presented (section 4.3). This is static data on the consumption and production of Vlieland and the renewable potential production on Vlieland. In the final section it is described how the additional required data can be obtained to make the dashboard more dynamic. First an outline of different data tools to obtain real-time and detailed data is given (section 4.4). From these data tools several scenarios were made. Finally, the results of the multi-criteria analysis are presented, in which the most desired combination of data tools is selected (section 4.5).

4.1 INTERESTS OF STAKEHOLDERS

In this section the results of both the interviews (section 4.1.1) and the surveys (section 4.1.2) are presented. In this way the interest of the stakeholders is determined.

4.1.1 Qualitative research

The summaries of the interviews with the different interviewees are given in Appendix IV. A simple overview of the answers on the general questions (Appendix I) is shown in table 4.1. The main observations from the interviews are:

- None of the interviewees opposes an energy dashboard on Vlieland. Most of the respondents express a mildly positive attitude towards the idea of an energy dashboard. The potential effect of the dashboard on tourist streams and the business of the questioned organization is estimated as positive. However, this effect is generally described as quite small, since most of the tourist are mainly engaged with holidays and leisure and have a minor focus on energy and sustainability related issues. A minority is obviously interested in a physical dashboard for their own location.
- From most of the interviewees, dynamic data on PV-production and net electricity and gas consumption is available. However, the knowledge of these stakeholders about possible ways to monitor this data is precarious. For some of them, the energy consumption and production is already monitored. For others there were some software issues, the availability of energy meters was unknown or meters have yet to be installed. The availability of data on solar collectors is less.
- The general attitude towards sharing data is positive: privacy does not seem to be a major issue. However, in case of the swimming pool, the camping site and the harbor, the opinion of the board on sharing data is decisive. The municipality has a say in this as well. Furthermore, in some cases it was mentioned that the information shown on the dashboard should not lead to a negative image of the questioned stakeholder.

The opinions on the presentation and the location of the dashboard are varying. Frequent observations include the following statements:

- Most interviewees react positive on presenting the data as real-time and as dynamic as possible.
- Most of the interviewees mentioned that it is very important to keep the energy dashboard very simple and palpable, referring to the leisure attitude of most of the tourists. It should be easily accessible and understandable for everyone. Therefore, it is important to think about the unit in which the energy consumption and production will be presented. Most people do not have a feeling for technical units, such as kWh. A more familiar unit should be used or units should be avoided at all.

- Some interviewees are interested in receiving insight in the real-time potential of solar and wind energy, while others are not. An important argument against displaying renewable potentials is that it would complicate the dashboard needlessly. A board member of the ECV was afraid that it would be interpreted as "*pushy*". Arguments in favour of displaying the potential of renewable energy include the fact that it would inform the public better on renewables. Another important argument in favour is that a potential that varies immediately with the sunshine and wind speed has an entertaining value. Additionally, LABVlieland is strong supporter of a presentation that is as real-time as possible.
- It is frequently mentioned that it is interesting to focus on the effect of energy saving measures and renewable energy installation on the gross energy consumption of the organization.

4.1.2 Quantitative Research

The results for the different questions of the survey are given in appendix V. In this section the general observations are discussed.

Table 4.1 – Main conclusions drawn from the interviews.
+ = positive, +/- = neutral, - = negative, 0 = not applicable.

Stakeholder	Interested in general dashboard	Interested in dashboard for own location	Renewable energy production present	Willing to share data
Tourism sector				
Campsite Stortemelk	+	+	+	+
Hotel Zeezicht	+	-	-	+
VVV office	+	-	-	-
Waddenhaven Vlieland	+	+	+	+
Energy and water sector				
Energy Corporation Vlieland (ECV)	+ (+/-)	0	-	0
Samsø Energy Academy	0	0	0	0
Us Koöperaasje	0	0	0	0
Vitens	+	-	+	+
Other Vlieland Based Stakeholders				
VMBO-Krijtenburg	+	+	-	+
Zwembad Flidunen	+	+	+	+
Governmental Organisations				
Gemeente Leeuwarden	0	0	0	0
Gemeente Vlieland	+	-	-	0
Staatsbosbeheer	+	-	+ (*)	+
Non-governmental organisations				
Urgenda	+	0	+	+

(*) Small-scale energy consumer. Already included in Production Installation Register (PIR).

Although the group of respondents is not representative for the total population of Vlieland, the results give an impression of the overall opinion. Despite the fact that the answers cannot be generalized, they do lead to some expectations of the preferences of the total population.

The first noticeable conclusion is that the majority of the respondents answered positively on questions concerning the desirability of an energy dashboard. Furthermore, the respondents generally consider themselves aware of their energy consumption, they think that increased insight leads to more energy savings and they would find an overview of the renewable potential of the island interesting. Respondents of the survey have no clear preference for a dynamic dashboard which is updated every 15 minutes over a dashboard which is updated each 3 months.

Concerning the inhabitants, most of the respondents have no problems with reporting their energy consumption and installing a smart meter. They also would like to compare their energy consumption with the average consumption. There is no clear preference for adding an element of competition between the wadden islands.

The visitors' answers show that it could be rewarding for accommodations and restaurants to be included in the dashboard. The answers imply that the visitors' behaviour would be influenced by information on the energy behaviour of accommodations/restaurants.

4.2 Data to display on the energy dashboard

After having done literature research on comparable projects and after having assessed what the preferences of the involved stakeholders are, the following sub-question can be answered:

1.2) Which data is relevant to display on the energy dashboard?

The following data will result in an increased insight for the different stakeholders:

- Gross energy consumption on Vlieland
- Renewable energy production on Vlieland

Next to this, several interviewees indicated that they would like to have an energy dashboard at their own location as well (Table 4.1). So, next to the main energy dashboard for the whole island, also local energy dashboards might be made. For this reason, data on energy consumption and production is acquired from the following stakeholders:

- Harbor
- Swimming pool
- Secondary school
- Campsite Stortemelk

Furthermore, data on energy consumption and production is acquired from:

- Vitens

Also, biomass production is taken into account. The reason for acquiring data from Vitens and data about biomass is that data on energy production should be as complete as possible. This is important for giving a realistic estimation of the gross energy consumption. Finally, including data from more parties provides the possibility to reach a higher level of detail on the dashboard.

Next to this, the quantitative research suggested that households would be interested in having more insight in their own energy usage (61.1%, see figure 4.11). For this reason, having a private energy dashboard at home might be interesting for the inhabitants as well.

Both the interviews and the literature (Darby, 2006) indicated that the energy dashboard should be simple and easy accessible. Therefore it is recommended that apart from one or more physical dashboards for the island and for interested stakeholders, an online energy dashboard especially for Vlieland is made. On the online energy dashboard, all interested people can find more detailed information. It would be interesting to divide the energy consumption in consumption per stakeholder: households, Vitens, harbor, swimming pool, secondary school, campsite Stortemelk and a remaining part. The energy production is specified per type of production: PV panels, solar collectors and biomass. Next to this, the potential renewable energy production of a wind turbine and PV panels is presented, as several interviewees stated this would be interesting. Furthermore, 69,7% of the visitors and inhabitants indicated they would find it interesting to see the potential renewable energy production. However, the production potential of renewable energy might not be shown on the physical energy dashboards, since a member of the ECV indicated that this could be interpreted as intrusive. Moreover, it would make the dashboard more complicated. By making both an online dashboard and one or several physical dashboards, all the data is accessible for people who are really interested while the energy dashboard for the main public remains simple and easy to interpret.

The next step is to acquire this data. The data is divided in data which is currently available (section 4.3) and additional required data (section 4.4). The consumption of Vlieland per sector per year and the amount of small-scale consumer connections with renewable energy production is currently available. Furthermore, the consumption of the different selected stakeholders is known and the renewable energy production of the campsite, harbor, Vitens and swimming pool is known. The data to calculate the potential renewable energy production on the island is also known. However, the currently available data is static data. Although a preference for a real-time or dynamic representation is not clear from the survey, in the interviews reactions on real-time or dynamic representation were rather positive. In addition, a real-time dashboard is preferred by LABVLieland. Therefore, additional data is needed.

By obtaining additional required data, the current data is made more detailed and real-time. This data can be obtained by implementing data tools. These data tools are methods to obtain real-time data on the energy consumption and production of Vlieland. The decision which combination of data tools are most suitable, is based on the Multi Criteria Analysis (MCA) described in section 4.4.

4.3 CURRENTLY AVAILABLE DATA

First a short overview of the electricity production and consumption on Vlieland is given below. In section 4.3.1 more detailed information is given on energy consumption, followed by production in section 4.3.2. The production is specified per production device: PV panels, solar collectors and biomass.

Figure 4.1. below gives insight on the energy balance of Vlieland. This graph includes the total energy consumption and production of Vlieland. The diagram on the left shows the total gross energy consumption (128.7 TJ). The majority of the gross energy consumption is through heat (72%) and (28%) is through the consumption of electricity. The diagram on the right shows the total renewable production (8 TJ). Of the total renewable production is (43%) heat and is (57%) electricity. A table of the energy balance is included in appendix VI. Note that not all production is included in figure 4.1 and table VI. Excluded production is described in section 4.3.2.

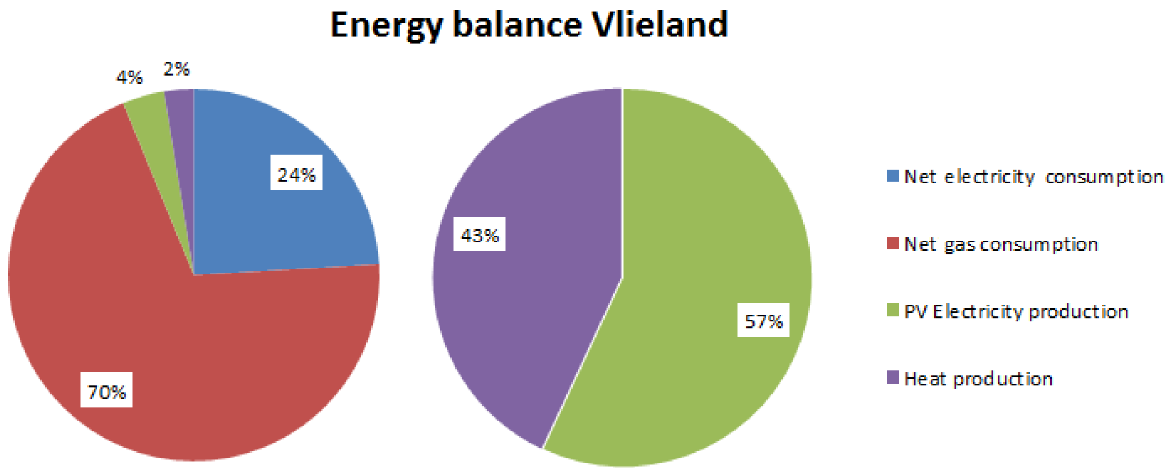


Figure 4.1 - Energy balance of Vlieland. The left diagram presents the gross energy consumption consisting of the net consumption (red and blue) and the production (purple and green). The right diagram presents the total production on Vlieland, divided in heat (purple) and electricity production (green).

4.3.1 Currently available consumption

In the year 2014 the total net gas consumption of Vlieland was around 90 TJ and the total net electricity consumption was around 31 TJ. This consumption includes all businesses and households. In figure 4.2, a trend line can be seen for the gas and electricity consumption of Vlieland from 2008 until 2014 (Energie in Beeld, 2015). In 2011 the gas consumption shows a large peak, for which the reason is unknown. The electricity consumption shows a small decrease over time. This could be caused by a reduction of electricity consumption, but also by an increase from production of electricity by renewables.

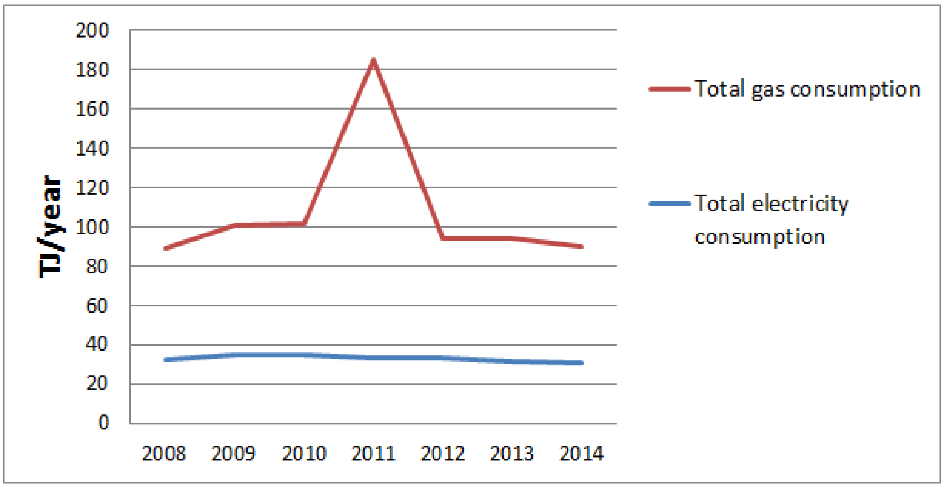
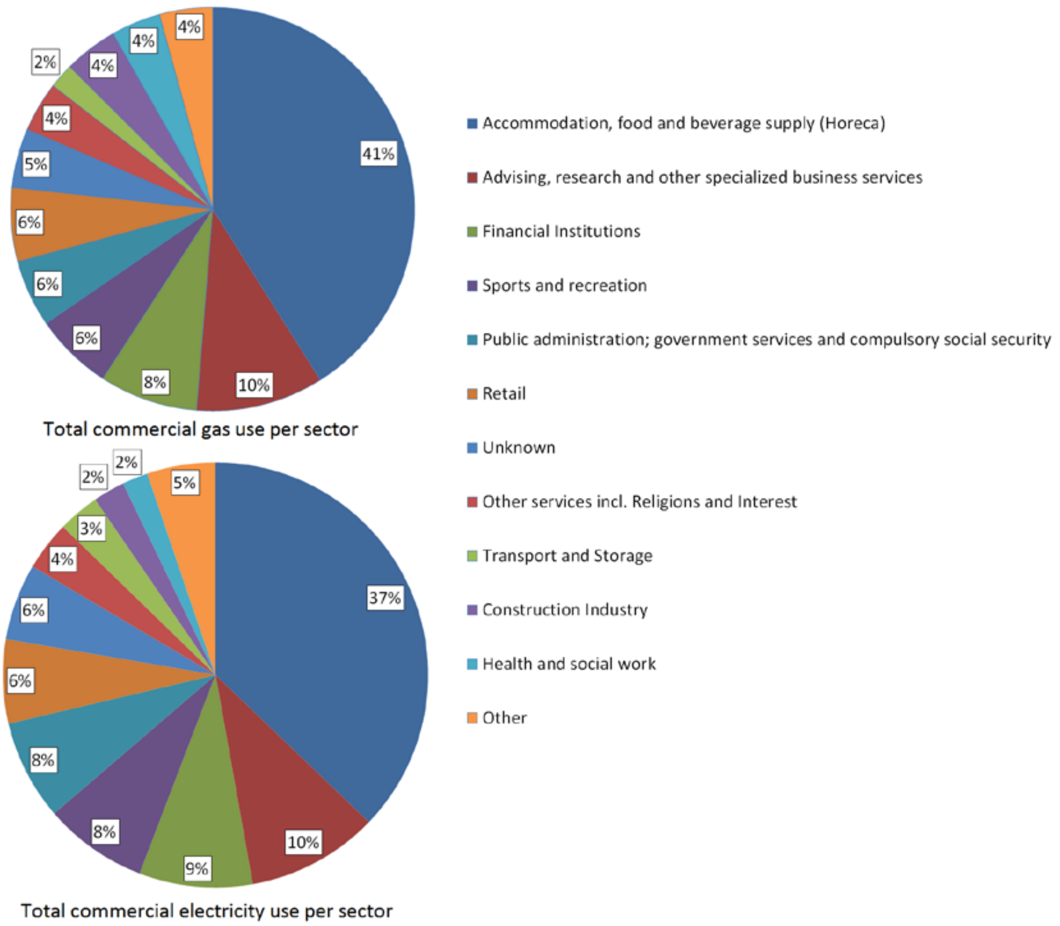


Figure 4.2 - Sum of total energy consumption for 2008 -2014 (Energie in Beeld, 2014).

The commercial gas and electricity consumption is given per sector and is shown in figure 4.3. Commercial consumption include businesses, so the households are excluded. From the commercial gas and electricity consumption, about 40% is consumed by the “Horeca” sector. This high percentage is caused by the 181,000 of tourists that visit Vlieland each year (Harlingen-online.nl, 2013). Due to privacy reasons, sectors consisting of less than six consumers are excluded from the graph. The excluded sectors are given in appendix VII (Energie in Beeld, 2015).



*other sectors include culture, wholesale, education and lease of movable goods

Figure 4.3 - The commercial gas and electricity consumption per sector, excluding households (Energie in beeld, 2014).

4.3.2 Currently available Production

First, an overview of the available renewable production resources is given. Next, each source of renewable production on Vlieland is discussed separately. These methods are production by PV panels, solar collectors and biomass, which are discussed below.

In figure 4.4 the renewable production from different sources is shown. This graph is compiled with data received from some of the selected stakeholders and calculations based on existing data for both biomass and the solar field. Most of the renewable energy production (92%) will be produced by the combustion of wood and by the solar field (after the PV panels are installed). There are some remarks on this graph. First of all, the solar field has not been built yet. There is also excluded production, namely the heat production by the solar collector at the harbor and the newly build school. Also the production by the urban wind turbines is excluded (as explained in section 1.3), since this data could not be obtained.

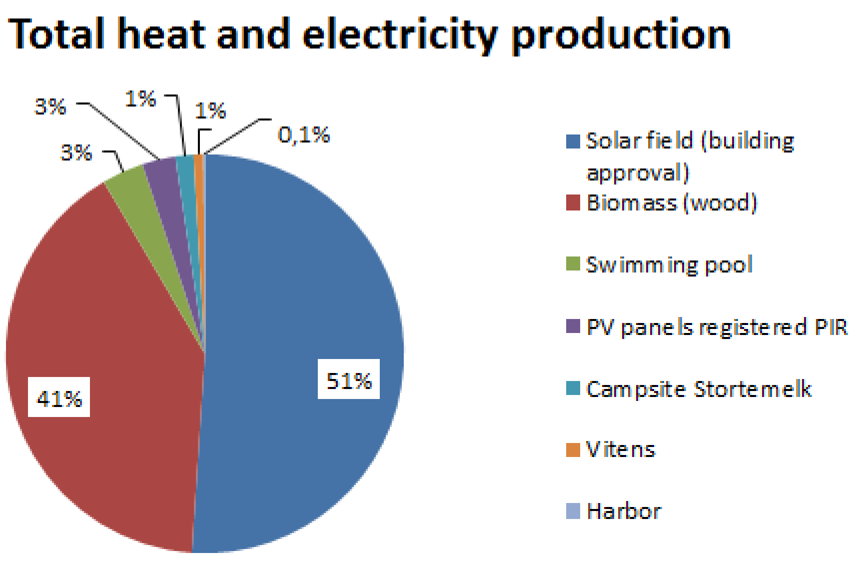


Figure 4.4 - Estimated renewable energy production on Vlieland. The following production is excluded: non-registered PV panels in PIR, solar collector of harbor, micro wind turbines. The energy neutral school is not built yet and is excluded. The solar field is included but not yet build.

Current production PV panels

An important renewable production source is formed by PV panels. For investigating installed peak capacity of PV panels, an important source of information is the Production Installation Register (PIR). In 2011, only 3 connections (max. 3x80 Ampere) on Vlieland were registered in the PIR. This number has increased to 17 in 2014. Together, the registered PV panels produced about 68 MWh in 2014 (Energie in Beeld, 2014). However, not all production of PV panels is registered in PIR. This is because it is not obligated to register PV panels. Also the large-scale consumers of electricity (more than 3x80 Ampere) are not registered in the PIR (Energie in beeld, 2015). Therefore the following large-scale consumers of electricity have been approached to receive a more complete overview of the total renewable energy production on Vlieland: harbor, campsite, swimming pool and Vitens.

Besides the current installed capacity, two new projects for installing new PV panels are made. Currently the municipality of Vlieland has assigned one hectare of the Vliehors to install new PV panels. It is estimated that this investment would result in the production of 1170 MWh per year, equal to 13.6% of the net electricity consumption of Vlieland (LABVlieland, 2015). Furthermore, a new energy neutral school is being build which will make use of PV panels. It is unknown how many PV panels are going to be installed and therefore it cannot be included in the production.

Current production solar collectors

Solar collectors are installed at the swimming pool and harbor. The newly installed solar collectors at the swimming pool will produce about 211 GJ in the form of heat annually. The solar collectors were installed less than a year ago, therefore this is only a rough estimation. In a later stage, more accurate data can be acquired. The amount of heat produced by the solar collectors at the harbor are unknown and therefore excluded from the energy production.

Current production biomass

Each year Staatsbosbeheer gives permission to cut down 500 cubic meter of wood on Vlieland (Staatsbosbeheer, 2015). This is the amount that the forest can produce sustainably. The inhabitants of Vlieland use a wood stove to produce heat from the wood. In order to calculate the effective heat produced from wood, the average efficiency of a wood stove is calculated (appendix III). This resulted in an average wood stove efficiency in the Netherlands of 57% (Koppejan, I. J., 2010; CBS, 2010), which means that 57% of the combustion heat is transferred to the room. In order to get the total heat retrieved from the combustion, the volume of 500 m^3 is multiplied by the caloric value of 21.3 MJ/kg (Toossi, 2008) and wood density of 550 kg/m^3 (Cutnell, 2009). The effective heat produced by this pine wood is 3.34 TJ. This is equal to 3.7% of the commercial gas consumption.

4.3.3 Estimated renewable energy production potential

To increase the amount of renewable energy produced, additional installations will be needed. In this section the annual energy potential for PV panels on Vlieland will be described. Next, the annual energy potential of a possible wind turbine is assessed.

Potential production PV panels

PV panels could potentially be installed on rooftops and on the fields of the Vliehors. When one hectare of PV panels is installed on the Vliehors and all available rooftops are occupied, a total of 3.5 GWh electricity is produced, which is approximately 12.7 TJ. It is estimated that a total of 1.9 GWh can be produced on 14,000 m^2 rooftops. On 10,000 m^2 field, 1.6 GWh can be produced, assuming 10,000 m^2 of PV panels installed in this area. In figure 4.5 the hourly PV electricity production potential of 2014 is shown.

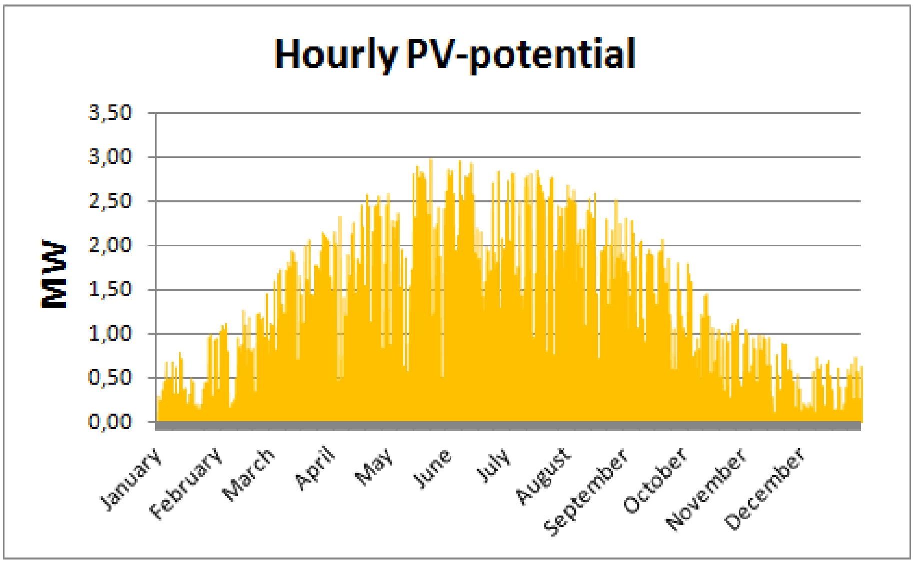


Figure 4.5 - Hourly production potential by PV panels on 10,000m2 field, plus 14,000 m2 of rooftops

Potential production wind energy

Figure 4.6 shows the estimated hourly potential production of wind energy of Vlieland for 2014. The total production potential of a large wind turbine (2 MW) of 80 m hub height produces 6.8 GWh (24.5 TJ) a year, while a small wind turbine (0.1 MW) of 18m hub height produces 0.43 GWh (1.5 TJ) a year.

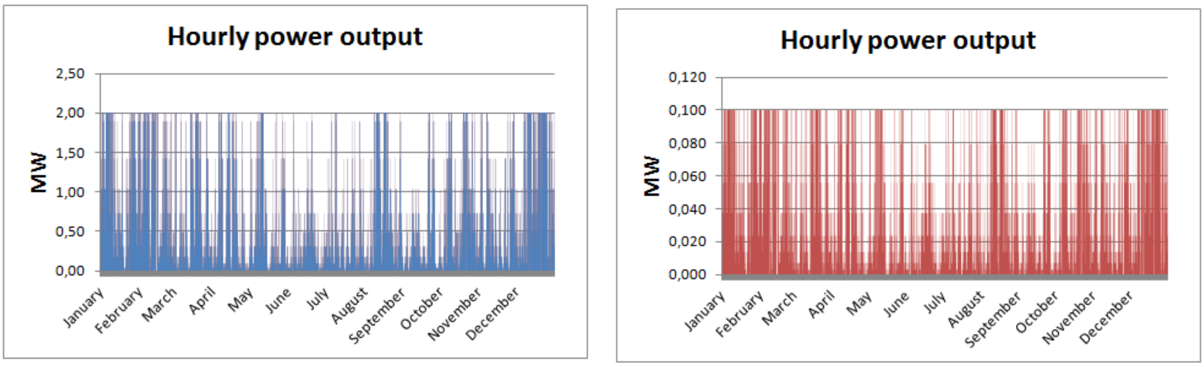


Figure 4.6 - (left) Hourly production potential of 2014 by a 2 MW wind turbine and (right) a 0.1 MW wind turbine

Below an example day graph is shown of the potential production of a large wind turbine of 2 MW (left) and a small wind turbine of 0.1 MW (right).

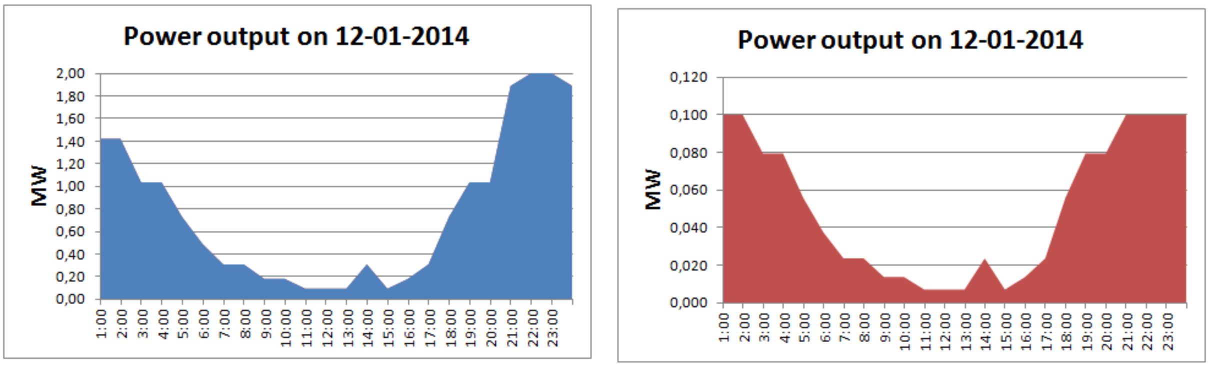


Figure 4.7 - Hourly production potential of 12-Jan-2014 by a 2 MW wind turbine (left) and a 0.1 MW (right) wind turbine

4.4 Data tools to obtain the additional required data

The additional required data can be obtained by using different data tools. In this section the following data tools are discussed separately:

- Meter on gas and electricity connection between island and mainland
- Reading P1 of smart meters in households
- Reading P4 of smart meters in households
- Consumption profiles for households
- Reading meter of large-scale consumers
- Using last year's data of large-scale consumers
- Measuring production
- Estimating production
- Estimating real-time renewable energy production potential

The different data tools received a scoring on the following criteria: costs, social impact, complexity and quickness of implementation. In table 4.4 an overview of the data tools and their scoring is given.

4.4.1 Meter on electricity and gas connection between island and mainland

One cable for electricity and one pipeline for gas, connect the island with the mainland. Vlieland can import energy produced at the mainland through these connections. With a meter on these connections, it is possible to measure the net import of energy to the island. The net import of energy is defined as the energy imported from the mainland to the island minus the energy exported from the island to the mainland. When the net import is zero over a certain period of time, the island is energy neutral. At the moment, the net imported energy is positive all the time. In this case, the net import of energy is equal to the gross energy consumption on Vlieland minus the energy production on the island. In other words, the net energy import is equal to the net energy consumption on the island.

Liander is the grid operator for electricity on Vlieland (Liander, 2015c). According to an employee of Liander (2015g), there are two meters on the electricity cable between the mainland and Vlieland. There is one 20 kV meter on the mainland and a 10 kV meter at Vlieland. The meter on the island must be read out. The data of these meter could be communicated every five minutes or more often.

Enexis is the grid operator for gas on Vlieland (Gasunie, 2015). It is unknown if there is a meter on the gas pipeline between the mainland and Vlieland. If a gas meter is present, the costs are low. In this case, only possible license costs for reading out the meters are to be paid. For scoring this data tool, is was assumed this is the case. Therefore a score of 1 was assigned to the criteria "costs" of this data tool. However, this is highly uncertain. Installing a meter on the gas pipeline has no social impacts on the different stakeholders on Vlieland (score: 0), since no local stakeholders are involved in the process. For complexity a medium score is assigned (3), since the meter is a technological device that has to be installed and maintained by experts. This implies a high complexity. On the other hand, the low number of stakeholders involved lowers the complexity. The quickness of implementation is estimated to be medium (3) as well. An overview of these scores are given in table 4.4.

4.4.2 Reading P4 of smart meters in households

The forthcoming installation of smart meters in the Netherlands creates new possibility for energy monitoring (Slimmemeters.nl, 2015). More information on the background and technical aspects of smart meters can be found in appendix VIII. Data retrieving from smart meters could be achieved in two ways: using the P4-port and the P1-port. The P4-port, which sends data on gas and electricity two a database of the utility, is explained in this paragraph. However, first a brief description of the general approach of the two smart meter based data tools is given below.

When considering implementation of the smart meter data tools (both the P1-port and P4-port data tool), it must be taken into account that quickness of implementation is an important criteria. It takes too long to wait for Liander to implement smart meters for the entire municipality. However, providing the entire municipality with smart meters before Liander decides to do so, would involve major expenditures on applications. Furthermore, the possibility of reading out smart meters from all households is not realistic since not everyone will allow this, for instance for privacy reasons. Therefore, in the described smart meter data tools it is assumed that the data on consumption of the total group of households is extrapolated from a sample. These sample households will receive a smart meter before Liander starts implementation of smart meters on Vlieland.

The considered sample size is twenty households. This size is used because it is estimated to be a good balance between costs and complexity on the one hand and accuracy on the other hand. From twenty households a good extrapolation could be made (accuracy), but it does not lead to loads of extra work or investments (cost and complexity). It is possible that the annual energy consumption of the approached households deviate from the average consumption profile. In order to create a representative extrapolation, it has to be determined which share of the total energy consumption by households on Vlieland is represented by the twenty households from the sample. Annual energy bills from the twenty households can show what the annual energy consumption of this sample group is. The share of the sample group of the total annual energy consumption (which could be retrieved from Energie in Beeld (2015)) of all households can be calculated. This share can be used as a factor, in order to extrapolate the real-time consumption of the total households from the data of the sample households. This way, an estimation of the real-time consumption of the total household group can be made, which can be showed on the energy dashboard. For the P1-port and P4-port data tools, the sample size could be expanded in the longer term. This is especially realistic after Liander started to install smart meters in all households of Vlieland.

Regarding costs, expenditures for smart meters have to be made for the twenty sample households. Therefore, these costs (see appendix VIII) are taken into account for all scenarios that include one of the smart meter related data tools. This is the case for both the P4-port and P1-port data tool.

The first pathway to read data from a smart meter is described as the P4-data tool (see figure 4.8). Using the P4 port of smart meters, data can be read out every fifteen minutes and with one day delay. The P4 tool is the most accessible way to read out data from smart meters. Though, due to privacy regulations, cooperation with a ODA-certified organization is required, which is further explained in appendix XI. For households connecting to an ODA, the ODA does not charge costs. However, for getting insight in the data of one consumer as an external party, the ODA does charge costs. Price indication from ODA-certificated organisations (table 4.2) suggested amounts of €10,- to €20,- per connection. In the case a larger number of households will be connected, the payments could be lower. The installation of the smart meter forms the majority of the costs. Hence, in comparison to other data tools the costs are moderate (costs = '3' as input for MCA, see table 4.4).

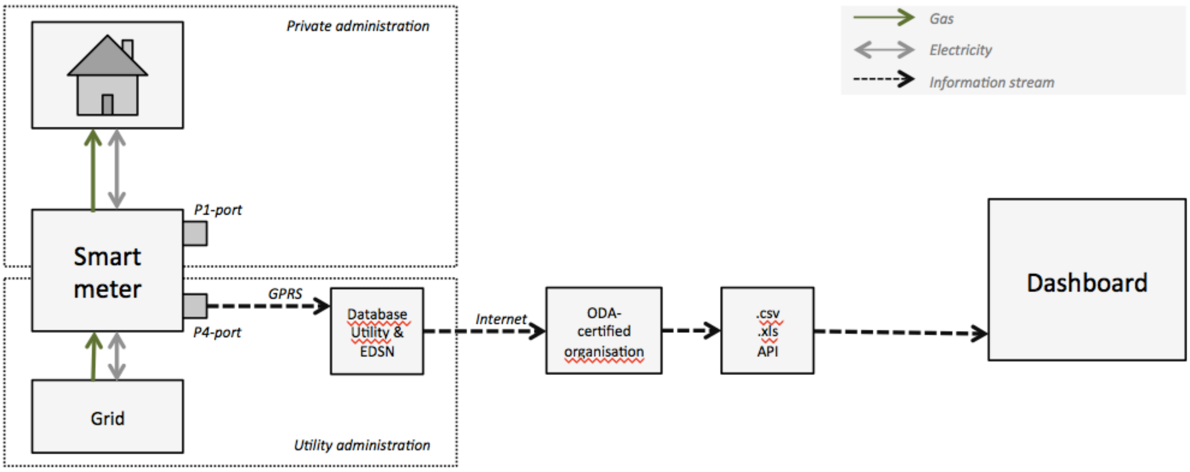


Figure 4.8 - Visualization of the pathway of the P4-data tool

Since LABVlieland, or the organization that executes the setup of the energy dashboard, is not the house owner, permission is required. Information from personal communications (slimmemeteruitlezen.nl (2015), Enepa (2015)) by ODA-certificated organisations suggests that no complex legal contracts are needed. A simple indicative contract between the external party and the household or perhaps just some e-mail iteration will satisfy the demands of the ODA-certified organization, regarding the protection of the privacy of households. However, twenty agreements have to be made additional to the installation process of twenty smart meters with the risk of contingencies (complexity = '4' as input for MCA, see table 4.4).

Table 4.2 - Brief overview indications of offers of ODA-certificated organisations.

ODA-organization	Contact person	Price indication	Data format
Slimmemeteruitlezen.nl (Enepa)	A. Derksen	€20,- per connection	.csv, .xls, API
Slimmemeterportal.nl	R. Mulder	€20,- per connection	.xls

The implementation time of finding twenty agreed households might cost a lot of time. Also the installation of the smart meters will take some weeks. Setting up and verifying agreements for twenty households will add the last part of the implementation time. However, except for the smart meters no special devices has to be installed and no sustaining internet connection has to be constructed (Quickness of implementation= '-' as input for MCA, see table 4.4).

Even though data will only be used after permission of the house owner, the method of the P4 data tool has some negative social impact. Since the consumption data becomes public, it could create some feeling of a loss of privacy for the house owners. However, since the information is bundled in a sample package of approximately twenty households, this effect will be flattened (social impact = '4' as input for MCA, see table 4.4).

As described previously, there is a delay in the P4-data of approximately twenty-four hours. Therefore, the data will be shown on the dashboard as the data of the previous day. This reduces the accuracy of the data, since it does not represent the real-time fluctuations of the consumption anymore. The effect of for instance sudden weather developments or events on the consumption rate will not become clear on the dashboard, using the P4 data tool. However, the dashboard has data updates every 15 minutes for electricity and every hour for gas, which adds quite some dynamics to a scenario that includes this data tool.

4.4.3 Reading P1 of smart meters in households

The second on smart meters relying data tool described in this research, is based on the usage of the P1-port (see figure 4.9). The P1-port is intended for personal usage and delivers highly dynamic data, which is also more complicated to read out. This is explained further in appendix IX. The P1-port gives data on gas consumption in the same frequency as for the P4-port. However, data on electricity consumption is given every ten seconds (Liander, 2014). Therefore, the P1-data tool adds more dynamics to a certain scenario than the P4 data tool. Since there is no delay between the energy consumption and the data transmission (which is one day for P4), results in a very high accuracy. The data for the household group is extrapolated from twenty households, which is done in the same way as described in section 4.4.2.

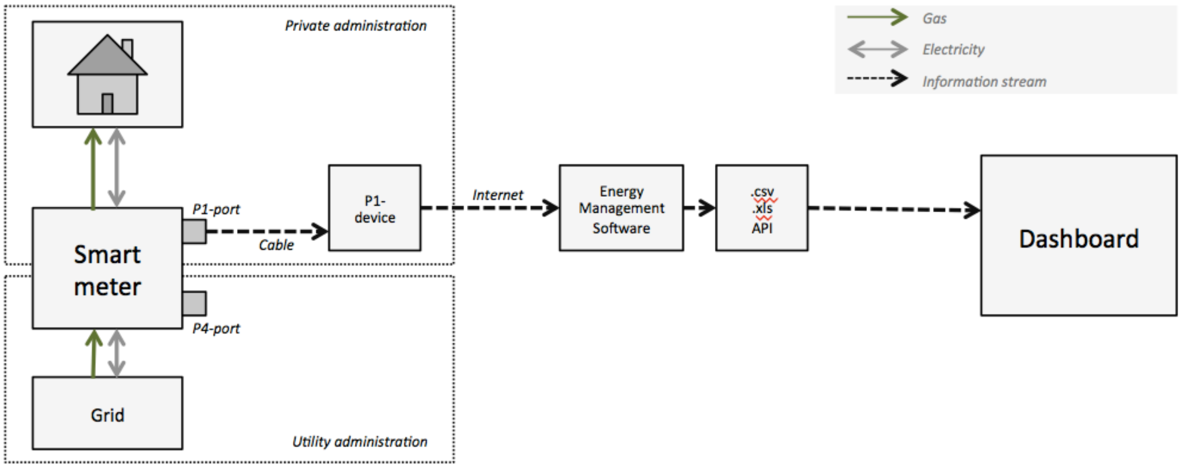


Figure 4.9 - Visualization of the conventional pathway of the P1-data tool

Since data from the P1-port is more difficult to read out (see appendix IX), hardware is needed to convert the P1-signals, which is available for approximately €80,- per smart meter connection (Table 4.3). For these devices an internet connection is necessary. It seems that in order to avoid Linux programming it is advisable to use paid energy monitoring services, for instance delivered by Enelogic. This involves annual payments. In combination with the installation costs of the smart meter, this makes this data tool quite expensive (costs = '4' as input for MCA, see table 4.4 (end of data tool section)).

Table 4.3 - Examples of P1-reading software and hardware. Sources: Plugwise (2015), Milieucentraal (2015), Enelogic (2015).

Company	*P1-hardware*	*Costs*	*Energy platform*	*Costs/year*
Plugwise	P1-smile	€99	Management portal	No indication
Qurrent	Qbox	€90	Qurrent website / app	No indication
Enelogic	P1-uitlezer	€79	Enelogic Energiemanager	€240,-

For the P1-data tool, the assumption has been made that there will be chosen for the easiest pathway in terms of technique and ICT, at the expense of extra costs. These costs could be avoided, leading to a lot of programming work. Two alternative pathways within this data tool are possible (see appendix IX, figure X.21). Information from personal communications (Watt Now, 2015) indicates that this is not recommendable, since these unconventional pathways require ICT expertise and are quite unproved.

For the P1-port data tool, smart meters must be installed, agreements with households have to be made and hardware must be installed in twenty different households. For this reason complexity is created (complexity = '5' as input for MCA). Compared with other data tools, quite some steps must be made. The sub-processes required for the P1-port data tool are connected in series. Hence, progress in one step depends on the progress in another step. This creates the risk of delays in the implementation phase. Therefore, it is estimated that the implementation of this data tool will take quite a lot of time (Quickness of implementation = '--' as input for MCA, see table 4.4).

The P1-port data tool has an important negative social impact. Highly dynamic data is monitored in homes of stakeholders. Unless the fact that a sample of twenty households is extrapolated, it might lead to privacy issues. Leakage of this data could possibly provide interesting information for hackers, other criminals, certain companies or governmental surveillance organisations. Even if this is not proved household could experience this change (Burgerrechtenbeweging Vrijbit, 2015) . Also the installation proceedings could be experience as negative by the involved persons, which also affects the magnitude of the social impact (social impact = '5' as input for MCA, see table 4.4).

4.4.4 Consumption profiles for households

Most of the gas and electricity consumption of households in the Netherlands is measured and communicated once a year. Because production and consumption needs to be equal at all times (Tennet, 2015), a dynamic estimate has to be created. These estimates are called Synthetic Load profile (SLP) (VREG, 2015). These load profiles are used in the Netherlands to estimate the consumption of different types of consumers, but not specifically for Vlieland (Nederlandse energiedatauitwisseling, 2015). Therefore using these profiles will create a dynamic consumption profile for the 550 households (stadindex.nl, 2015) on Vlieland, but they might not be representative and precise.

There are ten different electricity SLPs and four gas SLPs, which represent the consumption of different kind of consumers. A gas SLP is estimated for a whole year per hour and electricity is estimated for a whole year each fifteen minutes. These profiles are adjusted each year and could be used to estimate the consumption of all households on Vlieland a little dynamically, but obviously not real-time. The costs of this method is judged as 0, because there are no costs involved for acquiring the profiles (costs = '0' as input for MCA, see table 4.4). A social impact is absent, since there are no people involved in creating this method (social impact = '0' as input for MCA, see table 4.4). The complexity is also 0, because this is the easiest method to get a dynamic consumption of the households (complexity = '0' as input for MCA, see table 4.4). This method can be quickly implemented, since all data is available and it is does not depend on external parties (quickness of implementation = '5' as input for MCA, see table 4.4).

In order to estimate the consumption of households on Vlieland different SLPs can be used. For electricity the E1a and the E1b SLP represent the consumption of a household, these are profiles created for connections smaller than or equal to 3 X 25 AMP (Liander, 2015h). Detailed information can be found in appendix X. The difference between the E1a and E1b profile is a single and a double counting mechanism (night consumption). Since there is no information available on which kind of meters are installed on Vlieland, the average of the two profiles is taken to derive a generalized SLP. In figures 4.10 and 4.11 a year profile of 2015 and a random day profile is shown.

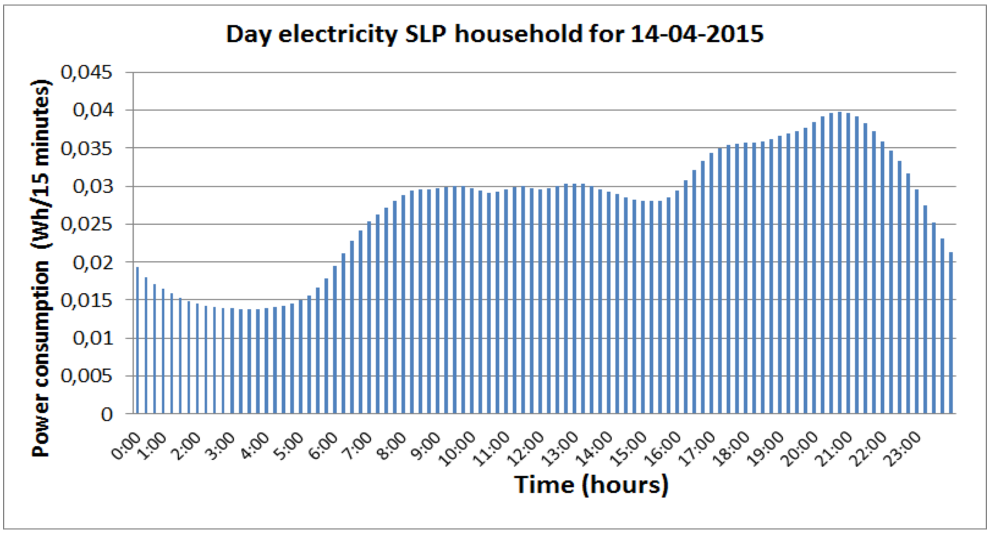


Figure 4.10 - Example day quarterly Electricity SLP of 2015 (Nederlandse energiedatauitwisseling, 2015)

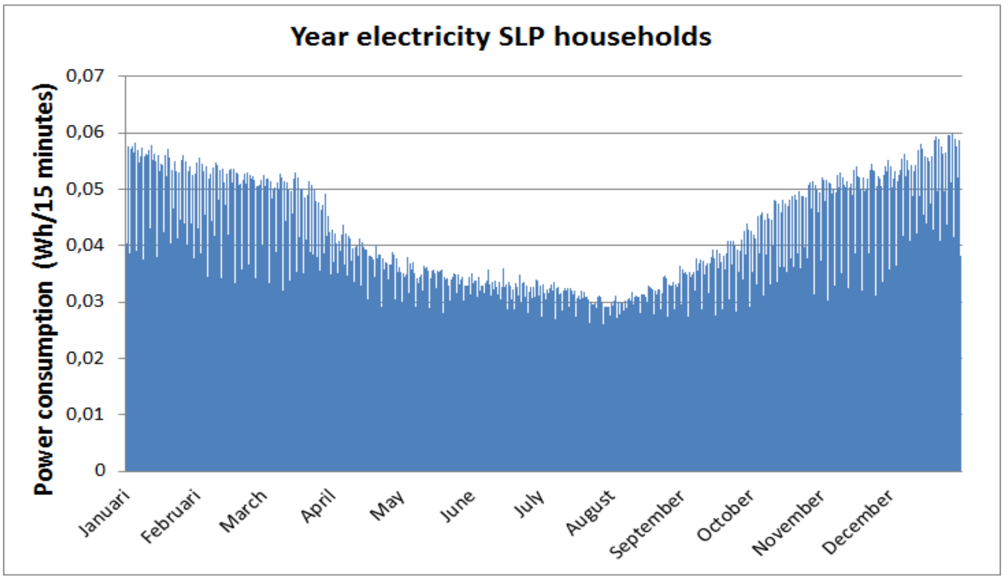


Figure 4.11 - Quarterly Electricity SLP of 2015 (Nederlandse energiedatauitwisseling, 2015)

The gas consumption of a household can be estimated as well. This profile represents the hourly gas consumption of an average Dutch household. A G1a consumer uses less than 5000 m^3 and is measured by smaller type than a G6 meter, or has no meter at all (Nederlandse energiedatauitwisseling, 2015). A G6 meter measures volumes smaller than 10 m^3/h, but larger than 0.06 m^3/h (SanderVunderink, 2015). In figures 4.12 and 4.13 an hourly household SLP of 2015 and a gas SLP of a random day is displayed. The gas SLP is calculated with the hourly temperature on Vlieland in 2014 and the SLP G1A data (KNMI, 2015; Gasunie, 2012, p. 30). Since the consumption profiles for gas are largely dependent on temperature, these profiles could be used real-time when the actual temperature on Vlieland is measured and used for calculating the ‘actual’ consumption profile (KNMI, 2015)

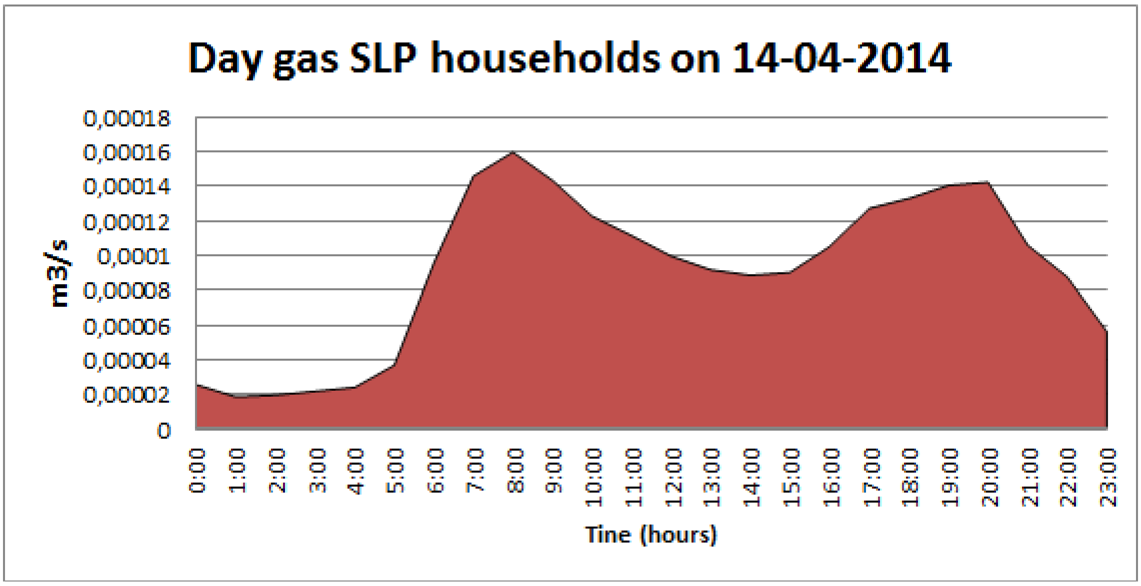


Figure 4.12 - hourly gas SLP of 14-04-2014 of a household (Nederlandse energiedatauitwisseling, 2015)

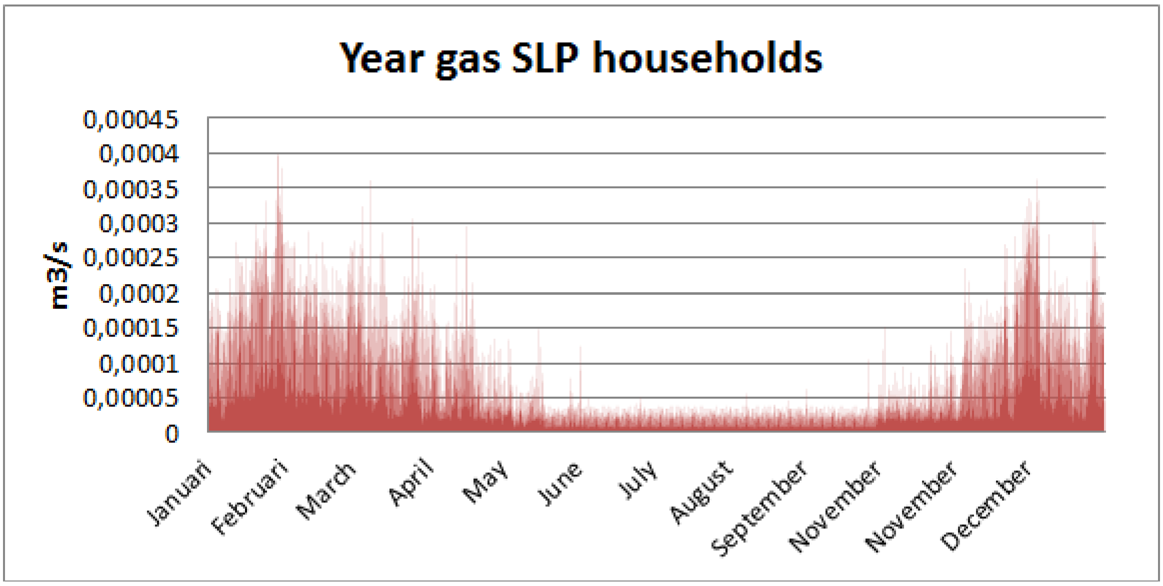


Figure 4.13 - Hourly household SLP of 2015 (Nederlandse energiedatauitwisseling, 2015)

4.4.5 Reading meter of large-scale consumers

Multiple large-scale consumers could be integrated into the energy dashboard. Large-scale consumers are already obligated to use a similar device as the smart meter, this obligation is called "metering responsibility" (VEMW, 2015). Unlike small-scale consumers, whose energy consumption is measured by the grid operator by default, a large-scale consumer can outsource this measurements. The large-scale consumer can choose between fourteen different recognized measurement companies (Tennet, 2015). Gas consumption must be measured hourly (VENW, 2015b), while electricity must be measured at least every fifteen minutes (VENW, 2015a). For electricity this measurement can be communicated at the end of the day, or can be communicated real time. For gas it is more complicated, because possibly the old gas meters have to be replaced in order to obtain the gas data automatically (Liander, 2015b).

In order to communicate this measurement real-time, a gprs logger has to be installed. According to the measurement company Westland Infra, their measurements can be communicated every five minutes. (Westland infra, 2015)

To integrate real-time data of large-scale consumers in the energy dashboard, an automatic connection through a so called “web service” should be created by an IT team of LABVlieland. This means that the consumption of the selected stakeholders could be updated real-time with a maximum interval of fifteen minutes for electricity and every hour for gas. The complexity of this method lies in the fact that a lot of different parties are involved. Each large-scale consumer could have a different measurement company. Therefore the data could be delivered in several different data formats. Furthermore, agreements have to be made with each different measurement company. In addition, the approval of each large-scale consumer has to be given (Westland infra, 2015). For this reasons, a score of 5 on complexity is used in the MCA (see table 4.4).

There are costs involved in creating an automatic web service, because a web service is an additional service of an measurement company (Liander, 2015f). Assuming 6 involved stakeholders, a duration of 5 years and a cost of € 14,- a month (Westland infra, 2015) per large-scale consumer, the costs would add up to €5040,- for five years (scope until 2020). Therefore, this data tool is assigned a 5 on costs (see table 4.4). The social impact is assigned a medium score of 3, since the large-scale consumers have to give their permission on using their data and are therefore slightly bothered. Furthermore private data on their company or organization is made public. Since quite a lot of steps have to be undertaken before this data tool would be operational, the quickness of implementation is assigned a ‘-’ (see table 4.4).

4.4.6 Using last year’s data of large-scale consumers

Another option to obtain data on the consumption of selected large-scale consumers is to estimate it. This could be accomplished by using historical consumption. Large-scale consumers should be approached once a year in order to get hourly gas consumption data of 2014 and electricity consumption per 15 minutes. A hand-made profile can be created for a whole year for the selected stakeholders separately. This profile has to be adjusted for the new year (holidays, events, weekends etc. have to match with reality). This adjusted profile can function as an estimation of the real-time consumption of the selected large-scale consumers.

The scoring for the costs is 0 (see table 4.4), because the required data is available for free or at little costs. The consumers would be bothered once a year only, therefore the social impact score is 1 for this data tool. Furthermore, not a lot of private information is given, since it is historic data. The tool scores a 2 on complexity, since the data has to be obtained only once a year and no new installations need to be done. (see table 4.4). For this reason, also the implementation can be achieved rather quickly (quickness of implementation = ‘+’ in MCA.

4.4.7 Measuring production

The net consumption (total consumption minus production) is measured by the meter on the main gas and electricity connections entering the island and/or by smart meters. In order to calculate the gross energy consumption, the production on the island has to be measured or estimated.

The production of the small-scale consumers will be estimated in all cases, since the cost and the complexity for measuring these data is high relative to the small share in the total renewable production. The method for estimating the production of small-scale consumers is explained in section 4.4.8. The production of large-scale consumers can be measured or estimated. In this research, the large-scale consumers concerned are:

- Swimming pool
- Vitens
- New secondary school 'De Krijtenburg' (in development)
- Campsite
- Harbor
- Vliehors (in development)

In this section, measuring energy production of large-scale consumers is treated. First, electricity production by PV systems is discussed. Next, energy from solar collectors and wood are treated.

Some houses and businesses are already equipped with a production meter for their electricity production that is able to communicate real-time. A reason for this is that a production meter is required in order to receive the sustainable energy subsidy (SDE) (energietechnologie.nl, 2010). Other houses and businesses still need to be equipped with a production meter. The costs for a new, privately installed production meter in combination with a device for digitizing the data, are about € 100,- to € 150,- (Wattcher.nl, 2015; bespaarbazaar.nl, 2015). If the fuse box must be made suitable for installation of a production meter first, another € 300,- should be added (nieuwegroepenkast.nu, 2015). For this data tool, it is assumed that 5 large-scale consumers, which already have a suitable fuse box, still need a production meter. For these reasons, the score for the costs is 1 (see table 4.4).

The final step is to connect the software of the different production meters with the software of the dashboard, so that the data can be obtained and visualized real-time. This method requires automatic connections to a variety of measurement systems. Creating all these different reading methods could be difficult. Therefore the score on complexity is 3 (see table 4.4). Since the large-scale consumers would have to give their approval and would have to cooperate, the social impact received a score of 2. The quickness of implementation is estimated to be medium and received a +/- score (see table 4.4).

Solar heating is another method to use the sun as a renewable energy source. The largest producer of heat by solar collectors on the island is the swimming pool. This system is equipped with a meter measuring the amount of energy in GJ that is transferred to the water (Orgatech, 2015). This data is measured real-time and could be used directly for the island's renewable energy production. Possible other installations of solar heating equipped with a comparable meter can be treated the same way. If no meter is installed, installation can be considered. However, these costs are not taken into account in this data tool.

The real-time energy consumption from wood is estimated by definition and therefore treated in 4.4.8 only.

In order to get insight in the gross consumption of the island, ideally all production is measured. The list of included stakeholders needs to be extended in the future when more renewable energy is produced by different stakeholders.

4.4.8 Estimating production

Another option is to estimate the total production of renewable energy real-time. The renewable energy produced by PV panels could be estimated in two ways.

The first option is to use the total installed peak capacity. In this case, the total installed peak capacity of all PV panels must be known. In addition, the peak capacity in combination with the real-time production of at least one PV system has to be known. In the equation, this system is called 'measured system'. This way, production data of the measured system can be extrapolated to the total amount of PV systems. Equation 4.1 could be used to calculate the total current production of all the target systems together:

$$total\ current\ production\ [W] = \frac{current\ realtime\ production_{\ measured\ system}\ [W]}{installed\ peak\ capacity_{\ measured\ system}\ [W_p]} * \sum_i \left[peak\ capacity_{target\ system\ i}\ [W_p]\right] \quad (4.1)$$

In which:

G = solar irradiance at ground level [W/m^2]

$G_{total\ annual}$ = total annual solar irradiance at ground level [kWh/(m^2.year)]

Instead of using Watt as unit for the real-time production, the unit kWh per certain period (e.g. per 15 minutes or per day) can be used. The outcome will be in the same units as the units used for the current real-time consumption. The downside of this method is that the measured systems are assumed to be representative for all other systems at the island. In other words, their overall efficiency is assumed to be equal to the average on the island. This is not necessarily the case since both positioning and system efficiency differ among systems. The few measured PV systems are not average by default. However, although the accuracy is lower than when all production devices are measured, it is still reasonably high. An advantage is that solar irradiance on the island is directly used and the data is obtained real-time.

The second option is to use the total annual electricity production. This electricity production can be divided by the cumulative solar irradiance in a year. This way, the production per stakeholder per amount of solar irradiance can be calculated. Real-time production from PV systems can be estimated using real-time data on solar irradiance. When the results for each target system are added up, total current production of the target systems is derived:

$$total\ current\ production\ [W] = \sum_i \left[\frac{annual\ production_{\ target\ system\ i}\ [kWh/year]}{G_{\ total\ annual}\ [kWh/(m^2.year)]} * G\ \left[\frac{W}{m^2}\right]\right] \quad (4.2)$$

in which

$$G_{total\ annual}\left[\frac{kWh}{m^2.year}\right] = average\ annual\ solar\ irradiance\ \left[\frac{W}{m^2}\right] * 8760\left[\frac{hours}{year}\right] / 1000 \quad (4.3)$$

The data for the total annual production of the selected large-scale consumers is already obtained in section 4.3. Data on current solar irradiance is available from KNMI per hour (KNMI, 2015). The measurements are performed in Leeuwarden. It is also possible to measure the current solar irradiance locally and at a higher frequency, using a solar irradiance meter. Solar irradiance meters are available from € 80,- (lightinthebox.nl, 2015). Using a solar meter would highly increase the accuracy of this option. However, a disadvantage is that the selected stakeholders do not always possess accurate production data of the previous year. The major advantage of this method over the first one is that differences between PV systems in positioning and internal efficiency are automatically accounted for. Overall, this option is recommended over the first option, especially in case a local solar meter is used. After all, in this case only annual production data in combination with the relatively inexpensive solar meter are needed to derive rather accurate and detailed information.

It would be best to use a combination of these methods in order to estimate the total production. For households, the first option can be used. The peak installed capacity of registered PV systems of small-scale consumers is collected in the production installation register (PIR). This method seems most appropriate for the households since annual production data of households is difficult to obtain and would cause extra social impact. For the selected large-scale consumers, the total production in a year could be used in combination with solar radiation data (option 2). It is feasible to acquire annual production data of large-scale consumers. In defining the scoring for the MCA for this datatool, this combination is assumed, including the use of a solar radiation meter.

For solar collectors, if no real-time meter is present, but the average flow volume and the average water in- and outflow temperatures are known, the average useful power output from the collector can be calculated using equation 4.4 (Twidell & Weir, 2015, p. 81):

$$P_u\ [\mathrm{W}] = \rho\ \left[\frac{\mathrm{kg}}{\mathrm{m}^3}\right] * V_{\mathrm{flow}} \left[\frac{\mathrm{m}^3}{\mathrm{s}}\right] * c\ \left[\frac{\mathrm{J}}{\mathrm{kg.K}}\right] * (T_2\ [\mathrm{K}] - T_1\ [\mathrm{K}]) \tag{4.4}$$

In which:
P_u = average useful output power from the collector [W]
ρ = density of fluid [kg/m^3]
V_{flow} = Volume flow [m^3/s]
c = specific heat capacity [J/kg/K]
T_2 = average temperature of the fluid when it leaves the collector [K]
T_1 = average temperature of the fluid when it enters the collector [K]

When this average useful power output is multiplied by the annual amount of operational hours, the energy production per year is derived. Once this annual energy production is known, the real-time production can be estimated using the same equation (4.2) as for estimating real-time production by PV cells for large-scale users.

There are two possible methods for real-time estimating energy consumption in the form of wood. The first method is by determining what part of the heat used on the island is produced by wood (3.7%, see section 4.3.2) and multiply this by the real-time measurement of the imported gas through the main gas pipeline to Vlieland. Another option is to calculate how many households (65.9) could be provided with heat using the available amount of wood. For this calculation, it is assumed that the average consumption of a household is 1,440 m^3 (NIBUD, 2015). The hourly gas consumption curve (SLP) could be multiplied by 65.9 in order to get a dynamic wood consumption. Both methods are questionable since it is assumed that consumption of biomass follows exactly the same patterns as the consumption of natural gas.

The costs for this data tool received a score of zero, since using the PIR register is free, acquiring annual production data from large-scale consumers is free and a solar radiation meter is rather cheap. Furthermore, no costs are involved with making estimations on solar collectors and effective heat from biomass. The social impact received a 1 since the only botheration is that large-scale consumers are asked to communicate their total production annual. The complexity received a 1. There are several stakeholders involved, but not much actions from their side are required. In addition, there seem to be no really complicated data involved in this data tool. The quickness of implementation is very high (++). In fact, this data tool can be implemented immediately since (raw) data is directly available (see table 4.4) or can become available soon.

4.4.9 Estimating real-time renewable energy production potential

It is also possible to present the production potential of wind turbines and PV panels, given in section 4.3.3, real-time.

In order to display the real-time wind turbine potential on the energy dashboard, a real-time data stream of wind speed is needed, which can be obtained from the KNMI (2015). This wind speed is then inserted into equation 3.4 (section 3.3.3).

A comparable method can be used for the real-time production of PV panels. In equation 3.2 and 3.3 (section 3.3.3), a real-time solar irradiance data stream can be inserted. The solar irradiance data can be measured locally, using a solar irradiance meter, as explained in the section 4.4.8.

4.4.10 Overview of data tools' scoring

In the previous section, the different data tools each received different scoring on the different criteria used for the MCA. An overview is given in table 4.4.

Table 4.4 - The scoring on the different criteria for all the different data tools.

Criteria	Net usage island	Consumption households		Consumption selected large-scale consumers			Production	
	Meter on cables	SM P4 data	SM P1 data	Consumption profiles	Reading meter	Using data last year	Measuring production	Estimating production
Cost	1	3	4	0	5	0	1	0
Social impact	0	4	5	0	3	1	2	1
Complexity	3	4	5	0	5	2	3	1
Quickness of implementation	+/-	-	--	++	-	+	+/-	++

4.5 Selecting scenarios

By combining the data tools, different scenarios have been made. With these scenarios a Multi-Criteria Analysis (MCA) was performed (section 4.5). The different scenarios received a scoring on the different criteria as described in appendix XI. Furthermore, the weighting factors per criteria were determined (appendix XII). The MCA resulted in a ranking of the scenarios in order of desirability. This ranking is based on the different scoring on the criteria and the weighting factors. The different scenarios and the results of the MCA are presented in this section.

4.5.1 Composing the scenarios

After having determined which data tools are possible to acquire the additional data and to make it real-time and more detailed, different scenarios can be made (see table 4.5). To limit the amount of possible scenarios, several constraints are composed. These constraints are mainly based on the advice on what to display on the energy dashboard and on which places an energy dashboard is desired (section 4.2). The following constraints have been applied to derive the first 12 scenarios:

- The total production and gross consumption must be visualized on the energy dashboard.
- Data of the whole island, households and the selected stakeholders (section 4.2) must be acquired.
- The data must be updated hourly or more frequently.

The real-time potential renewable energy production (section 4.4.9) will also be used for the online dashboard, but this is not evaluated in the different scenarios, since the data tool will be used in every scenario and therefore it would not influence the results of the MCA.

Furthermore, two additional scenarios are created: the easiest scenario (scenario 13) and the scenario without a meter on the cable (scenario 14). In scenario 13, a meter on the cable is present and production data and households' consumption are estimated. Acquiring consumption data of the large-scale consumers is left out entirely.

The final scenario (scenario 14) is the only scenario in which a meter on the main electricity and gas connections is not present. Without the meter on the connections, the total net energy consumption of the island is not directly measured. Therefore, a lot of measuring has to be done to derive insight in the energy situation of the whole island. As much as possible large-scale consumption and production must be measured. This means that more meters for large-scale consumers must be installed than initially described in the data tool for 'reading meter of large-scale consumers'. This heavily increases costs of the scenario, social impact and complexity.

Table 4.5 – The different scenarios used for the Multi-Criteria Analysis. The scenarios are created from the different data tools available to acquire the additional required data. The selection of the scenarios is based on several constraints. SM = smart meter.

	Island	Households			Selected large-scale consumers		Production	
Scenario	Meter cable and pipeline	SM P1 data	SM P4 data	Consumption profiles	Reading meter	Using last year's data	Measuring production	Estimating production
1	X	X			X		X	
2	X	X			X			X
3	X	X				X	X	
4	X	X				X		X
5	X		X		X		X	
6	X		X		X			X
7	X		X			X	X	
8	X		X			X		X
9	X			X	X		X	
10	X			X	X			X
11	X			X		X	X	
12	X			X		X		X
13	X			X				X
14		X			X		X	

The scoring of the scenarios is used as input for the MCA analysis and is explained in appendix XI. Furthermore weighting factors have been assessed to the different criteria. The weighting factors for the different criteria are presented and explained in appendix XII.

4.5.2 Results of the MCA

The results of the Multi-Criteria Analysis are presented in figure 4.14. Scenario 12 and 13 both received the highest overall score of 0.59. Scenario 14 received the lowest overall score of 0.29. The other scenarios received a score in between these two values.

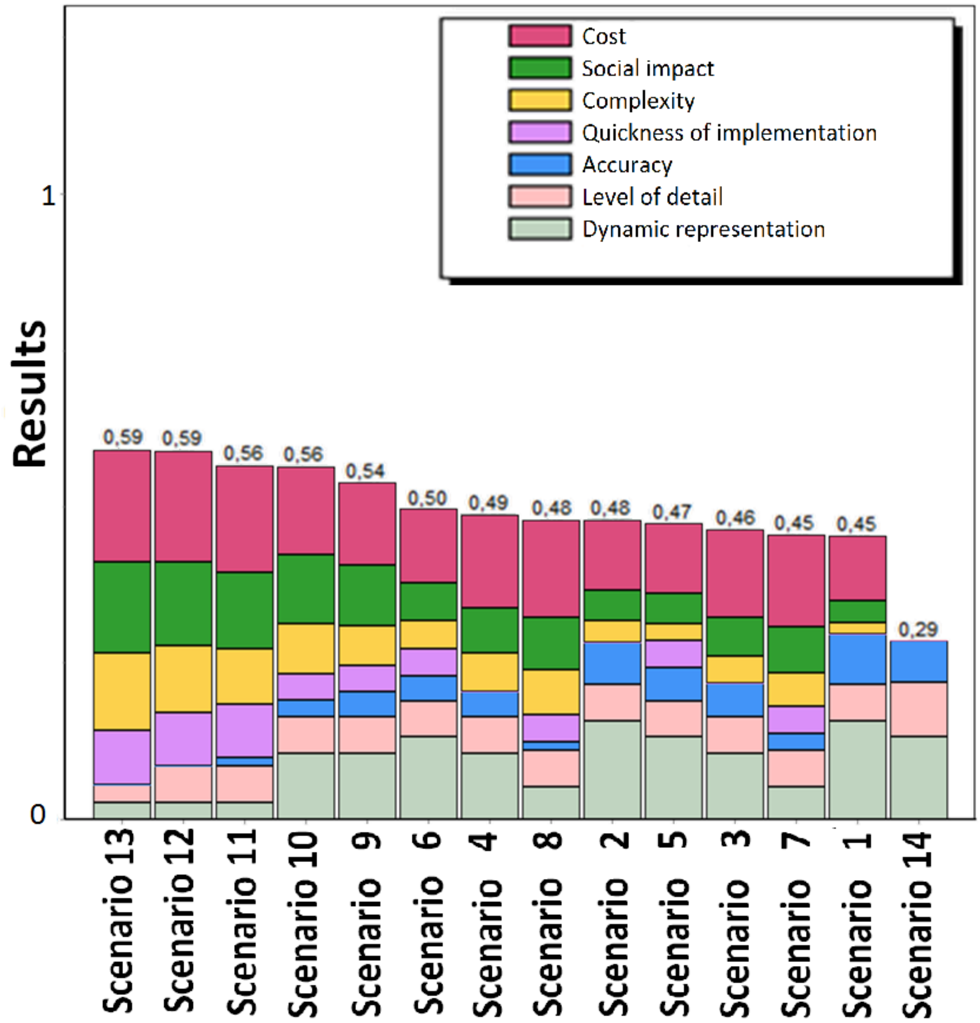


Figure 4.14 - The results of MCA. The scenarios received a score on the following criteria: cost, social impact, complexity, quickness of implementation, accuracy, level of detail and dynamic representation. These criteria all received a different weighting factor. To derive the end score of each scenario, the weighted criteria scores are added up.

4.5.3 Sensitivity analysis

In appendix XIII, the results of the sensitivity analysis on the weighting factors of the seven criteria are presented separately.

First, weighting factors for cost, social impact, complexity and quickness of implementation are varied in a range from +/- 8% and higher. In that case, scenario 12 and scenario 13 remain in the first and second position. When these criteria receive a lower weighting factor than +/- 8%, scenario 9, 10 and/or 11 become the most desirable scenario. With the original weighting factors, these three scenarios are now at the 3rd, 4th and 5th position.

A remarkable change can be seen when varying the weighting factor for accuracy. When the weighting factor for accuracy is above 20%, scenario 1 and 2 receive the highest overall score. These scenarios do not receive a very high overall score with the original weighting factors.

For a weighting factor higher than 10% on level of detail, scenario 13 loses its first position. The higher the weighting factor for level of detail, the worse the overall score of the MCA becomes for scenario 13. For scenario 14, the opposite is the case; the higher the weighting factor for level of detail, the higher the overall score of the MCA. No changes occur in position for scenario 1 until 12, since these scenarios received the same scoring on level of detail.

When varying the weighting factor for dynamic representation it can be seen that below a weighting factor of +/- 20%, scenario 12 and scenario 13 remain on the shared first position. Between 20% and 30%, scenario 10 becomes the most desired scenario. Above a weighting factor of 30% for dynamic representation, scenario 2 becomes the most desired scenario, followed by scenario 1. However, a weighting factor above 30% for dynamic representation is not very likely.

4.5.4 Uncertainty analysis

In appendix XIV the results of the uncertainty analysis on both the weighting factors and scoring of the criteria are presented.

When the weighting factors were varied with 50% of their original value, scenario 13 and 12 still receive the highest overall score in almost all cases and scenario 14 receives the lowest overall score in all cases. Furthermore, scenario 10 and 11 remain on the 3th and 4th place and scenario 9 on the 5th place. For the other scenarios a larger variation in positions can be seen.

When the scoring for the criteria related to implementation and operation were varied, the same effects occur as when varying the weighting factors. When the scoring for the criteria related to output were varied, these effects are even stronger. Especially scenario 11, 10 and 9 are strongly bound to the positions 3, 4 and 5 respectively. So, changing the scoring with 30% does not result in a different position for these scenarios.

5. Discussion

This section starts with an interpretation of the results of the MCA in order to give an advice to LABVlieland on which scenario to use to obtain the additional required data. Secondly, the data quality and assumptions of the research are discussed. Finally, several recommendations for future research are given.

5.1 Interpretation of MCA

In this section the results of the MCA are interpreted in order to give an advice to LABVlieland on which scenario to use to obtain the additional required data. Scenario 12 and 13 both received the highest overall score of the MCA. For this reason these two scenarios are most desirable using the original weighting factors.

The difference between scenario 12 and 13 is that in scenario 12 production data from the large-scale consumers is estimated by using last year's data. In scenario 13, large-scale consumers' production is left out. This means the level of detail is higher for scenario 12. In the sensitivity analysis it can be seen that when the weighting factor for level of detail increases, scenario 13 becomes less desirable. The turning point occurs at a weighting factor very close to the original weighting factor used for level of detail. This suggests that scenario 12 is a more stable scenario. For these reasons scenario 12 is recommended over scenario 13.

So, it is recommended to implement scenario 12. Once the dashboard is implemented, a next step could be to improve the data presented on the energy dashboard. Different criteria might become more or less important over time. Quickness of implementation and level of detail will probably become redundant when the dashboard is already created and operational. In case LABVlieland wants to improve the data, the accuracy will become more important and therefore this criteria will receive a higher weighting factor. In the sensitivity analysis it can be seen that, when a weighting factor of 20% for accuracy is applied, scenario 1 becomes the most desired scenario. A weighting factor of 20% for accuracy is not unlikely when improving the energy dashboard. This means that scenario 1 becomes a good target to achieve for in the long term. From now on the implementation of scenario 12 is called 'the first implementation phase' and the implementation of scenario 1 is called 'the second implementation phase'.

5.2 Data quality and assumptions

In this section, the validity of the results of this research is discussed. Attention is paid to weak points in the methods, uncertainty in data, missing data, and assumptions that were made.
First, the interviews are discussed (section 4.1.1). The process of selecting the interviewees has been influenced by time constraints and the preferences of LABVlieland. Possibly, some relevant stakeholders are left out. Some stakeholders did not respond in time or were addressed too late. Furthermore, the interviews were used for indicative purposes. Therefore, the analysis of the interviews has been brief. The interviews have been transcribed nor analyzed according to official qualitative research methods.

During the quantitative research (section 4.1.2), not enough respondents were surveyed to make sure that the results are significant for both the inhabitants and the visitors. The survey took place in a specific place (on the ferry) and within a specific time frame (may 2015). This means that the respondent group is not randomly selected. Therefore, certain characteristics may be over- or underrepresented. Due to the season, it is likely that the type of bathers was different than it would be during the summer. There were also relatively many hotel visitors, since the temperatures were not pleasant enough for a stay at the campsite. Also, the amount of elder respondents was relatively

high, most likely due to the fact that the survey did not took place during holidays and most visitors were retirees. Furthermore, the results could be biased, since some of the passengers on the ferry did not want to participate. Possibly, respondents that wanted to cooperate had a more positive opinion about renewable energy on average compared to passengers who refused the survey.
Concerning the part on currently available data (section 4.3), a general remark is that final energy consumption data is used for both electricity and gas consumption. These values are added together to derive the net energy consumption on the island, without converting to primary energy first. From a scientific point of view, this is questionable since energy in the form of electricity has a higher quality than energy in the form of gas. In other words, more energy is needed to produce 1 GJ of electricity than to produce an amount of gas containing 1 GJ of heat. The issue with primary and final energy is also important for the representation of the energy situation on the energy dashboard. In the energy dashboard, as proposed in this research, gross final energy consumption will be compared to the total final renewable production. It is likely that a large part of this renewable production consists of electricity while a large part of gross final energy consumption consists of energy in the form of gas. In that case, the share of renewable energy in the gross energy consumption will be underestimated. However, in view of the transparency and simplicity of communication, simply providing final energy may be preferable.

A remarkable observation in the section on currently available consumption data (section 3.1), is the large peak in the consumption of natural gas in 2011. No explanation is found for this phenomenon. Last of all, commercial sectors which have less than six grid connections are excluded from the consumption graph for privacy reasons.

Concerning the currently available production data (section 4.3.2), heat production by the solar collector at the harbor and electricity and heat production by the secondary school (which is under construction), are not taken into account yet. Heat from the solar collectors owned by the swimming pool is accounted for, but the annual production has been estimated in this research since the meter has been installed less than a year ago. Data quality could be improved next year, when the total annual production is known. PV production on the island is probably underestimated, because some PV panels are not registered in the production installation register (PIR). Since the estimations of the energy production by small-scale consumers in this research are based on this register, part of the production is excluded. Moreover, the PIR is not extremely reliable since owners of PV systems have to report the peak capacity of their system themselves. This can cause errors. Furthermore, the harbor of Vlieland and campsite Stortemelk have installed several urban wind turbines. These wind turbines perform below expectation since, according to the owners, the turbines are broken most of the time. Therefore, the technical data from the manufacturers website does not represent the actual production. The harbor and campsite Stortemelk do not have more reliable data on the performance of these urban wind turbines. For this reason the energy production of these urban wind turbines is not taken into account. The estimation on energy production in the form of biomass is uncertain due to assumptions on the type of wood (100% pine wood) and the efficiencies of the wood stoves used. Additionally, some wood may be used outdoors for recreational purposes. In this case, no natural gas is replaced. There is a small uncertainty in the efficiency of a Dutch woodstove. This is caused by assuming an equal subdivision in types of fireplaces within one category, as can be seen in Appendix VII. The data on density and caloric value used, are uncertain as well. An uncertainty in caloric value is caused by possible variation in drying of the wood. An uncertainty in the density is caused by differences in the growing process of the wood.

For the renewable energy production potential (section 4.3.3), some uncertainties in the data occur. For PV production potential, the total available surface is an assumption, estimated by the research of Hanssen et al (2014). Furthermore, an assumption has been made on the average efficiency difference between PV systems on rooftops and a solar field like the Vliehors. Systems on rooftops are assumed to be less efficient due to shadow-effects and non-ideal positioning. An estimation is made for the final efficiencies. For wind energy, load hours and efficiencies are not sure. Efficiency depends on the type of turbine. A reduction of load hours due to maintenance work and other outages is not accounted for. Therefore the calculated production might be higher than the actual production.

Concerning the data tools, it was difficult to define exact scores on the data tools (section 4.4). For the first data tool (section 4.4.1), the meter on the main electricity cable and the gas pipeline, especially costs are highly uncertain. License costs for reading out data of the electricity meter are not known. No information is available on the gas meter at all, since Enexis could not be reached for an interview. Also for other data tools, costs are roughly estimated mostly and IT costs have not been taken into account. For this reason, an ordinal scale was used for costs. In this way the costs become relative, so they could be compared between the different data tools and scenarios. For certain tools or scenarios, decisions are made which highly influence the costs. For example, for each scenario considering the SM P1 or P4 data tools it is decided that initially 20 smart meters in households are read out. This quantity is arbitrary and does have high influence on the costs. Since the scoring of the costs was very uncertain, an uncertainty analysis was performed in the MCA in which the scoring was varied by 75% of the original value (see appendix XIV). In this way the uncertainty of the costs is taken into account in the outcome of the MCA. Also the social impact and quickness of implementation of a certain tool are difficult to predict accurately. However, the scoring on these criteria was assumed to be more accurate than the costs. The scores on complexity are uncertain as well. Due to a lack of knowledge on IT processes and time, it was difficult to predict the complexity of the raw output data of a certain tool. The effects of all of these uncertainties are surveyed in an uncertainty analysis (see appendix XIV).

When deriving the scenario-scores on criteria related to data output, namely “accuracy”, “level of detail” and “dynamic representation” it was assumed interactions between different tools occurred. Therefore, the scores on these criteria were assigned to the scenario as a whole. For criteria related to implementation and operation, interactions between tools are assumed to be absent. Therefore, the scores on these criteria are added up for the different tools within one scenario.

In this final part of the discussion of data quality and assumptions, the MCA is treated (section 4.5). To start with, the different criteria used in the MCA show certain overlap. For example, both the “accuracy” and the “dynamic representation” account for the question in how far the data is real-time. To illustrate this, one should imagine that yesterday’s data is presented today under the guise of being current, real-time data. When a sudden abnormality in consumption occurs today, the truly real-time energy consumption deviates from the presented data which were measured the day before. This results in a lower score on the accuracy. A day later, this abnormality will occur on the dashboard. This results in a lower score on the dynamic representation. There is a comparable effect for the criteria “complexity” and “quickness of implementation”. It is important to realize this when interpreting the results.

5.3 Recommendations for future research

One of the most important pieces of information still missing in this research is information about the meter on the main gas pipeline between the island and the mainland. It was tried to derive this information, however, it is not clear whether such a meter is present and if it can be read out automatically. The methods and costs for implementing (if necessary) and reading out this meter should be investigated.

To estimate the real-time production by PV systems, the annual production of the systems or the total installed peak capacity is needed. However, for small-scale consumers, annual production is not known. Unfortunately, the information on total installed peak capacity is incomplete, since not all systems are registered in the PIR. Investigating this 'hidden' capacity is a recommendation for further research. This can be done by stimulating inhabitants to register their production device in the PIR. Another method would be to send a drone over the island in order to count all visible PV panels installed on the roofs. Investigating possibilities to estimate the production of other renewable production sources is a recommendation for further research as well. For example, a heat pump is going to be installed in the school. A method should be developed to investigate how much net energy is produced with this device.

In this research, the focus was on surveying and presenting energy consumption and production. Energy savings are not communicated nor directly encouraged. It would be very interesting to investigate methods to visualize energy savings or energy saving potentials. Energy savings could be visualized by showing the development of the gross consumption data over time. Energy saving potentials could be visualized by showing the consumption reduction of a certain saving measure when the full potential of this measure would be implemented.

Additionally, the best way to communicate the data should be investigated. It is clear that data should be presented as simple as possible. Therefore, it must be decided in which unit the data is to be presented. For the main dashboard, units might be avoided at all by using different colors for gross consumption and production. Another possibility is to express energy consumption in number of households. Energy production could also be expressed in CO_2-savings, which would give a totally different view. For the online energy dashboard, information might be presented in more detail. Further, although converting all data to primary energy is scientifically sound, it is not clear if communicating primary energy on the dashboard is an advantage. After all, the dashboard must be easy to interpret. It is recommended to consult a communication expert in order to get an opinion on how to present the obtained data on the energy dashboard. In line with this recommendation, attention should be paid to the design of the energy dashboard.

Finally, it should be investigated in more detail how the raw data can be processed and in which software programmers this is possible. Especially real-time raw data and raw data in multiple different formats may be complicated to handle. In the end, the data should be presented in a simple and concise way. It has to be investigated how this conversion step can be made. Additionally, it has to be clear how to update and maintain the dashboard over time.

6. CONCLUSION

In this research the following main question is answered:

"Which data on energy consumption and production is relevant for developing an energy dashboard for Vlieland and how can this data be obtained?".

From the research it is concluded that relevant data is real-time data on gross energy consumption and energy production. In addition, some large-scale consumers are interested in the representation of data specific for their own organization. Furthermore, it is relevant to provide data on the production potential of renewable energy.

Data on annual electricity and gas consumption is currently available per sector. Annual production data of PV systems of small-scale consumers is partly available via the PIR. For some large-scale consumers, production data is available real-time. For other large-scale consumers, only annual production data is known or no production data is available at all. Annual production of biomass in the form of wood is known as well, and the heat available from this wood is estimated using the average calculated efficiency of a Dutch woodstove. The annual potential production of solar energy can be estimated by combining the total available area on the island with system efficiencies of PV panels and available solar irradiation data. The potential production of wind energy can be estimated based on available data on wind speeds.

The currently available data consists of static, annual data. Since a real-time dashboard is desired, nine methods to acquire real-time data on energy production, production potential and consumption are formulated. These methods are called data tools. Several combinations of these data tools are made. This way, fourteen different scenarios are composed. The first twelve scenarios are selected using the following constraints: gross consumption and production of the whole island must be shown, data of the households and the selected stakeholders must be acquired and the output must be updated hourly or more frequently. Furthermore, two additional scenarios are created: one scenario excluding large-scale consumers' consumption and one scenario without a meter on the cable. Based on a multi-criteria analysis, it is concluded that a certain scenario consisting of five data tools, is most desirable for the first implementation phase. These five data tools are: a real-time meter on the gas and electricity connection between island and mainland, estimating energy consumption of households based on national consumption profiles, estimating energy consumption of large-scale consumers based on last year's data, estimating real-time renewable energy production and estimating the real-time potential of renewable energy production based on real-time solar irradiance and wind speed. During the second implementation phase, more and more data can be measured instead of estimated.

The result is one main physical dashboard presenting the real-time gross energy consumption for the whole island in combination with the renewable energy production on the island. In addition to this main dashboard, several local energy dashboards might be created for interested parties. The presented information on all the physical dashboard(s) should be kept very simple and easy to interpret. Next to the physical dashboards, an online energy dashboard could be created containing more detailed data for those who are interested. On this website, the gross energy consumption can be divided in households, Vitens, harbor, swimming pool, secondary school, campsite Stortemelk and a remaining part. The energy production can be specified per type of production: PV panels, solar collectors and biomass. Furthermore, the real-time potential of renewable energy production of a small and a large wind turbine and PV panels can be presented on the website.

7. ADVICE

The research consisted of two parts: which data on energy consumption and production is relevant for an energy dashboard and how to obtain this data. Several recommendations are made on what to display on an energy dashboard, followed by recommendations on how to obtain this data.
The following data will result in an increased insight:

- Gross energy consumption on Vlieland
- Energy production on Vlieland

It is recommended to display this data on together on one main physical energy dashboard. Next to this, several large-scale consumers indicated that they would like to have a physical energy dashboard at their own location as well. So, next to the main energy dashboard for the whole island, it is recommended to consider developing additional energy dashboards for the following large-scale consumers:

- Harbor
- Swimming pool
- Secondary school
- Campsite Stortemelk

Next to this, the quantitative research suggested that owners of households are interested in having more insight in their own energy consumption (61.1%, see figure 4.11). For this reason an energy dashboard is also interesting for the inhabitants to have at home. However, for houses equipped with a smart meter, already a lot of online energy dashboards exist. For this reason it is recommended not to make a dashboard for the inhabitants separately, but recommend them to install a smart meter at home and make use of the already available online dashboards. Examples of these online dashboards are given in section 4.4.2, table 4.2.

It is recommended to make the physical dashboards simple and easily accessible. To provide more detailed information on the energy situation of Vlieland, it is recommended to also develop an online energy dashboard for Vlieland. On this online dashboard, the energy consumption can be divided in consumption per stakeholder: households, Vitens, harbor, swimming pool, secondary school, campsite Stortemelk and a remaining part. The energy production can be specified per type of production: PV panels, solar collectors and biomass. Furthermore, the potential renewable energy production of a small and a large wind turbine and PV panels can be presented. By making both an online dashboard and several physical dashboards, the data will be accessible for users who are really interested. At the same time, the energy dashboard for the main public will remain easy to interpret.

The following recommendations are focused on how to obtain this data for the energy dashboard. The data currently available data is only static data. For the energy dashboard it is aimed to make the data real-time and dynamic. Therefore several data tools to obtain real-time data on energy production and consumption have been outlined, described in section 4.4. Of these data tools different scenarios have been made. It is recommended to start with scenario 12. In this scenario the data on the consumption of households, consumption of large-scale consumers and the production is estimated. Scenario 12 consistent of the following data tools:

- Meter on gas and electricity connection between island and mainland
- Consumption profiles for households
- Using last year's data of large-scale consumers
- Estimating production
- Estimating real-time renewable energy production potential

This scenario is easy and fast to implement, the social impact is low and it does not include high costs. For this reason it is the most desired scenario to start developing the energy dashboard. However, the accuracy is quite low, since most of the data is estimated. Once the energy dashboard is developed, a next step would be to improve the energy dashboard. Once a higher accuracy is desired, scenario 1 becomes the most interesting scenario. Scenario 1 consistent of the following data tools:

- Meter on gas and electricity connection between island and mainland
- Reading P1 of smart meters in households
- Reading meter of large-scale consumers
- Measuring production
- Estimating real-time renewable energy production potential

This scenario is more complex to implement and it includes higher costs. However, the accuracy, level of detail and dynamic representation are very high. For this reason it is recommended to implement scenario 1 in the second phase of the development of the energy dashboard.

In figure 7.1 the different steps to reach scenario 12 in the first phase and scenario 1 in the second phase are presented. A more elaborate explanation of the different steps is given in appendix XV. Also the costs included and the parties to contact are mentioned.

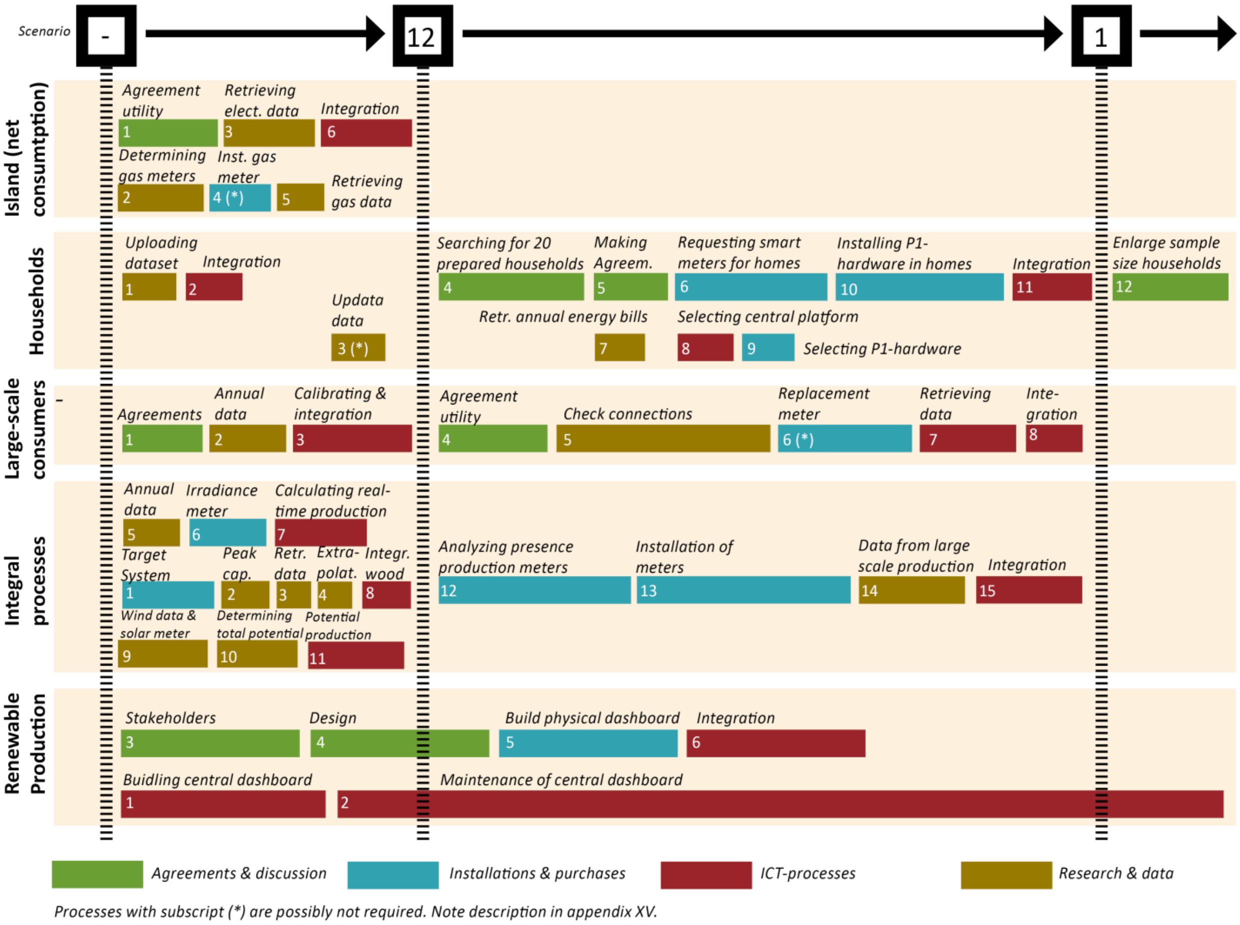


Figure 7.1 - Visualization of the required steps for the different data tools in order to create a dashboard, in which scenario 12 is implemented first followed by scenario 1.

An IT team is needed to acquire data from the different measurement devices and to develop the online energy dashboard. Furthermore, it is recommended to let a specialized team design the physical energy dashboard, since it is important to make the energy dashboard as clear as possible to make it understandable. It is recommended to assign one person to keep the energy dashboard up to date. For any help on the energy related issues, our team can be contacted.

8. REFERENCES

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9. APPENDICES

APPENDIX I – SEMI-STRUCTURED INTERVIEWS (DUTCH ONLY)

The structured questions are the most general questions. These questions are asked to each stakeholder with the exception of Bouwe de Boer (Ús Koöperaasje) and Søren Hermansen, because they are not involved with Vlieland directly. The stakeholder specific questions are specified for each stakeholder.

Structured questions

- Introductie en aanleiding van het interview vertellen
- Wat is uw rol binnen de organisatie?
- Wat vindt u van het ambitiemanifest voor energieneutraliteit in 2020? Hoe staat uw organisatie hier tegenover?
- Welke informatie zou voor uw organisatie interessant zijn om te zien op een energie dashboard?
- Hoe zou u deze informatie gepresenteerd willen hebben?
- Voor welke partijen op het eiland zou u het interessant vinden om data gepresenteerd te hebben op een energy dashboard? Dus voor voor de haven, camping etc. apart of alleen voor het gehele eiland?
- Heeft u ook eigen energie productie?
- Welke data over het energiegebruik en -productie van uw organisatie zijn er bij u bekend?
- Zouden deze data gebruikt mogen en kunnen worden voor het energie-dashboard?

Stakeholder specifica questions:

Antoine Maartens – *Urgenda*

- Met wat voor soort vragen (ook eventuele klachten of suggesties komen inwoners en toeristen naar het energieloket?
- Houd je gegevens bij over het type vragen en in hoeverre zouden deze gegevens - indien aanwezig - gebruikt kunnen worden door LAB-Vlieland?

Jan van der Veen - *Camping Stortemelk*

- Heb je een (actueel) overzicht in de toeristenaantallen op jouw camping en hoe zou je hier eventueel aan kunnen komen?

Jan den Ouden - *ECV*

- Hoeveel leden heeft de ECV op dit moment op Vlieland?

Henk Visser en Joke Weeda - *Gemeente Vlieland*

- Hoe ver is het met de implementatie van de zonnecentrale op de Vliehors?

Anke Bruin - *Staatsbosbeheer*

- Sommige bewoners kunnen gekapt hout gebruiken uit het bos. Om hoeveel hout gaat dit?

Erik Houter - *ECV / Hotel restaurant Zeezicht*

- Heeft u ideeën over de financiering van bijvoorbeeld een meter op de elektriciteitskabel die het eiland binnenkomt?

Hessel Brandsen - *Middelbare school*

- Doen jullie iets met de leerlingen rondom het energie manifest voor 2020? Jullie zijn bezig met het bouwen van een nieuwe duurzame school. Krijgen jullie hier ook eigen energie productie?
- Gaan jullie ook een energie dashboard daarvan maken voor de leerlingen of zouden jullie dat interessant vinden?

Annie Beiboer - *VVV Vlieland*

- We denken over de mogelijkheid om het energiegebruik op het eiland te relateren aan het aantal mensen dat op het eiland verblijft. Wat is er bij de VVV bekend over het aantal bezoekers (aantal passagiers op de boot)?

Cees Potiek - *Vitens*

- Vitens is bezig met het opwekken van energie uit methaan. Doen jullie dit ook op Vlieland?

Gerard Lits – *Zwembad*

- In het zwembad hebben jullie al een energy dashboard voor jullie bezoekers. Wat is jullie ervaring hiermee? Welke dingen vind je er goed aan en wat zou je kunnen verbeteren?

Søren Hermansen - *Samsø (Søren is from Denmark, so interview is in English)*

- What is your role in the development of the energy neutrality of Samsø?
- What was the inducement to make Samsø energy neutral?
- Which obstacles were present and how did you overcome these obstacles?
- To what extent has there been support for the energy neutrality of the island and how is the support established?
- How would you describe the variety of inhabitants and tourists on Samsø? What type of tourists visit the island and what are their characteristics?
- Comparing Vlieland and Samsø, what do consider to be the main differences between the two island, regarding the process towards energy neutrality?

Bouwe de Boer - *Afdeling Economische zaken van Gemeente Leeuwarden / Ús Koöperaasje*

- Hoe wordt er rond de 2020-doelstellingen van Leeuwarden gecommuniceerd over de duurzaamheids- en energiebesparende maatregelen?
- Wat is jouw advies voor het creëren van draagvlak binnen de gemeente Vlieland? Welke informatie denk jij dat het meeste kan bijdragen ter creatie van betrokkenheid voor het vraagstuk bij de gemeente?
- Heb je kennis van energie-dashboards of vergelijkbare projecten elders?

Appendix II – Questionnaire Inhabitants and Visitors (Dutch only)

This Appendix includes the Dutch survey which was handed out to the inhabitants and visitors of Vlieland on the ferry.

Fijn dat u onze enquête wilt invullen! Deze bestaat uit 15 tot 20 vragen en het invullen zal circa 5 minuten in beslag nemen.

Deze vragenlijst is opgesteld door vijf studenten energiewetenschappen aan de *Universiteit Utrecht*. In opdracht van de stichting *LABVlieland* doen wij onderzoek naar de mogelijkheden voor het opzetten van een zogenaamd 'energie-dashboard'. Het doel van het dashboard is het bieden van inzicht in het energiegebruik van Vlieland en de productie van hernieuwbare energie. Middels deze vragenlijst hopen wij een beeld te krijgen van de mening van bewoners en eilandgasten over een dergelijk dashboard. Alvast bedankt!

Algemeen deel (7 vragen)

Vraag 1 - Stelling: ik ga bewust met energie om.

helemaal oneens	oneens	neutraal	eens	helemaal eens

Vraag 2 – Een overzicht hebben van het energiegebruik en de energieproductie van heel Vlieland dat ***elk kwartier*** wordt bijgewerkt, lijkt me interessant.

helemaal oneens	oneens	neutraal	eens	helemaal eens

*Het energieverbruik kan over een bepaalde periode variëren, bijvoorbeeld doordat iemand een vaatwasser of een ander apparaat aan- of uitzet. Ook de energieproductie kan variëren, bijvoorbeeld doordat een wolk voor de zon zorgt dat een zonnepaneel minder energie produceert.

Vraag 3 – Een overzicht hebben van het energiegebruik en de energieproductie van heel Vlieland dat ***elke drie maanden*** wordt bijgewerkt, lijkt me interessant.

helemaal oneens	oneens	neutraal	eens	helemaal eens

Vraag 4 - Ik denk dat ik op Vlieland zuiniger zou zijn met energie als ik inzicht had in het energieverbruik van het eiland.

helemaal oneens	oneens	neutraal	eens	helemaal eens

Vraag 5 – Kunnen zien hoeveel elektriciteit een aantal zonnepanelen of een windmolen op Vlieland op dit moment zou kunnen produceren, lijkt me interessant.

helemaal oneens	oneens	neutraal	eens	helemaal eens

Vraag 6 - Kunnen zien hoeveel energie er op het eiland per persoon wordt gebruikt lijkt me interessant.

helemaal oneens	oneens	neutraal	eens	helemaal eens

* Dit kan berekend worden door op een bepaald moment het totale energie gebruik te delen door het totaal aantal aanwezigen op het eiland.

Vraag 7 - Staat u ingeschreven als inwoner van de gemeente Vlieland?

ja (sla straks vraag 17 t/m 20 over)	nee, ik ben een toerist (sla vraag 8 t/m 16 over, ga door naar vraag 17)	nee, anders (sla vraag 8 t/m 16 over, ga door naar vraag 17)

Eventuele op- of aanmerkingen:____

Onderdeel uitsluitend voor inwoners van de gemeente Vlieland (9 vragen)

Vraag 8 - Wekt u thuis zelf duurzame energie op? Met andere woorden: heeft u zelf zonnepanelen, een zonneboiler of een windmolentje?

Ja	Nee (sla vraag 9 en 10 over)

Vraag 9 - N.a.v. vraag 8: weet u hoeveel duurzame energie u produceert?

Ja	Nee (sla vraag 10 over)

Vraag 10 - Ik zou het prima vinden als mijn duurzame energieproductie zou worden verwerkt in een productieoverzicht van het hele eiland.

helemaal oneens	oneens	neutraal	eens	helemaal eens

Vraag 11 - Meer inzicht in mijn persoonlijk energiegebruik in huis lijkt me interessant.

helemaal oneens	oneens	neutraal	eens	helemaal eens

Vraag 12 - Mijn eigen verbruik vergelijken met het gemiddelde verbruik van woonhuizen op Vlieland lijkt me interessant.

helemaal oneens	oneens	neutraal	eens	helemaal eens

Vraag 13 - Een competitie-element tussen de Waddeneilanden op het gebied van duurzame energie lijkt me interessant.

helemaal oneens	oneens	neutraal	eens	helemaal eens

Vraag 14 - Ik zou het prima vinden om zelf vier maal per jaar online mijn meterstanden door te geven, als dit gebruikt wordt voor het maken van een overzicht voor het eiland.

helemaal oneens	oneens	neutraal	eens	helemaal eens

Vraag 15 - Een slimme meter* (die mijn verbruik op elk moment bijhoudt) in mijn huis laten plaatsen lijkt me geen probleem

helemaal oneens	oneens	neutraal	eens	helemaal eens

*Een slimme meter is een digitaal apparaat waarmee u de actuele energieconsumptie in uw huis kan bekijken. Uw gegevens worden niet gedeeld als u daar niet mee instemt.

Vraag 16 - Ik zou het prima vinden als mijn actuele gas- en elektriciteitsverbruik zou worden verwerkt in een verbruiksoverzicht van het hele eiland.

helemaal oneens	oneens	neutraal	eens	helemaal eens

Eventuele op- of aanmerkingen:____

Onderdeel uitsluitend voor bezoekers / toeristen (4 vragen)

Vraag 17 - In wat voor type accommodatie verblijft u op het eiland?

Geen verblijf	vakantiehuisje	hotel	jachthaven	tent	sta)caravan	familie/vrienden

Vraag 18 - Meer inzicht in het energieverbruik van een accommodatie/horecagelegenheid lijkt me interessant.

helemaal oneens	oneens	neutraal	eens	helemaal eens

Vraag 19 - Ik zou het interessant vinden om te weten wat verschillende accommodaties/horecagelegenheden aan energie verbruiken en/of aan duurzame energie produceren.

helemaal oneens	oneens	neutraal	eens	helemaal eens

Vraag 20 - Als een accommodatie informatie biedt over het energiegebruik of duurzame productie, zou dit in mijn keuze positief meewegen.

helemaal oneens	oneens	neutraal	eens	helemaal eens

Eventuele op- of aanmerkingen:____

Algemeen deel: gegevens (4 vragen)

Vraag 21 – Wat is uw leeftijd?

< 18	18-26	27-40	41-65	>65

Vraag 22 - Wat is uw hoogst afgeronde opleiding

Geen	Middelbare school	MBO	HBO	WO

Vraag 23 – Wat is uw geschatte netto jaarinkomen?

< € 18.000	€ 18.000 – 36.000	€ 36.000 – 54.000	> € 54.000

Vraag 24 – Bent u een man of een vrouw?

Man	Vrouw

Eventuele op- of aanmerkingen:____

- Einde. Bedankt voor uw medewerking! -

In the table below an overview of different fireplace efficiencies is given. From these efficiencies an average fireplace efficiency is calculated, which is used in section 3.2.2.

Table X.1 – Average efficiencies for different fireplaces (Koppejan, I. J. 2010), Toossi, R. (2008), John D. Cutnell, K. W. (2009).

	Efficiency	Produced heat (kW)	number of hours a year	calculation used heat per year (kWh)	Number of fireplaces *1000
open haarden	0.1	1.5	70	645,750	615
inzet, ongekeurd	0.5	7	291	867,762	71*
inzet gekeurd	0.6	7	291	723,135	71*
inzet, DIN+	0.72	6	302	536,050	71*
vrijstaand, ongekeurd	0.6	7	509	2,606,928	146**
vrijstaand, gekeurd	0.75	7	509	2,085,543	146**
vrijstaand, DIN+	0.75	6	528	1,854,336	146**
Average Efficiency	57.17%				

* Equal subdivision of total of 213 in the category “inzethaard of ingebouwde afsluitbare haard”.
** Equal subdivision of total of 439 in the category “vrijstaande afgesloten kachel”.

In this section all 15 interviews are briefly summarized and the most important statements are listed. These interviews have been used in chapter 4.2. Note that the interviewees are not quoted directly except when indicated otherwise.

Date: Saturday 9 may 2015
Stakeholder: Campsite Stortemelk
Interviewee: Jan van der Veen
Occupation: Director

Structured questions

Which data on the energy consumption and production of your organization do you have?

There is data on the amount of energy generated by the PV-panels on our roofs and the amount of energy, which is delivered back to the net. For the campsite it is not known to what extent an energy monitor like "Powerman" could be used. The campsites energy meter does show the amount of energy that is produced and delivered back.

Could these available data be used for an energy dashboard?

This data could be used for a dashboard, if the board and the municipality agree with this, assumed that this situation is technically achievable.

Which information is interesting to see on an energy dashboard for your organization and how should this information be showed and processed?

From past experiences it is known that most of our guests show very little interest in sustainability- and energy related topics. People are mainly celebrating their holidays. When the information could be presented in a clear and easy way, perhaps the information could reach these people. Also negative information could help to increase the interest in some messages, provided that this message is not too negative. The dashboard could help to improve the image of the island as a whole. Furthermore, there is cooperation with the Wateralliantie Leeuwarden to design some luxury dwellings. An energy dashboard could reveal more information and interest on these efficient dwellings. However, a lot of people would not be interested in this kind of information.

Other relevant topics

Data on the amount of tourists is available, even on the level of detail of one day or a couple of days. If the campsite is fully occupied, there are 3.500 guests. The reception keeps track of this kind of data and delivers it to the municipality. This data could also be used for an energy dashboard.

Date: Saturday 9 may 2015
Stakeholder: Camping Stortemelk
Interviewee: Lammert de Graaf
Occupation: Chief area and building management

Structured questions

Which data on the energy consumption and production of your organization do you have?

There are 27 PV-panels on the interviewee's personal roof, with a total capacity of around the 327Wp. The campsite also has solar collectors and PV-panels for the sanitary houses. The production of the house and the campsite are linked to software (Solarman). The data is logged.

Could these available data be used for an energy dashboard?

The interviewee is prepared to share the data on consumption and production to support the dashboard, also regarding the data of the camping. Privacy is probably not a major issue, since islanders have no secrets about these kind of issues.

Which information is interesting to see on an energy dashboard for your organization and how should this information be showed and processed?
The total consumption of the campsite combined with the share of renewable energy that is produced. Preferably shown for all different technologies. A deeper level of information (showing which company has made which investment and the result of those investments) could also be interesting. There is also room for commercials or for example PV-panel producers. However, tourists are generally not very interested in sustainability. They are celebrating holidays and do not want to be bothered too much with those kind of issues. The dashboard could provide information on the sustainable initiatives of the island and the companies, which could result in more support. A good example leads to good behaviour.

<u>Other relevant topics</u>
Investments in renewable energy are more expensive for islanders since there are high costs for transporting those goods. The campsite cannot make more investments in renewable energy, since the maximum annual redelivery of electricity is almost reached.

Date: Saturday 9 may 2015
Stakeholder: Samsø Energy Academy
Interviewee: Søren Hermansen
Occupation: Director
<u>Structured questions</u>
What was the inducement to make Samsø energy neutral?
''Samsø wanted to reach energy neutrality because it makes sense''. Especially moral motivations were important. Samsø does it for the own population, for Denmark and for the world.

Which obstacles were present and how did you overcome these obstacles?
People were afraid for change / conservativeness was present. Another obstacle is that not all the required expertise was available among the workers in order to adapt the energy systems, for example in the cases of insulation of buildings. However, workers were retrained and this created new job opportunities.

To what extent has there been support for the energy neutrality of the island and how is the support established?
First of all the statement that there is a lack of support from the municipality could be a premature or wrong statement. On Samsø there were some issues regarding the energy neutrality ambitions. People were afraid for change. However, strong leadership should lead to accomplish the ambitions. On Samsø this process elaborated well, which changed the conservativeness of people. Organizing detailed debate about the topic and thereafter elaborating the policies will create a mess.

What do you consider as the main differences between the obstacles of Vlieland and Samsø in the process of reaching energy neutrality.
First of all Samsø does not have a natural gas connection, which is positive for reaching the ambitions. Furthermore, Samsø has farming and therefore opportunities for biomass production. An observation from personal perspective: the Danish believe in communities, which creates possibilities for cooperative energy ownership and accelerates the transition. The Dutch are more individual and do not cooperate very frequently.

Does Samsø have initiatives comparable to an energy dashboard?
No. There is communication about the ambition to the outside world, but there is no well-organized communication to the inhabitants and population.

Do you think an energy dashboard could help to create support and what would you advice to show on an energy dashboard
Point out what the positive effect is of certain measures. This stimulates the support of the people. Furthermore gaming effects are attractive in those types of communication strategies.

Date: Saturday 9 may 2015
Stakeholder: Urgenda
Interviewee: Antoine Maartens
Occupation: Manager energy window Vlieland
Structured questions
Which data on energy consumption and production of your organization do you have?
Urgenda manages an energy neutral residence on Vlieland. Open Energy Monitor is used in order to monitor the real-time energy consumption and production. The monitor includes the PV-panels, all individual IR-panels for heating, boiler and the cooking device. There are plans to install a ridge blade (horizontal) wind turbine.

Could these available data be used for an energy dashboard?
Yes.

Which information is interesting to see on an energy dashboard for your organization and how should this information be showed and processed?
It is possible to communicate 'via the heart', but also to focus on economics. Including a future perspective in the communication is the most effective.

What type of questions (or contingent questions or suggestions) do inhabitants and tourists bring to the energy window?
Especially questions about advice on energy consumption for building a new house are asked. Heat is the mainly the focus of the advice. Furthermore, we give presentations to inform the inhabitants about energy related issues.

Date: Wednesday 20 may 2015
Stakeholder: ECV / Hotel Zeezicht
Interviewee: Erik Houter
Occupation: Commissioner + treasurer ECV, owner Hotel Zeezicht
Structured questions
Which data on the energy consumption and production of your organization do you have?
Not much actually. The energy consumption of the hotel is not known. A smart meter is present most likely but the interviewee does not have information about it.

Could these available data be used for an energy dashboard?
Yes, but the data is currently not known.

Which information is interesting to see on an energy dashboard for your organization and how should this information be showed and processed?
The current energy usage seems interesting to show, for instance for each day or each hour. Furthermore, the share of this energy that could be generated renewably could be interesting. The estimation of the renewable potential of a wind turbine or a solar field is also interesting. The amount of persons on the island seems less relevant. An overview of the whole island is very interesting. The interviewee is not convinced about separating large stakeholders like the swimming pool, harbour and the campsite. The data should be very easy to understand must not be too complex.

Other relevant topics

More information on the costs of a meter on the cable from the island should be addressed to Liander or the municipality.

Date: Wednesday 20 may 2015
Stakeholder: ECV
Interviewee: Jan den Ouden
Occupation: Chairman ECV

Structured questions

Which data on the energy consumption and production of your organization do you have?

Not much. When the solar field on Vliehors is in use, the energy production of this field will be known exactly. There are also a lot of private (non-registered) PV-panels on Vlieland. It is hard to obtain the data from those panels. Data on energy consumption that is available for the ECV in the future are monthly. When the smart meters are installed and when a certain party is allowed to read those, the data becomes more dynamic. If these data is bundled the privacy issues diminish.

Could these available data be used for an energy dashboard?

Yes (potential data of Vliehors).

Which information is interesting to see on an energy dashboard for your organization and how should this information be showed and processed?

Renewable energy production together with energy consumption is not yet interesting, because there is not enough energy production on the island. An estimation of the renewable potential could be a bit pushy. Installing a dashboard at the harbour and the campsite is good, the swimming pool already has one, which is nice. The boat could be a nice place to communicate to the tourists, while the school could be used to reach the inhabitants. Especially children are very impressionable.

Other relevant topics

The ECV is a very young organization and is recruiting customers since April 2015.
A potential source of energy is the horse-based fertilizer. There is a production of 400 m^3 each year, and two-third of this fertilizer is shipped to the mainland. This fertilizer could be used on the island as well. The total potential space for PV of the island is 5-6 hectares, 3.5 on the Vliehors and the remainder on roof.

Date: Wednesday 20 may 2015
Stakeholder: Municipality Vlieland
Interviewees: Henk Visser en Joke Weeda
Occupations: Alderman renewable energy and control officer Municipality Vlieland

Structured questions

Which data on the energy consumption and production of your organization do you have?

Annual energy usage is available, obtainable by the energy window and the Grontmij report. Data on the production of energy are hard to obtain: there are several private (non-registered) PV-panels on the island.

Could these available data be used for an energy dashboard?

yes, the data of the energy window are public available.

Which information is interesting to see on an energy dashboard for your organization and how should this information be showed and processed?

Renewable energy production compared to energy consumption is interesting, even if there's not much renewable production yet. It is likely that the energy dashboard will increase the involvement of inhabitants. The dashboard should be easy to understand. Several sub-dashboards divided on the island would be very nice. Currently there is a dashboard for the swimming pool, but this dashboard is way too complicated.

Other relevant topics

The development plan of the solar field on Vliehors has been approved for the surface of one hectare. This surface could be expanded later to 3 hectares. Furthermore, the cable of this solar field will already have a meter. The municipality has stimulated the instalment of large amount of smart meters because of potential negative social impacts.

Date: Wednesday 20 may 2015
Stakeholder: Staatsbosbeheer
Interviewee: Sonja Vrijenhoek
Occupation: Chief executive Staatsbosbeheer Vlieland

Structured questions

Which data on the energy consumption and production of your organization do you have?

Annually, an amount of 500 m^3 wood is chopped, which is equal to or less than the amount of wood that grows. A maximum of 5 m^3 could be harvested per household. The wood exists for 90% out of pine trees. There is currently no information about the PV panels on the roofs of Staatsbosbeheer and the amount of energy consumed.

Could these available data be used for an energy dashboard?

Anonymously the data could always be shared.

Which information is interesting to see on an energy dashboard for your organization and how should this information be showed and processed?

Personally the interviewee is curious about the energy consumption and production every 15 minutes. The display of the energy consumption should be easy to understand and tangible. For Staatsbosbeheer the dashboard is not necessarily needed. It could be interesting to include this for information centre "Noordwester"

Date: Wednesday 20 may 2015
Stakeholder: Waddenhaven Vlieland
Interviewees: Jan Lever / Cornelis de Jong*
Occupation(s): Harbor master / Harbor master

*The interviewees are not members of the board of the harbour foundation. Their vision on the questions is characteristic, but potentially not completely representative.

Structured questions

Which data on the energy consumption and production of your organization do you have?

There is currently no knowledge about the monthly energy consumption of the harbour. There is energy production through PV-panels. This information could be gathered but there are currently some problems with the software. These problems could be solved if there is attention for it.

Could these available data be used for an energy dashboard?

This should be fine, if the energy situation of the harbour is not shown in a very negative way for the other islanders. The yachts are getting more luxurious with net connections of 16 Ampere and 230 Volts or even a power flow. A major share of the energy consumption of the harbour is determined by the amount of guests in the harbour. The harbour is 'as green as our guests'. It is important that the information of the guests is shown in different dynamic settings. So also moments of low production combined with large energy consumption are shown, along with the more positive moments.

Which information is interesting to see on an energy dashboard for your organization and how should this information be showed and processed?
We do not control our own energy consumption totally, were dependent on our guests and the weather. In the summer the most guests are here and we are afraid that during the summer the harbour gets a very negative image in your dashboard. It is hard to present the data in a proper way. However, the dashboard should be accurate and bring the truth to the people. Which is a hard dilemma and we do not know how we should do this in the best way. In an annual overview those problems diminish.

Date: Wednesday 20 may 2015
Stakeholder: VMBO Krijtenburg
Interviewee: Hessel Brandsen
Occupation: Interim-director
Structured questions
Which data on the energy consumption and production of your organization do you have?
Currently a new school building will be built, since they are fusing the VMBO Krijtenburg and the primary school. This building will be energy neutral partly because of solar energy. The external party that is concerned with this could provide us with the extra information about these energy topics.

Could these available data be used for an energy dashboard?
According to us all this data on production and consumption should be used for the energy dashboard. This new build property should have an inspiring character and it is good to present some insight about energy. There are no privacy concerns. The municipality governs the school so their opinion on these matters is crucial in getting approval.

Which information is interesting to see on an energy dashboard for your organization and how should this information be showed and processed?
Students are not interested in energy on the first hand. They are mostly not involved in the energy neutrality manifest. Teachers are more involved, but especially privately. It is important that the communication is simple and tangible. It is interesting if the production and consumption is shown with different colours depending on whether it is going good or bad. Showing the dashboard at the entrance of the school could be a good option. It is important that a recognizable unit is used for the dashboard.

Date: Thursday 21 may 2015
Stakeholder: Vitens
Interviewee: Cees Potiek
Occupation: Manager water purification Vlieland
Structured questions
Which data on the energy consumption and production of your organization do you have?
Vitens consumes 100.000 kWh on Vlieland and produces 18.000 kWh with our PV panels. Vitens Vlieland has a smart meter because were defined as a large user of energy.

Could these available data be used for an energy dashboard?
The communication office of Vitens has to make a decision about this.

Which information is interesting to see on an energy dashboard for your organization and how should this information be showed and processed?
An energ -dashboard for Vitens would not be too interesting, but the water consumption is interesting for a dashboard. Personally I do not think that there should be new infrastructure to show the dashboard, but using it for the boat to Vlieland seems nice. I think that it could be good to use wind turbines and PV panels as units for the dashboard, this could be controversial but it will work.

Other relevant topics
Vitens Vlieland has some flexible energy consumption. There is water storage of 600 m3. For comparison: at a busy and sunny day the water usage of the island is 1200 m3. We could theoretically help with peak shaving the electricity demand of the island.

Date: Thursday 21 may 2015
Stakeholder: VVV Vlieland
Interviewee: Annie Beiboer
Occupation: director
Structured questions
Which data on the energy consumption and production of your organization do you have?
There is insight in the number of tourists and the amount of transfers through Doeksen. There is no insight in the consumption of dwellings. This is desirable for the future.

Could these available data be used for an energy dashboard?
The amount of transfers by Doeksen is only intended to use intern. Those data should be collected from Doeksen. Doeksen is also aware of the average time of stays. So combined with the amount of passengers, the amount of people on the island could be estimated and used for the dashboard. There is a small amount of dwellings with PV panels, but those dwellings are in private ownership so we have no data on consumption and production for those dwellings.

Which information is interesting to see on an energy dashboard for your organization and how should this information be showed and processed?
If the data is dynamic, that makes it fun. The amount of visitors on the island, the renewable potential is also an option. Tourists have no information about the ambition manifest. There is no information available. It is very nice if visitors could get knowledge about Vlieland's ambitions. Doeksen TV (the show on the boat) could be a very useful tool to do so.

Other relevant topics
Tourists have no information about the ambition manifest. The political leader of Vlieland has an energy neutral house. New dwellings will be built in the dunes. About 85% of the visitors have the Dutch nationality. "Uit het kastje" is a local magazine.

Date: Thursday 21 may 2015
Stakeholder: Swimming pool Flidunen
Interviewee: Gerard List
Occupation: Technical service
Structured questions
Which data on the energy consumption and production of your organization do you have?
There are PV panels and boilers installed. We keep track of our energy production by those panels through monitoring software. The temperatures of the solar collectors are available. For consumption both our electricity and our gas consumption are available as well.

Could these available data be used for an energy dashboard?
If the board and the municipality agree those data streams could be used for the dashboard. In the pool we have our own dashboard as well.

Which information is interesting to see on an energy dashboard for your organization and how should this information be showed and processed?
The most important information would be the total power: when are the peaks in energy production and how this relates to the demand for energy? With other words: the data could be used for the demand side management in the pool. For customers this would not be directly interesting. When communicating the results, it would be good to compare the data with the data before the sustainable changes were implemented. So the effect of investing in sustainable energy would become directly clear. Progress should be visible. It is also important that the data should be easy and tangible. Children are not that interested and most parents are also not very enthusiastic. Visitors do not know units such as kWh. Make sure that the units of the data are understandable. For example with full or empty buckets to let people know if the current scoring of the pool good or bad.

Date: Tuesday 26 may 2015
Stakeholder: Economic affairs of the municipality of Leeuwarden / Ús Koöperaasje
Interviewee: Bouwe de Boer
Occupation: Energy coordinator / Founder
Structured questions
How has the support for the 2020-goals developed?
There are no clear signs of a strong support for those goals from the citizens of Leeuwarden. A lot of citizens are not aware of the goals and wind turbines are not popular. Our cooperation focuses mainly on the groups that are cooperative instead of the groups that are sceptical.

Could you describe to what extent those goals are handled in a top-down or a bottom-up approach? In other words: is the initiative from politics or are some goals determined by the support of the citizens?
For households, the municipality tries to stimulate bottom-up initiatives. Ús Koöperaasje has an important role in the gathering parties that have the ambition of founding a local energy cooperation or want to make use of one. The organization provides renewable energy

How is the communication about the 2020-goals and the sustainable and saving-measures?
For households, the communication goes through the energy cooperation. There is also an platform that acts like an energy forum (http://www.slimwoneninleeuwarden.nl/).

What are the main differences between the ambitions for reaching the 2020-goals of Vlieland and Leeuwarden?
The municipality of Vlieland is much smaller than Leeuwarden. For small communities there are tons of opportunities for establishing energy corporations, which are useful for increasing the attitude and support for the energy challenges. A city has a lower potential for this.

How do you consider the problems with the support for the 2020-goals on Vlieland (and therefore also the support of renewable energy)?
It is important that there is a bottom-up solution. The establishment of energy corporations could play an important part in increasing the support of inhabitants.

What is your advice for improving support at the municipality of Vlieland? Which information could contribute towards support the most?

For some buildings the availability of data could be interesting, for example at the school. It is particularly interesting if this data could be compared with a "average building" and to emphasize which events are increasing and decreasing the energy situation of a building at a certain moment in time. This increases the awareness of the people.

Do you know some comparable projects?
- Energinet.dk
- Possibly at Ameland
- Alliander wants to map the energy usage of some Frisian villages

Thursday 9 June 2015, 12 June 2015
Stakeholder: Liander
Interviewee: Hans Schneider
Occupation: Senior consultant energy transition
Structured questions
Which data on the energy use- and consumption of your organization do you have?
Liander is the electricity grid operator. The cable between Vlieland and mainland is measured. In the station at the mainland there is a 20kV measurement and at Vlieland a 10kV measurement. The differences between the two measurements are losses. Data should be available at least every 5 minutes. Not all information is clear yet. It is unclear if data is available which is updated more frequently. Also if the data may be used is unclear.

Some other suggestions:
Mpare is a company that can use P1 data for applications.
P4 data can be gathered by a ODA party. A list of ODA parties can be found at vmned.nl/onze-leden.

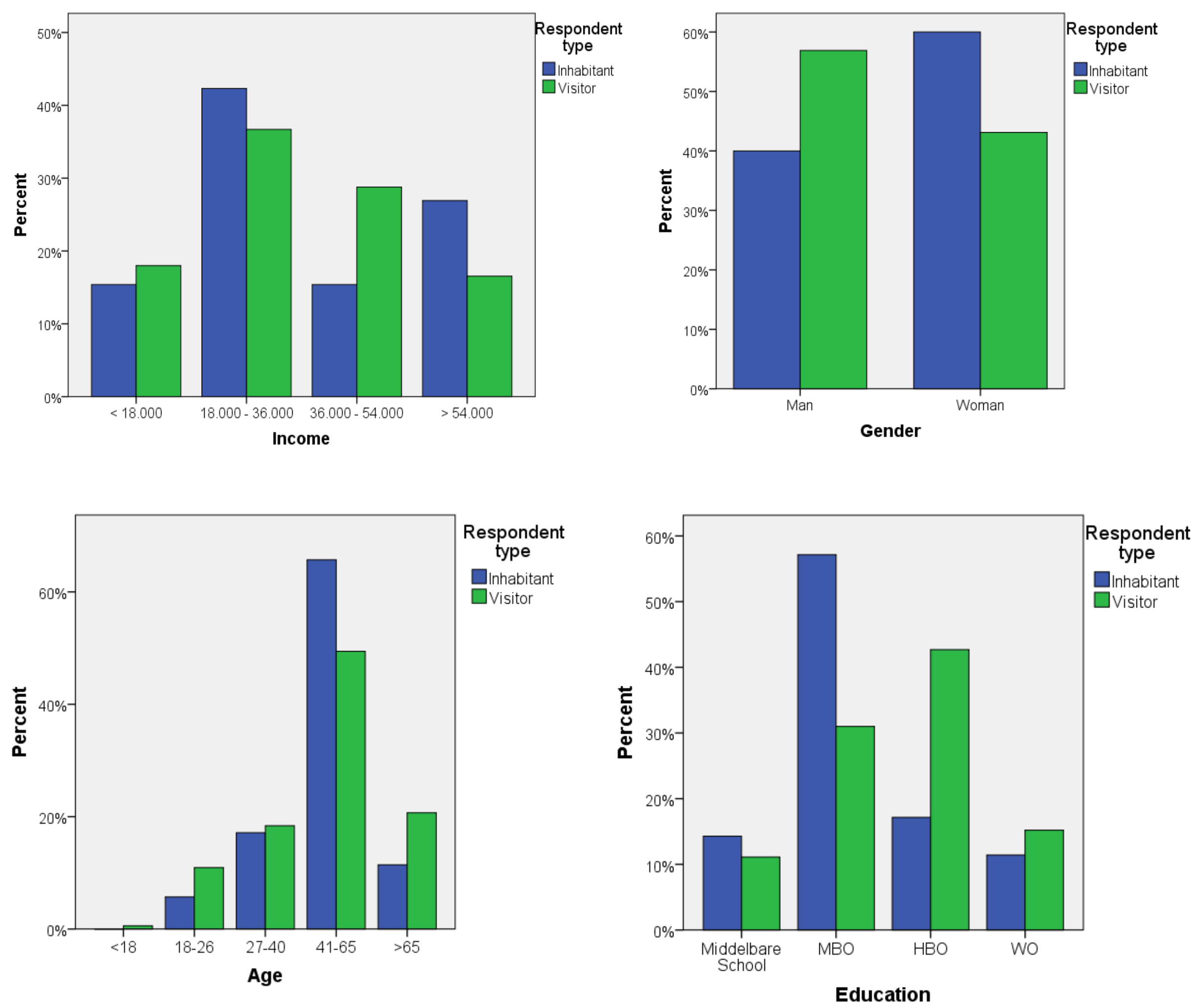
APPENDIX V - QUANTITATIVE RESEARCH

In this appendix the descriptive results of the quantitative research are displayed. First, the general statistics are described. Second, an overview of the results from the most relevant general questions is given. Next, the specific questions for inhabitants and visitors are discussed. Then the non-response issues are discussed. In the final part the statistical tests are conducted.

General survey statistics

In total 211 surveys have been conducted. As discussed in the method, almost all of the surveys were conducted on the ferry between Vlieland and the mainland to make sure the inhabitants would not be bothered. For this reason there is an under-representation of inhabitants in the respondents. Of the 211 respondents, 175 where visitors and only 36 were inhabitants.

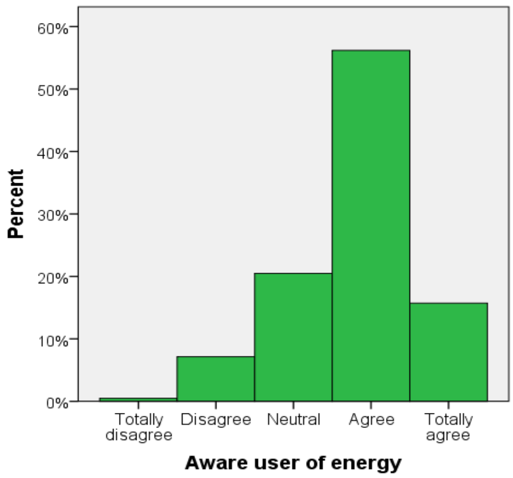
The majority of the respondents is older than 40. For most questions, there are no significant differences in response between the two groups (inhabitants and tourists). A difference is the level of education, which is on average higher for the visitors compared to the inhabitants. The general survey statistics (age, income, education and gender) are presented in figures X.1 - X.4.

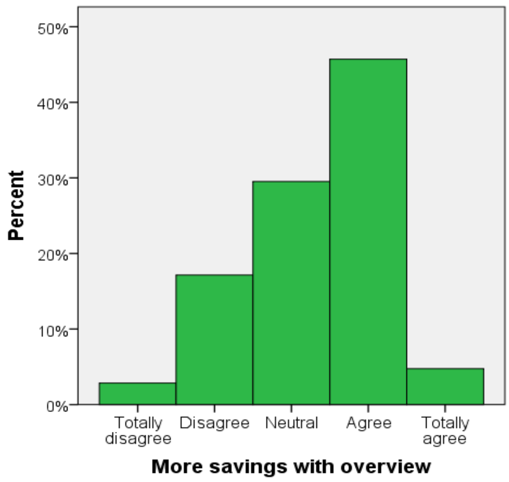


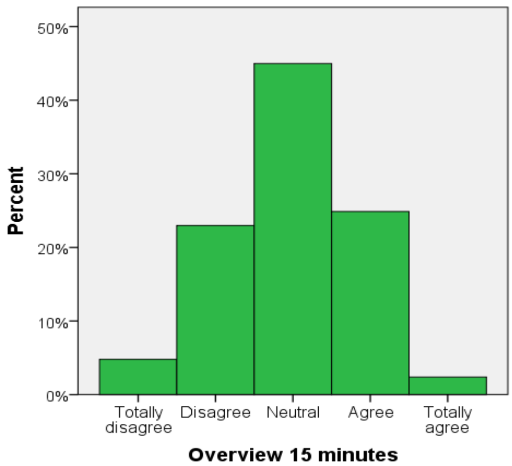
Figures X.1–X.4 - socio-economic statistics of both respondent groups

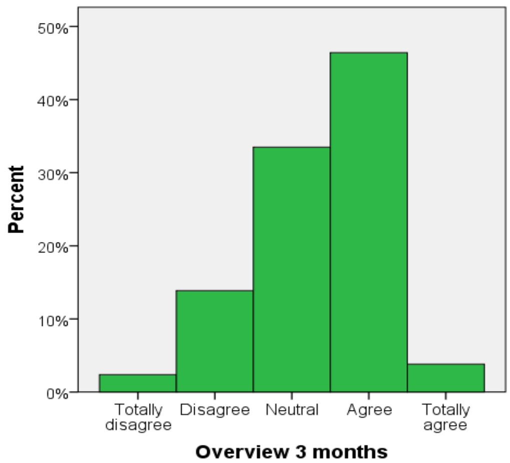
Questions for both groups
In the survey, six questions are determined for both inhabitants and visitors. In this section the results are displayed for the total sample size. In the next section these questions are tested for both groups in order to check if the results differ significantly.

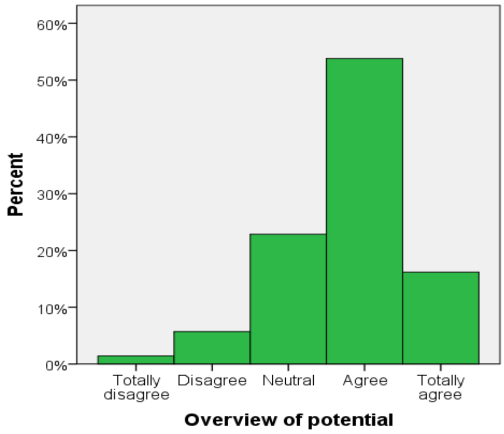
When answering the energy related questions the respondents are in general positive. When comparing the answers of these there are some observations. To start with, the respondents seem to be slightly more interested in an overview that will be updated every three months. Apparently the respondents do not attach added value to a real-time overview. Secondly, an overview of renewable potential seems more interesting than an overview per person. Finally, it seems clear that the respondents confirm the usefulness of a dashboard considering energy savings and the respondents state that they are aware of energy. The results are shown in figures X.5-X.10.

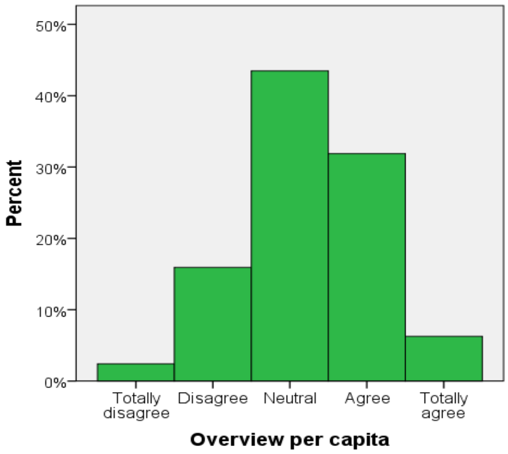










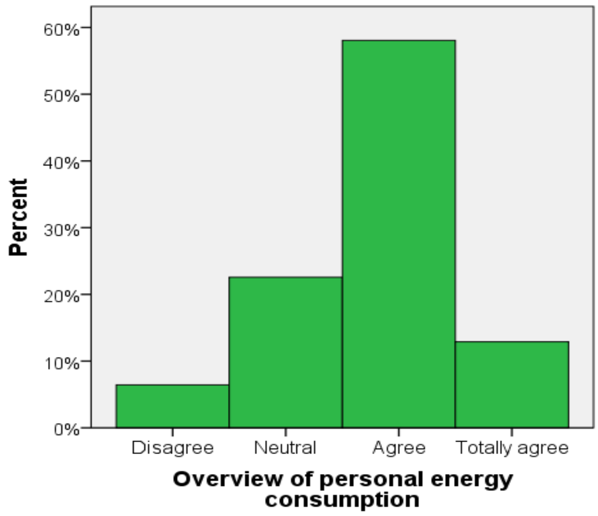


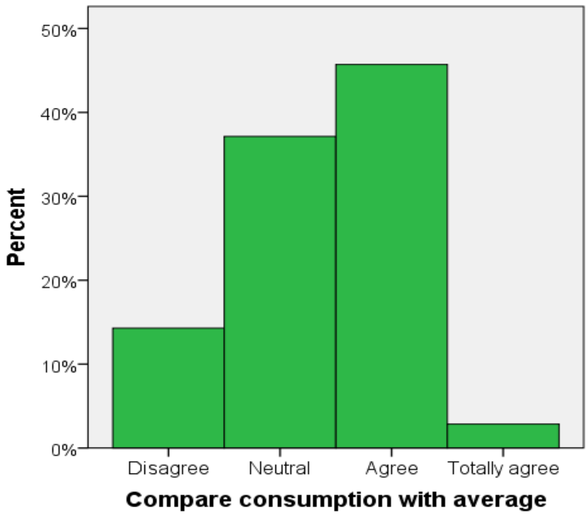
Figures X.5 – X.10 - Energy related question results

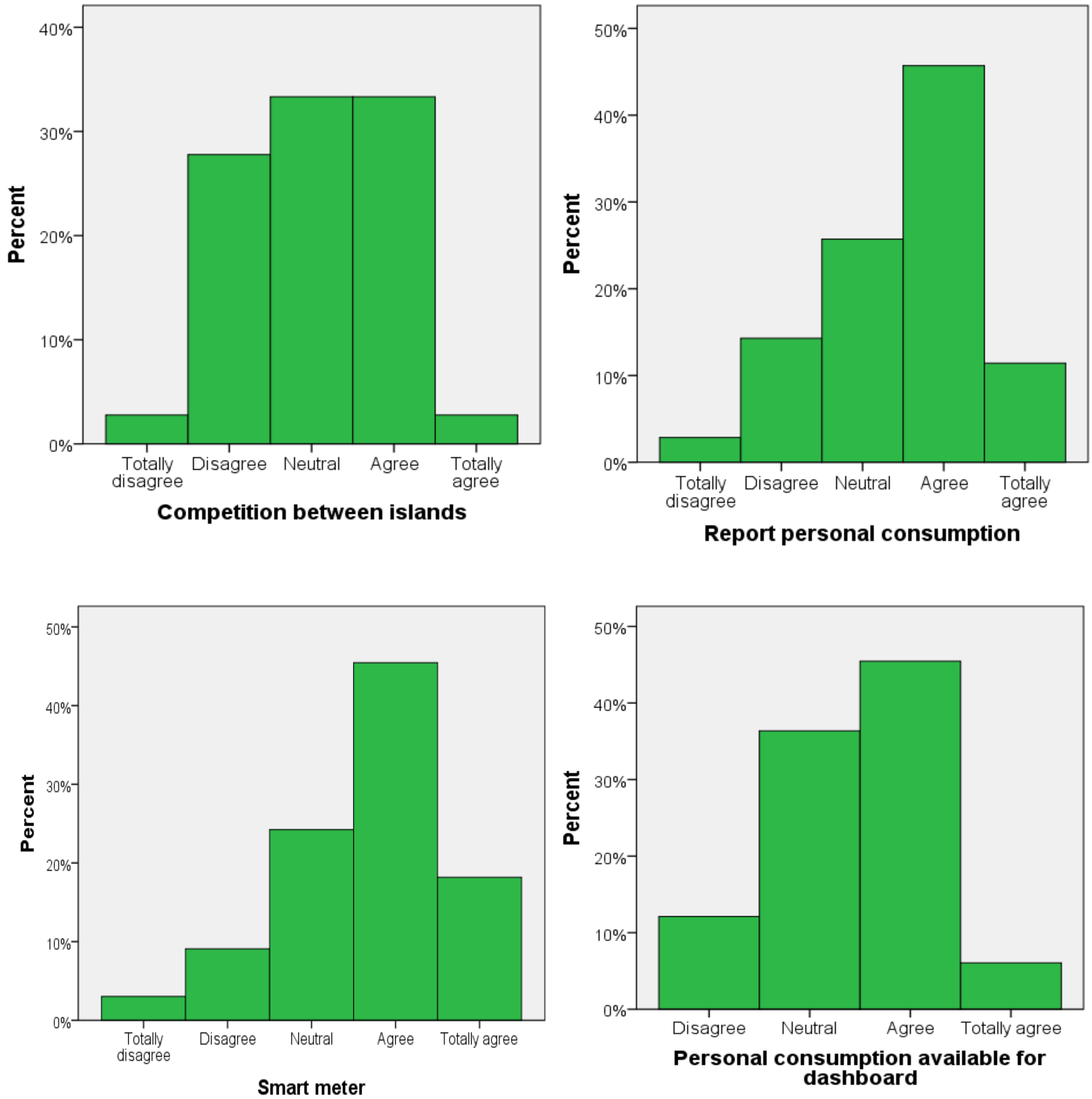
Specific questions

The previous questions were to be answered by all 211 respondents. In this section, the specific questions for both inhabitants and visitors are discussed separately. First the inhabitant-specific questions are discussed.

The first issue is a consequence of the low number of inhabitants among the respondents, only 36. This resulted in a low number of only 6 respondents having their own renewable energy production at home. Although 6 out of 36 is a high share, this number is too low for reliable observations on renewable energy. Hence, the questions considering renewable production (questions 9 & 10 in appendix II) are not discussed.







Figures X.11 - X.16 - Inhabitant specific question results

Most inhabitants among the respondents would like to have more insight in their personal energy consumption. Most of them are also interested in comparing their energy consumption with the average consumption of a household on the island. Furthermore, most inhabitants among the respondents are willing to share their data in order to contribute to the dashboard and would have no objections against installing a smart meter in their dwellings. For the competition element between the islands, the preferences are divided amongst respondents.

The final set of questions is answered by visitors of Vlieland. The results are shown in figures X.17-X.20.

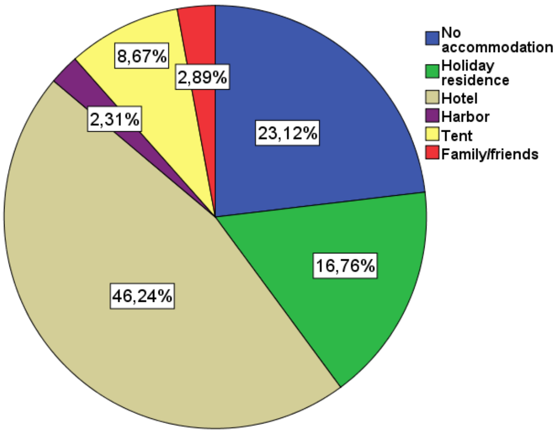
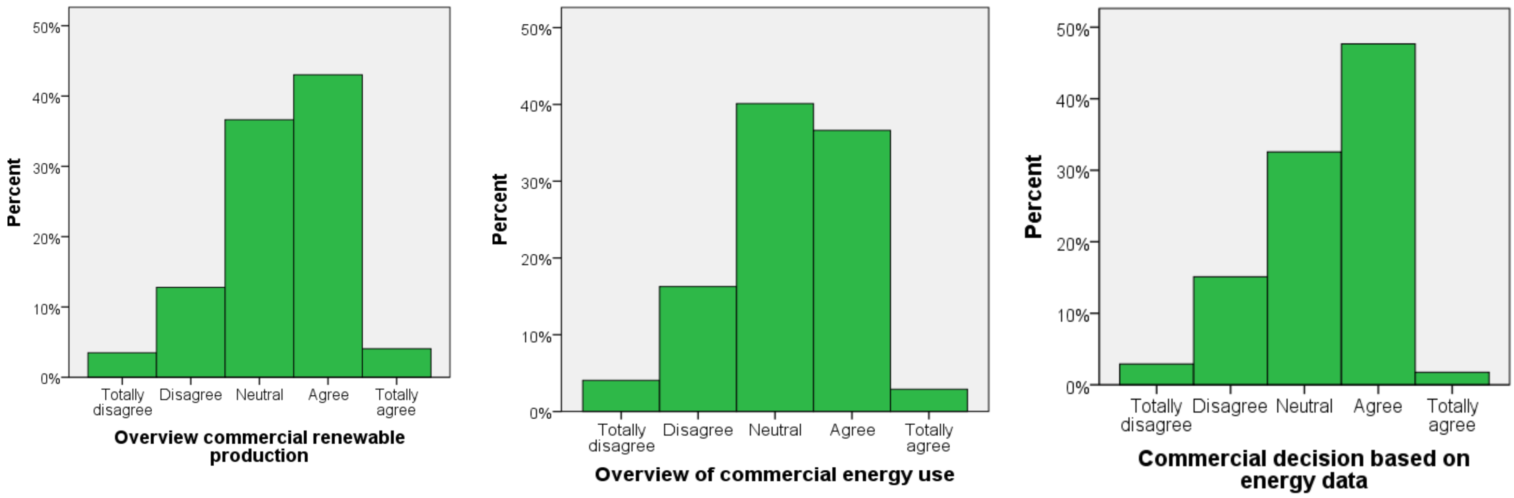


Figure X.17 - Accommodation types



Figures X.18-X.20 - Visitor specific question results

From the statistics in figures 4.17-4.19, it seems that companies in catering and hospitality might improve their attractiveness to visitors by showing their energy consumption and production. The majority of respondents in the visitor group appreciates the idea of having an overview of the energy consumption of companies on the island. They might even base their decisions based on this data.

Item non-response

In surveys in general, there are usually missing values. This could be caused by the structure of the survey (for example the stakeholder specific questions) or because respondents do not want to answer certain questions, which is repeatedly the case*. In the table below the total item non-response is shown.

Table X.2 - Overview of questions and non-response items

Question	*Total item non-response*
Aware user of energy	1
Overview 15 minutes	2
Overview 3 months	2
More savings with overview	1
Overview of potential	1
Overview per capita	4
Respondents type	0
Renewable energy at home	1
How much renewable energy at home	29
Report renewable energy at home	29
Overview of personal energy consumption	5
Compare consumption with average	1
Competition between island	0
Report energy consumption	1
Smart meter	3
Personal consumption available for dashboard	3
Accommodation type	2
Overview commercial renewable production	3
Overview commercial energy consumption	3
Commercial decision based on energy data	3
Age	2
Education	5
Income	46
Gender	2

Statistical tests

The final part of this section consists of the Student's T-tests, which determine whether the answers for the energy related questions differ significantly between visitors and inhabitants. To achieve this for 6 questions, 6 independent sample student's t-tests are conducted. The probability of the variance in answers is tested in these tests and the significance (2-tailed (p)) shows the this probability. The base hypothesis (no difference between respondent groups) is not rejected since $p \geq 0.05$ in each test. So, it can be concluded that the answers of the groups do not differ significantly. See table X.3 for the results:

Table X.3 - Level of significance of the general questions

Question	*Sig (2-tailed) (p)*
Aware user of energy	0.887
Overview 15 minutes	0.682
Overview 3 months	0.487
More savings with overview	0.504
Overview of potential	0.317
Overview per capita	0.177

Table X.4 - Group Statistics

	Type respondent	N	Mean	Std. Deviation	Std. Error Mean
Aware user of energy Overview 15 minutes	Inhabitant	36	3.78	.637	.106
	Visitor	174	3.80	.840	.064
Overview 3 months More savings with overview	Inhabitant	36	2.92	.770	.128
	Visitor	173	2.98	.899	.068
Overview of potential	Inhabitant	36	3.44	.877	.146
	Visitor	173	3.34	.851	.065
Aware user of energy Overview 15 minutes	Inhabitant	36	3.42	.806	.134
	Visitor	174	3.30	.934	.071
Overview 3 months More savings with overview	Inhabitant	36	3.89	.708	.118
	Visitor	174	3.75	.861	.065
Overview of potential	Inhabitant	36	3.42	.874	.146
	Visitor	171	3.20	.879	.067

Table X.5 - Students T-tests for Independent Samples

		Levene's Test for Equality of Variances		t-test for Equality of Means						
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	95% Confidence Interval of the Difference	
									Lower	Upper
Aware user of energy Overview 15 minutes	Equal variances assumed	2.297	,.31	-,.42	208	.887	-.021	.148	-.313	.271
	Equal variances not assumed			-,.70	62.993	.865	-.021	.124	-.269	.226
Overview 3 months More savings with overview	Equal variances assumed	.060	,.07	-.410	207	.682	-.066	.161	-.383	.251
	Equal variances not assumed			-.454	56.734	.652	-.066	.145	-.357	.225
Overview of potential	Equal variances assumed	.287	,.93	.697	207	.487	.109	.157	-.200	.418
	Equal variances not assumed			.683	49.688	.498	.109	.160	-.212	.430
Aware user of energy Overview 15 minutes	Equal variances assumed	1.368	,.43	.670	208	.504	.112	.167	-.218	.442
	Equal variances not assumed			.738	56.249	.464	.112	.152	-.192	.416
Overview 3 months More savings with overview	Equal variances assumed	4.585	,.33	.887	208	.376	.136	.153	-.166	.438
	Equal variances not assumed			1.008	58.594	.317	.136	.135	-.134	.406
Overview of potential	Equal variances assumed	.406	.525	1.353	205	.177	.218	.161	-.100	.535
	Equal variances not assumed			1.358	50.994	.181	.218	.160	-.104	.540

This appendix shows the energy balance of Vlieland, with actual numbers. Note the difference between the net electricity consumption and gross consumption. The gross consumption is the total of all production and consumption. The heat production is the sum of production from biomass and heat production from solar collectors.

Table X.6 - Energy balance of Vlieland

Production and consumption	Absolute production [TJ]	Share of total gross consumption
Net electricity consumption	30.97	24%
Net gas consumption	89.67	70%
PV Electricity production	4.70	4%
Heat production	3.32	3%
Total gross consumption	128.65	100%

Due to privacy reasons, sectors with less than six consumers are excluded from the graph which presents the total consumption on Vlieland per sector. The excluded sectors are given in table X.7 (Energie in Beeld, 2015).

Table X.7 - Overview of excluded sectors

FOR COMMERCIAL GAS USE	FOR COMMERCIAL ELECTRICITY CONSUMPTION
Production	Production
Distribution and trading of electricity, gas, steam and air conditioning supply	Distribution and trading of electricity, gas, steam and air conditioning supply
Industry	Industry
Information and communication	Information and communication
Education	Agriculture, forestry and fishing
Renting and trade in real estate	Renting and trade in real estate
Production and distribution of water	Production and distribution of water
Sewerage, waste management and remediation activities	Sewerage, waste management and remediation activities

Since 2012 the Dutch government has instructed utility companies to install smart energy meters for all households (Ministerie van Economische Zaken, 2012), which will be completed in the period towards the year 2020. Households have the right to decline the installation of a smart meter, or it could be switched off by the utility (Consuwijzer, 2015). However, from the first installation period it seemed that a negligible minority objected the installation (Ministerie van Economische Zaken, 2012). Also the results of the quantitative research done on Vlieland seem to indicate that the share of the population of the municipality that oppose the installation of smart meters (figure 4.15) is small. Therefore it is undisputed that in the period towards 2020 the majority of the households on Vlieland will receive smart meters.

Electricity and gas consumption of small-scale energy consumers is measured by utilities. This is done in order to enable energy companies to set up their consumers' energy bills. Often analogous meters measure consumption data. Alternatives for analogous meters have recently been developed. So-called 'smart meters' frequently deliver automatic data transfers on energy consumption of a certain household to a digital database of the concerned utility (Energie Data Service Nederland, 2013). Smart meters make the consumption verifying process more efficient for grid operators. This will lead to lower operation costs for grid operators and could therefore lower energy costs (Rijksoverheid, 2015).

Beside the advantages for grid operators and energy companies, the smart meters provide new possibilities for monitoring energy consumption data for other interested parties. This could be interesting for instance for the households themselves, which could use actual data on energy consumption for detecting energy saving potential or the effect of previous energy saving measures on energy consumption. In contrast to analogous meters, smart meters deliver actual data streams on consumption with frequencies up to one set of data per ten seconds (Slimmemeters.nl, 2015). Therefore, collecting consumption data from smart meters of small-scale consumers form an important potential data tool for an energy dashboard on Vlieland. There are different methods to read out the data from smart meters. This will be explained further in section 4.4.2 and 4.4.3 and appendix IX.

Liander is the providing utility on Vlieland for small-scale consumer connections. Smart meters are currently not widespread on Vlieland, since the installation of smart meters in the municipality has not yet been included in the planning of the first installation sessions (Liander, 2015), which covers the period towards March 2016. However, utilities offer an urgent request option for the individual installations. The terms set up by Liander for an urgent request include the payment of a €72.60 (consumption tax included) compensation (Liander, 2015).

There are two conventional possibilities for reading data on energy consumption from a smart meter. For this, covenant with the Dutch Smart Meter Requirements the so called DSMR P4-port and DSMR P1-port (in this research designated respectively as P4-port and P1-port) can be used (Slimmemeters.nl, 2015).

Smart meters automatically send data to the providing utility. Via a so-called 'P4-port' data on energy consumption is sent via the utility to a central database of Energy Data Services Nederland (Energy Data Services Nederland, 2013). Once per day the smart meter sends data of every 15 minutes on electricity consumption and data hourly data on gas consumption (Slimmemeters.nl, 2015). Households can retrieve this data in order to have a look into the dynamics of their energy consumption. For this purpose energy data companies may use the data of the utilities to give small-scale consumers insight in their energy usage. Using the P4-port is the first assessed method for collecting household consumption data.

Because of privacy issues not all external parties are authorized for getting insight in smart meter data. Only a so-called 'Onafhankelijke Diensten Aanbieder (ODA)' is certificated for this. A certain certificate has to be handed over by the 'College Bescherming Persoonsgegevens', a Dutch institute on personal privacy issues (College Bescherming Persoonsgegevens, 2015). However, the approval process requires a lot of effort regarding ICT, regulations and other bureaucratic steps (Ealyze, 2015). Hence, it is very presumable that gaining data for an energy dashboard via the P4-way requires the cooperation with an ODA-certified organization.

A second possible way to approach the energy consumption of the households is extrapolating from data measured by the P1-port of smart meters (see figure 4.9). This port is available on most of the smart meter models and is intended for personal usage. Using data from the P1-port does not require cooperation with ODA-certificated organisations, which clearly has advantages. However, the P1-data is complicated to read out digitally (Liander, 2014). Technical and programming skills are required. Nevertheless, energy management companies have recently developed software and hardware in order to offer amateurs the possibility to read out their P1-port.

There are two alternatives for purchasing expensive software in order to use the P1-port data tool. Firstly, the annual energy platform charges can be avoided by encoding data using own energy monitoring software (see table 4.3) with Linux (Embezon, 2015). Examples are shown in online forums. Secondly, the professional P1-reading hardware could be substituted by a raspberry pi device (Embezon, 2015). This also requires additional programming skills. Therefore, for non-ICT experts it is not recommendable to start this type of sub-process within the conventional data tool (personal communication with Watt Now (2015)).

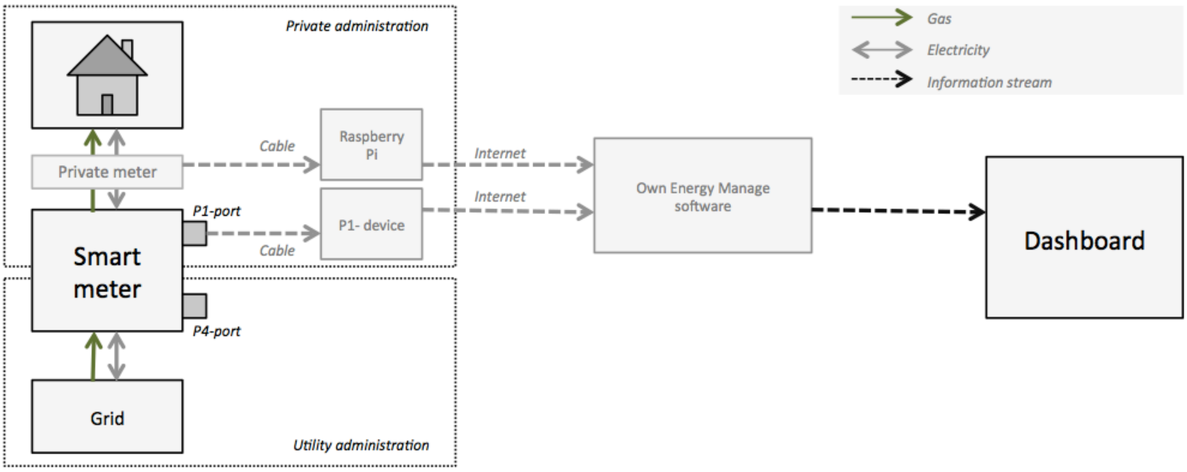


Figure X.21 - visualisation of two alternative methods within the described P1-data tool: installing own energy manage software and installing own private meters.

Furthermore, also the use of the smart meter could be made redundant (see figure X.21), which saves effort and costs (Watt Now, 2015). From information by personal communications with an energy monitoring company (Watt Now, 2015), this could be achieved without major adjustments to the meter or the grid connection of a certain household. There are different devices suitable for this, each with their own level of detail and costs. In this alternative of the P1-data tool, only the home monitoring systems are relevant. When focusing on affordability the emonTX-system setup is a feasible option (Openenergymonitors, 2015). Using an open energy monitoring systems could reduce the costs of the data tool, but there are still expenses involved. Probably the complexity of the data tool will increase significantly, especially in the case of installing own gas meters.

Below the description is given of the different SLPs for electricity and Gas. For electricity the E1a + E1B is combined as one profile. A 50% share of each profile might not be representative for household on Vlieland. Also some households might have a larger connection than the usual size.

Table X.8 - Electricity SLP descriptions (Nederlandse energiedatauitwisseling, 2015)

SLP name	Description
E1a	<= 3x 25 Ampere, single counting mechanism
E1b	<= 3x 25 Ampere, double counting mechanism night
E1c	<= 3x 25 Ampere, double counting mechanism night active price (same as E1b)
E2a	> 3x25 Ampere <= 3x80A, single counting mechanism
E2b	> 3x25 Ampere <= 3x80A, double counting mechanism
E3a	>3x80 Ampere, < 100 kW, BT<= 2,000 hour
E3b	>3x80 Ampère, < 100 kW, BT > 2,000 uur, BT <= 3,000 hou
E3c	>3x80 Ampère, < 100 kW, BT > 3,000 uur, BT < 5,000 hou
E3d	>3x80 Ampere, < 100 kW, BT >= 5,000 hour
E4A	All measured connection triggered by a signal public lighting, with a connection load less than 100kw.

Table X.9 - Gas LSP descriptions (Nederlandse energiedatauitwisseling, 2015)

SLP name	Description
G1A	small scale gas consumers without a measuring device , small scale gas consumers without a measuring device with a standard year consumption < 5,000 m3(n;35.17) and with a gas measuring device ≤ G6
G2A	small scale gas consumers who do not meet the criteria for profile category G1A
G2B	empty
G2C	large consumers with a consumption <170,000 m3 (n; 35.17) per year which are not equipped with an hour meter and daily or hourly readings

As mentioned in the methods, scenario scores for costs, social impact, complexity were derived by adding up the scores of the tools on these criteria for each scenario. This resulted in a ratio scale. The quickness of implementation was determined by the data tool in the scenario which takes the most time to implement. This resulted in a --/++ scale. Accuracy, level of detail and dynamic representation are determined for the scenarios as a whole. Next, the arguments for the assigned scores on these three criteria are given.

For accuracy, the P4 data were considered less accurate than P1 data, since the current consumption is estimated using the consumption of the day before when the P4 port is used. When user profiles are used for household consumption, the accuracy is even lower. In this case, profiles based on national averages are used and therefore the data is less adapted to Vlieland than P1 or P4 data. For large-scale consumer usage, accuracy is lower when current consumption is estimated based on last year's consumption data than when meters are read out. In the latter case, data is known precisely. Finally, measuring production results in a greater accuracy than extrapolating production data based on wind and solar irradiance data.

The level of detail is equal for the scenario 1 to 12, since all these scenarios give insight in the consumption of households and some large-scale users, and production. For scenario 13, large-scale consumers are excluded. Therefore the level of detail is lower in this case. Scenario 14 receives the highest score on level of detail, since data of multiple large-scale consumers are measured.

The dynamic representation is the lowest for scenarios 12 and 13. In these scenarios, all data is based on user profiles or old data. Therefore, there is no immediate effect of changes in the current situation. When the P4 port of households' smart meter is read out, the dynamic representation increases. In this case, effects of current changes are shown the day after. Reading out households' P1 port, heavily increases the score on dynamic representation. After all, in this case the households' consumption data is updated every 10 seconds instead of every 15 minutes, and the data is real-time and not from the day before. For large-scale consumers, reading out meters leads to a higher score on dynamic representation due to the connection with the current situation. For estimating or measuring production, there is no difference in dynamic representation. In both cases, acquired data is as well frequently updated as real-time, since both methods include immediate changes in wind and solar irradiance.

All these considerations together resulted in the scenario scores as given in table X.10.

Table X.10 – The scoring for the different criteria used in the MCA for all scenarios. The scoring for cost, social impact, complexity are summed for the different tools. For quickness of implementation the worst scoring of the data tools is used. The scoring for accuracy, level of detail and dynamic representation are determined per scenario.

Scenario	Costs	Social impact	Complexity	Quickness of implementation	Accuracy	Level of detail	Dynamic representation
1	11	10	16	--	+++	++	+++
2	10	9	14	--	++	++	+++
3	6	8	13	--	+	++	+
4	5	7	11	--	+/-	++	+
5	10	9	15	-	+	++	++
6	9	8	13	-	+/-	++	++
7	5	7	12	-	-	++	-
8	4	6	10	-	--	++	-
9	7	5	11	-	+/-	++	+
10	6	4	9	-	-	++	+
11	2	3	8	+/-	--	++	--
12	1	2	6	+/-	---	++	--
13	1	1	4	+/-	---	+	--
14	25	13	18	--	++	+++	+++

Final weighting factors are based on weighting by LABVlieland and weighting by our team.

First, the weighting factor as decided by LABVlieland are discussed. The social impact was given the highest weighting factor, for the reason that LABVlieland wanted to avoid botheration for inhabitants as much as possible. The secondly important factors were the costs and the quickness of implementation. Costs are important for obvious reasons. And since the target year for energy neutrality is 2020, scenarios that can be implemented within a short time were strongly preferred. This quickness is necessary for being able to use the dashboard as a device to target the energy neutrality goal. The following important factor is the dynamic representation. LABVlieland considered the frequency of data updates to be important, for example because of the fun in seeing the effect on solar energy production of a cloud before the sun. This would make the dashboard interesting and attractive. The next important criteria was complexity. Complex and therefore vulnerable scenarios are less desirable, but complexity was no important deal-breaker. The least important criteria according to LABVlieland were level of detail and accuracy. This is because LABVlieland considered estimated data of almost the same value as measured data. In addition, detailed subdivisions within consumer and producer groups were not high valued.

Next, the weighting as decided by our team is discussed. The most important criteria according to our team were costs and complexity. At the moment, no money is available yet. It is possible that money is found, but the more expensive an option is, the more actions must be undertaken to acquire the money. Complexity is considered important because it is connected with the vulnerability of the option. The next important factor was the quickness of implementation, for the same reasons as mentioned for LABVlieland. The dynamic representation is weighted 15% by our team, since a high frequency of data updates is important for using the data as a learning tool (Darby, 2006). Accuracy and level of detail were weighted somewhat higher than LABVlieland's weighting of these criteria, since it is known that less detailed data and less accurate data is less credible and therefore less effective (He, 2010; Darby, 2006). The most important difference with LABVlieland's weighting lies in the social impact: it was weighted 8% by our team versus 23,5% by LABVlieland. The reason for this is that our team expected social impact to be of small importance overall. This was also indicated by the results of the survey, indicating that privacy would be no problem. For most scenarios, only stakeholders who contribute voluntarily to the data are involved. Therefore, botheration or privacy issues may be less important and should not be overestimated.

The weighting factors were determined as given in table X.11.

Table X.11 - Weighting factors for the MC, determined by LABVlieland and our team.

Criteria	Our team	LABVlieland	Final Weighting
Costs	19.5 %	17.5 %	18.50 %
Social impact	8.0 %	23.5 %	15.75 %
Complexity	19.5 %	12.5 %	16.00 %
Quickness of implementation	17.0 %	17.5 %	17.25%
Accuracy	11.0 %	5 %	8.00 %
Level of detail	10.0 %	7.5 %	8.75 %
Dynamic representation	15.0 %	16.5 %	15.75 %

In this appendix the results of the sensitivity analysis are presented separately. These results show how the decision will change when individual weighting factors are varying. These results are used in section 4.5.3.

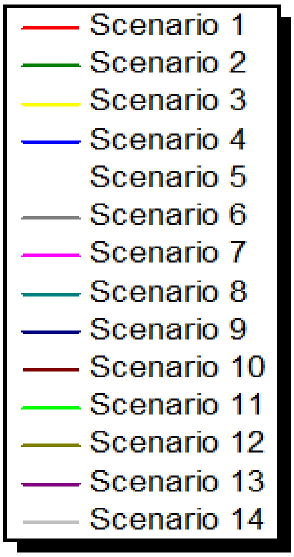


Figure X.22 - Legend for the sensitivity graphs presented in figures X.22-X.28.

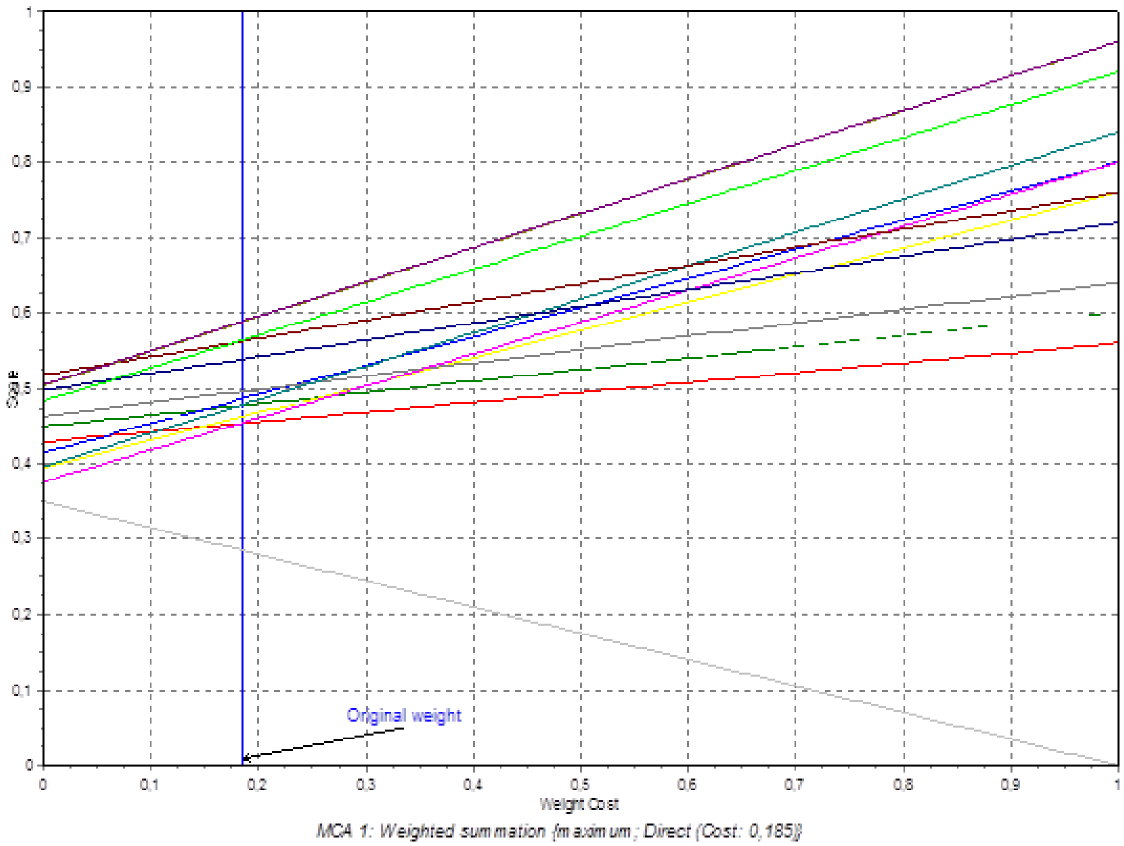


Figure X.23 - Sensitivity analysis for the weighing factor of costs.

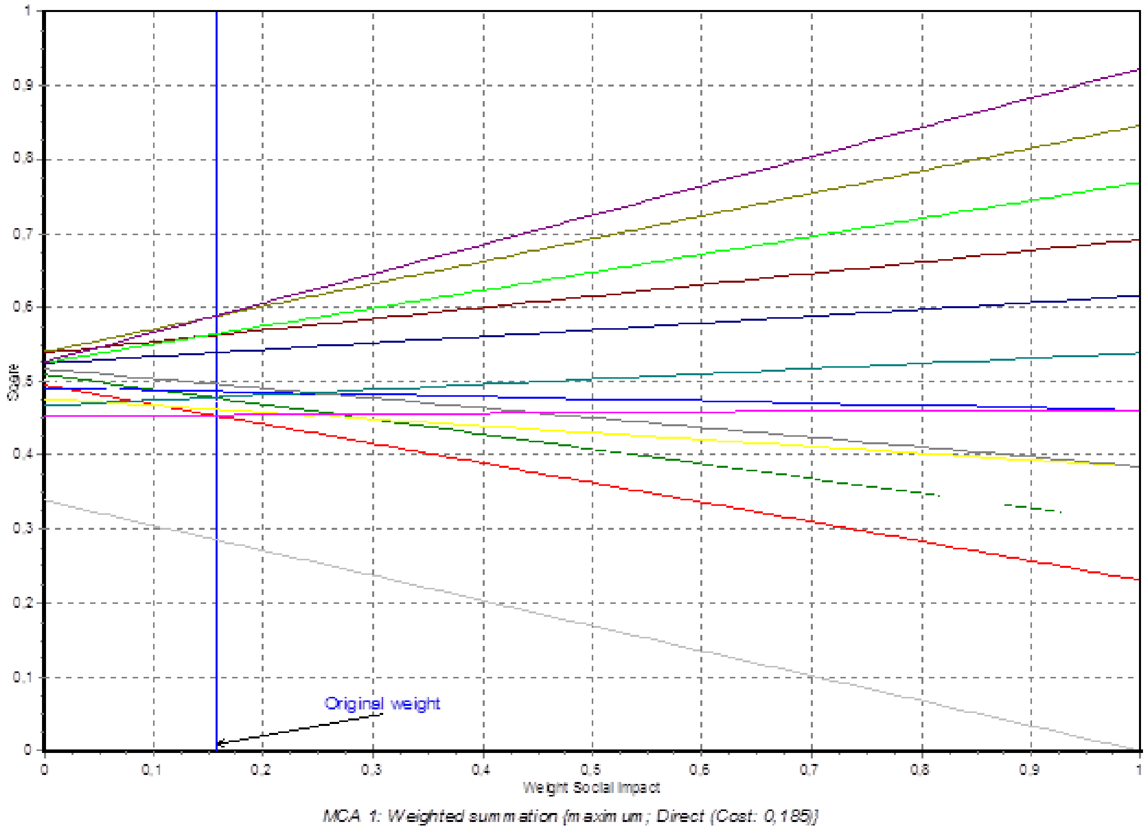


Figure X.24 - Sensitivity analysis for the weighing factor of social impact.

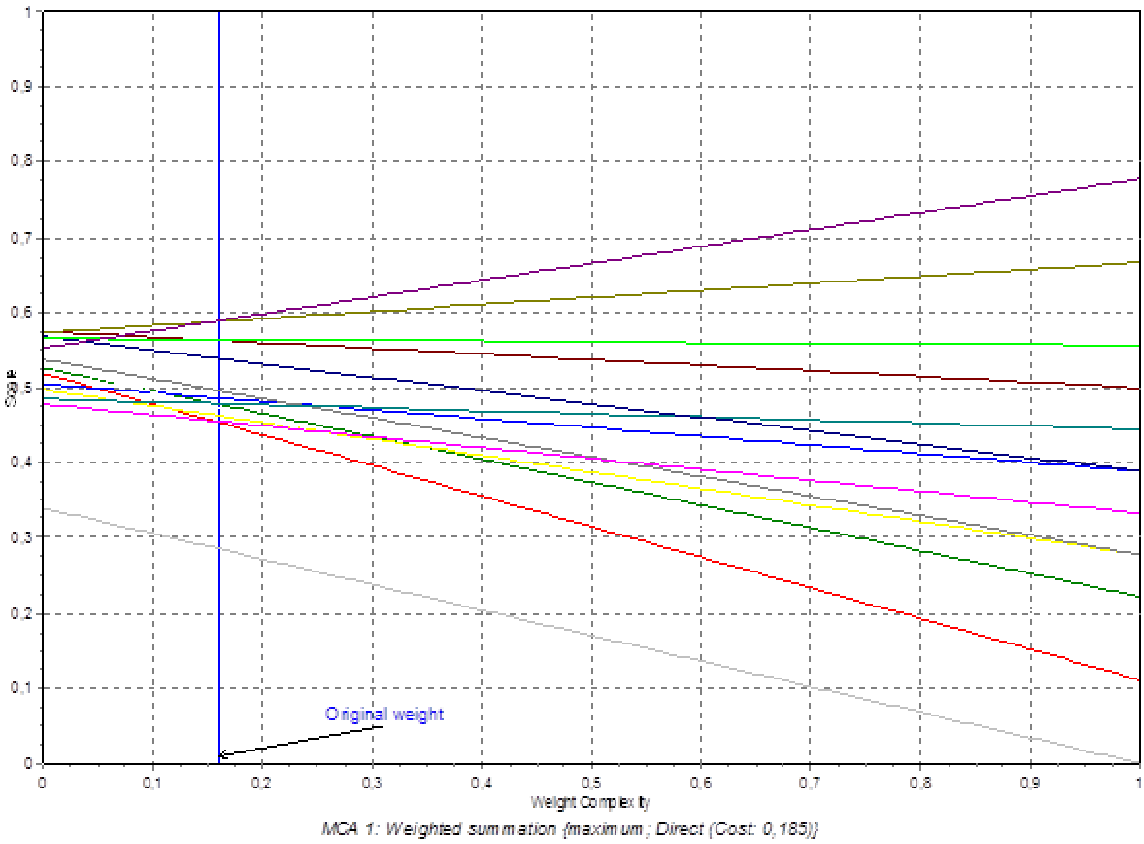


Figure X.25 - Sensitivity analysis for the weighing factor of complexity.

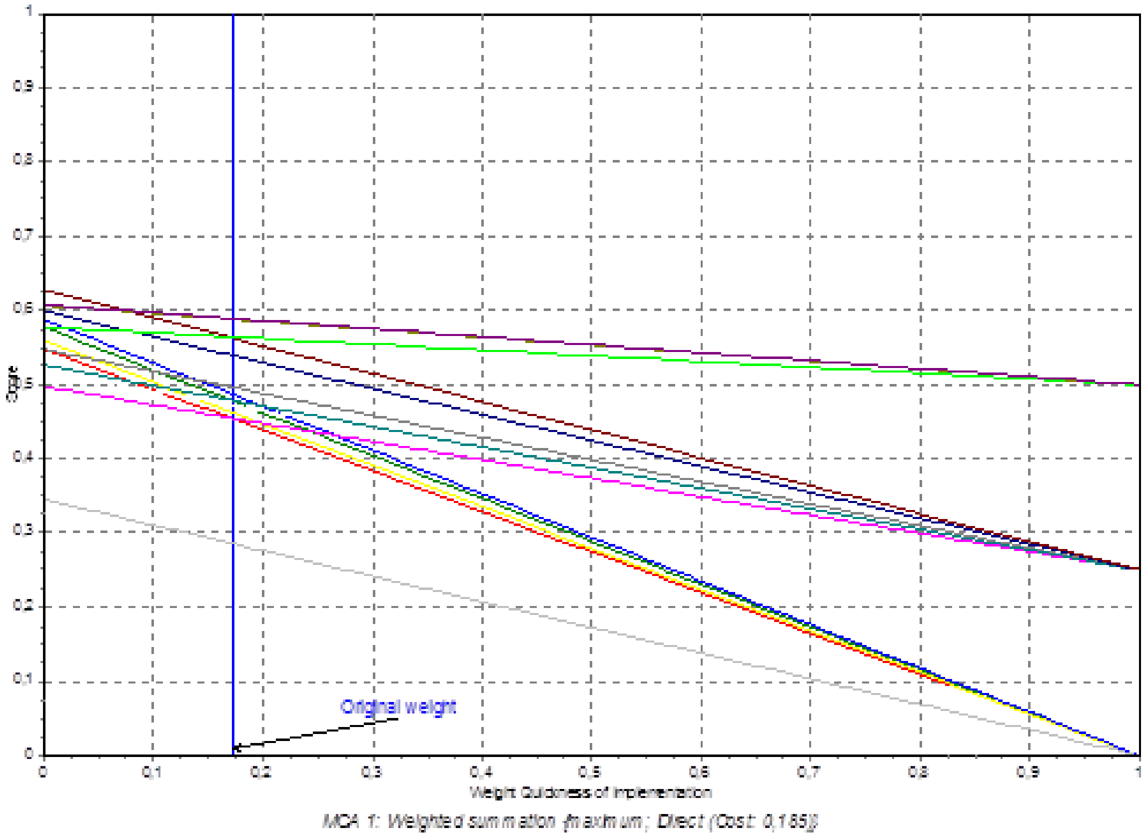


Figure X.26 - Sensitivity analysis for the weighing factor of quickness of implementation.

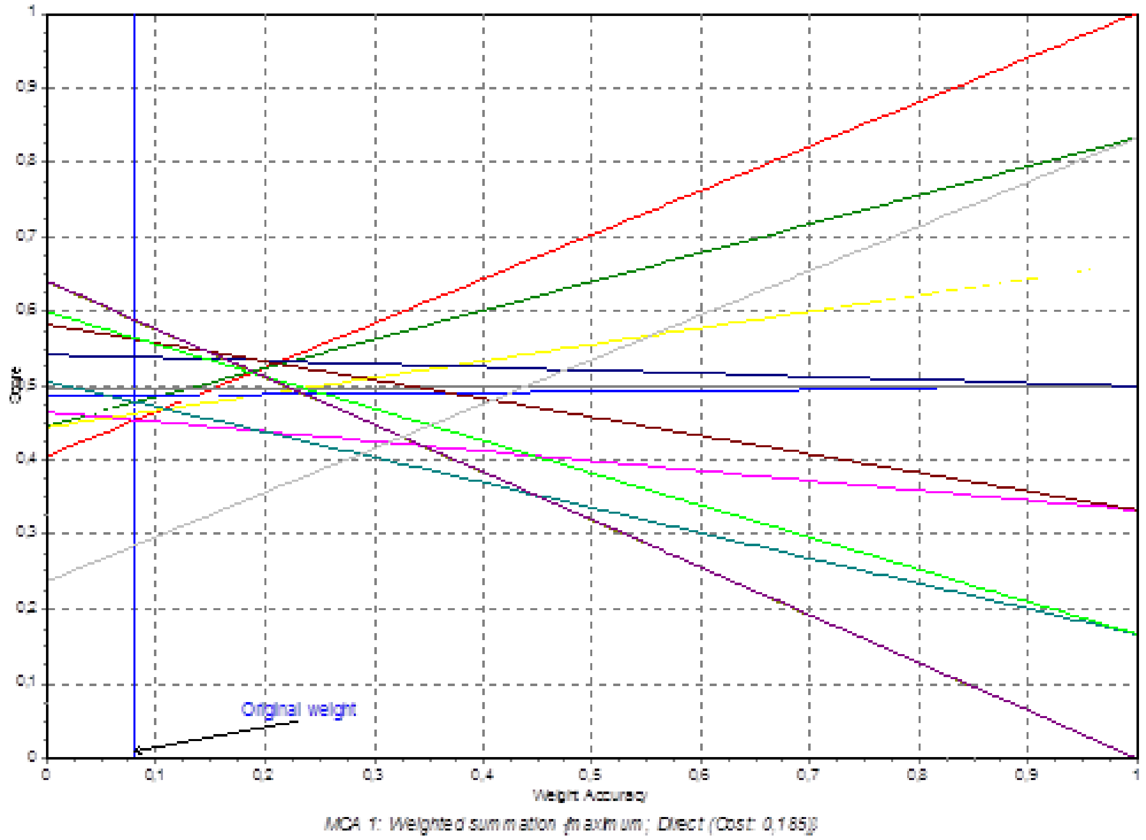


Figure X.27 - Sensitivity analysis for the weighing factor of accuracy.

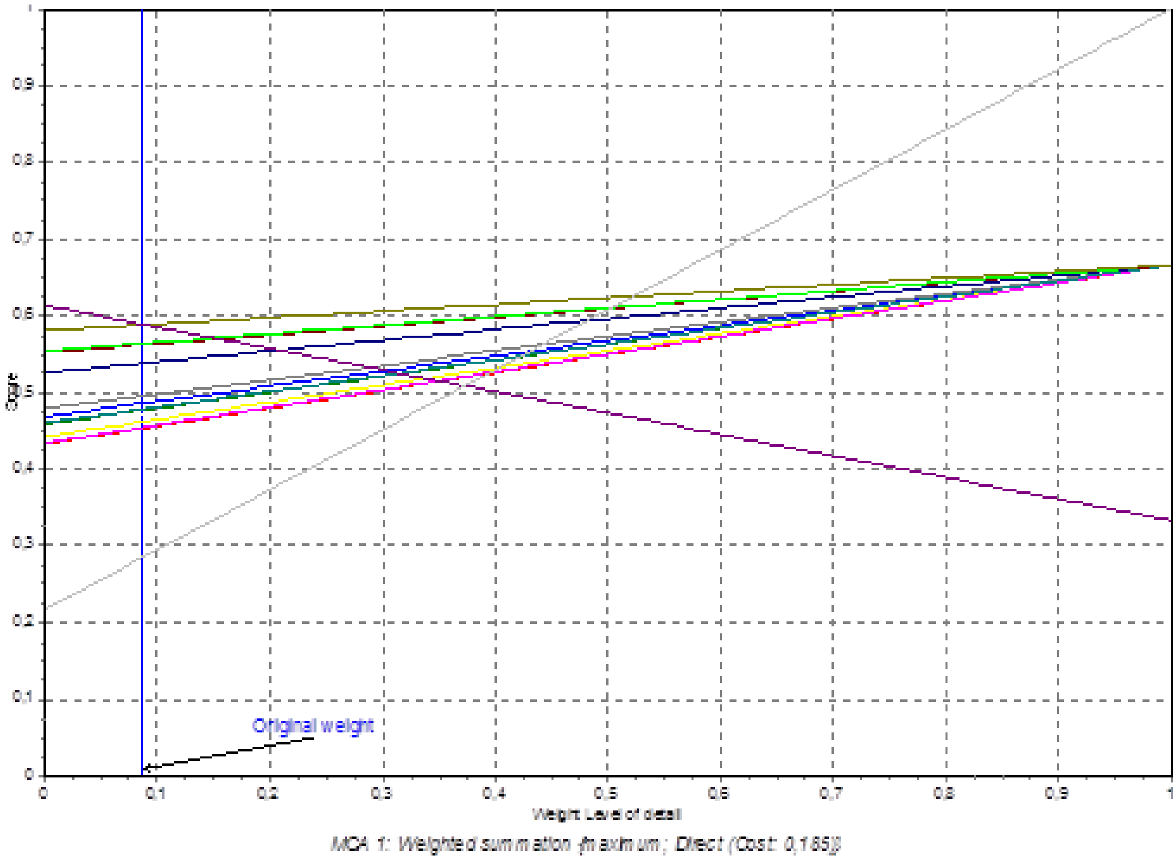


Figure X.28 - Sensitivity analysis for the weighing factor of level of detail.

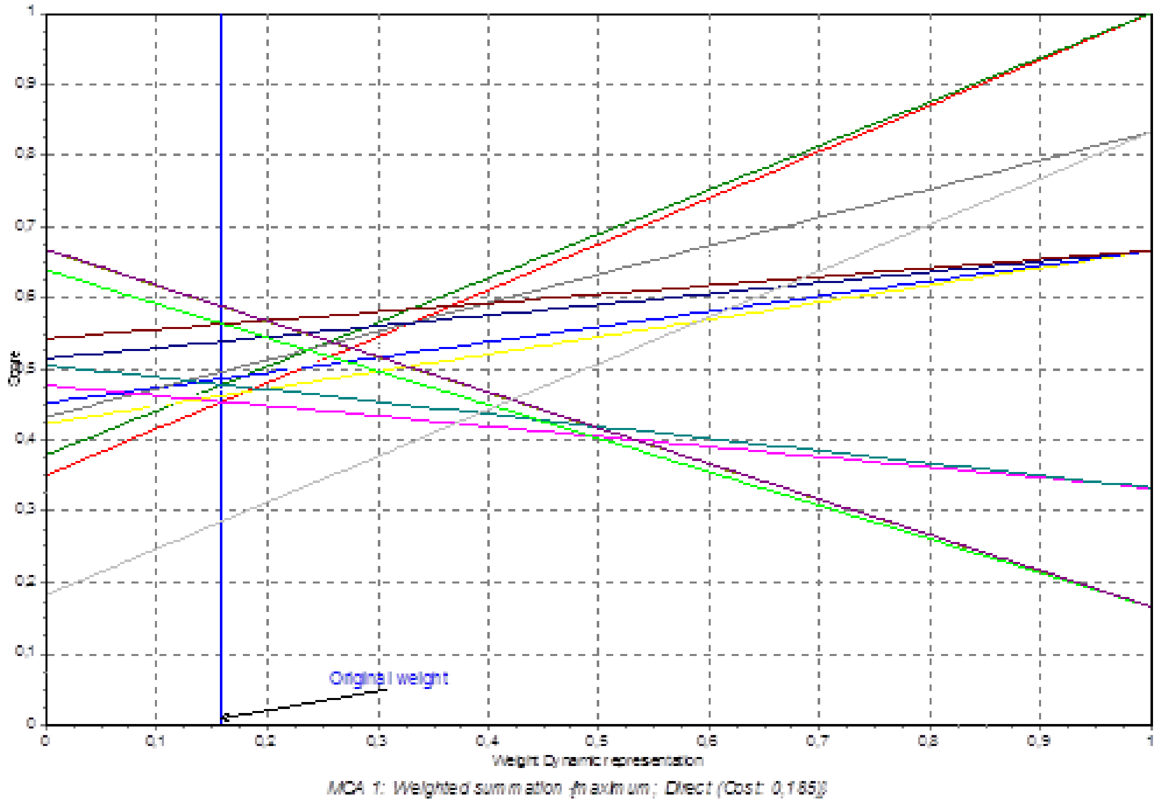


Figure X.29 - Sensitivity analysis for the weighing factor of dynamic representation.

In this appendix the results of the uncertainty analyses are presented. These results show how the ranking will change when the criteria scores and weighting factors are varying. These results are discussed in 4.5.4. Note: the order on the Y-axis represents the original outcome of the MCA

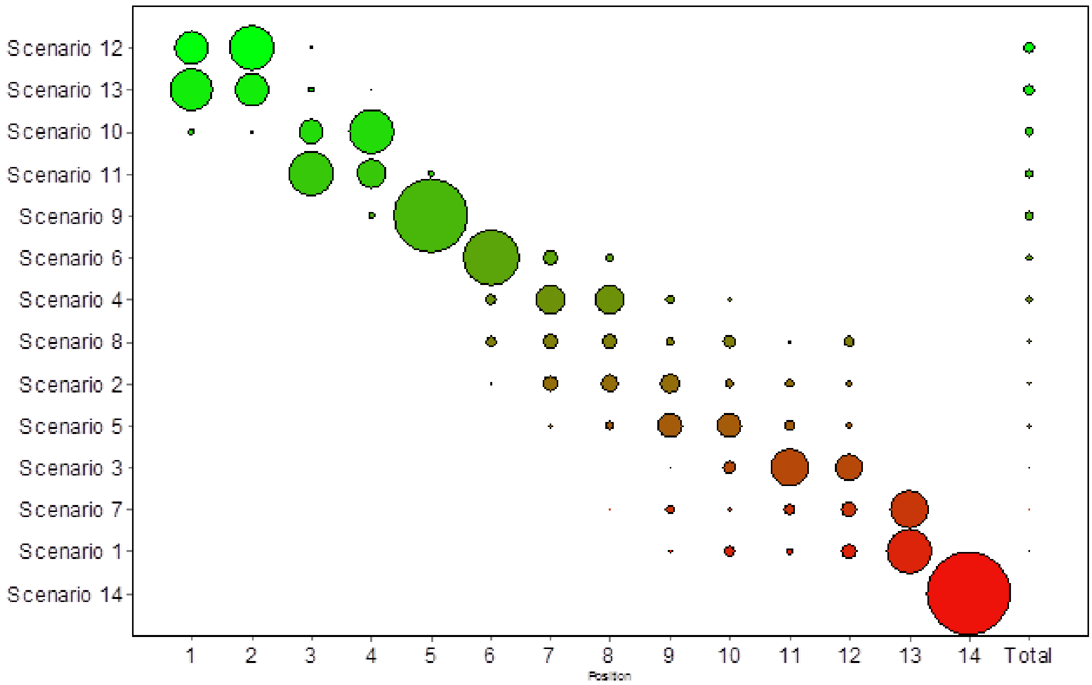


Figure X.30 - Uncertainty analysis of the MCA. The weighing factors are varied by 50% of their original value.

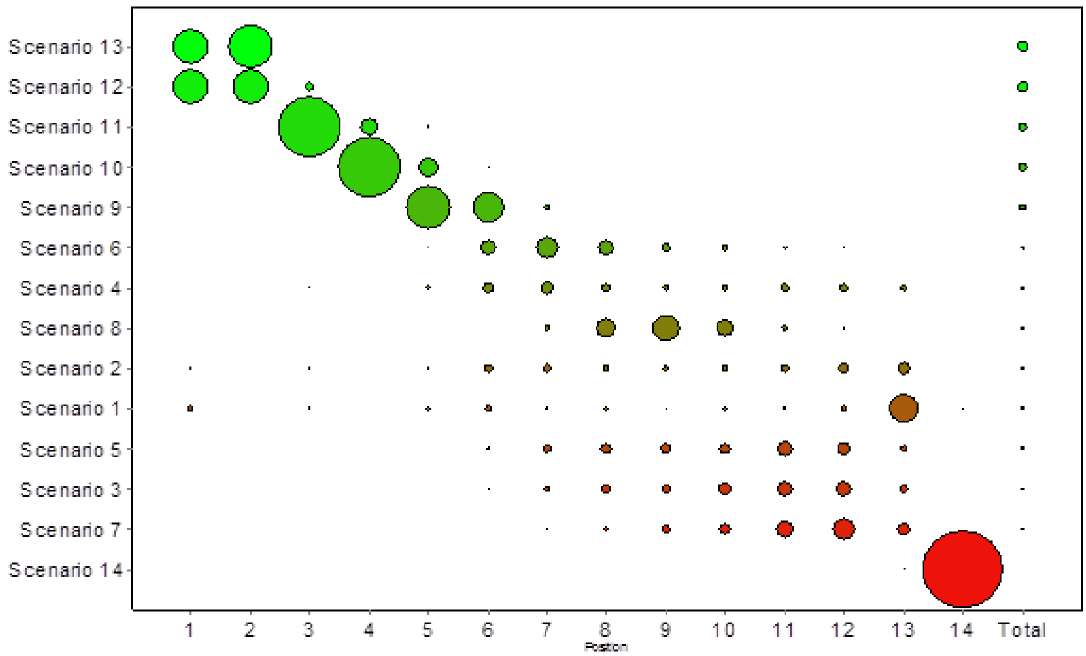


Figure X.31 - Uncertainty analysis of the MCA. The scoring values for the criteria related to implementation and operation are varied as follows: costs 50%, social impact 30%, complexity 50%, quickness of implementation 30%.

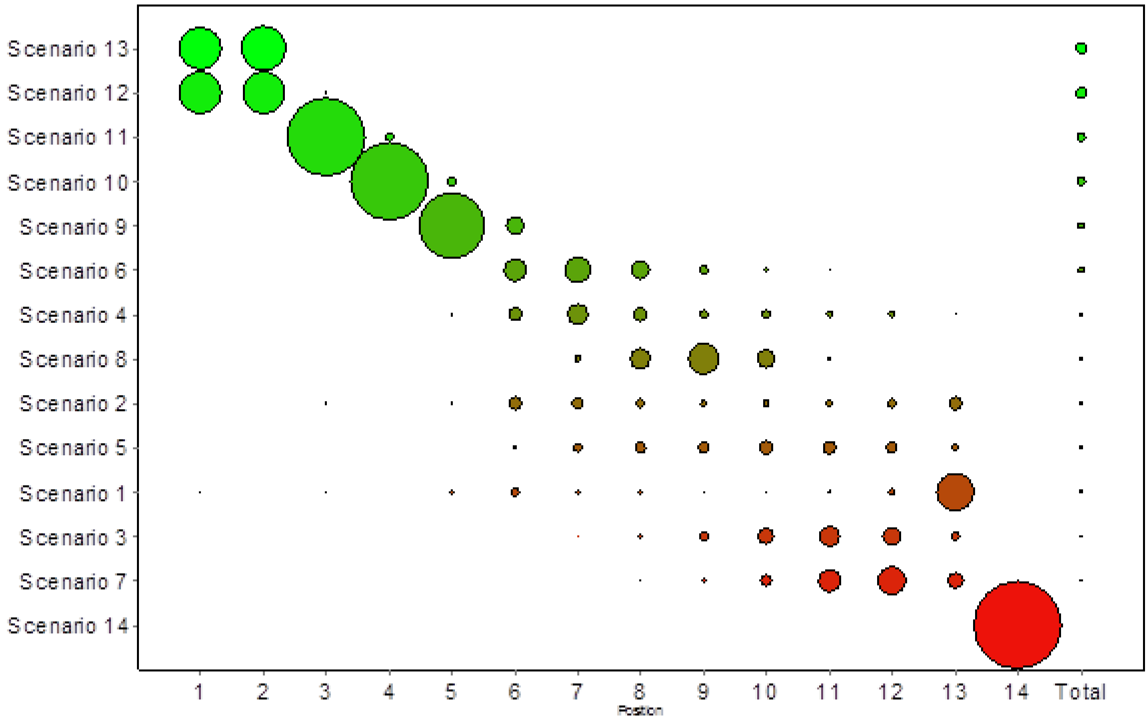


Figure X.32 - Uncertainty analysis of the MCA. The scoring values for the criteria related to data output are varied as follows: accuracy 30%, level of detail 30%, dynamic representation 30%.

The sections below describe the different processes that are summarized in the advice (chapter 7). The execution of the data tools is explained per group, by giving all the required steps. To every step a code including two letters and a number is attached, which refers to the steps in the advice diagram (figure 7.1). This appendix contains the table of all required steps in order to achieve scenario 12 and 1. The tables are given in the following order: net consumption of the island, following by the consumption of households, large-scale consumers and the renewable production of both households and large-scale users. Furthermore, the last table contains all the steps required for the underlying integral processes of setting up a dashboard.

Per table, the data tool for scenario 12 is given first, followed by the data tool for scenario 1. Note that for all tables abbreviations (LABV = LABVlieland, HHs = (total group of) households, LSC = large-scale consumers, Ut. = utility, in some cases mentioned as ‘’measuring company’’) are used. Further, some price indications, process descriptions, stakeholders and sources must be interpreted differently. This is marked by annotations from (*a) to (*j). Descriptions are given below the tables.

Table X.12 describes the processes for the implementation of the data tool to obtain the net energy consumption of the island. This will be achieved by retrieving the data on gas and electricity consumption. All processes described from data tools for measuring the islands net consumption are encoded with the letters IS.

Table X.12 - The description of the processes for the implementation of the data tool 'meter on electricity and gas connection between island and mainland'.

Code	Description of process	Sources & stakeholders	Estimated costs (€)	Transaction description
Implementing data tool of section 4.4.1: Meter on electricity and gas connection between island and mainland				
IS1	Making agreement with utility on using the data measured from the electricity connection	Liander	0	-
IS2	Determining if approp. meter exists on a gas connection and which grid operator manages it and making agreements	Liander for electricity and Enexis for gas. However, nobody within Enexis could confirm this.	0	-
IS3	Retrieving electricity consumption data from grid operator	Liander	0 – 500 (*d)	LABV > Liander
IS4	Installing appropriate gas meter, if applicable	Enexis, or other grid operator that manages the gas connection	0 – 3000 (*d)	LABV > Liander or other Ut.
IS5	Retrieving data on gas consumption from grid operator	Enexis, or other utility that manages gas connection	0 – 500 (*d)	LABV > Liander or other grid o.
IS6	Integration of data streams in dashboard	-	- (*a)	-

(*a) – costs with this remark are dependent on the required ICT efforts. These costs are unknown and cannot be estimated independently.
(*d) – Costs with this remark are raw indications with a high uncertainty and depend heavily on agreements with utilities.

Table X.13 describes the processes for the implementation of the data tools to obtain the net energy consumption of a sample households, in order to extrapolate the energy consumption of the total group of households on Vlieland. The first data tool described is the consumption profile, which is recommended to implement in the first phase. Next, the steps for the P1-port data tool, which will follow in a second phase phase, is given. All processes for the group of households are encoded with the letters HH.

Table X.13 - The description of the processes for the implementation of the data tool 'consumption profiles' and the data tool 'reading P1 of smart meters in households'.

Code	Description of process	Sources & stakeholders	Estimated costs (€)	Transaction description
Executing data tool 4.4.4: Consumption profiles for households				
HH1	Obtaining dataset of gas and electricity consumption profiles for households	Nederlandse energiedatauitwisseling (2015). Could be updated every year.	0	-
HH2	Integration the dataset of consumption profiles in dashboard	-	0 (*a)	LABV > ICT
HH3	Repeating processes from HH1 and HH2 when new cons. profiles are available.	Nederlandse energiedatauitwisseling (2015). Note: only if necessary	0	-
Executing data tool 4.4.3: Reading P1 of smart meters in households				
HH4	Searching for twenty households willing to cooperate with processes required for P1 data tool	Municipality might assist, own network, network of already prepared households, etc.	0	-
HH5	Making agreements on meter and other installations and privacy issues, perhaps by contract	Prepared households	0	-
HH6	Requesting smart meters for twenty prepared households	Liander	1400 (*b)	HHs > Liander
HH7	Retrieving last annual energy bills of prepared household, which is needed for extrapolation calculation	Prepared households	0	-
HH8	Selecting central energy management	Platforms suggested in table 4.3 and description of section	1000 (*i)	LABV > platform

	platform, perhaps already fulfilled in process HH10	4.3.3., internet forums (*i)		service
HH9	Selecting and purchasing P1 hardware and eventual purchases for internet connection in houses	Hardware suggested in table from section 4.3.3, internet forums (*i)	2000 (*i)	LABV > store
HH10	Installation P1 hardware, checking internet connection and connecting to energy management platform	User manuals of purchased products	0	-
HH11	Integration of P1-data in dashboard	-	0 (*a)(*i)	-
HH12	Repeating steps process HH4 to HH9 to enlarge sample size, perhaps smart meters already implemented	See previous processes. Check website Liander for smart meter implementation agenda	0 (*b)	- (*b)

(*a) – costs with this remark are dependent on the required ICT efforts. These costs are very uncertain and cannot be estimated independently

(*b) – costs and transactions with this remark are dependent on the smart meter installation program of Liander, which can reduce the implementation costs of the data tool if the installations occur on the short term

(*i) - costs with this remark are based on the conventional P1-data tool. Note that there are also two possibilities for avoiding purchasing costs of hardware and software required to read P1-data. Check this description in section 4.4.3 and appendix IX (note figure X.21).

Table X.14 describes the processes for the implementation of the data tools to obtain the net energy consumption of the selected large-scale consumers which have an energy consumption that is relevant for the energy dashboard. It consists of the method of using last year's data, which will be implemented in the first phase. In a later phase this could be substituted by reading out the meters of these large-scale consumers. All the processes from data tools for measuring large-scale consumers' consumption are encoded with the letters LS.

Table X.14 - The description of the processes for the implementation of the data tool 'using last year's data of large-scale consumers' and the data tool 'reading meter of large-scale consumers via a web service.

Code	Description of process	Sources & stakeholders	Estimated costs (€)	Transaction description
Implementing data tool of section 4.4.6: Using last year's data of large-scale consumers				
LS1	Making agreement with all selected large-scale consumers about receiving their last-year data	Selected large-scale consumers	0	-
LS2	Retrieving these data-sets from the measuring companies, annually.	Different measuring companies, every year. Note: depends on desired dynamics	0 – 1500 (*e)	LABV > Measuring companies
LS3	Calibrate datasets to days of the week (mo-su) and holidays & integration in dashboard	Use calendar of Vlieland to check if busy crowded weeks are equal to those in dataset	0 (*a)	-
Implementing data tool of section 4.4.5: Reading meter of large-scale consumers via a web service				
LS4	Making agreement with all selected large-scale consumers for reading out data from the meters	Selected large-scale consumers, boards and directions of organisations and municipality	0	-
LS5	Check if connections and meters are suitable for reading out real-time data	Liander and other measuring companies, selected large-scale consumers	0	-
LS6	Possible replacement of electricity or gas meters of selected large-scale consumers	Liander and consumer with outdated meter	0 – 2000 (*d)	LSC > Utility
LS7	Retrieving data on electricity and gas consumption of large-scale cons. from utility	Liander and selected large-scale consumers	5000 (*c)	LABV > Measuring company
LS8	Integrating data stream in central dashboard	-	0 (*a)	-

(*a) – costs with this remark are dependent on the required ICT efforts. These costs are unknown and cannot be estimated independently.
(*c) – These costs include the sum of the annual costs. An operation period of five years is assumed.
(*d) – Costs with this remark are raw indications with a high uncertainty and depend heavily on agreements with utilities.
(*e) – Costs with this remark depend on the decision on the by LABVlieland desired dynamics of the data. For instance: month or week data on electricity consumption is often available in the energy bill of a large-scale consumer. However, fifteen-minute data must be retrieved from measuring companies, which could include costs for some measurement companies.

Table X.15 describes the processes for the implementation of the data tools to obtain the production of energy by PV-panels or solar heating systems. The first described data tool is based on estimating the production for both the large-scale and small-scale consumers. The second data tool is recommended to develop in the second phase and contains processes to measure the real-time production of solar energy. Furthermore steps to implement the data tool to estimate the renewable energy production potential are given. All processes from data tools implemented in order to monitor the renewable energy production are encoded with the letters PR.

Table X.15 - The description of the processes for the implementation of the data tool 'estimating production' and the data tool 'measuring production'.

Code	Description of process	Sources & stakeholders	Estimated costs (€)	Transaction description
	Implementing data tool of section 4.4.8: Estimating production			
PR1	Choosing target system for both PV and Solar heating systems & make agreem. (*h)	A few households and preferably one large-scale cons./prod. (for ex. Flidunen)	0	-
PR2	Determining total PV and solar heating peak capacity of all households (*h)	Use PIR-register, or estimate capacity by hiring drone or from the ground.	0 - 500 (*g)	LABV > company
PR3	Retrieving data from target systems (*h)	Chosen households	0	-
PR4	Integrating retrieved data in dashboard and extrapolating to total of PV and solar heating	Using results from PR3 and PR1, see description in section 4.4.8	0 (*a)	-
PR5	Obtaining annual production data of Large-Scale consumers	From administration of Large-scale consumers	0	-
PR6	Installing solar irradiance meter for estimating real-time irradiation on Vlieland	Buying meter from store and license from municipal gov. or from other stakeholders.	200	LABV > store
PR7	Calculate real-time production of large-scale consumers & integration	Using method and formula from 3.3.3 (potential production PV-panels)	0	-
PR8	Integration of energy	Using calculations from	0 (*a)	-

	produced by wood in dashboard by calculating gas savings	section 3.3.2 and method of section 4.4.8		
Implementing data tool of section 4.4.9: Estimating renewable energy production potential				
PR9	Acquiring wind data and contingent installing solar meter (depends on PR6)	Wind: hourly speeds are measured by KNMI. Solar: search on internet for meters	0-200	LABV > store
PR10	Determining (total) potential for wind and solar energy on Vlieland	Municipality, for information on solar fields. For wind, see section 3.3.3	0	-
PR11	Integration data of potential renewable production in dashboard	Use formulas and calculations described in section 3.3.3	0 (*a.)	-
Implementing data tool of section 4.4.7: Measuring production				
PR12	Analysing presence of digital PV-meters and GJ-meters with 15 (elec.) / 60 (gas) min. upd.	Selected large-scale consumers	0	-
PR13	Contingent installation of PV-meters or GJ-meters if these are not yet present for all selected consumers	Selected large-scale consumers, installation company, consultant with knowledge on system perhaps	0 – 2000 (*f)	LSC > installation company
PR14	Retrieving data from new large scale renewable energy installations (e.g. wind turbine)	For solar installations on Vliehors: municipal board.	0	-
PR15	Integrating data streams of meters in energy dashboard	-	0 (*a)	-

(*a) – costs with this remark are dependent on the required ICT efforts. These costs are unknown and cannot be estimated independently.
(*f) – Costs with this remark are dependent on the presence of appropriate current meters, PV-meters and GJ-meters. This is currently uncertain, which lead to a high uncertainty in the estimated costs.
(*g) - Processes and costs with this remark depend on decision within step. Hiring a drone could lead to annual expenditures for updating peak capacity numbers, while estimating from the ground is likely to be free. Another more complex method is to let households and large-scale consumers register their peak capacity.
(*h) - Process with this remark are based on the first of the options to estimated harvested energy from solar systems (PV and heat), which is the method that is described the first in section 4.4.8.

Table X.16 described the integral processes required to set up an energy dashboard, supporting the other processes executed in order to implement a certain data tool. The processes include processes required for a digital dashboard and processes needed to develop a contiguent physical dashboard. All described integral processes are encoded with the letters IN.

Table X.16 - Description of all integral processes required for setting up an energy dashboard, including sub-dashboards.

Code	Description of process	Sources & stakeholders	Estimated costs (€)	Transaction description
Implementing data tool of section 4.4.1: Meter on electricity and gas connection between island and mainland				
IN1	Choosing or building central dashboard software or energy manager service incl. site	Hiring ICT-experts could be crucial. However, note platforms from table 4.3.	1000 – 2500 (*c)	LABV > ICT or LABV > platform
IN2	Maintenance of central energy dashboard	If complex, hire ICT-experts. For using existing platforms, this could be done by LABVlieland	0 – 5000 (*c)(*a)	LABV > ICT
IN3	Asses which stakeholders are interested in digital or physical sub-dashboard and make agreements	Ask stakeholders (selected 6 LSC's and Doeksen) or municipality, Analyse interviews (app. IV)	0	-
IN4	Design dashboard	Create interdisciplinary brainstorm session with artist and technical specialists. Use results of report	0 - 2000	LABV > designers
IN5	Build physical dashboard and contingent sub-dashboards on the island.	Municipal gov.: ask permission Stakeholders: ask permission Hire construction company	1000 – 10,000 (j.)	LABV > construc. company
IN6	Integration of physical dashboard with data from digital dashboard.	-	0	-

(*j) – Costs with these remarks heavily depend on the size of the physical dashboard, which will be determined in a later stadium. Therefore, this is still a very uncertain estimation.