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Participation in energy communities: preferences of Dutch house holds a stated choice experiment

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A stated choice experiment

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Preface

This research was conducted as graduation project for the master Construction Management and Engineering, at the Technical University of Eindhoven. With a great interest in the sustainable development and smart cities, this research is very relevant to my interests. In the past months I got the opportunity to develop more knowledge about this subject, and conducted a questionnaire. The combination of the technical complex system, and the involvement of people's opinion was really interesting to me.

I would like to thank my supervisors Gamze Dane, Aloys Borgers and Qi Han for their time and expertise. Although it has been a weird year with COVID-19 not allowing face-to-face meetings, the time the supervisors took in the flexibility to schedule meetings and give feedback is very appreciated. Without the involvement of a company, the feedback of professors was more important. Furthermore, I would like to thank my family and partner for hearing me out on the topic and give me feedback about handling situations, and my friends for being of great help in testing the questionnaire. I am very happy with the end results, and especially the personal development I had during the process, and to finish my career as a student with this report.

Enjoy reading this research!

Jasmijn de Groot

Tilburg, March 2021

Summary

The current energy system is facing challenges regarding the use of fossil fuels and achieving the climate goals of the European Union. The current energy system is based upon a top-down system where energy is generated from fossil fuels and delivered via the transmission network to the households, and other energy requesting parties. The integration of renewable energy sources is an important topic in society as well as in research. However, for electricity, only 26 per cent is generated from renewable energy sources. In the upcoming years, this should be increased, but issues related to the grid are facing. Where the current electricity system is centrally located throughout the Netherlands, this will probably change to a decentral system where energy is generated and used locally. Households are important stakeholders in this process and can play a role in the purchase of electricity generation systems. Their willingness to operate in local energy systems (energy communities) is quite unknown. Therefore, in this research, the following main question will be answered: "*What characteristics of energy communities and Dutch households influence the choice between energy communities?*"

Energy communities can be described in multiple definitions, where many of them have the overarching goal of integrating households actively in the supply and demand for energy. One of the examples is an energy cooperative, where members buy a share of the generation system for either solar or wind energy. Households are compensated with an electricity price reduction, and therefore, benefit from their investment. Another option is to become an active participator in the energy grid, also called prosumers. Prosumers produce energy themselves and can share the over-supply with other grid participators. A group of prosumers can form a prosumer community, where a group or contractual relationship binds them to generate, share and consume energy. A prosumer community is more effective compared to an individual prosumer due to the natural demand-side management and peak shaving.

The preference for participation in an energy cooperative or a prosumer community is measured with a Stated Choice Experiment. This experiment consisted of attribute levels, which are based upon a literature study. The stated choice experiment is divided into two scenarios. The first scenario represented the prosumer community, involving personal investment in a generation system. The second scenario represented the energy cooperative, where a joint investment is done in a shared electricity generation system for either solar or wind energy.

The selection of attributes was based on earlier research and literature. The development of an energy community can be divided into technological, financial, management and psychological aspects. In order to create a network where a bi-directional exchange of electricity can take place, a smart grid is necessary where measurement and communication are important aspects of the grid. This bi-directional exchange is necessary to generate electricity in a community and supply this to the individual buildings, and to feed an over-supply of electricity back to the grid. In the past years, the development of generation systems increased, where wind and solar energy represent the most attractive options for renewable energy generation. An energy cooperative can develop wind and solar projects and the members of the cooperative invest in shares of this project, depending on their preferred investment height. The investment height and the associated benefits represented one of the attributes. Also, the investment height for private investments in a generation system was an attribute. This attribute incorporated a small and a middle-sized PV system including the option to invest in energy storage. Energy storage will become more important due to the changing 'Salderingsregeling'. This regulation will phase out the compensation households with PV panels get for their over supply of electricity. As a result, the change of this regulation will affect the benefits system owners will get for their PV system over the years. The investment in both storage and PV increases the investment costs but stabilizes the yearly energy costs. Another option to decrease the congested transmission

network is to include demand-side management, where shifting the use of electricity is part of the process. As an important part of the technological developments and financial savings of the smart grid, the presence of an energy management system is applied as an attribute as well.

Furthermore, characteristics regarding the community are presented in the stated choice experiment. The effects of size of the community, in terms of members, are measured. Additionally, the information provided for an energy cooperative is included as an attribute. Finally, an attribute is included for the management of the system. Research about the system management pointed out that for an energy cooperative the majority is managed by the initiators (volunteers or members), in combination with an energy supplier (company). However, there are possibilities that the municipality (government) is involved in the support, participation or financial feasibility. For a prosumer community, it is unknown who should do this management, but the same possibilities are presented in the stated choice experiment. The complete stated choice experiment is combined in a questionnaire, together with questions regarding socio-demographic characteristics and statements about decision-making variables. These decision-making variables were determined based upon environmental behavioural models; the most frequently mentioned variables being: environmental attitude, subjective norm, and locus of control. To include the community aspect, community identity, independency and trust were used as decision-making variables as well.

The data collection resulted in a none representative sample of 134 respondents. The multinomial logit model is used to estimate the importance and significance of the attributes. The conclusion from this model is that there is an overall preference for scenario 1, private investment. Besides this result, significant findings are found for private investment height, joint investment height, presence of an energy management system in scenario 2, joint investment, and the management by volunteers. A mixed logit is estimated as well. The model performs better compared to the multinomial logit model. Investment height was found to be heterogeneous, which means that taste variation occurred among respondents. The number of members, information provision and management show homogeneous results. The last model used in this research is the latent class model, which resulted in two groups. These groups are analysed upon the presence of respondents in these classes. Class 1 consisted of respondents with a preference for alternative 1, private investment, and class 2 with a preference for alternative 2, joint investment. High household incomes (>100,000 euro) seem to appear more often in the first class. Furthermore, the decision-making variables affect class membership as well. In class 1 a significant overrepresentation of respondents with a high environmental attitude, subjective norm, and desire for independence are found. Class 2 represents a higher percentage of people with high trust in energy suppliers. At last, community identity and locus of control have no significant values.

Samenvatting

Het huidige energiesysteem is gericht op het gebruik van fossiele brandstoffen waardoor er uitdagingen ontstaan om het Klimaat Akkoord van de Europese Unie te behalen. Het huidige systeem is gebaseerd op het ‘top-down’ leveren van fossiele energie, via het distributienetwerk naar huishoudens en andere partijen met een vraag naar energie. De introductie van hernieuwbare energie is een actueel en belangrijk onderwerp in de maatschappij en in wetenschappelijke onderzoeken. In 2020 werd slechts 26 procent van de energie opgewekt uit hernieuwbare bronnen. Om te voldoen aan de Nederlandse doelstellingen zal dit percentage verhoogd moeten worden, maar hierbij komen uitdagingen voor het transmissie netwerk kijken. Het huidige systeem is centraal geregeld en geplaatst door heel Nederland. De verwachting is dat dit zal veranderen in een decentraal systeem waar de opwekking van energie lokaal geregeld zal worden. Huishoudens zijn belangrijke belanghebbenden in dit transitieproces en zij kunnen een rol spelen in de aanschaf van lokale energiesystemen. De bereidheid van huishoudens om deel te nemen in lokale energiesystemen (energiegemeenschappen) is echter nog onduidelijk. Vandaar dat er in dit onderzoek de volgende hoofdvraag zal worden beantwoord: Welke kenmerken van energiegemeenschappen en van Nederlandse huishoudens beïnvloeden de keuze tussen energiegemeenschappen?

Energiegemeenschappen kunnen op verschillende manieren worden gedefinieerd. Veel van deze definities hebben een overkoepelend doel betreffende het actief deel laten nemen van huishoudens in het opwekken en gebruik van energie. Een van de voorbeelden van een lokale energiegemeenschap is een energie coöperatie. Hierbij kopen deelnemers een onderdeel van een opwekkingssysteem voor bijvoorbeeld zonne- of windenergie. Huishoudens worden door een vermindering op de energieprijs gecompenseerd voor hun investering, wat een voordeel op de totale energierekening kan opleveren. Een andere optie is om als huishouden zelf een actieve deelnemer te worden in het netwerk, een prosument (English=Prosumer). Prosumenten produceren met een opwekkingsysteem energie en delen eventuele overschotten met andere deelnemers. Een groep prosumenten kan ook een gemeenschap vormen, een prosument gemeenschap, waarin contractuele overeenkomsten zorgen voor een verplichting om energie op te weken, te delen en te consumeren. Een groep van prosumenten is effectiever in vergelijking met een individuele prosument door de variatie in verbruik van energie van huishoudens en door het op een natuurlijke manier kunnen opvangen van de pieken in het netwerk.

De voorkeur voor deelname aan een energiecoöperatie of prosumentengemeenschap is gemeten met een Stated Choice Experiment. Dit experiment bestond uit attribuutniveaus, welke zijn gebaseerd op literatuuronderzoek. Het genoemde keuze-experiment is gebaseerd op twee scenario's. Het eerste scenario stelt de prosumentengemeenschap voor waarbij een persoonlijke investering in een generatiesysteem wordt gedaan. Het tweede scenario betreft de energiecoöperatie, waar gezamenlijk wordt geïnvesteerd in een gedeeld elektriciteitsopwekkingssysteem voor zowel zonne- als windenergie.

Het kiezen van attributen is gebaseerd op eerder onderzoek en literatuur. De ontwikkeling van een energiegemeenschap kan worden onderverdeeld in technologische, financiële, management- en psychologische aspecten. Om een netwerk te creëren waar tweezijdige uitwisseling van elektriciteit kan plaatsvinden is een smart grid nodig, waarbij meten en communiceren belangrijke aspecten van het net zijn. Deze tweezijdige uitwisseling is nodig om elektriciteit op te wekken in een gemeenschap en deze te leveren aan de individuele gebouwen, en om een overschot aan elektriciteit terug te leveren aan het net. De afgelopen jaren is de ontwikkeling van opwekkingssystemen toegenomen, waarbij wind- en zonne-energie de meest aantrekkelijke opties zijn voor duurzame energieopwekking. Een energiecoöperatie kan wind-

en zonne-projecten ontwikkelen waarbij de leden van de coöperatie investeren in aandelen van dit project, afhankelijk van hun gewenste investeringshoogte. De investeringshoogte en de daarbij behorende voordelen vormden een van de kenmerken. Ook de investeringshoogte voor een private investering in een opwekkingssysteem was een attribuut. Dit kenmerk had zowel een klein als een middelgroot PV-systeem inclusief de mogelijkheid om te investeren in energieopslag. Door de veranderende Salderingsregeling wordt energieopslag belangrijker. Door deze regeling wordt de vergoeding die huishoudens met een PV-paneel krijgen voor hun aanbod van elektriciteit geleidelijk afgeschaft. Als gevolg hiervan zal de wijziging van deze verordening gevolgen hebben voor de financiële voordelen die systeemeigenaren in de loop van de jaren voor hun PV-systeem zullen krijgen. De investering in zowel opslag als PV-systeem verhoogt de investeringskosten, maar stabiliseert de jaarlijkse energiekosten. Een andere optie om het overbelaste transmissienetwerk te verminderen, is door vraagzijdebeheer (demand-side management) op te nemen. Hierbij maakt het verschuiven van het elektriciteitsverbruik deel uit van het proces. Als belangrijk onderdeel van de technologische ontwikkelingen en financiële besparingen van het smart grid is ook de aanwezigheid van een energiemanagementsysteem als attribuut toegepast.

Verder werden kenmerken met betrekking tot de energiegemeenschap gepresenteerd in het genoemde keuze-experiment. De effecten van de grootte van de gemeenschap, in de vorm van het aantal deelnemers, zijn gemeten. Daarnaast is de voorkeur voor frequentie van informatieverstrekking gemeten. Ten slotte is er een attribuut opgenomen voor het beheer van het systeem. Onderzoek naar het systeembeheer wees uit dat bij een energiecoöperatie het merendeel wordt aangestuurd door de initiatiefnemers (vrijwilligers of leden) in combinatie met een energieleverancier (bedrijf). Er zijn echter mogelijkheden dat de gemeente (overheid) wordt betrokken bij de ondersteuning, participatie of financiële haalbaarheid. Voor een prosumentengemeenschap is het onbekend wie dit beheer zou moeten doen, maar dezelfde mogelijkheden werden gepresenteerd in het genoemde keuze-experiment. Het volledige keuze-experiment is gecombineerd in een vragenlijst, samen met sociaal-demografische kenmerken en uitspraken over beslissingsvariabelen. Deze beslissingsvariabelen werden bepaald op basis van omgevingsgedragsmodellen waarbij de meest genoemde variabelen waren: klimaatbewustzijn, subjectieve norm en locus of control (vertrouwen dat eigen gedrag invloed heeft). Om het gemeenschapsaspect op te nemen, zijn de gemeenschapskenmerken onafhankelijkheid en vertrouwen van en in externe partijen als beslissingsvariabelen gebruikt.

Gegeven de niet representatieve steekproef van 134 respondenten is een Multinomiaal Logit model geschat om het belang van de attributen te bepalen. De conclusie van dit model is dat er een algemene voorkeur is voor scenario 1, private investeringen. Naast dit resultaat zijn significante bevindingen gevonden voor private investeringshoogte, gezamenlijke investeringshoogte, aanwezigheid van een energiemanagementsysteem in scenario 2 en het beheer door vrijwilligers. Het Mixed Logit model werd ook gebruikt. Het model presteert beter in vergelijking met het Multinomiale Logit model. De investeringshoogte blijkt heterogeen te zijn met variatie in voorkeur onder de respondenten. Het aantal leden, de informatievoorziening en het management laten homogene resultaten zien. Het laatste model dat in dit onderzoek is gebruikt, is het Latent Class model, waarmee de respondenten in twee groepen konden worden verdeeld. Klasse 1 bestond uit vooral uit respondenten met een voorkeur voor alternatief 1, private investering, en klasse 2 uit respondenten met een voorkeur voor alternatief 2, gezamenlijk investering. Respondenten met een hoog gezinsinkomen (> 100.000 euro) blijken vaker in de eerste klasse voor te komen. Verder blijken de antwoorden op de stellingen met betrekking tot de beslissingsvariabelen ook invloed te hebben op de klasse waar een respondent toe behoort. In klasse 1 is een significante oververtegenwoordiging gevonden van respondenten met een hoge klimaatbewustheid, subjectieve norm en verlangen naar onafhankelijkheid.

Klasse 2 vertegenwoordigt een hoger percentage mensen met een groot vertrouwen in energieleveranciers. Voor zowel de gemeenschapsaspecten als locus of control zijn geen significante relaties gevonden met de keuze voor een van de twee gemeenschappen.

Abstract:

The increasing problems with climate change and the measures taken because of them increase the demand for renewable energy sources (RES). The transition from current central generated electricity to more local supply is expected. This research adds new information regarding the preferences of households in the participation in a local energy community. A stated choice experiment is used to estimate the characteristics that increase the choice for participation in an energy cooperative or a prosumer community. The analysis conducted with a Multinomial Logit and Mixed Logit model show that these characteristics are investments in a storage facility, total investment height, presence of an energy management system and management by volunteers. Latent Class models show that a prosumer community is chosen by households with a higher income, a higher environmental attitude, a higher subjective norm and with a greater desire to be more independent. People preferring an energy cooperative have a higher trust in energy suppliers.

Keywords: energy community, cooperative, prosumer, discrete choice experiment

List of abbreviations

CBS	Company for measurement of statistics (Dutch: Centraal Bureau van Statistiek)
CES	Community energy storage
DSM	Demand Side Management
EC	Energy community
EMS	Energy Management System
HES	Home energy storage
LEM	Local Energy Market
SCE	Stated Choice experiment
P2P	Peer-to-peer community
PCG	Prosumer Community Group
PRP	Program Responsible Party
PV	Photovoltaic
RES	Renewable energy source
TPB	Theory of Planned Behaviour

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1 Introduction

In this first chapter the research topic will be introduced, starting with a sketch of the context and the definition of the problem. As a result of this problem, research questions are formulated, which will be answered in this report. The main research question will be supported by multiple sub-questions. In order to answer the research questions a research design will be discussed in the third section. At last, a reading guide for this thesis is integrated in this chapter.

1.1 Problem definition

In 2019 the amount of energy used from renewable energy sources (RES) in the Netherlands was still too low. The transition to RES in the Netherlands is too slow to meet the ambitions of the government (CBS, 2020b). The percentage of people buying sustainable energy contracts is still only at one third of all Dutch users, which is mainly due to personal perceptions about sustainable energy (Duurzaam Nieuws, 2019). To increase the use of RES and encourage more people to do so, multiple options have been introduced. The development of local energy projects is rising in the Netherlands. One of the options is development of energy communities. Energy community is a general term for a local energy project, which can be arranged in multiple manners. An energy community can be developed around the purchase of an energy generation system, which can be installed in the home, in the household's neighbourhood or at other nearby external locations. In this thesis the focus will be on private users of energy and specifically on households and its communities. In 2019, in the Netherlands 582 energy cooperatives were founded, where energy is generated at a collaborative energy plant which supplied electricity for 97,000 households (HIER Opgewekt, 2020a). Prosumers are emerging, a prosumer is someone who not only consumes electricity, but also produces it from renewable energy sources (Ford et al., 2016). These can also be combined in a community, a prosumer community, in order to share electricity. By implementing more energy communities, the percentage of energy generated by RES is likely to increase. Currently, around 12.5 per cent of the Dutch houses generated electricity using PV panels (Alphens, n.d.). For implementation, the willingness of Dutch inhabitants is important. Before inhabitants want to participate, considerations must be made and decisions taken. Choices and preferences determine these considerations. Characteristics of households can play a role in the decision-making, both their socio-demographic characteristics and their psychological reasoning regarding sustainable energy measures. Researches have conducted studies on these variables. They were based on the willingness to change energy consumption or to apply sustainable energy measures (Frederiks, Stenner & Hobman, 2015), but were not directly related to prosumers or communities (Micheals & Parag, 2016). The technical and financial aspects of communities have already been studied (Rathnayaka et al., 2015) and willingness to participate in a prosumer community is already confirmed by de Vet (2018). However, no difference has been made between different community types. In order to influence the enrolment of energy communities a better understanding about the household's preferences and its attributes is needed.

1.2 Research questions

In this thesis the following research question will be answered:

"What characteristics of energy communities and Dutch households influence the choice of energy communities?"

In order to answer the main question, the following sub-questions will be answered:

- SQ1: What is the current position of households in the energy market?
- SQ2: Which local energy community types can be described and what are their characteristics?
- SQ3: What decision-making variables concerning energy related behaviour are relevant to participation in energy communities?
- SQ4: What characteristics of energy communities are in what way associated with deciding to participate in an energy community?
- SQ5: What is the influence of the decision-making variables to participation in energy communities?

1.3 Research design

In order to answer the research questions, multiple tasks will have to be conducted. Although preferences of people are difficult to measure, a Discrete Choice Experiment (DCE) is an option (Shen, 2005). Combining the DCE with a literature study as well as with exploratory interviews provides in both quantitative and qualitative research. A summary of the conducted interviews is visible in Appendix I: Interviews. The literature review will be divided into five sections. In the first section the current electricity systems will be elaborated, including supporting regulations which influences the future energy market and its users. After this an estimation of different energy communities will be determined. Together with a review of the literature regarding the technological developments necessary to apply an energy community and the social effects on the community but also the variables influencing the decision-making. The literature review serves to obtain information for the preparation of a questionnaire. With the DCE several attributes will be presented to the respondents, and they can indicate their personal preferences. After data collection, analysis will be conducted. The most obvious analysis method is the random utility model (Hensher et al., 2015). The choice is made to conduct three analyses on the data, the multinomial logit model (MNL), the Mixed Logit (ML) model, and the Latent Class analysis. The connection of the research questions and the research design is visible in Table 1, and Figure 1 visualizes the complete research design.

Table 1. Research questions and research design

Research question	Method
SQ1: What is the current position of households in the energy market?	Literature study, interviews
SQ2: Which local energy community types can be described and what are their characteristics?	Literature study
SQ3: What decision-making variables concerning energy related behaviour are relevant to participation in energy communities?	Literature study
SQ4: Which characteristics of energy communities are associated with deciding to participate in an energy community?	Stated Choice experiment, Multinomial Logit model & Mixed Logit model
SQ5: What is the influence of the decision-making variables to participation in energy communities?	Stated Choice experiment, Latent Class model

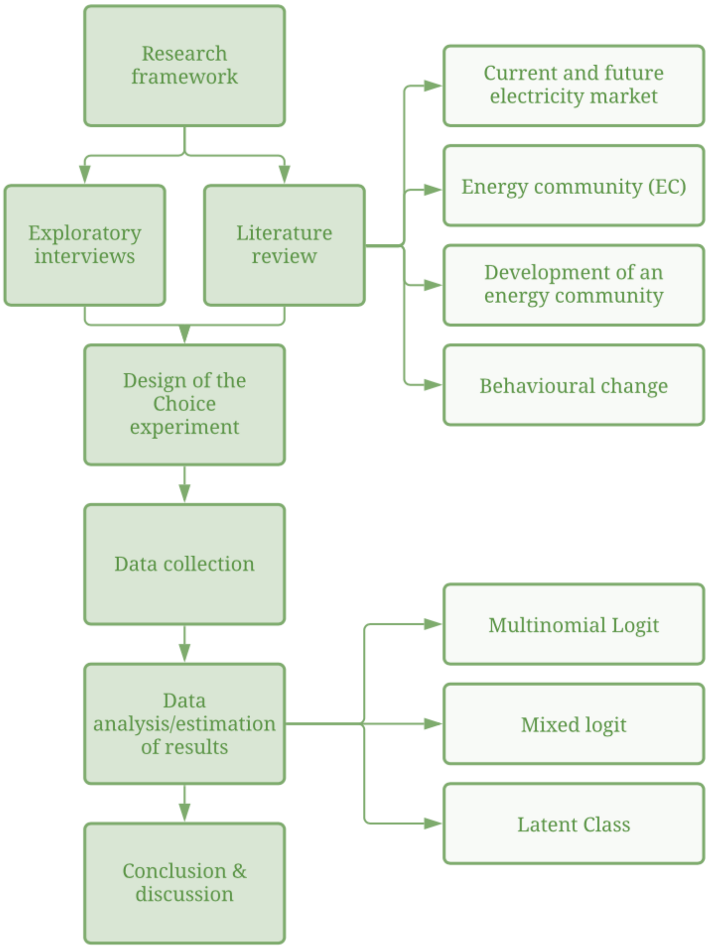


Figure 1. Research Design

1.4 Reading guide

This thesis consists of five chapters. Chapter 2 implies the literature review regarding research about the current situation of the energy market and possible changes in the future regarding energy communities. Furthermore, the technical, financial, and management aspects for these energy communities are discussed in this chapter. Also, the underlying decision-making variables based on environmental behavioural models are extracted from the literature review. The Stated Choice Experiment will be explained in Chapter 3, including the attributes and variables extracted from the literature review and the decisions made regarding the models and analyses. Chapter 4 shows and explains the results of the data collection based on the Stated Choice Experiment. First, the descriptive statistics are discussed followed by the Multinomial Logit Model, Mixed Logit model and the Latent Class Model. Chapter 5 discusses the conclusions of this research, including the answers on the research question. This chapter also includes the scientific relevance of this research and recommendations.

2 Literature review

In this chapter the literature related to the research topics will be discussed, with a focus on the development of energy communities and their effects. At first the current market structure will be explained, together with its pitfalls. Also, solutions for the future will be discussed with specific attention to local production with a sustainable energy source. After this, energy communities will be compared. In the third section the local energy projects will be elaborated on technical, financial, legal and social feasibility. In the last section the scientific literature of behavioural models in environmental studies, and variables indicating whether behavioural change has taken place, will be discussed. This chapter focuses on determining definitions and characteristics of energy communities as well as factors related to households' decision-making.

2.1 Energy market in the Netherlands

In the Netherlands energy is delivered via a top-down approach, where suppliers deliver the electricity from generation (top) to the consumer (down). With this type of system, the electricity flow is uni-directional, which means that it only flows in one way (Mahmud et al., 2020). Until 2004 the Dutch consumer was not able to choose which energy supplier delivered electricity and/or gas, it depended on the regional supplier. The liberalisation of the energy market due to the Electricity Act of 1998, made choices for energy supply possible. Consumers were able to clarify their preferences. Suppliers offered differences in price, service and level of sustainability (Energievergelijken, n.d.). Since 2004, freedom of choosing increased, energy prices became more competitive and the customer experience became more important (Energievergelijken, n.d.). These developments will be elaborated in the next sections.

Dutch electricity market

The process of electricity purchase is shown in Figure 2. Generation is the first part, and is done by Vattenfall, Essent, Engie, Deltam Eneco and EON. The Dutch electricity market is largely depending on fossil fuels, where only a small fragment of 18 percent was produced via Renewable Energy Sources (RES) in 2019 (CBS, 2020a). In the top-down approach the energy supplier is responsible for the generation, and therefore for the choices about the energy source. The system is arranged around big power plants, the entry of smaller and local suppliers is more difficult (Weterings et al, 2013). In the Netherlands, three types of energy have been marked by the colours grey, orange and green. Green energy is the same as sustainable energy, where there is no dependency on fossil fuels (Duurzaam Actueel, 2018-a). The term 'orange energy' is confusing because it is green energy but entirely generated from renewable energy sources in the Netherlands. Examples are windmill parks, solar panels and biomass industries. The energy generated by solar panels in the domestic environment is also called orange (Energievergelijking, 2020). Every kWh generated via a sustainable method gets a certificate. These certificates are issued within Europe and can be sold to other companies and countries. The risk with this system is that grey energy, energy that is generated from non-renewable energy sources, can be sold as green energy (Duurzaam Actueel, 2018-b). In short, the new term orange energy defines that the energy is completely renewable and generated in the Netherlands.

After generation, the program responsible party (PRP) comes in place. Tanrisever et al (2013) defined their tasks as "ensures the real-time balance of the grid, since electricity cannot be stored and has to be consumed at the time of production". This party is mainly involved in the forecast of the electricity demand. In the Netherlands, the same company is responsible for the balance of supply, demand and the transmission. Transmission is done by the grid operator, TenneT. They are also responsible for checking the network for safety and investing in the extension of networks (Netbeheer Nederland, 2019).

The distributors take care of the final supply of electricity. About the distribution, Tanrisever et al (2015) stated: “the distributor is responsible for the construction, maintenance, management and development of the transportation and distribution networks for electricity between the high voltage grid and the customers”. The distribution is based on the geographical location, on the region they are operating in. Therefore, no choice can be made between the distributing companies, which are Enexis, Liander, Stedin, RENDO, Coteq, Enduris and Westland Infra (Energievergelijken, n.d.).

The suppliers are responsible for delivering electricity according to the contract with the consumer. In 2017 there were 40 suppliers in the Netherlands, but this number constantly grows (Bours, 2018). The supplier cooperates with the metering company who collects the data of the consumers and shares this with the consumers (Tanrisever, 2013).

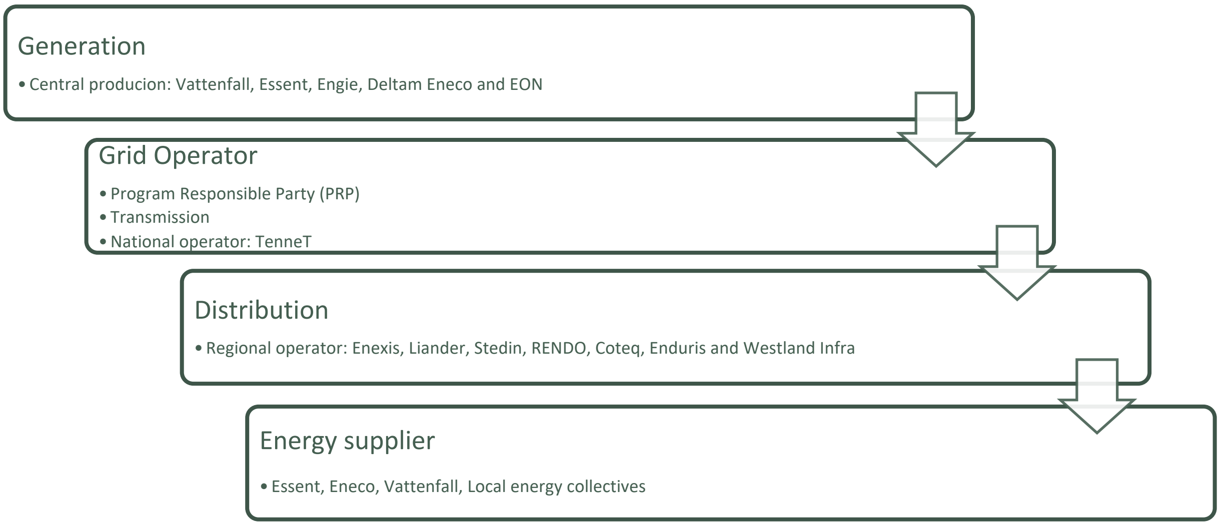


Figure 2. Dutch Energy market (Netbeheer Nederland, 2019; Tanrisever et al., 2015)

Consumers choose a supplier and enter into a contract with them. The main reason for people to transfer to another supplier in 78 per cent is the price. And in 16 per cent of the cases sustainability is the main reason to change an energy contract. Other reasons for transferring are presents received, special services and the overall service of the supplier (Bours, 2018). There is a positive development in the number of contracts with green or orange electricity. The number of completely green and orange contracts has increased from 8 per cent in 2015 to 27 per cent in 2017. This is due to the increased supply of orange energy, but also to an increasing demand. Especially in between 2015 and 2017 the bigger energy suppliers, such as Vattenval and Eneco, started providing orange energy. Nevertheless, since 2017 the growth stagnated, because there was no further increase in new orange energy suppliers (Pauwels, 2021).

Pitfalls

The current energy system is based on the principle of producing when there is demand, and expectations regarding demand and supply are set by PRP. The supply of electricity in the current system is well regulated. This is not the case with RES since they are weather dependent (Weterings et al., 2013). Due to the introduction of RES, the energy system needs to be more flexible because of the fluctuating deliveries of solar and wind energy.

Van Loo (n.d.) expects that before 2030 the flexibility of the system should double and between 2030 and 2050 it should triple, compared to the current situation. The main reasons he gives are the increase of energy consumption and the growing usage of solar and wind energy.

The shift to more renewables in energy supply is necessary to comply with the Climate Agreement of the European Union (European Union, 2017). The current top-down energy delivery system is mainly based on fossil fuels, so it leaves a major challenge for the infrastructure in the Netherlands (Ecovat, 2019). The national electricity grid is originally developed in the uni-directional flow, where the biggest grid sizes are around the generation facilities and in urban areas. In rural areas, where less people live, small electricity grids are available. Due to the development of windmills and solar parks in these areas, the demand for more capacity increases. For the development of a decentral system, the improvement of a high voltage network is an issue because it is a time-consuming process (Netbeheer Nederland, 2019).

Also, the current system has some disadvantages according to Tomc & Vassallo (2015). First, during the transmission process, electricity losses occur. In the Dutch distribution process a total amount of 4-5% of the electricity is lost during the distribution, in 2014 a percentage of 4.77% (Indexmundi, 2019). The multiple stakeholders and the long delivery process could explain these losses, making it an inefficient way of conversion of electricity. Furthermore, the transmission process from national to the regional grid makes the process vulnerable at some locations. Also, during the day, peaks in the energy demand occur which can cause inefficient provision during these periods (Tomc & Vassallo, 2015).

Dutch policy

The Netherlands are part of the European Union. Therefore, targets and regulations are based upon the European Unions' regulations together with the Dutch law. The European commission developed policy standards in 2016 for climate and energy. It indicates, until the year 2030, the CO2 emissions should be decreased with at least 40 per cent compared to the base year 1990. Instead of decreasing the CO2 emissions with 40 per cent, a decrease of 49 per cent will be the goal until 2030 for the Netherlands. In 2050 the emission of CO2 should be decreased with 95 per cent compared to 1990 (Rijksoverheid, 2020c).

Also, the share of renewable energy should be increased to 27% and there should be a decrease of 30% of the energy use in Europe in 2030. The Netherlands created more ambitious goals to have 70 per cent of the electricity generated from renewable sources in 2030, and a complete use of renewables in 2050 (Klimaatakkoord, 2019). To achieve this, much has to be done because the current share of renewable electricity is only 26.3 percent. The electricity generation is done via wind on-shore (7.9%), off-shore (5.1%), PV panels (6.6%) and biomass (6.6%) (Van Gastel & de Jonge Baas, 2021). The share of renewable energy, where electricity and heating are combined, is below 11 per cent in 2020 of the total energy supply (Energie opwek, n.d.).

To achieve these goals the Dutch government has developed sectoral goals. For the built environment the most important transition will be to transform to a gas free heating system. In 2050 every house (7 million) and other buildings (1,5 million) should be free of gas. In August 2020 91 per cent of the buildings were attached to the gas network (Natuur & Milieu, 2020) In 10 years, in 2030, a share of 1.5 million houses should already be disconnected from the gas network (Rijksoverheid, 2020b). Multiple solutions are available, for example a heat network, heat pumps or a full electric system. (Klimaatakkoord, 2019). As a result, a higher demand of electricity will occur. The gas-free development is the responsibility of the municipalities, plans for the development of gas-free neighbourhoods need to be presented in 2021 at last. Part of the responsibility and investments for sustainable improvements of houses lays with the homeowner, or in case of renters, with the building owner. In cooperation with the municipality, responsibility for a neighbourhood approach for disconnecting from gas can be taken and a fully gas free house can be created.

Measures

In order to achieve the developed policies, the government tries to stimulate sustainable measures or makes use of non-renewable energy less attractive. A few of those regulations are relevant for the energy markets, and also have effects on the households. At first, the government uses taxes to discourage the use of gas. Therefore, in the past years the height of the taxes for gas increased, where it decreased for electricity (Klimaatakkoord, 2019). This is visible in Table 2. Another increasing tax is the ODE (Opslag Duurzame Energie- en Klimaattransitie), which is tax for both electricity and gas. With the proceeds of the ODE the government finances stimulating subsidies for investments in sustainable energy and its systems (Belastingdienst, 2020). Electricity is seen by the government as a necessity. Therefore, a tax relief is given back to every household based on the tariff in the table. This amount increased in the past years but covers only part of the energy expenses of a household (Rijksoverheid 2021).

Table 2. Development of energy tax 2013-2021 (Belastingdienst, 2021)

Tax	2013	2014	2015	2016	2017	2018	2019	2020	2021
Gas [€/m^3]*	0.1862	0.1894	0.1911	0.2514	0.2524	0.2600	0.2931	0.3331	0.3486
Electricity [€/kWh]*	0.1165	0.1185	0.1196	0.1007	0.1013	0.1049	0.0986	0.0977	0.0942
ODE heating [€/m^3]*	0.0023	0.0046	0.0074	0.0113	0.0159	0.0285	0.0524	0.0775	0.0851
ODE electricity [€/kWh]*	0.0011	0.0023	0.0036	0.0056	0.0074	0.0132	0.0189	0.0273	0.0300
Tax relief electricity [€]	318.62	318.62	311.84	310.81	308.54	308.54	257.54	435.68	461.62

**prices excluding VAT*

Another form of stimulation of sustainable living is the use of subsidies for investments. Since 2021, the government developed a subsidy scheme called ISDE (Investeringssubsidie duurzame energie en energiebesparing voor woningeigenaren), where the focus is on sustainable energy and energy efficiency. With the regulation, homeowners can get subsidies for extra insulation, heat pumps, connection to a heat network and solar boilers. Depending on the system size, building size, and an energy label, the amount of subsidy can be calculated via a tool (RVO, 2021). Earlier, there were also subsidies for PV panels, but these are withdrawn. Nevertheless, there is a compensation in the form of VAT (BTW) refund when PV panels are bought, a compensation of 21 per cent on the total expenses.

Currently, there is a regulation so-called the 'salderingsregeling'. This regulation is applicable for small generators. It calculates the amount of generated electricity which is returned to the grid and subtracts this from the total energy demand of a certain household, on a yearly basis. Households receive the same tariff for the returned electricity as they would have to pay for supplied energy. Therefore, households do have a financial gain by generating energy. However, this regulation is about to change, starting in 2023 and ending in 2031. In 2023 the government intends to lower the amount of compensation until it is zero in 2031. This means that the financial benefit households receive for generating their own energy will decrease (Rijksoverheid, 2019). The lowering of the regulation will influence the revenues of solar panels or other renewable energy generators. The result will be that during the day (when the PV panels generate electricity), nothing has to be paid for electricity when there is enough supply of the PV panels. But, during the evening, when there is no storage and no generation, households will have to pay for the electricity they use according to the regular energy tariff. When the energy supply during the day exceeds the daily demand, the over-supply of electricity can be returned to the grid. The energy supplier will compensate the household for this oversupply, which is currently between 5 and 7 cents/kWh. Compared to the fee that has to be paid for one kWh of supplied electricity, 22 cents/kWh, this is much lower (Hendrikcs & Mesquita, 2019), and therefore financially less beneficial.

The last relevant regulation for sharing energy is organised among neighbourhoods. It is called the 'Postcoderoosregeling', which allows households in the same postal code region to share energy (Campos et al., 2020). For example, outside the postal code region it is not allowed to share energy with friends or family. This requires a license including strong regulations in organizational, technical, and financial aspects (Hazenberg, 2019). Nevertheless, within the same postal code it is possible to share energy, including energy from bigger sized systems with community investments (solar or wind parks). In the latter, members of a community will get a reduced tariff for electricity for 15 years. From 2021 onwards, the 'Postcoderoosregeling' will change to a subsidy for cooperatives for 15 years, where the owners' association or cooperative is responsible for assigning this to its members, creating a less complex tax system is organized for the government. Higher subsidies should increase the attractiveness of creating a middle-sized generation system (between 15 and 300 kWp for solar projects and between 500 and 1000 kWp for wind projects). The current regulations regarding postal code regions remain the same (HIER Opgewekt, 2020-b). The height of the subsidy and what the impact for investing households will be is, until now, unclear.

Expectations

The shift to a system where RES will be used instead of fossil fuels is complex and can be done in multiple ways. The market will change to a more decentralized system with smaller producers of RES (GEF, 2018). Figure 3 shows the expectation regarding the transition of the energy system. A shift from large power plants to multiple smaller production units based on RES is expected. With this shift to multiple smaller production units, the scale of the energy system becomes smaller and more regional instead of national, this also holds for the transmission. The distribution will be more bi-directional. Remarkable in the expected change in the energy system is the participating consumer, which becomes more active. Instead of only purchasing energy, they are also able to generate, store or give back to the grid (GEF, 2018).

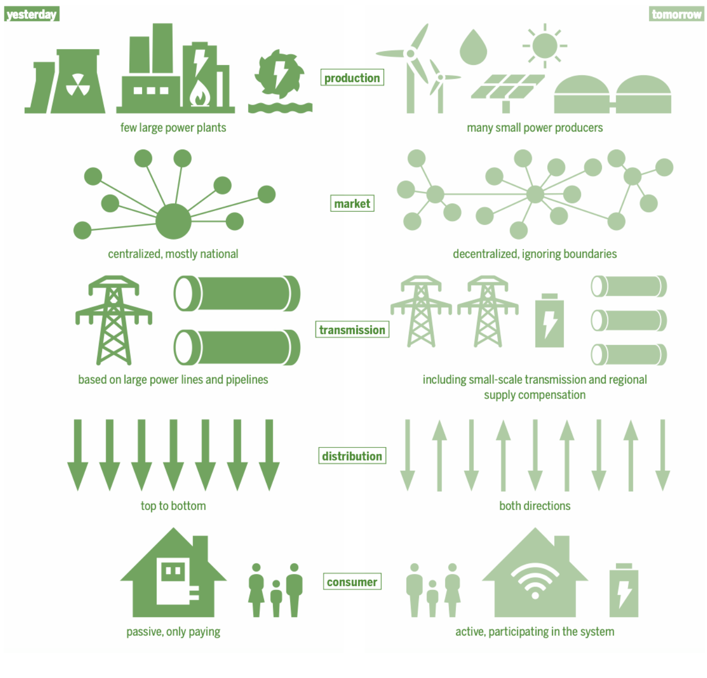


Figure 3 Expected changes in energy system (GEF, 2018)

Prosumer

The outlined developments and expectations with regard to the energy market in the first part of this chapter influence the role of participants. As can be expected their role will become more important in the future. The definition of a prosumer used in this thesis is defined in the following way: "An energy prosumer is a consumer of energy who also produces energy to provide for their needs, and who in the instance of their production exceeding their requirements, will sell, store or trade the surplus of energy" (Ford et al., 2016). In the case of a prosumer, the passive traditional consumer changes to a more actively involved prosumer in generation and distribution of RES (Van Summeren et al., 2020). With this change towards a more active participant in the energy market, the prosumers can have more control in both their consumption and distribution of energy (Lavrijssen & Carrillo Parra, 2017).

One of the most important differences with the traditional consumer is the involvement of the consumer. In the traditional system, decisions are made by the supplier and information about the usage of electricity is given after metering. By becoming prosumer, the management of energy behaviour is given into their own hands. Direct changes in demand can be seen by the prosumer (Mengelkamp et al., 2019) and decisions are made by the individual (Rathnayaka et al., 2014a). By becoming prosumer, people have the opportunity to change the current system into a grid with bidirectional flow. With this change the prosumer has the opportunity to change the current system. At first, the installation of microgeneration is done by the prosumer. The demand and supply happen within the same environment, with the possibility of extending this to a local community. The problem of the vulnerable traditional system is becoming more local and therefore trackable (Reijnders et al., 2020). With the involvement of peak load management, peaks in the demand can be solved (Oberst et al., 2019).

To conclude, the current energy market is built around large power plants and big energy suppliers are leading the market. Due to the new climate goals of the European Union and the Netherlands, the traditional generation of energy from fossil fuels needs to change to a system where energy is generated from renewable energy sources. The Dutch government introduced regulations in order to stimulate local production with the 'Postcoderoosregeling' and benefits of PV with the 'Salderingsregeling'. But these regulations are changing, which will probably have impact on Dutch households. The expectations are that the national energy grid, build around large power plants, will change from a top-down structure to a decentral system, where the households are actively involved. Therefore, the definition of a prosumer becomes relevant. Prosumers have more control over their demand and supply of energy and, by doing so, can change the market by getting actively involved in the supply and demand of renewable energy. In order to develop local energy projects with RES, the factors related should be discussed. In the next section, multiple local energy projects will be discussed.

2.2 Local energy systems

Regional sustainable solutions have become familiar in the past years, but have got multiple names and different associated definitions with them.

Communities

Community energy is a general term for a local energy system. In this case, a community is bounded by their geographical location where the inhabitants work as an entity. They are responsible as a community for the generation, distribution and consumption of the energy from the system, whether this is done directly or indirectly. The community members are (partly) owners of the microgeneration system which can be determined by themselves, and therefore, have a responsibility for costs of realization and the benefits that are associated with the system (Tomc & Vassallo, 2015).

A local energy community can have the potential to supply in the needs of the inhabitants together with an initiative that fits the local inhabitants. With this community, inhabitants are brought together and will be working on the achievement of a common goal (Koirala et al., 2016). The community which is applied in a specific place can be differentiated based on generation, transmission, distribution, supply and demand, governance and ownership (Creamer et al., 2018).

In the past years, different communities have been mentioned in literature. Table 2 gives an overview of some of the definitions mentioned in different kind of researches. It could be concluded that most of them are overlapping in their goals and description. Overall, they are introducing renewable energy sources in a local community, some where it is only specified on RE (Renewable Energy) and some where the overall sustainability of the community is the common goal.

Some of the community types are not only involved in RE but overlap in more sustainable innovations, which are not chosen (ICES/CEC) (Koirala et al, 2016;Gui & MacGill, 2018). Some of the definitions are more general and relate to the overall definition of an energy community (LREO/ESC/REC/LEM) (Boon & Dieperink, 2014; Schweizer-Ries, 2008; Azarova et al., 2019; Mengelkamp et al., 2019). This leaves only a few definitions, where the topics with prosumer community group (Rathnayaka et al., 2015) and prosumer-to-grid models (Parag & Savoscool, 2016) are overlapping. The P2P community is a less structured way of sharing resources, but in principle it works the same as a prosumer community (Luth et al., 2018). It can be summarized in the following community types: the energy cooperative (Filipovic et al., 2019; Hufen & Koppenjan, 2015), and the prosumer community (Parag & Savoscool, 2016). These two community types will be explained further and will be compared.

Table 3. Overview of community energy projects.

Definition	Description	Source
Peer-to-peer models	"P2P is the ability to trade electricity with one another, gain revenue for excess power, use a low-cost settlement system to reduce electricity bills and improve returns on investments in distributed generation"	(Lüth et al., 2018)
Prosumer-to-grid models	Prosumers that are connected to the microgrid, where this can function as an island (off-grid) or grid connected.	(Parag & Savocool, 2016)
Organized prosumer groups	Local prosumer markets where the smart grid is used to locally organize communities which manage their energy demand, with local balancing, stakeholder needs and presumption services.	(Parag & Savocool, 2016)
Energy cooperatives	Shared citizen ownership and operation of renewable resources. The local cooperative is functioning as retail organization selling renewable energy.	(Filipovic et al., 2019; Hufen & Koppenjan, 2015)
Local energy market (LEM)	"A market platform for trading locally generated energy among residential customers within a geographically and socially close community"	(Mengelkamp et al., 2019)
Renewable energy communities (REC)	'Groups of citizens, social entrepreneurs, public authorities and community organizations participating in the energy transition by jointly investing in, producing, selling, distributing and consuming renewable energy"	(Azarova et al., 2019)
Prosumer community group	"A network of prosumers having relatively similar energy sharing behaviour and interests, which make an effort to pursue a mutual goal and jointly compere in the energy market"	(Rathnayaka et al., 2015)
Energy sustainable communities (ESC)	"Communities that use RES and act in an energy-efficient way, with incorporating use of resources and emission production"	(Schweizer-Ries, 2008)
Local renewable energy organization (LREO)	"Organizations, initiated and managed by actors from civil society, that aim to educate or facilitate people on efficient energy use, enable the collective procurement of renewable energy or technologies or actually provide energy derived from renewable resources for consumption by inhabitants, participants or members"	(Boon & Dieperink, 2014)
Integrated community energy system (ICES)	"Supplying a local community with its energy requirement from high-efficiency co-generation or tri-generation as well as from renewable energy technologies coupled with innovative energy storage solutions as well as electric vehicles and demand-side measures"	(Koirala et al., 2016)
Clean energy community (CEC)	"Social and organizational structures formed to achieve specific goals of its members primarily in the leaner energy production, consumption, supply, and distribution, although this may also extend to water, waste, transportation, and other local resources"	(Gui & MacGill, 2018)

2.2.1 Energy cooperative

In the Netherlands, if a group of people (community) wants to generate energy, a legal form must be established. A cooperative is the most used form. It consists of a board and members where the members are part of the decision-making process (HIER Opgewekt, n.d.). The manner of decision-making, management or share of benefits depend on the specific cooperative. The members can decide how they will regulate these things. The cooperative decides about what type of renewable energy source will be used. In the Netherlands in 2019 there were 582 energy cooperatives, with an estimated amount of 85,000 members. Most of the cooperatives developed solar projects (80%) and wind projects (24%). The current trend is an increase in the number of projects which aim on heating and mobility (HIER Opgewekt, 2020).

According to HIER Opgewekt (2020) there are two types of cooperatives in the Netherlands:

- local energy cooperatives: the focus is on making the environment more sustainable. They are not only focused on renewable energy but also on energy efficiency and new technologies. In 2019 there were 448 of these local cooperatives.
- production cooperatives: these cooperatives are specifically focused on the generation of renewable energy. It is often a part of local energy cooperatives which are separated due to its legal form (118 in 2019). Other production cooperatives are developed by inhabitants (57), owners association (13), companies (3) and project developers (61).

The cooperatives have different possibilities to gather the financial sources in order to place a local energy system. The 'Postcoderoosregeling' makes it possible to share energy with members of the same postal code. With this arrangement it is mandatory that the cooperation is the one who owns the installations for RES generation. This makes it possible for members to buy a share, for example one solar panel (300 euros). Earlier, these cooperatives were financed completely by small companies and inhabitants, but with the increasing amount of the systems, banks and developers become involved more often. Developing a cooperative has the advantage that members are not liable for financial risks (HIER Opgewekt, 2020). Energy cooperatives are developed out of the intention to make energy use more sustainable, but also because of the dissatisfaction with suppliers and companies associated with energy supply, as well as the associated financial benefits and being more involved in the community. Not only energy goals can be achieved by developing a local cooperative with citizen involvement. Social cohesion, increase of liveability, more sustainable behaviour overall are also some of the associated benefits of the development (Klopstra & Schuurs, 2013).

2.2.2 Prosumer community

An individual prosumer is functioning on its own but can be united in a prosumer community. This prosumer community is a group of prosumers, sharing and consuming the electricity locally (Olivier et al., 2017). In a prosumer community the goals of the group are more specified and are used as a guideline. The forming of the group depends on the interests of the community members (Parag & Savocool, 2016). Because of the natural location of houses (geographical location) only small groups can be developed among neighbours (Sousa et al., 2019). Another definition of the prosumer community is the goal-oriented prosumer community (GPC) or the prosumer community group (PCG). When the prosumer community is coupled via the geographical location, the GPC is based on mutual goals. The extension towards a GPC is likely to be more interesting for involvement. Individual prosumers are likely to be more interested to be coupled with households with similar goals. Because of coupling in this manner, the mismatch in expectations and opinions could be minimized. The GPC can be stable in a longer period of time (Rathnayaka et al., 2014a).

The members of the group are partners and should work together to achieve the community goals and provide each other with the services, for example electricity and storage (Parag & Savocool, 2016). Every member of the group shares its oversupply of resources with the group, without having direct contracts with all members. Oversupply is shared with the group, not with a single household. With the involvement of a community manager the electricity can be handled centrally (Sousa et al., 2019). With this type of community issues depend on the complexity and costs of the management between the individual prosumers. Also, connections should be arranged and managed and peak demand in the group handled (Parag & Savocool, 2016).

There are strong motivations why it is useful for both the individual and a region to have prosumer communities. Individual prosumerism has the disadvantage of being inefficient because most of the energy is generated via solar panels. As explained earlier, in this system, the electricity generation depends on the weather circumstances and the generation during the hours the sun is shining. Due to the inefficiency and insecure delivery of energy by an individual prosumer, the prosumers will not get access to the energy market as supplier of energy (Rathnayaka et al., 2014a). Participating in a community, where multiple prosumers are active, could result in a more reliable supply of energy without the interference of the main grid. The bargaining power of the prosumer increases with community involvement and can make the gap smaller with the current energy suppliers (Ciuciu et al., 2012). Espe et al (2018) mention that the efficiency of the grid usage improved with integrating prosumers in a smart grid. The main reasons they give for these findings are the communication about and with household appliances by the use of smart devices and by offering storage options and methodologies for matching demand and supply for energy.

From the prosumers point of view, the desire to decrease on costs of energy, to live more environmentally friendly, and the solar panels becoming more standard, are some of the main reasons why people choose for a more sustainable way of living (Ford et al., 2016). The main drivers of participants of a local energy community were explicitly the locality of the RES and the local identity. Furthermore, sustainable solutions for the energy targets, social cohesion, local employment opportunities, economic motives, the feeling of having control and trust over the RES, having active information about energy use and possible feedback, are drivers in becoming prosumer (Timmermans, 2017).

A less structured version of a prosumer community can be the Peer-to-peer (P2P) community. The P2P community is a possibility for the inhabitants to create arrangements between two or more households. Therefore, prosumption services can be divided between these households (Parag & Savocool, 2016). Peer-to-Peer (P2P) trading makes it possible for the peers to collaborate with the systems they own. Two peers can negotiate on the supply of energy without involvement of supervision (Sousa et al., 2019) or conventional energy suppliers (Ning et al., 2018). As a consequence, there is a freedom for the households in their choice in how they participate, with whom, etc., all to the preference of the peer. With this less structured system, the guarantees for a high-quality energy supply are less insured compared to a prosumer community. Also grid operators should be involved in the system to analyse system behaviour and ICT systems need to be introduced (Sousa et al., 2019).

The peers in the network function on their own, and possibly according to their contracts with others. Bilateral contracts are contracts which are used for a longer time. They are used to negotiate price and quantity for the traded energy. For a certain amount of time, people with these contracts are supplied with energy at first. The remaining energy from peers is returned to the market where real-time trading happens, with trading based on a bidding process (Li & Ma, 2020). Peers who are not supplied in their energy needs, will be supplied by the energy supplier at a rate of 22 cents/kWh (November 2020) (CBS, 2020)

A consequence for households is that they can set their preferences by themselves, and requirements for price and quantity can be laid down in a contract between peers. A more real-time energy trading with actual prices is possible. Prices of energy fluctuate during the day, so cheaper prices are possible compared to the traditional prices (22 cents/kWh). With this system prosumers are able to increase their revenues from their PV system, and consumers are able to buy cheaper electricity at certain times (12,09% decrease per day) (Li & Ma, 2020).

2.2.3 Challenges with communities

With a new innovative system, challenges occur regarding the implementation. These challenges are related to financial, management, technological, policy and psychological aspects (Lavrijssen et al., 2017; Mamounakis et al.,2018; Ford et al., 2016; Zafar et al., 2018; Sousa et al., 2019; Rathnayaka et al., 2014; Razzaq et al., 2018; Iliopoulos et al., 2020). The technological challenges are focused on grid functioning, the integration of renewable energy and its functioning, and as already mentioned, the weather dependency is an issue with this kind of RE. Financial challenges are an issue in most of the new solutions. The costs of the systems are quite high for most households, which can cause negative perceptions about the introduction of energy communities. This is associated especially with the willingness of households to pay, the length of payback period, fear of costs and the height of the benefits. The management of a prosumer community is also an interesting but complex aspect. Due to the many stakeholders and their individual goals and preferences, no overall solution has been developed yet. The legalisation of sharing energy in the Netherlands is an advantage for the integration of the system, but obstacles as the ‘Postcoderoosregeling’ make it more difficult to share energy outside the postal code. The last challenge category depends on the psychological aspects, with a focus on the individual’s perception and participation. In Figure 4 the most important challenges in relation to participation in a prosumer community are summarized, the specific challenges related to a prosumer community are indicated by (pc). Otherwise it also holds for an energy cooperative, p2p community or the other community types described.

Technological	Financial	Management	Policy	Psychological/social
• Absence of metering real-time data (pc) • Reliability • Maintenance • Grid congestion • Unpredictable supply (weather)	• Costs of system and installation • Length of payback period • Cost of storage facilities • Short period funding • Fear for costs and the height of benefits	• Attraction of new participants • Categorizing prosumers in groups (pc) • Defining mutual goals (pc) • Stakeholder management • Treatment of all members	• Definition of prosumers in EU (pc) • Legal obstables • Legal form of cooperative	• Lack of commitment • Lack of knowledge • Prosumers staying inactive (pc) • Security and privacy • Lack of information and support

Figure 4. Challenges with prosumption

To conclude, for different forms of energy communities, all with their own characteristics, multiple definitions have been developed. Most of these definitions use the prosumer as active component in the supply and demand for electricity and, in some cases, heating. Out of the multiple definitions two different terms, which can change the local energy market in their own manner, can be extracted. An energy cooperative is developed at an external location where households can own a piece of the project by buying a share, for example with the ‘Postcoderoosregeling’ members can use the tax reduction to reduce their energy bill. The other chosen term is the prosumer community, where households act as prosumer by generating their own electricity. Combining prosumers in a community has the advantage of being more efficient in the energy supply, due to a natural development of different energy use patterns of households. A less structured form of a prosumer community can be described as a P2P community, which leaves a part of the network free to use by prosumers and where they can form contractual relations between peers to share resources.

With these two communities, challenges in the development are likely to occur. Technological, financial, management, policy and psychological challenges are associated with both community types. In the next section the technological and financial aspects related to the development of an energy community will be discussed.

2.3 Technological and financial aspects

The technological development of a community can be different for the two discussed community types. In this section the important technological development of the components for an efficient electricity network will be discussed. The difference is made between domestic measures and community measures. At first the community network will be discussed, followed by manners of generation, energy storage and energy management systems.

2.3.1 Community network options

Smart grid

For a community to be able to function as a community, either coupled or not coupled with the national electricity grid, a smart grid is necessary. The smart grid is "An electric system that uses information, two-way, cyber-secure communication technologies and computational intelligence in an integrated fashion across electricity generation, transmission substations, distribution and consumption to achieve a system that is clean, safe, secure, reliable, resilient, efficient and sustainable" (Espe et al., 2018). A smart grid system works together with multiple stakeholders in a network and is bidirectional.

In order to have a good functioning smart grid network, the grid should at least contain smart devices, bidirectional communication possibilities, an advanced software infrastructure and an energy sharing network for the prosumers (Rathnayaka et al., 2012). One of the most important necessities for the smart grid to function as it should be is the development of Internet of Things (IoT), where various sensors are integrated which control the system (Ciuciu et al., 2012).

The smart grid is another way of distributing energy in a grid compared to the traditional utility grid. The traditional grid is mainly focused on the distribution of energy from the generator to the consumer (top-down and one-directional). With the involvement of ICT tools and smart generation technologies a bidirectional grid can be developed with the following benefits: self-healing, safe from cyber-attacks, plug-and-play facilities, flexible and user-friendly (Rathnayaka et al., 2012a). With the involvement of smart meters, the prosumers get more accurate information and up-to-date information, and thereby awareness about their energy behaviour (Dane et al., 2020).

Virtual Power Plant

A Virtual Power Plant (VPP) can be seen as a form of a smart grid. This system enables the energy, which is generated in a community, to be consumed within the community (Van Summeren et al., 2020). The VPP is defined as: "A software-based solution that aggregates distributed energy resources into one coordinated and controlled portfolio that operates as one single entity similar to a conventional power plant, and which allows for performing roles in the electricity system related to managing and trading of electricity" (Van Summeren et al., 2019). The VPP consists of generators, controllable loads, and possible storage systems, together in one cluster. The generator of energy could consist of both renewable energy and fossil fuels to supply the electricity (Saboori et al., 2011).

Microgrid

Another functional system is the microgrid, which is a smaller system compared to the VPP. The microgrid is defined as "an electricity distribution system containing loads and distributed energy resources, (such as distributed generators, storage devices, or controllable loads) that can be operated in a controlled, coordinated way either while connected to the main power network or while islanded" (Marnay et al., 2015). The microgrid is a system that can function on its own. Due to the less intermediary parties, transaction costs and losses can be decreased (Nosratabadi et al, 2017; Rathnayaka et al., 2014).

Both VPP and microgrid are based on a technical system which results in a fixed combination of prosumers, extension with other prosumers is more difficult (Rathnayaka et al., 2014). It could be said that this results in a rather inflexible system.

2.3.2 Energy generation

Renewable energy could be used to generate energy and is an energy source which is inexhaustible in nature. Renewable energy generation can be done in different scale levels. In this research the focus is on development of generation systems for households. Therefore, the neighbourhood level and individual building level will be analysed. For the individual building, only houses will be incorporated, other buildings will be neglected in this research.

Neighbourhood level generation

Neighbourhood level generation is related to the energy cooperative and allows the energy source to be bigger than at individual buildings. The most common energy cooperatives generate electricity via wind or solar energy (HIER Opgewekt, 2019). Where the domestic generation depends on a small scale due to the available roof-space or the size of a windmill, the joint investment is based upon bigger sized systems depending on the needs of the neighbourhood. The most common energy generation measures are solar and wind energy.

Solar energy

Solar energy is used to generate electricity, but also water can be heated, using the power of the sun. The most common system is the Photovoltaic (PV) panel where the sunlight is converted to electricity (Evans, 2011). The PV panels have the advantage of being scalable. Depending on the electricity demand, a number of panels can be determined. Furthermore, maintenance is only needed in a few cases and with the generation no noise will be created. Due to the use of sunlight, the system depends on the weather conditions (Sendy, 2020). Although, PV panels generate electricity even on a cloudy day, but the efficiency of the system increases with sunnier weather.

Within 'Postcoderoos' projects, in which the inhabitants of the same postal code buy a share in the solar panels of members in the same area, a certificate can be bought for 320 euros and these are transferable between members. The participants have the right on a discount on energy taxes, 12.65 cent/kWh in the cooperative (Zon op Nederland, 2020). This sum is calculated and accompanied by the energy supplier. The payback period is between 8 and 10 years (RVO, n.d.-b).

Wind energy

Wind power is used to convert kinetic energy into electricity. Windmills are available in different sizes, de bigger the size, the more electricity can be generated. Just like solar energy, wind energy depends on the weather. The big windmills are placed around the country, but also on water are big electricity generation plants installed. The downside is the visual damage in the surroundings the windmills cause. Another disadvantage of wind energy is the associated noise of the mills, but according to Wang & Wang (2015) this is less compared to city traffic. However, the impact windmills have on the surroundings, specifically the impact on animals (birds) is unknown (Wang & Wang, 2015) The size of the system make wind energy is less preferred in neighbourhoods or at the individual building level.

The development of windmill parks can take 5 to 10 years due to grid developments, solar parks an be developed between 1 and 3 years. Therefore, the trade-off between location and the necessity for that specific location is important since grid changes are time-consuming and expensive (Netbeheer Nederland, 2019).

An example of a joint investment is 'Winddelen' where the cooperative sells shares of a big wind turbine, each with a yearly supply of 500 kWh. When the complete number of shares of the wind turbine is sold, the cooperative will be the owner. The proceeds from the wind turbine will benefit the owners. Whenever there is no wind, the energy company (Greenchoice in this case) delivers electricity with the regular tariff (0,22 euro/kWh). The delivering period is as long as the wind turbine works, this can be between 10 and 20 years. The cost of a share is between 200 and 350 euro, and the yearly maintenance costs are between 15 and 25 euro. A household can own 85% of their yearly energy demand via wind shares, for a household of 2 or 3 people this will be a maximum of 6 shares. Profit expectation is 5% on yearly basis, which can grow whenever electricity prices increase. The households decrease their costs of the delivery of electricity (0.08 euro/kWh (Energievergelijken, n.d.)), but still have to pay the taxes and distribution costs (0.14 euro/kWh) (RVO, n.d.-a). After two years contracts can be sold per half year, based on the lifespan and energy costs at that time. This is done by the company at the owner's instruction (de Windcentrale, n.d.).

Assuming a yearly demand of 2832 kWh, based upon estimations of NIBUD (Gaslicht, n.d.), with a capacity of one wind share, the maximum of 85 per cent will be achieved with 5 shares. For solar shares it will take 9 shares, although the benefits are growing faster for wind energy. Table 4 shows the comparison between wind and solar shares.

Table 4. Benefits for shares of a cooperative

Number of shares	Cost wind	Benefits wind	Cost solar	Benefits solar
1	€ 275.00	€ 35.05	€ 320.00	€ 18.93
2	€ 550.00	€ 70.10	€ 640.00	€ 37.85
3	€ 825.00	€ 105.15	€ 960.00	€ 56.78
4	€ 1,100.00	€ 140.20	€ 1,280.00	€ 75.71
5	€ 1,375.00	€ 175.25	€ 1,600.00	€ 94.64
6	-	-	€ 1,920.00	€ 113.56
7	-	-	€ 2,240.00	€ 132.49
8	-	-	€ 2,560.00	€ 151.42

The systems do not require additional systems within the households. In the cases described above, the household invests in an external location to be developed and benefits from the reduced tariff. This can be at a roof of a local farmer, but also on an empty site where either PV panels or wind turbines can be placed, depending on the geographical situation. Depending on the size of the system (number of Watts placed at a location), possible grid reinforcements should be done to overcome the overload in the grid (PBL, 2014).

Biomass energy

Another form of RES is the use of biomass. In order to generate energy, both heating and electricity, waste products from biomass are burned. This waste can be agricultural waste or wood for example. This energy generation option burns materials, but as a result, carbon dioxide is emitted. This makes the generation option not better than fossil fuels in terms of CO2 emissions. Using waste as material for generating electricity, only a reduction in waste is eco-friendly (Evans, 2011). For biomass energy generation, no specific energy cooperative projects where the neighbourhood is part of the supply and demand of electricity have been adopted. Therefore, this will be neglected.

Individual building generation

Before energy generation can take place, a system should be purchased. The size of the system influences the purchase value, which results in a payback period. This payback period can be calculated by incorporating the investment costs of RES system and system requirements, yearly decrease in costs, the supply of energy, the demand of energy, energy tariff and associated taxes, and feed-in compensation (Verheij et al., 2020). The system costs can be split up in investment costs, maintenance and operation costs and energy management (Espe et al., 2018). As for the neighbourhood generation, different systems can be applied in order to generate electricity. Although heating is an important aspect, the focus of this section is on the electricity generation via renewables.

Solar energy

Probably the most seen and known RES which are applicable for households to generate electricity are the photovoltaic (PV) panels. The past years a growth occurred in the number of PV panels placed on both houses and company buildings, which is shown in Figure 5. The number of megawatts generated in 2019 is almost 350% higher compared to 2015. The number of households with solar panels is about 1 million in 2020. This number increased in the past years enormously. The shorter payback period and positive development of prices made purchasing panels more attractive (Ten Teije, 2020).

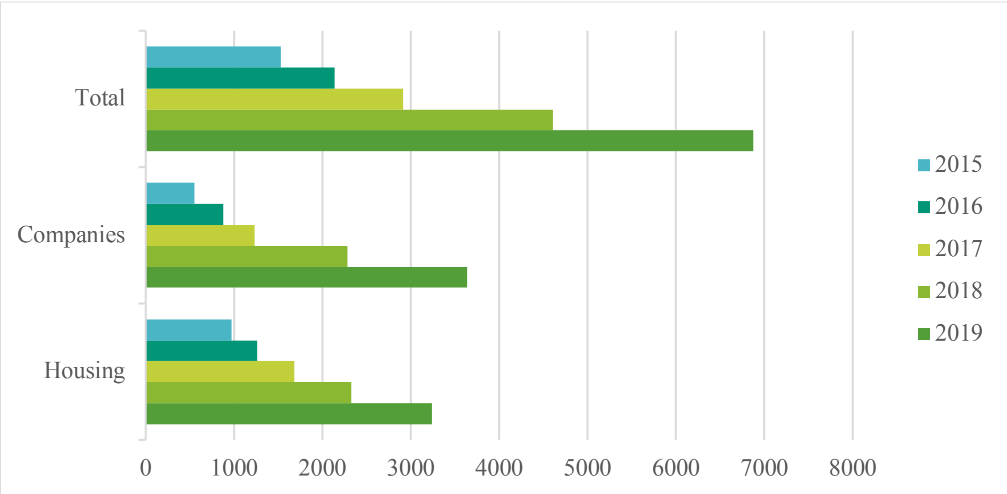


Figure 5. Installed sizes of PV panels in Megawatt (CBS, 2020a)

The investment costs for solar panels in the Netherlands consist of costs for the system itself and costs for installation. The price of the panels encounters about 75 per cent of the total investment (Milieucentraal, n.d.-d). Depending on the orientation of the roof (preferred orientation is south due to the most solar hours in a day) and the amount of roof space, a household can calculate what the number of panels is that they can apply. When the roof space is too small to supply for the electricity needs of a household, the grid will deliver the remainder of the electricity. In case of a prosumer community, this is done by other households in the neighbourhood which have an overcapacity of generated electricity. The electricity need depends on the household themselves: on their behaviour, the housing type but also the number of inhabitants. Table 5 gives an overview of the average amount of electricity use per housing type, split up between one-person households and multi-person households. As can be concluded, differences occur in housing type and the size of the household.

Calculations can be made regarding the number of panels necessary to supply in the own needs of one household, based on the average of electricity use per building type. In the calculations, panels of 290 Wattpiek (WP) are used (Energiewijzer, 2020). The calculations in Table 5 show the rounded number of panels necessary to supply in the own needs of a certain housing type. The bigger the house, the more panels needed.

Table 5. Electricity demand and PV panels per housing type (Milieucentraal, n.d.-b).

Household size	Apartment	Small house	Medium-sized house	Big size house	Detached house
1 person	1550 kWh	1690 kWh	2000 kWh	Unknown	Unknown
Required PV*	6 (*5.9*)	7 (*6.5*)	8 (*7.7*)	-	-
2 or more persons	2220 kWh	2780 kWh	3260 kWh	3860 kWh	4450kWh
Required PV*	9 (*8,5*)	11 (10.7)	13 (12.5)	15 (14.8)	17 (16.9)

* *Number between brackets show calculated results*

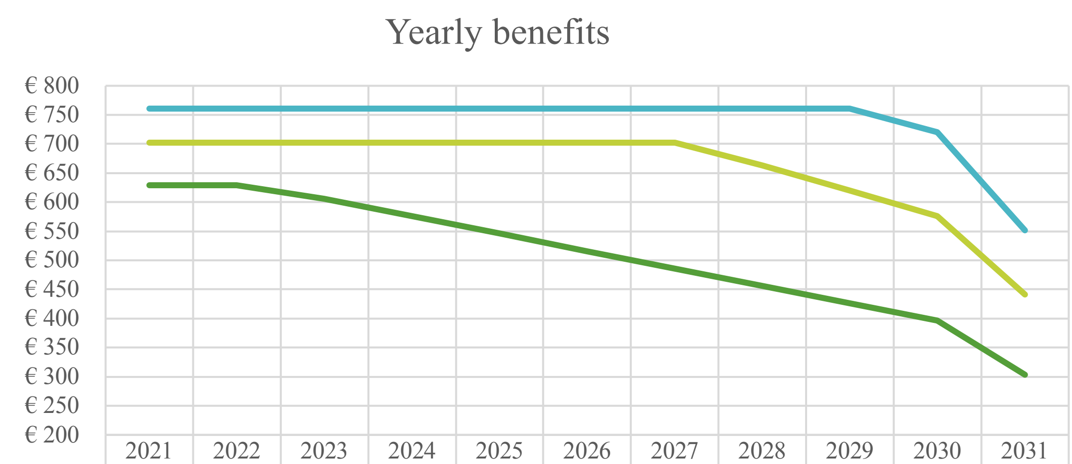
The height of the investment and the length of payback period in solar panels are the two biggest barriers in the decision to buy solar panels (Ford et al., 2016). The investment costs of the solar panels in 2020 are visible in Table 6. The costs after payback of the taxes are also shown. As explained before, the Dutch government arranged the possibility to ask a refund for taxes (BTW, 21%). These taxes are applied for the purchase as well as the installation of the PV panels (Belastingdienst, 2020). Furthermore, several municipalities offer different regulations regarding grants. The national subsidies have been ended but some of the municipalities help homeowners in improving the sustainability of their home. The payback period decreases with the increase of the number of panels, but on average, the payback period of solar panels is between 6.5 and 8 years, assuming that the service life of the panels is 25 years (Zonnepanelen-info, 2020).

Table 6. Costs of solar panels and payback period (Zonnepanelen-info, 2020)

Number of panels	Price including tax*	Price excluding tax	Payback period
8	€4,156.-	€3,435.-	8.2
13	€6,274.-	€5,185.-	7.7
16	€7,264.-	€6,004.-	7.2
18	€7,700.-	€6,363.-	6.8
20	€8,402.-	€6,944.-	6.7
21	€8,808.-	€7,279.-	6.6

**Tax 21 per cent*

The phasing out of the 'salderingsregeling' affects the payback period and the estimated benefits of PV panels. Figure 6 shows the decreasing effect on the yearly benefits, estimation of the graph is based upon calculations in Appendix II, scenario 1, 2 and 3. In the figure is visible that a higher number of PV panels results in a more constant yearly benefit for the upcoming 10 years. This effect is due to the direct use of energy. More PV panels generate a higher supply for direct use of energy (which is free of costs) and less electricity from the grid (which is more expensive) is needed. The lines in the graph show the benefit development for the upcoming ten years. It is visible that the system with 11 panels shows the first effects of the decreasing compensation percentage (due to the 'salderingsregeling'). This regulation is phasing out gradually with 9 per cent per year, but in 2030 the last 28 per cent is phased out immediately. Therefore, the strong decrease in benefits is visible. The higher the number of panels, the more electricity is generated. Therefore, more electricity is available and a relatively lower share of the electricity demand is affected by the difference in compensation.



	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031
11 panels	€ 629	€ 629	€ 606	€ 576	€ 546	€ 516	€ 486	€ 456	€ 426	€ 396	€ 303
16 panels	€ 702	€ 702	€ 702	€ 702	€ 702	€ 702	€ 702	€ 663	€ 620	€ 577	€ 441
20 panels	€ 761	€ 761	€ 761	€ 761	€ 761	€ 761	€ 761	€ 761	€ 761	€ 721	€ 552

Figure 6. Yearly benefits of PV panels including changing regulations

Wind energy

As with PV panels, a small windmill can be placed on the property of the households. The system is not that much applied due to the need of permits and the geographical dependency due to the wind speed at a location (Milieucentraal, n.d.-e). Also, to supply in the energy needs of a household, a windmill of 5 meters wide should be applied (Duurzaam thuis, 2020). The investments in windmill systems have a wide range because of the differences in power. The overall costs for generating one kWh of energy with small windmill systems ranges between 25 and 35 cents. In contrast to the big windmills small windmills are much more expensive, since prices for a bigger windmill are around 8 cents/kWh (Milieucentraal, n.d.-e). Compared to the current energy prices of 22 cents/kWh, a windmill system is less attractive and therefore receive not as much attention compared to solar systems.

2.3.3 Energy storage

A storage system is intended to store the over-supply of electricity generated via the RES. The problem with solar and wind energy is that it depends on the weather, and especially with solar energy, which depends on the solar hours during daytime. In general, households use more energy during the evening because of being at home. An evening peak exists of about 4 hours (Diwan, 2019). So, with solar and wind energy, there is a mismatch between supply and demand. Both energy sources depend on the seasons as well, as can be seen in Figure 7.

A storage system is of great importance to overcome the mismatch between supply and demand and the seasonal peaks. This storage can be done via Household Energy Storage (HES) and Community Energy Storage (CES), as solutions for a prosumer community. Within the concept of HES many prosumers should have their own (battery) storage system. The management system can react to changes in prices, in times of oversupply lower prices are more likely, and the HES can be charged. During higher priced periods, the storage can be discharged. The CES is another innovation, where a management system can manage the shares of each household in the storage system. The same principle of charging and discharging during price changes can be applied to the energy management system (Van der Stelt et al., 2018).

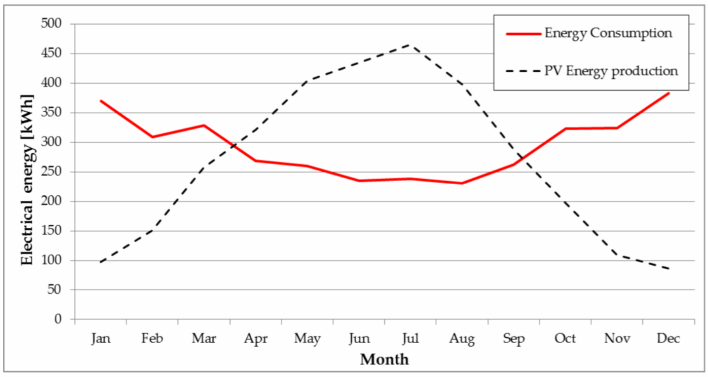


Figure 7 Building electricity use during the year (Jannelli et al., 2014)

Kappner et al (2019) performed a financial study about the effectiveness of PV panels and storage systems. They concluded that it is more advantageous whenever the PV system is larger. Derived from a financial analysis about battery storage systems, it was recommended to skip the storage from a financial perspective. But from a non-financial perspective, the self-sufficiency increases with incorporating a storage system as prosumer. They compared the amount of self-sufficiency with and without a storage system. In Germany, the range of self-sufficiency without a storage system was between 40 and 50 per cent and with a small storage system of 6kWh up to 95 per cent. It is important to notice that a larger storage system does not increase the self-sufficiency above 95 per cent (Kappner et al., 2019).

The prices of battery storage systems remain high, although it is expected that the costs for purchase will decrease. Costs per kWh of storage are between 700 and 1000 euros (Milieucentraal, n.d.-c). The current battery storage systems are sized between 2 and 10 kWh, depending on the size needed for the household. But, seasonal storage needs a lot more storage capacity to overcome the seasonal peaks. Figure 8 shows a more detailed yearly energy generation per month. As can be seen, in the winter months only a fragment is generated. With an estimated daily demand for electricity of 8 kWh (based upon the yearly demand of 2832 kWh), generation in the winter months is not enough with a 16 PV-panel system. As long as the ‘salderingsregeling’ is in effect, storage investments are financially less attractive because of the high costs. In the future, when this arrangement will be phased out, storage can become more favourable.

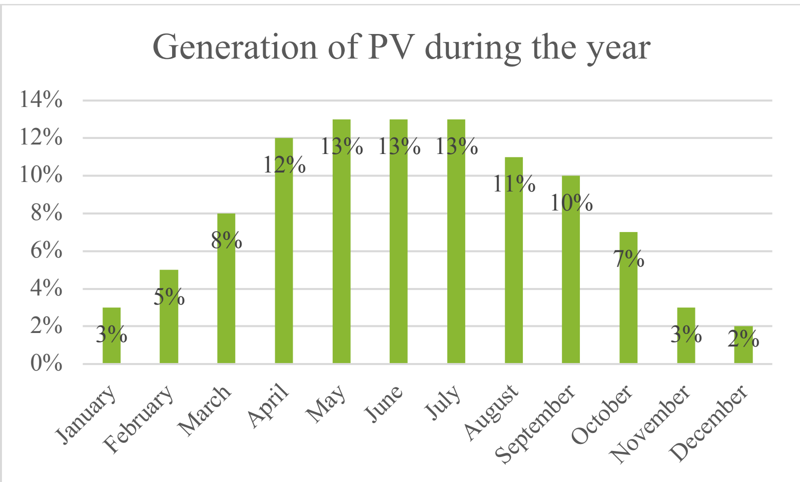


Figure 8. Share of generation of PV per month (Milieucentraal, n.d.-d)

CES has the advantage of multiple people sharing their energy with the storage facility. However, sharing energy with others is also possible. In a community a natural demand side management is active, because peaks are flattened due to changing behaviours among the members. A CES can be a lot smaller than a HES, which affects the height of the investment for the storage system. Compared to the 6-kWh system of HES, the CES can be 4 kWh per household. Due to research of Bardour et al (2018) the optimal CES can function with 65 per cent capacity compared to a HES. On the other hand, the HES has higher benefits, especially with the bigger sized systems. The calculations of the effects of introducing a storage system, are visible in Appendix II, scenario 4 and 5. Table 7 shows the effects of HES and CES on the electricity costs.

Table 7. Effects of number of PV panels and storage on energy costs.

Number of PV panels	Electricity costs no storage	HES electricity costs	Cost decrease compared to only PV panels	CES electricity costs	Cost decrease compared to only PV panels
6	€499.82	€302.33	€197.50	€306.32	€193.50
7	€469.68	€247.85	€221.83	€273.11	€196.56
8	€439.53	€205.06	€234.47	€247.22	€192.31
9	€409.39	€172.81	€236.58	€222.64	€186.74
10	€379.24	€145.74	€233.50	€198.48	€180.76
11	€349.09	€117.61	€231.48	€174.25	€174.84
12	€318.95	€89.48	€229.47	€152.35	€166.59
13	€288.80	€64.51	€224.29	€130.45	€158.35
14	€258.66	€39.93	€218.73	€109.26	€149.39
15	€228.51	€18.06	€210.45	€89.02	€139.49
16	€198.36	€-5.03	€203.39	€68.01	€130.36

2.3.4 Energy management systems

The management system is the overarching system which combines al the systems in the residences. Most important are the systems that are able to control and manage (Parag & Savacool, 2016), gather information and have communication technologies and optimization techniques (Zafar et al., 2018).

An energy management system consists of Advanced Metering Infrastructure (AMI) and Home Energy Management System (HEMS) (Razzaq et al., 2016). These energy management systems should be able to solve all the aspects mentioned before: measurement of energy data, communication with the grid, information about real time prices and working appliances (Ciuciu et al., 2012). AMI is used to enable two-way communication between the grid and the users. For optimizing the indoor energy use, the HEMS is used.

Demand Side Management (DSM) is a management system which gives the prosumer the possibility to decide whenever the electricity will be used. The DSM focuses on grid load by shifting critical peaks and daily peaks through the prosumer's choices (Sipos et al., 2015). The first goal of the system is to reduce the overall energy consumption and to increase the overall efficiency. It controls the demand and actively controls sub-systems such as appliances. The second goal is to match supply and demand of energy by using sensors to control the energy consumption (Ozadowics, 2017). Within the DSM system, smart devices request power for using the device. By using a metering infrastructure, the costs for this handling will be send to the Demand Response Manager (DRM). The load controller together with the DRM send back a signal to the device which turns on (Sipos et al., 2015). The DSM system helps the prosumer in being able to use the energy most efficient, but hereby investments should be done as well. The assumption is that these sensors will help the prosumers efficiency. However, it still depends on the active involvement of the individual since they are the ones plugging in the devices and deciding on the price signals. Appliances should be smart in a way that they can react to price signals or have the possibility to postpone the use of energy. As mentioned before, due to the PV panels, the most electricity will be generated during the day. These hours will probably be the most efficient periods to use daily appliances, such as dryers and dishwashers. The active involvement of the prosumer is already mentioned, but this comes in place in these situations where they can react to generation signals and change their daily routine in using devices. High levels of demand decrease, which results in positive effects of less over-demanded overall power networks (Sipos et al., 2015).

DSM can be applied to decrease costs. Especially when the 'Salderingsregeling' is completely phased out, hours are cheaper to use household appliances or charge an electrical vehicle when energy generation takes place. The direct energy use of the PV panels is estimated at 30%, (Verheij et al., 2020) but increase or decrease (with the use of DSM) will have results on the benefits of PV panels. Based upon the average electricity use of 2853 kWh, the benefits per year are shown in Table 8, based upon the year 2031 when the 'Salderingsregeling' is completely phased out. A financial benefit can be achieved for 47.45 euros for a small system of 11 panels, further calculations throughout the years are visible in Appendix II.

Table 8. Effect of direct energy use on benefits.

Direct energy use	**20%**	**30%**	**40%**	**Change**
11 PV panels	€255.90	€303.35	€350.80	€47.45
16 PV panels	€372.22	€441.24	€510.26	€69.02
20 PV panels	€465.28	€551.55	€637.82	€86.27

To conclude, the technical development of an energy community depends on the community type and the way of generating electricity. A smart grid is necessary for making the flow bi-directional between buildings and the grid, but also for communication requirements. In an energy cooperative, the individual household buys a share of an electricity generation system. In the Netherlands, solar and wind projects have been developed already. Biomass projects in neighbourhood cooperatives are not known, but do have the disadvantage of CO2 pollution as well. For a prosumer community, the technical development is based upon an individual building. Therefore, issues regarding smaller scalable systems come into place. The most attractive option for households is installing PV panels, where the size of the system depends on the investment height and the available roof space. PV panels are financially attractive with payback periods between 6 and 8 years, but with the changing regulations for compensating the energy use, benefits will decrease in the upcoming years. Due to the peaks in the electricity demand during the day, storage will become more and more interesting especially with these changing regulations. However, the investment height in storage remains high, and this makes the purchase less attractive. The choice can be made for storage systems between a home energy storage or a community energy storage, where the community energy storage has the advantage that is does not have to be the same size as a home energy storage. Combing the storage opportunity with an energy management system, where demand side management is used to decrease the peaks in the energy use and use electricity on the times when electricity is generated, financial benefits can be achieved. The development of an energy community depends not only on the technical and financial aspects, also the management of the system should be determined. In the next section, the system management of both the energy cooperative and prosumer community will be discussed.

2.4 System management

For the development of either an energy cooperative or a prosumer community, the technical and financial developments are not the only aspects. The management of the complete system should be regulated in order to be developed. The development of an energy community encounters multiple stakeholders, for example, households, energy suppliers, grid operators and governmental parties.

Energy cooperative

An energy cooperative is initiated by citizens or local companies. In collaboration with the energy suppliers a cooperative can be developed. In general, the structure and flow of resources goes as visible in Figure 9. The cooperative members make a one-time investment to develop the energy generation system. The energy cooperative is responsible for the deliveries of electricity to the energy supplier who delivers the electricity to the cooperative members. The energy supplier pays the cooperative for the electricity they deliver, the profits can be shared with the members or used for more investments. The cooperative members pay the energy supplier for the electricity they use, but get a compensation for the energy tax due to the 'Postcoderoos' regulation.

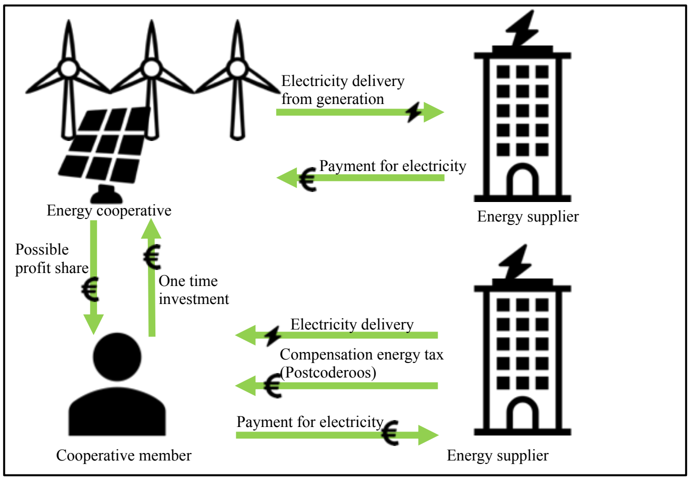


Figure 9. Organization of energy cooperative (HIER Opgewekt, 2017)

Normally, a municipality is not involved outside the legal framework. However, with the local policies regarding energy goals, municipalities are more likely to be involved. The associated benefits, mentioned in Chapter 2.2.1, learn the municipality that not only energy goals can be achieved with the introduction of local energy communities.

The role of the municipality in the development can be different, according to the following definitions (Klopstra & Schuurs, 2013):

- Coach: the municipalities supports the initiator in formulating their goals, and determining the needs of the initiators.
- Facilitator: the facilitator role is less involved, but is supporting the initiators by facilitating locations, expertise, and support in creating relevant contacts with other stakeholders.
- Service Provider: as service provider a formal role is assigned to the municipality, by supporting in the permit application, contacting citizens, and looking into possible locations.
- Participant: in this case the municipality can be participant as well by becoming customer of the cooperative, or be involved in the financial investments.

- Co-producer: as co-producer the municipality develops the cooperative as well, by fulfilling specific tasks and developing supporting plans.

Prosumer community

The technical and financial involvement of becoming prosumer is important. However, the process of becoming member of a community and contracting are also important. Where the energy cooperative develops a cooperative where members can be part of a joint investment, for a prosumer community this is different. In a prosumer community, individual prosumers are coupled based on their geographical location or virtually based on similar goals (Espe et al., 2018). But a virtual network and management system should be present to encounter the right performance of the system: an efficient sharing system without the use of the national grid, ideally.

The management of the prosumers consists of determining a negotiation process where energy can be traded. Furthermore, the definition of roles a prosumer plays should be determined, and whether they are able to meet the contractual relations. Also, some risk assessment should be done in order to overcome challenges like the peaks in demand and supply (Espe et al., 2018).

The energy prosumer generates its own electricity, but is still connected to the grid. Contractual relationship between the prosumer and grid operator, cannot be denied. Most people want to have the back-up of the grid, and conclusions from the storage analysis are that peaks in the demand and supply can be solved by storage, but not in every month. Therefore, a back-up of the grid is preferable. Figure 10 shows graphically the possible systems, determined by Parag & Savacool (2016), with P2P, prosumer in a microgrid (connected or off-grid) and organized prosumer groups. Due to the many possibilities and different structures, just like the different definitions from Chapter 2.2.1, no distinct management system is determined.

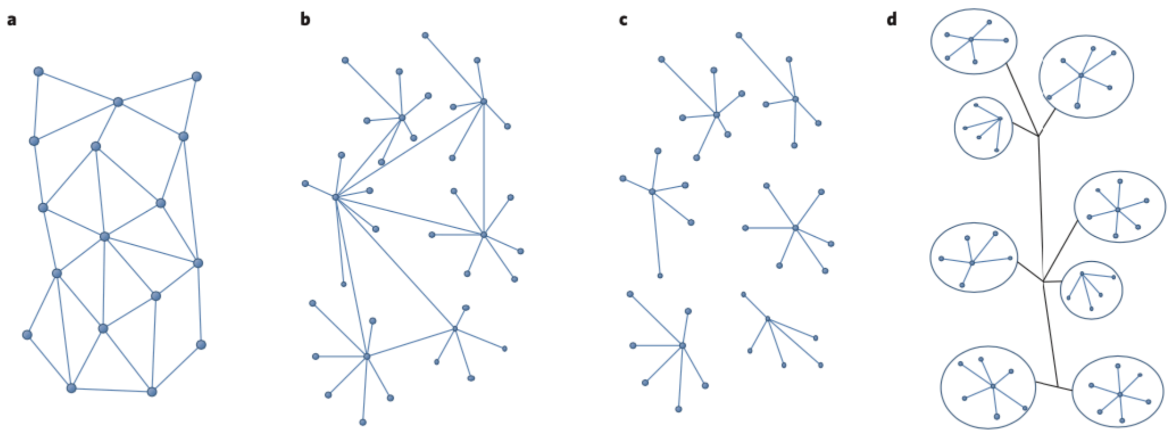


Figure 10. Possible prosumer grid structures (Parag & Savacool, 2016)

a.P2P network; b and c. Prosumers in microgrid; d. Prosumers in structured groups, using VPP.

The P2P network can be established as an online trading platform. This is done, for example by Vandebron, a Dutch company giving small energy producers the chance to trade their electricity for a specific price and a subscription fee (Vandebron, n.d.). Powerpeers is another Dutch company, making it possible to share electricity with others. The advantage of this system is the higher feed-in compensation prosumers get (11 cent) (Powerpeers, n.d.). In the P2P network the peers (prosumers and consumers) share their over-supply of electricity directly with other peers. Having only a trading platform and a contractual relation between prosumer and consumer will not be sufficient enough. Until now no platforms which are able to form prosumer communities have been developed.

A challenge in the development of a prosumer community is contracting prosumers. The prosumer is bounded via a contract, where generally an upper and lower bound is defined in the quantity of generated energy. Every household is likely to participate in a different manner and supply and demand will never be similar. Therefore, different outcomes can be expected in fulfilling this contract, for example meeting the contract, failing the contract by delivering too little, supplying too much energy, fluctuating deliveries or sharing behaviour (Rathnayaka et al., 2014b). Because of these different outcomes, the management is difficult and arranging well-functioning contracts is a challenge.

Rathnayaka et al (2014b) defined a framework to determine the ranking of different prosumers in the community, in order to find influential prosumers. This system is developed due to the many different behaviours that may occur, as mentioned previously. In the first place, there is determined what type of prosumer is dealt with. This could be a standalone prosumer, as the name already suggest, this prosumer supplies in its own demand and is not able to share or buy from other prosumers. Then there are the buying prosumers, who need to buy energy to meet the lower energy levels. And finally, the selling prosumer who sells the surplus of energy to other prosumers. According to the previous mentioned types, the prosumers will be ranked based on certain assessment criteria based on the behaviours of meeting the contract.

Rathnayaka et al. (2015) are the initiators of the goal-oriented prosumer community or the prosumer community group (PCG). They have developed a framework to manage the goals in the PCG. The first stage comprises the goal management, where the objectives of the community are determined. According to the research, there are a few key goals which can be achieved in the PCG:

- Resource objective: where the goal is based on using less resources. This can be split up in the equipment resource or human resource.
- Local demand objective: where the goal is based on the achievement of the demand for energy within the community group, without usage of other groups.
- External customer demand objective: where the previous objective was about keeping the demand and supply within the community, this objective is about supplying external consumers in their energy needs.
- Income objective: this financial objective is about the achievement of a certain income out of selling the energy to others.
- Cost objective: in this objective the operational costs are planned to be reduced.
- Sustainability objective: within this objective the goal is to achieve as much members to participate in PCGs who are willing to share their generated energy.

Summing up, the energy cooperative is a familiar network where the interaction between stakeholders is defined. The cooperative member is responsible for the investment in the cooperative, which delivers the electricity to the energy supplier. The energy supplier is involved by supplying energy to the members and compensate them by paying for the electricity. Depending on the legal structure of the cooperative, a profit share can be paid to the members. The municipality can play a role in the development of the cooperative, but has the opportunity to act to their preference. In comparison with the prosumer community, less is known about the structure and management. Innovative measures to couple prosumers and develop a framework based on goal sharing is developed. Furthermore, a virtual power plant or microgrid is used to create a basis for sharing resources among the community members. Nevertheless, the development of a group of prosumers has not resulted in any working platform, although there have been developments to deliver a trading platform for connecting prosumers and consumers with each other.

2.5 Behavioural change

Participation in an energy community is based upon a decision to participate. Characteristics of households can play a role in the decision-making, both their socio-demographic characteristics and their psychological reasoning regarding sustainable energy measures. Earlier conducted studies were based on the willingness to change energy consumption or to apply sustainable energy measures by individuals (Frederiks, Stenner & Hobman, 2015), but were not directly related to the differences between communities. Appendix IV gives a matrix of previous research into energy communities.

The way people deal with energy related issues is a result of a certain behaviour, it cannot be considered as behaviour itself. Research regarding this topic has been conducted in both economic and behavioural science. Where economic science focuses on which financial variables influence the decision most, behavioural science focuses on internal values, personality, and lifestyle (Kastner & Stern, 2015). On dealing with energy related measures two types of behaviour are related, efficiency behaviour and curtailment behaviour. Efficiency behaviour is about behaviour that is performed only once through investments. The second, curtailment behaviour, is about repetitive change of behaviour through changing the operational activities (Martiskainen, 2007). Karlin et al. (2012) described differences between the two behavioural types. In Table 9 an overview is given to summarize the differences between curtailment and efficiency behaviour.

Table 9 Differences between curtailment and efficiency behaviour (Karlin et al., 2012)

Attribute	Curtailment behaviour	Efficiency behaviour
Frequency	Repetitive	One-time
Cost	No/low cost	Investments
Actions	Behaviour, practise	Technical, purchase
Permanence	Reversible	Permanent
Lifestyle	Loss of amenities/comfort	No lifestyle change
Impact	Less impact, savings	Energy savings potential
Population	Anybody	Difficult for renters, low-income
Motivation	Saving energy, moral	Saving energy, rational

Both behaviours apply to becoming a prosumer and joining an energy community. When a consumer becomes a prosumer, he has to invest in the generation systems and the necessary metering system. After this change of efficiency behaviour concerning the domestic environment, curtailment behaviour becomes important. As mentioned in Chapter 2.1, the prosumer should change the habits they are used to in using energy and become an active participant in the energy market, which is line with the given description of curtail behaviourism.

As mentioned, efficiency behaviour is about investing in technical, more permanent factors. The change in behaviour towards investments in sustainable measures depends mostly on the willingness to pay for such an investment. This could be done by small investments, for example in sustainable lighting, LED, house isolation or a more efficient heating system. With prosumerism, this investment will be in a RES and a smart metering infrastructure. The most important reason why people do not apply even small or more expensive systems in the Netherlands is that people cannot afford these measures. In the past years, many researchers investigated the willingness to pay for house bounded solar panels (Abdullah et al., 2017; Claudy et al., 2010; Claudy et al., 2011). There is definitely a higher interest in investing in solar panels, but many households struggle with the height of investment, the lack of knowledge about systems and their trust in the solar panels (Abdullah et al., 2017). Also, the payback period (Claudy et al., 2010), market prices and subjective perception (Claudy et al., 2011) are topics people consider. The research of Vasseur and Marique (2019) in the Netherlands confirmed that the households that did not do technical investments already, 80 per cent will not do this either within a year. They asked statements about investments and motivations about various sustainable measures. They concluded that technical investments rely on the personal and financial situation of the respondent, where the behavioural change depends on the attitude towards the behaviour (Vasseur & Marique, 2019).

Environmental behavioural models

The behaviour of individuals is complex in a way that the decision-making models known from economic literature probably cannot be used (Frederiks et al., 2015). The choice for certain measures and changes in energy behaviour most likely apply whenever individual benefits are involved (Martiskainen, 2007). Many behavioural models have been developed to explain the (curtailment) behaviour of individuals. These models support the understanding of social and psychological influences related to environmental change measures. The models differ in terms of internal and external characteristics. Internal characteristics are about attitudes, values, habits and personal norms while external characteristics are about policy, regulations, and social norms (Jackson, 2005).

Many models start with the assumptions of an economic theory, where the costs and benefits of a certain decision are weighted. This led to Rational Choice models, where the decision-maker makes the decision based on a calculation between the costs and benefits of the behavioural change (Darnton, 2008). The process of choosing can be divided into the expectations of the outcome and the evaluation (Jackson, 2005). An example of Rational Choice models is the Consumer preference theory which is based on income, price levels, consumer's preference, and assumptions to increase the utility. The utility in this type of model is explained as levels of satisfaction, happiness or personal benefit which could be increased or decreased by the behavioural change (Darnton, 2008). Another example, the Attribute model, is based on the attributes of a product and the weights an individual attach to these attributes. Also, due to many critiques, the Expectancy-value theory was developed. This simple theory is based on the attitudes towards products or initiatives, measured by beliefs and evaluation. Finally, the Means-end Chain theory is a model, where the 'means are methods to achieve the 'end', a certain goal that satisfies the goals of individuals' (Jackson, 2005). The Rational Choice models are based on economic theories but are not fit to integrate psychological theories. Kastner & Stern (2015) concluded that a useful model should incorporate both internal and external factors, which include the following variables: attitude and motivation, contextual factors, social influences, personal capabilities, and habits (Jackson, 2005). Many psychological behavioural models have been developed in the past years, some of the well-known theories will be discussed further.

In Table 10 an overview is given of multiple psychological based environmental behavioural models; an extended explanation of these models is given in Appendix III. The most common theories are the Theory of Planned Behaviour (TPB), Norm Activation Theory (NAT), Value-Belief-Norm Theory, Theory of environmentally responsible behaviour (TRB), Attitude-Behaviour-Context model (ABC) and Theory of interpersonal behaviour (TIB). Every theory has its own variables, some are overlapping. None of the theories cover all the mentioned variables, although 'attitude' is in almost every model present. The contextual factors are mentioned in half of the models, not always under the same name, but situational factors or facilitating conditions are all meaning the same. Social influence is another variable which is mentioned in the TIB. A small part, the subjective norms are also applied in the TPB model. The personal capabilities can be assumed as a wide variable, with many optional sub-variables such as knowledge, perceived behavioural control, personality, and affect. The last variables integrated in only the TIB model are affect and habits, and the belief that the current behaviour of someone influences the overall behavioural change. The same holds for positive and negative emotions, these can affect the perception to behavioural change (Jackson, 2005).

Table 10. Summary of behavioural theories (Klockner, 2013; Jackson, 2005)

Behavioural model	Attributes	Description
Theory of Planned Behaviour (TPB)	Attitude, subjective norms, perceived behavioural control	Theory has a strong empirical support, but is underrepresenting the impact of morality and repeated behaviour
Norm Activation Theory (NAT)	Personal norms, awareness and responsibility	Theory explains morality, but neglects repeating behaviour and non-moral motivations
Value-Belief-Norm Theory	Personal values, beliefs, environmental attitude	Theory explains morality, but is neglecting repeating behaviour
Theory of environmentally responsible behaviour (TRB)	Knowledge, attitude, personality, situational factors	Model is overlapping with TPB, but incorporates more variables. The interactions between the variables have causal relations
Attitude-Behaviour-Context model (ABC)	Attitude, context	Model gives a visual representation of the relation between internal and external influences, but depends on the determination of the values of Attitude (A) and Context (C)
Theory of interpersonal behaviour (TIB)	Attitude, social factors, affect, habits, facilitating conditions	The theory gives more explanation than TPB/NAM and introduces habits which improves the explanation significantly. Because of the many variables the model becomes complex and is therefore less applied

In the past years' research has already been conducted between participation in energy measures, or specifically in energy communities, and decision-making variables as mentioned in the environmental models. It is proven that a positive environmental attitude influences the total energy consumption (Abrahamse & Steg, 2011; Sapci & Considine, 2014) or increases the willingness to buy energy-efficient appliances (Li et al., 2019). Therefore, there is reason to believe that environmental attitude has a positive impact on the willingness to participate in an energy community, this is confirmed by Hackbarth & Lobbe (2020) who found a relationship between willingness to participate in a P2P community and environmental attitude. Since this research is focussed on the difference between two energy communities, environmental attitude could influence the decision. In the phenomenon of attitude, motivation to do a certain behaviour is also measured in earlier research. The most important reasons for participation in a P2P community are the desire for regional production, transparency and independency (Hackbarth & Lobbe, 2020).

Social factors or subjective norm have been mentioned in the models TPB and TIB. Abrahamse & Steg (2011) did not find relationships between subjective norm and lower energy consumption, or willingness to buy energy-efficient appliances (Li et al., 2019). Social norms, as part of the subjective norms, do influence the willingness to participate in a community energy project (Kalkbrenner & Roosen, 2016). These different findings make it difficult to assume what would influence the choice for a community type.

Personal norms, values, knowledge and personality are all related to the personal capabilities of an individual. Knowledge is already been proven to influence the choice for participation or purchase of an electricity generation system (Hackbarth & Lobbe, 2020; Fielding & Head; 2021; Frederiks et al., 2017). Between personal characteristics (socio-demographic) and participation different outcomes have been found in the effect of age (Frederiks et al., 2017; Nair et al., 2010), gender (Kalkbrenner & Roosen, 2016; Ropusunska & Weglarz, 2019; Frederiks et al., 2017), education (Sardianou & Genoudi, 2013; Nair et al., 2010) and income (Kalkbrenner & Roosen, Frederiks et al., 2015; Sardianou & Genoudi, 2013). Therefore, no clear expectation can be defined and analysis of these values is recommended. Perceived behavioural control and locus of control did have a significant influence on pro-environmental behaviour (Sang et al., 2019; Trivaldi et al., 2015; Fielding & Head, 2012).

Habits play a role in routines that should be adopted and are found to have a relationship between daily and willingness to change behaviour (Ozaki, 2018). However, with becoming a prosumer the daily routine is not affected directly. Therefore, this variable can be neglected in further analysis of participation. An overview of past research into community participation, or becoming a prosumer is visible in Appendix IV.

To conclude, to become prosumer or participate in an energy community, members of households need to change in their curtailment behaviour as well as in their efficiency behaviour. Environmental behavioural models have determined decision-making variables that are important to change environmental behaviour. In the six selected behavioural models, overlapping variables are determined, but also differences detected. Attitude is the most common psychological factor in behaviour change and is likely to change the intention to perform a certain behaviour. Out of these models, it is expected that the environmental attitude influences the willingness to participate in an energy community as well. Furthermore, social factors such as subjective norms are mentioned, because the higher social influence of subjective norm also increases the willingness to perform the behavioural change. Other variables as personal aspects should be incorporated.

2.6 Conclusion

The current energy network is focussed on a central system. However, the expectation is that this will change into a local system in the future because more renewable energy sources need to be included. Therefore, the prosumer is defined as a household producing energy themselves, consuming this energy or deliver it back to the grid. The role of a prosumer makes it possible for a household to participate in the energy market, this gives answer to the first sub question. Concluded is that there are two different local energy systems, an energy cooperative and a prosumer community. The energy cooperative is based upon a joint investment in an electricity generation system. The prosumer community is based upon individual prosumers, who produce and share electricity. Depending on the community type, electricity is generated on the individual building level or at the neighbourhood level. The investment in a generation system depends on the type and size of the energy system, but also on regulations of the government. These regulations are changing; therefore, the financial benefits of a community will change in the upcoming years. The generation system is one of the technical aspects, the renewable energy sources are weather dependent. Therefore, peaks in the generation will occur, together with peaks in the demand of households a mismatch between supply and demand occurs. Storage is an option that will become more important and causes more financial stability with the changing regulations. However, the investment remains high. For the development of an energy community different technical development have to be done. A smart grid is necessary to create a network suitable for bi-directional supply and communication. To overcome the mismatch between demand and supply another option is to integrate an energy management system, which can shift households' energy demand to better times. Financial benefits can be achieved with this as well. The combination of all these systems into a community is a demanding process where management of the community becomes important. An energy cooperative is already applied in the Netherlands, and energy suppliers buy electricity from the cooperative while compensating them financially. For a prosumer community, such examples are not found. The characteristics of the two energy community types have been defined in this chapter, therefore, subquestion 2 is answered.

Together with technical, policy and financial developments psychological aspects play a role in the decision-making of individuals. Behaviour can be divided into curtailment behaviour, which is repetitive behaviour, and efficiency behaviour, which is related to a one-time occurring event, such as an investment. Environmental behavioural models determined variables influencing behavioural change. Attitude, social effects, contextual factors, personal capabilities and habits are found as categories. However, some of the relations were already found significantly associated with pro-environmental behaviour. The relationship with the choice for either one of the communities is unclear. Measuring all decision-making variables in one research will become too much. Therefore, the hypothesis is made that environmental attitude, social influence (subjective norm), personal characteristics (socio-demographic and locus of control) will have a positive influence on the choice for participation. These decision-making variables are supposed to relate to the choice for participation in either one of the energy communities, this is the answer to sub question three.

3 Methodology

In this chapter the methodology used in this research will be discussed more extensively. The Discrete Choice model will be discussed in the first section. A process with steps has been established to develop a Stated Choice experiment, all the steps will be discussed in the second section. Hereby, the content of the questionnaire will be determined. After this, an explanation will be given about the analyses which will be conducted after data collection.

3.1 Introduction

In order to answer the research questions, a methodology should be used. In this research the preferences of Dutch households regarding participation in energy communities will be explored.

In Figure 11 is shown that there are two approaches to measure preference, the Revealed Choice modelling or the Stated Choice modelling approach. The first approach, Revealed Choice modelling, is based upon real choices made by people. Stated preference modelling is divided into preference and choice modelling. In preference modelling, compositional modelling is an option. In this research type the respondent is asked to rate the importance of a variable. It is a useful method, but identification of preferences cannot be estimated (Kemperman, 2000). Decompotional modelling includes a trade-off between variables and the relative importance of the variables can be estimated. The Stated Choice modelling depends on hypothetical situations where respondents choose their preferred situation (Kemperman, 2000). This methodology is most useful in cases where new phenomena are presented to the respondents (Haegeli et al., 2009). In the case of measuring people's preference regarding energy communities, which is a rather new phenomenon, Revealed Choice modelling is not possible. Therefore, a stated choice experiment (SCE) has been conducted.

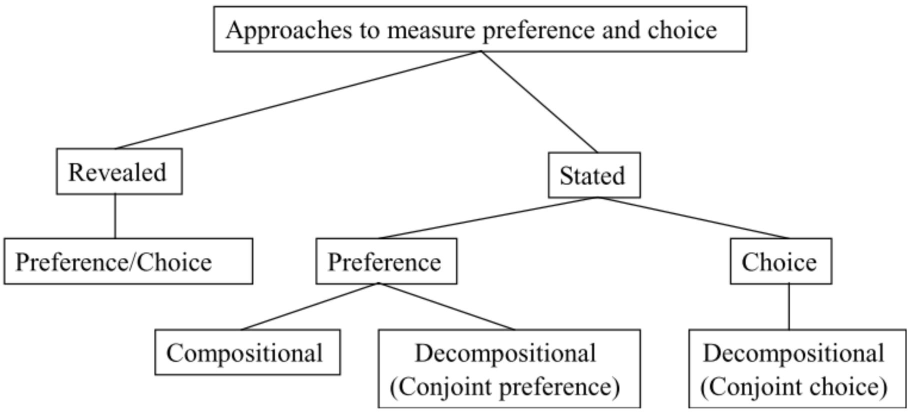


Figure 11. Measurement of preferences (Kemperman, 2000)

3.2 Stated choice experiment

In the previous section, the SCE was determined to be used in this research. Hensher et al (2015) have created an overview of the process to develop a stated choice experiment, which is visible in Figure 12. The first stage starts with the definition of the problem. The second stage consists of the refinement of alternatives, attributes and their levels. A SCE is based on the principle of repeatedly presenting choice sets to the individual, based on multiple alternatives and different attributes. After determining the content of the SCE, the third stage, the consideration of the experimental design, needs to be completed. In this stage the considerations regarding the design of the attributes and levels will be determined, which will lead to the generation of the design in stage 4. After the experimental design, the attributes can be allocated in stage 5.

Different combinations of the choice sets are possible. These will be determined in stage 6, followed by a randomization of these choice sets in stage 7. After completing the previous seven stages, the definite survey can be constructed, including the other variables needed for answering the research questions.

In the following sections the different stages will be applied to this research.

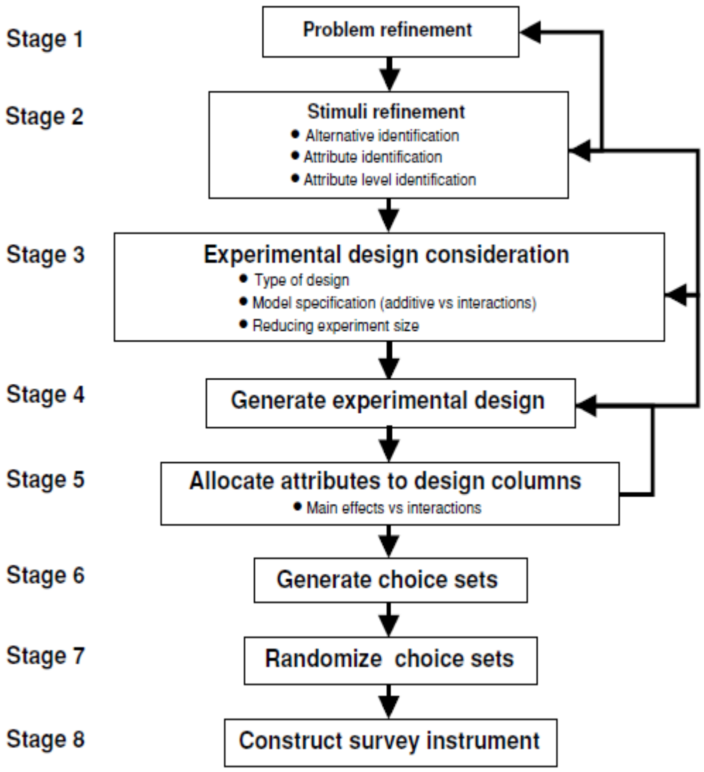


Figure 12. Stated Choice experiment stages (Hensher et al, 2015)

3.2.1 Stage 1: Problem refinement

The problem definition is set out in chapter 1.1. As explained, research has been conducted regarding energy communities, with a main focus on technical developments, financial feasibility and organizational structures. Also, the relationship between behavioural change and the application of sustainable energy measures have been explored. This behavioural change was explained as part of efficiency behaviour as well as curtailment behaviour, both influenced by attitudes and psychological influences. However, it is unclear to what extend these attitudes and psychological factors determine the preferences of Dutch members of households for participation in a specific energy community type, and which variables have an influence on their choice for participation in either an energy cooperative or prosumer community.

3.2.2 Stage 2: Stimuli refinement

Stage 2 consists of stimuli refinement which includes determination of alternatives, attributes and attribute levels.

Alternatives

According to Chapter 2.2 there are different possibilities regarding energy communities. Regarding investments the main conclusion was that there are two options: investments per households or community investments/projects. Because difficulties arose in making the combination within one alternative between community and private projects, it was chosen both options should be presented instead. Therefore, the respondent got the opportunity to choose between a household project and a community project. It could be said that the experiment has labelled choices. Because personal investments in PV panels could be difficult to realise in certain housing types, for example for renters or in the current situation in a neighbourhood, the choice between alternatives can be biased. Therefore, in this research the respondent was asked to assume they are moving to a new neighbourhood for a longer time. It is assumed they have the possibility to participate in an energy community and therefore had the possibility to choose between the two alternatives. Furthermore, to generalize choices, the respondent had to assume the situation where they will use 2800 kWh per year, and energy costs without any form of microgeneration will be 630 euros per year, based on the calculations in chapter 2.

The first alternative is based on personal investments within the domestic environment. It is based on the principle of prosumer communities, where households in the neighbourhood have their own microgeneration system. This system supplies in their own energy needs and shares oversupply to members of the community. A lifespan of 25 years is associated with the PV panels, and 15 years for battery storage.

The second alternative is based on a personal investment, but in a joint microgeneration form. This is based on the principle of an energy cooperative. Shares of a microgeneration system are assumed to be bought by the respondent, shares can be bought in either wind mills or solar panels.

Attributes

Attributes and their levels define the alternatives. Because there were two alternatives to choose from, there were attributes specifically related to the alternatives and attributes describing context. The latter were attributes determined by the individual household, and the characteristics of the community itself.

Investment in private microgeneration

The first attribute was the height of the financial investment in microgeneration for a household. Based on the literature review in Chapter 2.3, the most interesting and effective option for households is to invest in PV panels. The presented situation assumed that the future house is available for PV panels and is oriented in the correct way. Furthermore, in PV panels different sized systems are possible, and can be extended with a storage system. Also, in the upcoming years the regulation regarding ‘salderen’ will change, which will have an effect on the benefits of microgeneration systems for households in terms of payback period and electricity costs (Verheij et al., 2020a). Therefore, simply presenting the yearly benefits and the height of the investment would be incomplete and probably too positive. To present a clear insight in future benefits, graphs regarding the benefits were presented with this attribute together with the expected payback-period.

The levels of the first attribute were based on the necessities of the households’ energy demand. In the Netherlands the average energy demand for households is 2832 kWh. This amount of energy can be supplied by 11 PV panels (Milieucentraal, n.d.-b). An investment of 4,179 euros was necessary to install these panels, which resulted in a payback period of 7.42 years. Due to the new regulations, the revenues per year vary between 300 - 630 euros. A second option was to invest in more PV panels than required. An oversupply would arise and a feed-in compensation could be earned. An option was to install 16 panels, of which the investment was 6,078 euro and with a payback period of 8.75 years. The variation in revenues of the upcoming ten years would be between 440 and 700 euros. These variations in revenues were due to the regulation changes, but with a storage system these variations can be dealt with and more energy could be saved. The third option, investment in both panels and storage systems, required an investment of 11,178 euro with ranging revenues between 645 and 720 euros. Figure 13 presents the revenues graphs of the three levels. Rounded numbers were presented to the respondent due to readability. A more extensive explanation of the values and calculations of the investments is shown in Appendix II, scenario 1, 2, and 3.

Scenario 1: 11 PV panels

Scenario 2: 16 PV panels

Scenario 3: 16 PV panels & storage

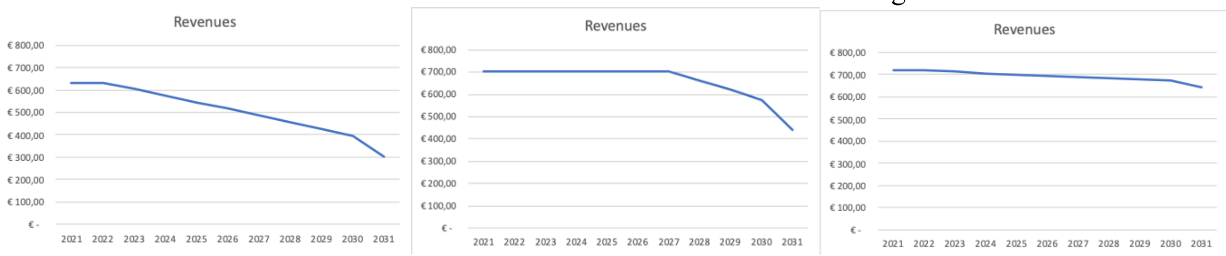


Figure 13. Revenue schemes private investment

Horizontal axis represents years, vertical axis the revenues of the system compared to no investment in PV panels. The Salderingsregeling is incorporated in the estimation of the revenues, this results in the revenue decrease over the years. A storage system of 6 kW is used in this case.

Investment in community microgeneration

Another option was a joint investment with the community, according to principles of ‘winddelen’ and ‘zonne-collectief’. Shares can be bought based on the electricity demand of a household. The maximum number of shares which can be bought is 85 percent of the electricity demand. The price of a share depends on whether it is wind energy or solar energy, because a different amount of energy per supply is received. In this research this difference, and therefore the preference of people between wind or solar energy, was neglected. With this type of community energy investment, households received a discount according to the “postcoderoos-regeling”. Therefore, only taxes needed to be paid and the costs of energy were paid via the investment. The choice was made to present the respondent with two levels based on an investment in community energy. The first level was a low investment for half of the energy needs, which resulted in an investment of 1,300 euro and yearly benefits of 80 euros compared to the base scenario. The second level was a higher investment of 2,600 euros and yearly benefits of 160 euros compared to the base scenario. Appendix II, scenario 6 and 7, shows the financial motivations regarding the community investment. Because the assumption cannot be made that people always want to invest in a microgeneration system and that they have the necessities for such an investment, another community level was formulated. An external party made the investment, while the household made the roof available for PV panels and a discount in the energy costs could be given.

Energy management system

An energy management system increases the effectiveness of the integration of microgeneration by scheduling the use of electricity during the day. Previous research pointed out that people are less interested in an automated energy management system, in which demand side management is applied (de Vet, 2018). However, along with microgeneration, financial benefits can be achieved by scheduling the use of household appliances. Especially in the future, when ‘salderen’ is no longer possible, the use of demand side management could become more attractive and cost effective for households. There are mainly three options regarding this subject: not applying, applying yourself or having an automated system. These three options were used as levels in the SCE, but an additional financial benefit for the systems was added to the options to give the respondent a perspective of what can be achieves with applying this. The first level is no energy management system, and the respondent does not have to schedule the use of household appliances. No financial benefits can be achieved, it can be more expensive in the future due to the mismatch between supply and demand. This option was not explicitly presented to the respondents. The second level was a system where households are self-responsible for the use of these appliances. Smart appliances were able to schedule for another time which was cheaper, calculations are shown in Appendix II, scenario 8. This option depends on the responsibility of the household. If the household does this optimally during the year, a financial benefit can be achieved of maximum 40 euros. An automated system was the third possibility. This system schedules the use of appliances meaning that there would be a decrease in flexibility in the use of appliances. However, it is more efficient and sustainable (Sipos et al., 2015). This reduced the costs with 50 euros and had major effects on the peaks in de energy network, Appendix II, scenario 8 gives a representation of the calculations. Because of ability to understand and readability, only the decrease in costs were presented in the choice sets.

Members of the community

Communities can be formed in multiple manners and differences can be applied in who can become a member. For example, in a prosumer community a virtual network can be developed but also a neighbouring network can be sufficient as explained in Chapter 2.2. This topic is related to the feelings of community, as well as the positive effects of familiar people to participate with and whether this stimulates the participation in one of the alternatives. As characteristics of the community, the number of members was incorporated in the model. In this case the effects of the size of the community was incorporated in both a private or a community project. This is identically applied for both alternatives. The first level is a random selection of 7500 members from the same postal code region. According to the regulations about energy sharing in the same postal code, this is the maximum number of members and it is based on the average number of households in a postal code in the Netherlands (CBS, 2018).The second level is a lot smaller, with maximum 500 households in a closer proximity to the households' home. The third and final level focuses on 200 households in the vicinity, with only neighbours. These number of households were set based upon the average amount of households in neighbourhoods.

Contract information in private microgeneration

Contract information is the information a household receives regarding their demand and supply of energy. In the Netherlands, software to have insight into the supply of solar panels has already been developed. Some are neglecting and not presenting the demand and do not support tips and tricks to have a more sufficient way of using energy. With the fact that a system is already present, and with the current trend of changing to a double meter, the information gathering for both demand and supply is nearby. Therefore, no attribute levels have been determined in this attribute, but a standard real-time information option is given. This is done to be able to compare the preference of this factor to the community microgeneration option.

Contract information in community microgeneration

In contrast to a system already present for the private investments, there is no actual software available for the community investments. Currently, the system functions with deposits for the use of electricity and a final settlement afterwards. With electricity meters installed in every house, people can keep track of the day to day energy use. Therefore, the base scenario for level 1 was described as monthly billing. The second level gave a little more information to the households, with daily information regarding both demand and supply. Therefore, households could keep track of their daily energy use and could change their behaviour. The third level gave the most information regarding supply and demand, with real time information and feedback about actions. This feedback could be explained as tips and tricks regarding energy conservation at different times, for example to minimalize the peaks in the network. In this case, with supply was meant the deliveries of the community project, and the revenues and costs associated with it.

Management of the community

According to the research of de Vet (2018), people are not interested in developing and maintaining the system themselves. Therefore, the assumption was made that there should be someone who manages the network. In general, there are three options; company, government, or volunteers, which is also described in Chapter 2.4. Therefore, these three management options were presented to the respondent. This could result in advice regarding who could manage the described system, and who is trusted the most with the supply of energy. The first two options, a company and the government manager, were assumed to have higher costs per households and charged a higher fee. It was assumed this is 25 euros per year, based on the initiative of 'winddelen' (de Windcentrale, n.d.). The third option was a volunteering member of the community, which encountered risks for responsibility and duration of the managing volunteer. Costs were assumed to be lower at 10 euros per year.

An overview of the given attributes and attribute levels is given in Table 11.

Table 11. Attributes and attribute levels

		Attribute	Attribute levels	Additional information
Private	1	Investment	€4000, €6000, €11000	Decrease in energy costs and benefit range
	2	Energy management system	None, personal, automatic	Decrease in energy costs
	3	Members	7500, 500, 200	-
	4	Contract management	Company, government, volunteers	Additional costs and responsibility
Community	5	Investment	€0, €1300, €2600	Decrease in energy costs and contract duration
	6	Energy management system	None, personal, automatic	Decrease in energy costs
	7	Members	7500, 500, 200	-
	8	Contract information	Monthly, daily, real-time	-
	9	Contract management	Company, government, volunteers	Additional costs and responsibility

3.2.3 Stage 3, 4 & 5: Experimental design

After the determination of the attributes and their levels, the stages for the determination of the experimental design started.

The experimental design was determined by the statistical program SAS. In Appendix V the experimental design is visible. Because there were two alternatives with their own attributes and levels, the choice was made to integrate nine attributes in total, see Table 11, although there were some overlapping attribute levels. If a full factorial design were to be used 19,683 choice sets needed to be tested. This is not possible to present in a survey. Therefore, the fractional factorial design is used. Hereby, an orthogonal fraction was chosen from the total number of combinations. As a result, a selection of 27 combinations was used this has been estimated by SAS in appendix V. 27 combinations was the least amount necessary to achieve a 100 per cent efficient design. Every respondent was presented with a selection of 9 choice sets. A choice set consisted of a randomly selected combination of alternative 1 (Private), 2 (Community) and the none option.

3.2.4 Stage 6 and 7: choice sets & randomization

Stage 6 consists of the identification of the choice sets. Limesurvey is used at the TU Eindhoven for creating surveys. Unfortunately, it is not possible to integrate a random selection of choice sets. The experimental design has been used to create 54 choice combinations. The 54 choice sets were divided into six blocks. Each respondent was presented one randomly selected blocks of choice sets. Each of the 27 combinations of the experimental design has been presented twice as alternative 1 and 2. An overview of the choice sets is visible in Appendix VI.

3.2.5 Stage 8: Survey development

The questionnaire was also developed in Limesurvey. The questionnaire was split up in three sections. The first section asked for the personal characteristics of the respondent, the second consisted of statements about the determined decision-making variables from chapter 2. The third section contained the SCE. The complete survey is visible in Appendix VII. The survey was conducted in both English and Dutch to have a greater audience in the Netherlands, and by doing so, not neglecting non-Dutch speaking inhabitants. The internet links were distributed, and respondents were able to change language in the menu at all times. The survey started with a short introduction to the context of the research, followed by an ethical introduction.

3.2.5.1 Part 1: Personal characteristics

Personal characteristics may influence behaviour and choices. Simple questions regarding personal characteristics were used as introducing questions. These questions were supplied with multiple choice options, which were mandatory to select. The response options were based upon the CBS standards in the Netherlands, and will be used to check for a representative sample (CBS, 2019; CBS, 2020c). The following characteristics were asked to the respondent:

- Age
- Gender
- Education
- Work status
- Household income
- Household size
- Number of children

Regarding the households, home ownership is incorporated as well as the investments already done in sustainable measures. Different energy measures are presented to the respondent, with a possibility available to fill in themselves. Examples are: PV panels, energy storage, heat pump, and extra insulation. Furthermore, a question regarding personal motivation for the decisions in the SCE is added to the context.

3.2.5.2 Part 2: Statements

The second part of the survey consisted of statements regarding the most important variables in the behavioural models. The twelve statements could all be scored on a 5-point Likert scale, ranging from strongly disagree to strongly agree, with the neutral options as middle.

Subjective norms

Subjective norm is one of the variables in the conceptual model. It can be split up in social norms and descriptive norms (Ham et al., 2015). To measure social norms, Clement & Chamberland (2014) developed two statements. The first statement is about how others are supportive in behaviour. In this research it was modified to a case of conserving energy. The second statement was about what people think they should do regarding energy conservation. The modified statements:

- In general, people who are important to me would support my efforts to conserve energy for environmental reasons.
- In general, people who are important to me think I should conserve energy for environmental reasons.

To incorporate the descriptive norm a statement was added. The statement was based on how other people are already behaving (Ham et al., 2015) and focused on what others around them are already doing.

- In my environment many people are actively involved in applying environmentally friendly measures.

Environmental attitude

As explained in Chapter 2.5 environmental attitude is in several behavioural models an important aspect. Other researchers (Kalkbrenner & Roosen, 2015; Vassuer & Marique, 2019; Goncalves Da Silva & Karnouskos, 2012) found already significant influence on the choice for participation in a specific community type. Therefore, there is a hypothesis that there is a relationship between overall participation in energy communities and the environmental attitude. Furthermore, the background of the transition to local systems is about environmental reasons. The following statements are included:

- I am concerned with the environmental problems.
- I am concerned with the use of fossil fuels and its effect.

Locus of Control

Locus of control was chosen to be part of the conceptual model since this was one of the variables in the behavioural models. These two statements, adapted from Fielding & Head (2017), indicate the person's internal locus of control. The sum of the outcomes gives a higher or lower internal locus of control of an individual (Fielding & Head, 2017):

- My personal actions can make a difference in the environment.
- My decision now, can protect the environment in the future.

Community identity

Community identity is a topic which was not included in the behavioural models in Chapter 2.5, but the participation topic is associated with community participation. Therefore, this topic is introduced in the statements as well. It could be defined as "feelings of attachment to the community, taking pride in the community, and having friends within the community" (Van Vugt, 2002, p797). But according to Kalkbrenner & Roosen (2016), community identity does not have a direct significant relationship with willingness to participate in a local energy community, and social norms and trust operates as mediation between the variables. Normally, community identity is measured with statements about the current neighbourhood people are living in. Therefore, the respondent was not asked to reflect on the current situation but more to what extent they thought the community identity was important to them.

The following statements were based on the research of Kalkbrenner & Roosen (2016):

- I think it is important to feel attached to the proposed energy community.
- I think it is important to feel pride about the proposed energy community.
- I think it is important to have friends within the proposed energy community.

Trust

Trust is used in the study of Kalkbrenner & Roosen (2016) as an intermediate factor which influences willingness to participate in a local energy community.

Trust is about mutual confidence in each other, and therefore important in the relationship and collaborations with one another. The research pointed out that general trust in people has a significant influence on participation in a community (Kalkbrenner & Roosen, 2016). Instead of using a general form of measuring trust via statements, in this research the importance of trust in third managing parties was measured explicitly.

- I trust energy suppliers and third parties to manage my energy conservation safely.

Independency

The principle of developing energy communities is built around local production and use of electricity and heating. An associated reasoning is made that people are more interested in the idea of being independent from the national grid. Independency can be associated with a prosumer community where no intermediate party is necessary to supply in the energy needs of a community. Therefore, a statement about respondents' vision on the independency is developed:

- I think it is important to be more independent from the current energy producers.

After these statements, PART 3, the SCE started.

3.2.6 Pre-testing

During the development of the survey, multiple versions were made to focus on clarity and readability. After the conceptual version was completed in Limesurvey®, a test was completed by close relatives and friends. A selection was made in different ages and knowledge backgrounds to receive as much feedback as possible. During this test, inconsistencies, textual clarity and presentation issues came forward. Inconsistencies in the tables used were solved, and clarifications were made in the naming of the sections. Furthermore, readability in both Dutch and English were at some points unclear and was solved. Presentation issues occurred by filling in the survey at a mobile device, due to the size of the tables in the SCE. Also, the visibility of the graphs was not good. This was not solvable, but advices regarding turning the mobile device screen were given with the distribution of the survey.

A second round of testing was used for friends and classmates to have a second check at the clarity and readability. Furthermore, this test round was used to check for inconsistencies and missing values in the generated data. An issue was found regarding the random selection of the block of choice sets to be presented, this was solved. Further spelling errors were fixed. After this second round of testing, the survey was ready for distribution.

3.2.7 Privacy

In the survey the data collection is done anonymously, no data collected is traceable to the respondent. At the beginning of the survey, a privacy statement was presented to the respondent. Without acceptance of this statement continuation to the survey was not possible, as should be incorporated according to the approval conditions of the Ethics Committee of the TU/e. Explanations regarding data collection and data saving were presented and respondents were made aware of the publication of results in the thesis. A respondent was given a random number ID which was not traceable. Further, date of completion was added as well. Because of the limited amount of requested personal data, no special procedure regarding ethics approval was necessary and extensive data management was not necessary.

3.2.8 Sample size

According to Bekker-Grob et al. (2015) samples over 100 respondents are creating a stable basis for analysis based on rules of thumb. Another standard rule is that one survey version should require more than 20 respondents (Bekker-Grob et al., 2015). In the case of this research with six surveys minimally 120 respondents are necessary.

3.2.9 Noise reduction protocol

During the process of data collection, it was expected that some responses could not be used. Limesurvey® has the opportunity to export only the completed surveys. In the survey, the most questions are mandatory, without completing these questions the respondent cannot continue. This will result in less missing value. Instead, the option "not prefer to answer" was given to the respondent at the mandatory questions. After the export of the questionnaire, the first part of the noise reduction protocol was to check for missing values. Secondly, a check was done for the outliers in the responses. The main focus of noise reduction was to check for 'no preference', neutral response, or answers with the same alternative in every question. Also, an age check was applied, ages below 20 years old were eliminated from the data due to relevance issues. The final check was the estimation of time used to conduct the questionnaire. The estimated time was set between 6 and 10 minutes, enough time to carefully read and select the answers. If the time used to fill in the survey was under 3 minutes, the response was deleted.

3.3 Data analysis

For the analysis of the survey data, several methods were applied. At first, the data needed to be coded. After this, analysis of descriptive statistics followed. Three models were used to analyse the choice data, Multinomial logit, Mixed logit and Latent Class.

3.3.1 Coding

Effect coding was applied for the variables. Because all attributes have three levels, the same method can be applied to all of these attributes. Levels were labelled by number 1, 2 and 3. The more basic levels were coded by -1 and -1, and the other levels were coded 1 and 0 or 0 and 1. Table 12 shows the overview of attribute levels and effect coding.

The labelled experiment results in a possibility for a specific choice regarding an alternative. Alternative-specific constants are advised to include (Hensher et al., 2015). Alternative 1, private investment has Constant 1 included. For alternative 2, community investment has Constant 2 included. The none option does not have constant, and is in both alternatives coded as 0.

Table 12. Attribute levels and effect coding

Attribute	ID	Level	X1	X2
Investment private	1	4,000 euro	-1	-1
	2	6,000 euro	1	0
	3	11,000 euro	0	1
Energy management system private	1	None	-1	-1
	2	Personal	1	0
	3	Automatic	0	1
Members private	1	7500	-1	-1
	2	500	1	0
	3	200	0	1
Management private	1	Company	-1	-1
	2	Government	1	0
	3	Volunteers	0	1
Investment community	1	1300 euro	-1	-1
	2	2600 euro	1	0
	3	0 euro	0	1
Energy management system community	1	None	-1	-1
	2	Personal	1	0
	3	Automatic	0	1
Members community	1	7500	-1	-1
	2	500	1	0
	3	200	0	1
Insight community	1	Monthly	-1	-1
	2	Daily	1	0
	3	Real time	0	1
Management community	1	Company	-1	-1
	2	Government	1	0
	3	Volunteers	0	1

3.3.2 Descriptive analysis

In the questionnaire, questions were asked in three parts. In the first part, the socio-demographic characteristics were collected. Statistical analyses of socio-demographic characteristics can be compared to the total Dutch population to establish representativeness of the research sample. The descriptive statistics of the respondents were analysed with frequency tables and cross-tabs in SPSS. Results were compared to the expected values based upon CBS information (CBS, 2020c) by means of the Chi2-test.

In the second part, the statements were presented. In order to analyse the collected data, the statements were grouped in the associated decision-making variable. Using cross-tabs, the socio-demographic characteristics were used to examine differences between groups.

The closing questions in de last part were also analysed using descriptive and frequency tables.

3.3.3 Multinomial logit

In a SCE, respondents are asked to choose an alternative from a set of alternatives. These choices can be analysed with random utility models (e.g. Hensher at al. 2015). It is assumed that individuals choose the alternative with the highest random utility U_{iq} where q denotes the respondent and i the alternative. The utility consists of two components, the observable component V and the unobservable component ε:

U_{iq} $= V_{iq} + \varepsilon_{iq}$ (eq. 3.1)

U_{iq} = Structural utility of alternative i of individual q
V_{iq} = Observed component of alternative i of individual q
ε_{iq} = unobserved error component of alternative i of individual q

The individual respondent acts according to their utility, the assumption is that they decide upon the maximum utility (Hensher et al., 2015). The structural utility V_{iq} can be calculated through

V_{iq} $= \sum_n \beta_{in} * X_{inq}$ (eq. 3.2)

β_{in} = Utility weight of attribute n for alternative i
X_{inq} = Score of the alternative i on attribute n for individual q

the following equation:

The multinomial logit model is one of the analysis methods most applied in SCE. The model expresses the utility of the respondent in a choice situation, a prediction regarding the preference of an individual can be estimated according to this model (Kemperman, 2000). The result consists of a probability between 0 and 1. The formula which incorporates the calculation of the probability (P_{iq}) to choose an alternative is as follows (Hensher et al., 2015):

The model performance can be estimated. Therefore, the McFadden's Rho-Square test can be used. The model's Log-likelihood (LL) can be compared to that of the base model with all β's equal to zero. The goodness-of-fit can be calculated according to the McFadden's Rho-Square test. The base model is used, in this case only three choice possibilities (scenario 1, scenario 2

P_{iq} $= \frac{\exp(V_{iq})}{\sum_{j=1}^{J} \exp(V_{jq})}$ (eq. 3.3)

P_{iq} = Probability of alternative i of individual q
V_{iq} = Observed component of alternative i of individual q
V_{jq} = Observed component of the number of alternatives in the choice set for individual q

and none). Therefore LL(0) can be calculated by multiplying the number of choices with ln(1/3). However, the Log-likelihood of the estimated model can be calculated as follows:

$LL(\beta) = \sum_q^N \sum_i y_{iq} \ln(P_{iq})$ (eq. 3.4)

LL(β) = Log-likelihood with estimated parameters (β)
N = total number of choices made in model
i = alternative
y_{iq} = Choice made by a respondent (n) for an alternative (i)
P_{iq} = Probability that a respondent (n) chooses as alternative (i)

The loglikelihood functions can be used to calculate the McFadden's Rho-Square. The Rho-

ρ^2 $= 1.0 - [\frac{LL(\beta)}{LL(0)}]$ (eq. 3.5)

LL (β) = Log-likelihood of estimated model
LL (0) = Log-likelihood of null model

Squared can be calculated with equation:

Another option is the Rho-Square adjusted, where the total number of choice alternatives (N_{alt}) and number of parameters in the model (N_{par}) are used as well. Therefore, a more unbiased result is given compared to the Rho-Square (equation 3.5)

$$\rho^2 \text{adjusted} = 1.0 - \left[\frac{N_{alt}}{N_{alt} - N_{par}}\right] * [1.0 - \rho^2] \quad \text{(eq. 3.6)}$$

N_{alt} = Number of choice alternatives
N_{par} = number of parameters in the model

3.3.4 Mixed logit

The random parameter mixed logit model is an additional option in analysing SCE data. A random component is added to the β's, which is time invariant but specific for the individual respondent. By adding random components, the variation in taste is incorporated. Depending on the outcomes of the mixed logit model, a more extensive analysis will be presented (Hensher et al., 2015). If the standard deviation of the random component is equal to zero, the model collapses to the multinomial logit model.

The performance of this model can be determined according to the LL and ρ^2 equations as explained in the previous section 3.3.3.

3.3.5 Latent class

Thirdly, the choice data was analysed according to the Latent Class model. With this method classes of individuals with similar choices can be grouped. It can be investigated whether group membership can be explained by socio-demographic or their preferences regarding statements for example. With the following equation the probability can be estimated (Hensher et al., 2015):

$$P_{iqt|c} = \frac{\exp(V_{iqt|c})}{\sum_{j=1}^{J} \exp(V_{jqt|c})} \quad \text{(eq. 3.7)}$$

$V_{iqt|c}$ = Structural utility for individual q of alternative i in choice set t given class c

For the Latent Class analysis socio-demographic characteristics and scores based upon statements are incorporated in the analysis. The statements are coded based upon the average score for the variable. The statement groups (for example environmental attitude, having two statements) are added, and divided by the number of statements. If the average score is above 4 (answer is agree or strongly agree) the respondent gets for that variable a high score being coded as 1 in the data set. In the estimation of the Latent Class analysis, there will be tested on the effect of a high score on the membership of each class. This is based upon the assumption that decision-making variables influence the intention to change behaviour when this is higher, according to the behavioural models. The probability an individual respondent belongs to a group can be calculated as follows (Hensher et al., 2015):

$$H_{qc} = \frac{\exp(z'_q \theta_c)}{\sum_{c=1}^{C} \exp(z'_q \theta_c)} \quad \text{(eq. 3.8)}$$

H_{qc} = prior probability for class c for individual q
z_q = observable characteristics for individual q
θ_c = a vector of parameters representing the influence of individual's q characteristics

Note that the parameters of equations 3.7 and 3.8 can be estimated simultaneously.

3.4 Conclusion

In order to answer the research questions, the methodology has been justified in this chapter. A Stated Choice Experiment was chosen in order to determine the choice preference of the Dutch population. A SCE is the most suitable method in assessing behaviour in hypothesized situations and predicting future behaviour. A labelled experiment was developed, the first alternative was based upon the prosumer community principle of having a personal microgeneration system and demanding and supplying a local virtual network with over-supply of energy. The second alternative was based upon an energy cooperative, where a joint investment is done by community members in bigger sized microgeneration systems. These scenarios were supported by five attributes, all specified on one of the scenarios. Differences between alternatives were set in investment height and type and information provision. Overlapping attributes were the presence of an energy management system, the number of members and the management. All attributes were determined by three levels, which were integrated in an experimental design. This experimental design resulted in six surveys with different random combinations of choice sets in the experiment. These six blocks consisted of nine choice sets which had to be completed by the respondent. The total questionnaire consisted not only of these nine choices, they were supported by questions regarding socio-demographic variables and twelve statements based upon the behavioural models.

Also, the determination of analysis methods was done. The socio-demographics and statements will be analysed using descriptive statistics, but also with cross-tabs in order to determine differences in choice based upon a societal group. Three analysis methods will be used for the SCE. At first the Multinomial logit model will be applied, but due to its limitations regarding taste effect the random parameter mixed Logit model will be used as well. At last, the Latent Class model will be used to predict preferences per class of respondents and membership of these classes.

4 Results

In this chapter the way in which the questionnaires were administered and the results of the analyses will be discussed. The first section describes the conduction of, and the global response at the survey, followed by the description of the sample. Also, the sample will be discussed regarding the socio-demographic characteristics and whether the sample is representative for the Dutch population. The second part of the questionnaire consisted of statements; the results will be discussed in the third section. After this section a description of the results of the Multinomial Logit model, the Mixed Logit model and the Latent Class model will be *given, followed by a discussion and a conclusion.*

4.1 Survey conduction and sample description

From December 17th 2020 until January 28th 2021 data collection took place. Multiple channels were used to distribute the questionnaire in order to reach as many respondents as possible. The first way was to distribute a flyer in a neighbourhood in Tilburg, the Netherlands. Via a QR-code the respondent was able to fill in the questionnaire. The second method was through a personal network via Facebook, LinkedIn and personal addressing. Third, professional networks of relatives were used to distribute the questionnaire within companies. A total of 211 people started the questionnaire, and 140 completed the whole questionnaire. Due to the privacy statement used in this survey, it is unknown how many people opened the questionnaire.

The first segment of the questionnaire was based on the personal characteristics of the respondents. Representativeness was determined by comparing percentages with the total Dutch population (CBS, 2019c), the total descriptive statistics are visible in Table 13. The first variable represented the age category of respondents. Especially the 20-29 years category is overrepresented in the sample with 30.7 percent, this is also relatable to the high Chi-square which is significant. This could be due to the personal network of the researcher. The category between 70-79 years is represented by only 1 person. This age category seemed difficult to be reached. An explanation could be that older people are less familiar with internet and digital surveys. The second variable, gender, is evenly represented in the sample with only a slight difference (less than 3%). This variable was found representative in the sample with the Chi-square test (p=0.064). In education, major differences occurred (p=0.000). There is an overrepresentation of higher educated people with 81.3 per cent, which is twice as high as the Dutch population. This was expected because of the way of distribution. Work status, the fourth variable, has also differences (p=0.000). Students are overrepresented (11.4%, in Dutch population 3.43%), while only one unemployed respondent participated. A major part of the sample was conducted by spreading the questionnaire within a company, this can explain the high percentage employed respondents (82.1%). Another category was the household income. Lower incomes are not represented as in the Dutch population. This can be explained by the education level and work status of the respondents because these are both highly present. The Chi-square test (p=0.000) showed that the null hypothesis (no differences) should be rejected. The household size was questioned as well as was the presence of children in households. Especially the one-person households are less represented compared to CBS statistics (15.7%). The relatively high percentage of students, often inhabitants of dorms, explain the unexpected high number of shared households. However, the results regarding the number of children in the household was found representative. Overall, the sample cannot be considered representative of the Dutch population.

Table 13. Representativeness of the sample (CBS,2020c)

		Sample count N=134	Sample percentage	Expected count	Netherlands percentage	Residual
Age χ^2=34.495 p= 0.000	20-29	43	32.1%	23	17.44%	20
	30-39	20	14.9%	22	16.77%	-2
	40-49	20	14.9%	23	17.24%	-3
	50-59	33	24.6%	26	19.77%	7
	60-69	17	12.7%	22	16.50%	-5
	70-79	1	0.7%	16	12.29%	-15
Gender χ^2=0.269 p= 0.604	Female	64	47.8%	67	49.65%	-3
	Male	70	52.2%	67	50.35%	3
Education χ^2=83.450 p= 0.000	Pre-school	0	0%	12	8.97%	-12
	Secondary school	13	9.7%	13	9.65%	0
	VMBO or MBO	28	20.9%	64	46.85%	-36
	Bachelor	93	64.4%	45	32.68%	48
Work status χ^2=51.763 p= 0.000	Student	16	11.9%	5	3.43%	11
	Unemployed	1	0.7%	22	16.07%	-21
	Employed	109	81.3%	92	68.79%	17
	Retired	8	6.0%	16	11.71%	-8
Household income χ^2=26.712 p= 0.000	<30	16	11.9%	35	26.03%	-19
	30-50	47	35.1%	29	21.27%	18
	50-100	46	34.3%	43	32.35%	3
	>100	22	16.4%	27	20.46%	-5
	No answer	3	2.2%	0	0.0	-3
Household size χ^2=53.419 p= 0.000	1	21	15.7%	51	38.51%	-30
	2	55	41.0%	44	32.64%	11
	3	23	17.2%	16	11.73%	7
	4	24	17.9%	16	12.02%	8
	>5	5	3.7%	7	5.10%	-2
	Shared Household	6	4.5%	1	0.51%	5
Children χ^2=5.374 p= 0.146	0	79	59.0%	90	67.30%	-11
	1	22	16.4%	19	13.99%	3
	2	26	19.4%	18	13.54%	8
	3 or more	7	5.2%	7	5.17%	0

At the end of the survey, the respondents were asked whether they have a specific goal they would like to achieve by participation in an energy community. Multiple options were possible, also the option “no, I do not want to participate”. The option of no participation is only chosen in one case, as can be seen in Figure 14. The most important reason seem to be the cost decrease (84 times), as well as a good investment of money (59 times). Another reason respondents gave is the sustainability in general (81 times). Also net-zero homes (46 times) or communities (34 times) are goals people are interested in. Locality of the community is chosen 41 times. The respondents were also offered an option “other”, where respondents were able to introduce other goals.

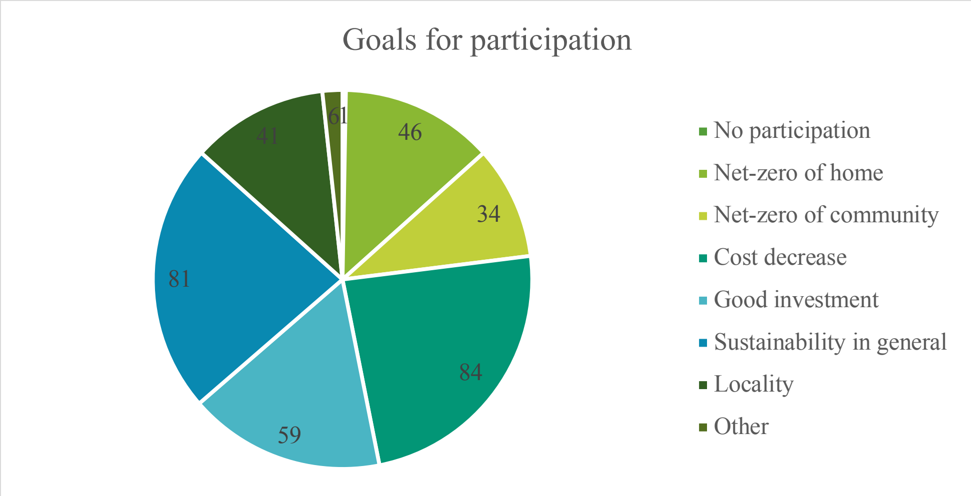


Figure 14. Goals for participation (count)

The final question was whether the respondents do already apply sustainable measures in their current home. Table 14 shows the results, a distinction is made between home-owners and renters. Home-owners are overrepresented with 103 respondents, compared to 31 renters. Already 28 percent of the respondents apply PV-panels, all, except one, by home owners. The highest percentage respondents (32.98%) apply insulation, however it is unclear whether these respondents invested themselves in insulation or if they referred to insulation already installed during construction, since four renters answered the same. Solar boilers and heat pumps are less applied (3.19% and 6.64%). And especially, the energy storage solution is applied only by one respondent. This is in line with the expectations regarding storage, since price and efficiency of available ES units, in combination with the 'salderingsregeling' is still financially unattractive. Instead, other options are mentioned like HR++ glass, pellet heating, 'Winddelen' (wind energy shares) and more sustainable household appliances. Twenty-five percent of the respondents do not apply anything, half of them are homeowners, the others live in a rental house.

Table 14. Energy measures already applied

Sustainable measure	Occurrence total	Percentage	Homeowners (N=103)	Renters (N=31)
PV-panels	53	28.19%	52	1
Solar boiler	6	3.19%	6	0
Heat pump	12	6.64%	10	2
Energy storage	1	0.53%	1	0
Insulation	62	32.98%	58	4
Other	7	3.72%	7	0
None	47	25.00%	24	23

4.2 Analysis of the statements

The questionnaire consisted of 12 statements regarding behavioural influence which were answered on a 5-point Likert scale. First, the answers of the total sample will be discussed. After this an analysis will be presented regarding the socio-demographic characteristics and the answers on the statements.

4.2.1 Subjective norm

A subjective norm was measured to determine whether influence of friends and family affect the decision making regarding sustainable energy measures. The subjective norm was split up in three statements. Together they determine the overall vision of the respondent. The first two statements concern social norms, the third is a descriptive norm. The majority of the respondents agree upon all the statements regarding the subjective norms. The percentages regarding strongly disagree are neglectable with percentages below 3%, and not visible in the graph in Figure 15.

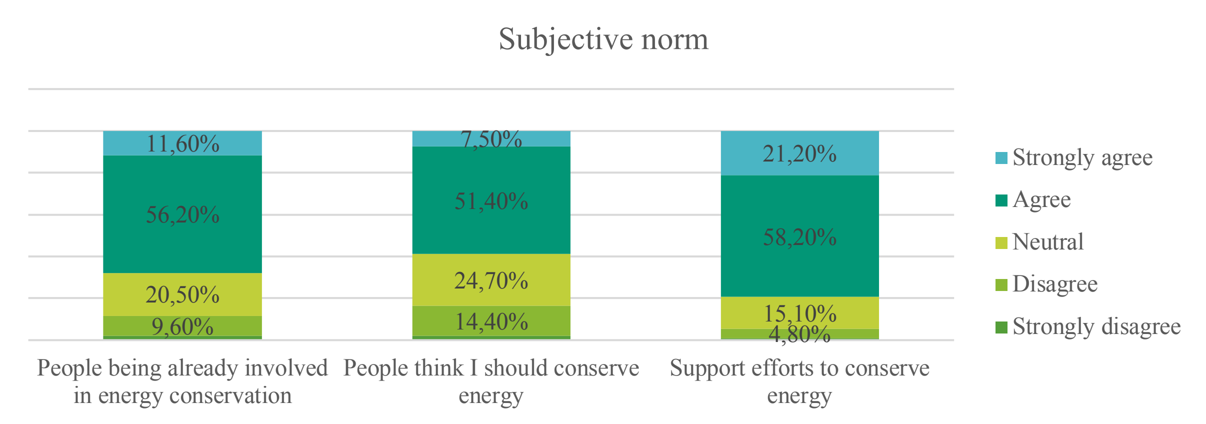


Figure 15. Results regarding subjective norm (percentage)

The sociodemographic characteristics are stratified to examine whether there are significant differences between groups. Appendix VIII shows the complete statistics of the crosstabs; the Chi square test is used to check the significance. At the 5% significance level there are no significant differences between the socio-demographic classes, therefore the null hypothesis cannot be rejected. At the 10% significance interval, only education level has a significant influence on the statement regarding people think I should conserve energy. Figure 16 shows the significant differences between the three educational levels. Especially lower educated respondents disagree more upon this statement, while higher educated people are more neutral about this.

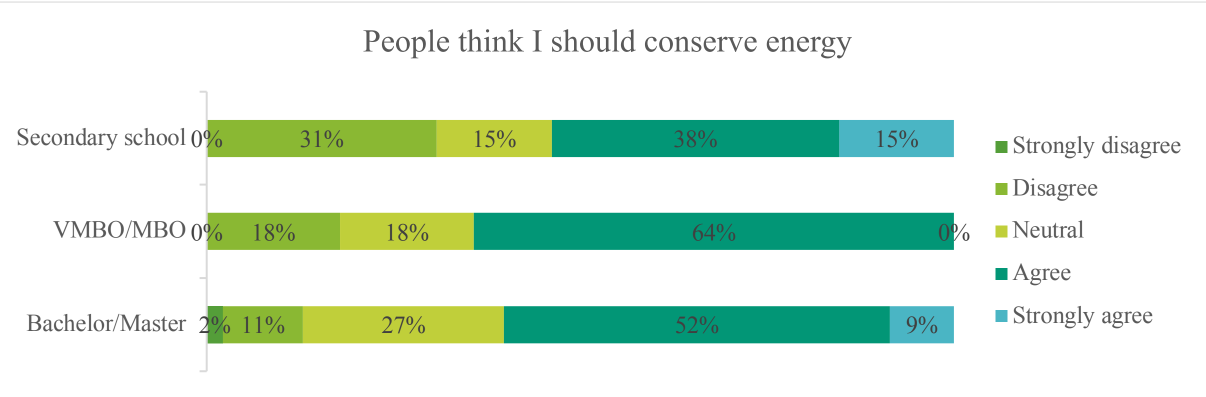


Figure 16. Education and social norm (percentage, significance < 0.1)

4.2.2 Environmental awareness

The second variable was the environmental awareness, which was asked in two statements about environmental problems and the use of fossil fuels. The percentages are visible in Figure 17. Almost one third of the respondents strongly agree upon the issues with the environment with 32.2%. Only four respondents (<2%) respond that they are not concerned with the environmental problems. Regarding the use of fossil fuels, ten percent disagree with the statements. These respondents do not consider the use of fossil fuels a problem.

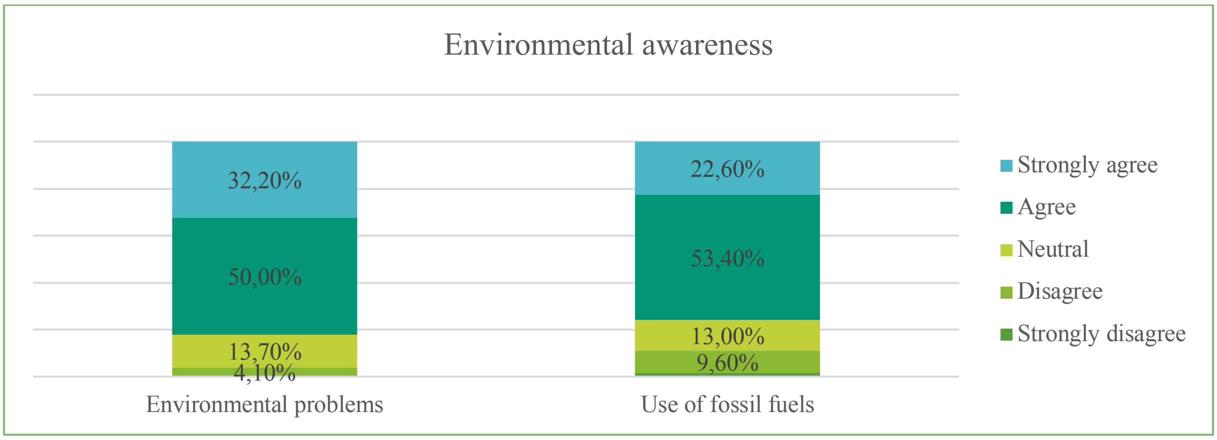


Figure 17. Results regarding environmental awareness

Differences between (socio-demographic) groups regarding these statements were examined. There were regarding environmental awareness no significant differences found between groups.

4.2.3 Locus of control

Locus of control was one of the examined behavioural influences as well. With two statements was measured to what extent people think the environmental issues are in their own control. Figure 18 shows the results for the two statements. Around ten per cent strongly disagree with the statements and do not think they can make a difference in protecting the future. The majority of the respondents (strongly) agree upon the statements about locus of control (resp. >69% and >64%).

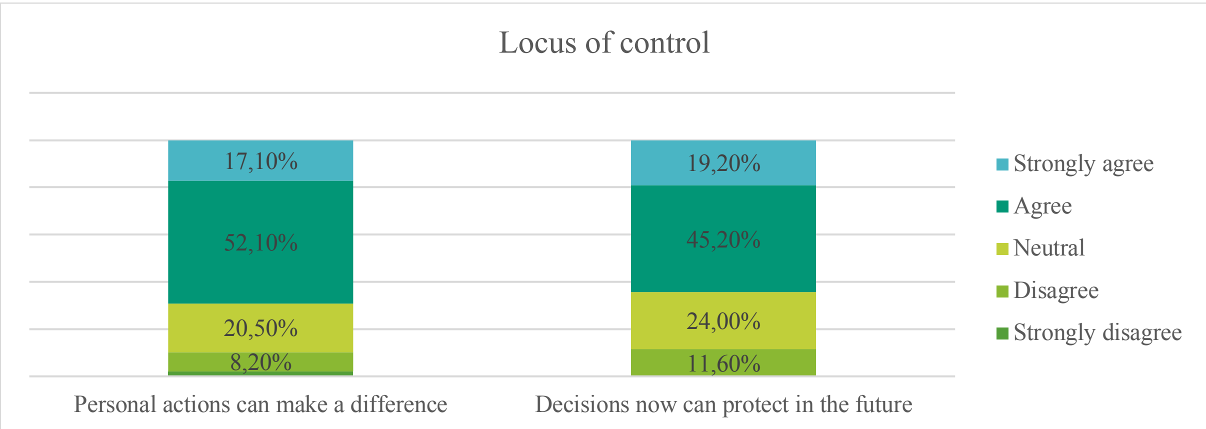


Figure 18. Results of statements regarding Locus of control

Figure 19 shows the significant ($p<0.05$) relationship between work status and locus of control: personal actions can make a difference. Student and employed respondent did strongly argee upon this statement, the retired respondents did not. Students did not even respondent that they disagree. Figure 20 shows the relationship between home ownership and the locus of control: decision now can protect in the future. Renters disagree (26%) on this statement, while home-owners (7%) disagree far less. However, the share of strongly agree is slightly higher with renters (26%) compared to the home-owners (19%).

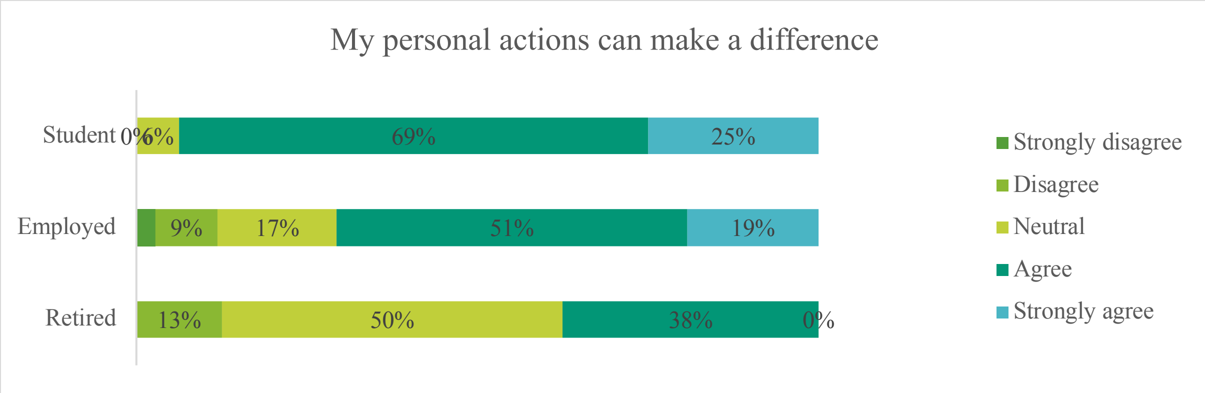


Figure 19. Locus of control and sociodemographic factors (P<0.05)

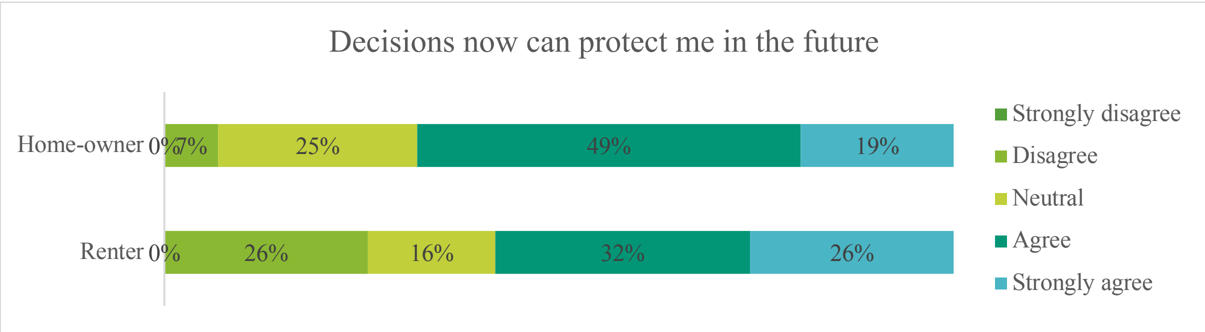


Figure 20. Locus of control and home-ownership (p<0.05)

4.2.4 Community identity

The graph in Figure 21 shows the results of the three statements regarding community identity. Especially the feeling of attachment to the community seems to be important. More than half of the respondents agree (46.6%) or strongly agree (7.5%). Feeling pride to be part of an energy community is important for agree (31.5%) and strongly agree (7.5%) of the respondents. Having friends have lesser group sizes on the agree side but yet, 33.6% agree and 2.1% strongly agree. More than 20% do not think having friends is important in participating in an energy community.

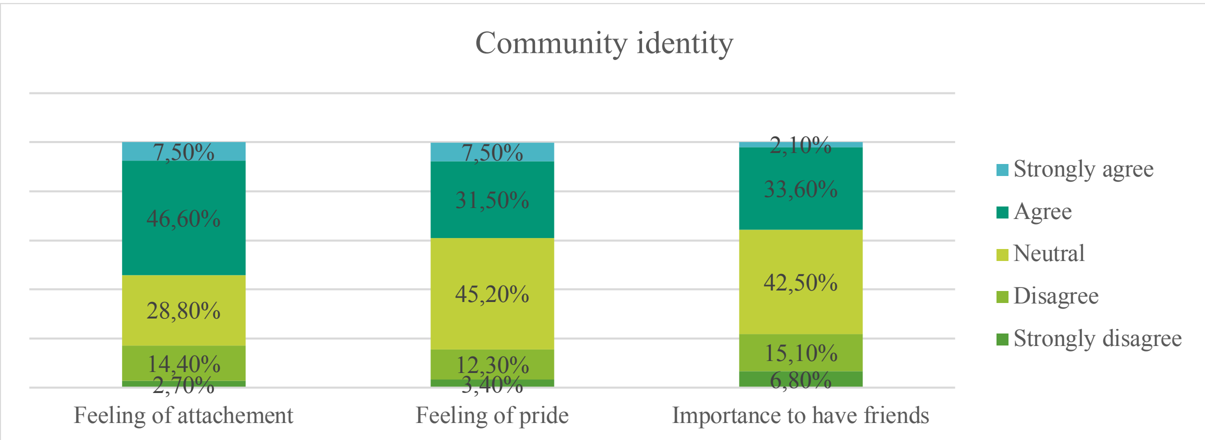


Figure 21. Statement results community identity

The statements regarding community identity have been explored with Chi square tests as well, but only the first statement regarding feeling of attachment shows significant differences between education categories (p<0.01). Figure 22 shows significant differences within the educational level of the respondents. Lower educated people, the people with secondary school, strongly disagree (15%) more upon this statement compared to VMBO/MBO or Bachelor and master. However, the also strongly agree (23%). The share of agree upon the statement is the highest with bachelor and master education respondents (53%).

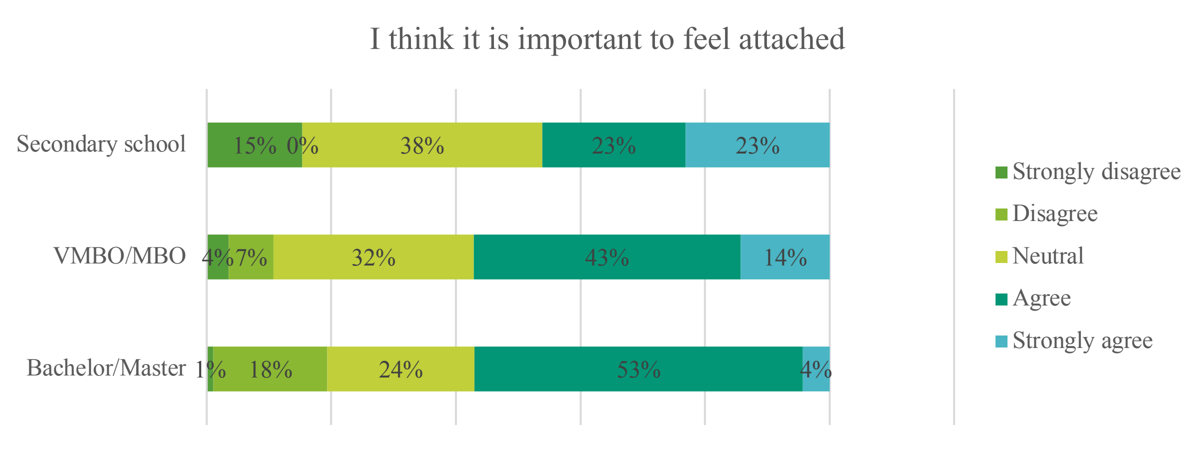


Figure 22. Community identity and sociodemographic factors (p<0.01)

4.2.5 Trust and independency

The results of the two statements regarding trust and independency are visible in Figure 23. In the questionnaire the respondents were asked if they trusted the current energy suppliers to act good. About 48 per cent of the respondents agree upon this statement, 28 per cent is neutral and 24 per cent disagrees. This means that almost one fourth of the sample does not trust the current suppliers. While looking at the statement regarding the importance of feelings of independency, the majority of 73 per cent would like to be more independent from the current suppliers.

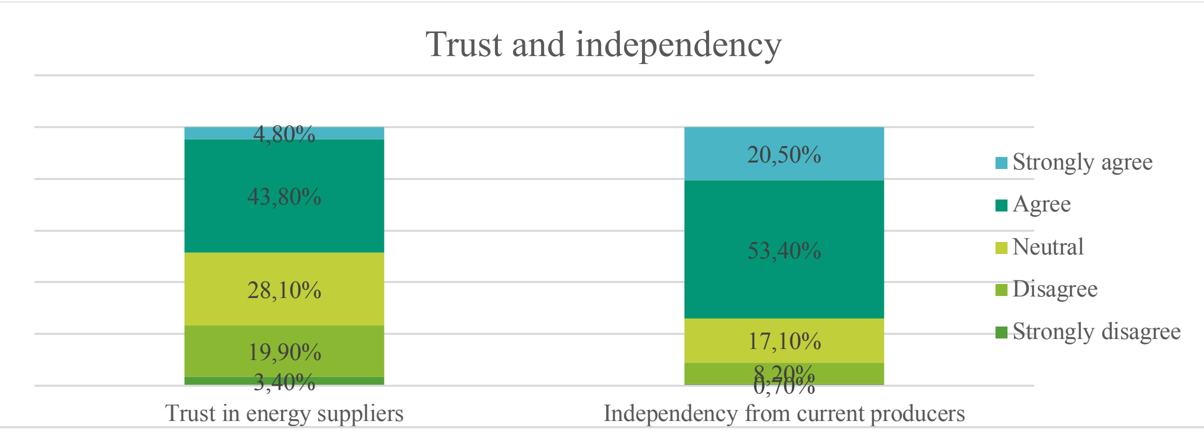


Figure 23. Results of statements regarding trust and independency

Trust does show significant differences between the respondent groups with different educational levels. Figure 24 shows that secondary school and VMBO/MBO have a higher trust in energy suppliers (respectively 62% and 54%). However, the higher educated respondent do not strongly disagree upon this statement. The desire to be more independent does show significant differences with gender ($p<0.05$). Figure 25 shows the differences between men and women, men have chosen ‘strongly agree’ more often (29%). Female respondents agree in most of the cases (66%).

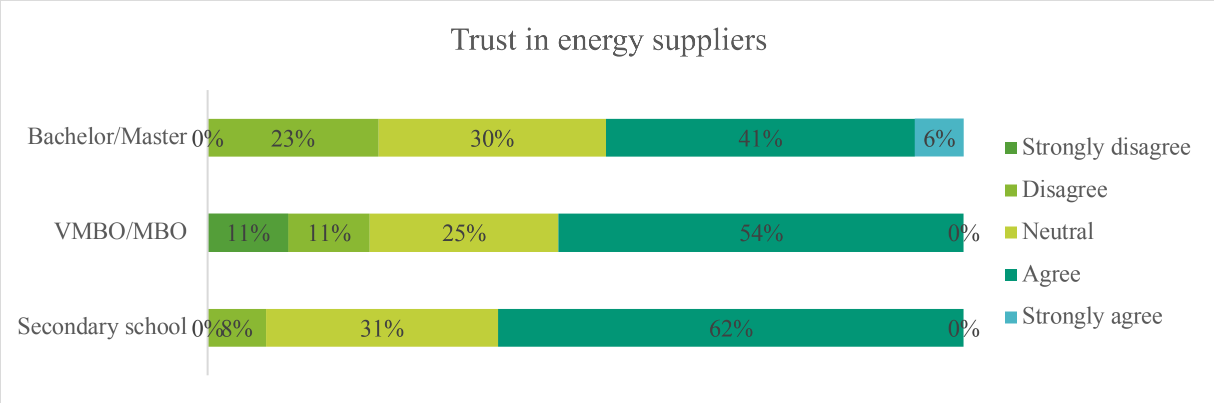


Figure 24. Results cross-tabs trust and education level (p<0.05)

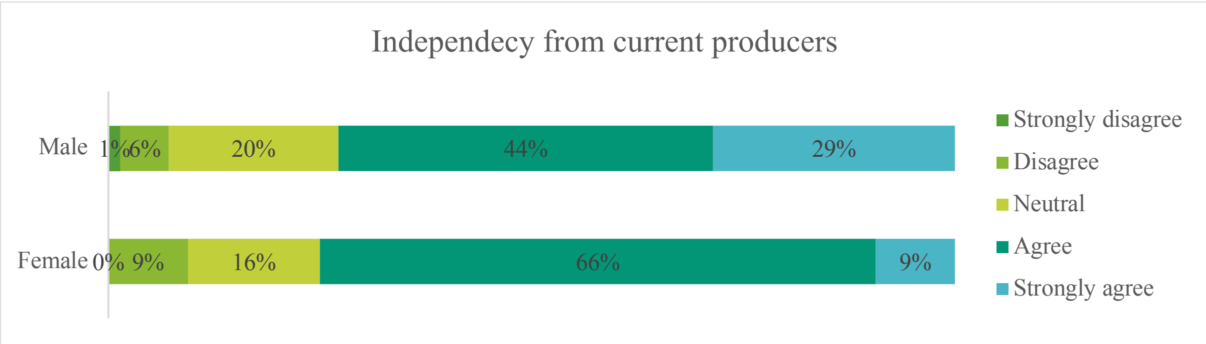


Figure 25. Results of cross-tabs independency and gender (p<0.05)

4.3 Multinomial logit model

The multinomial logit model is estimated with the software program "Nlogit". The results are presented in Table 15. The table presents different columns, the first columns represent the attribute and their levels which were determined in chapter 3.2. Due to the used effect coding schemes, only two of three attribute levels are estimated by parameters. These parameters are presented in the third column. The third level is calculated by the sum of both levels multiplied by -1. These parameters represent a value that reflects the part worth utility someone attaches to that attribute level. The mean part worth utility of each attribute is equal to zero. The higher the parameters the more influence this factor has on the choice. There is the possibility that this parameter represents a negative number, this means that the attribute has a negative effect on the choice made by the respondents. The fourth factor represents the two-tailed significance value, which determines the significance of the attribute value. The complete output of the MNL model is presented in Appendix IX.

Only a few attribute levels are significant. In the first place the two constants, which are added to include the respondent's overall preference for a certain scenario (p<0.01). Furthermore, the 16 panels & storage have significant, but negative impact on the decision (p<0.01). Other significant values are the community investment with an investment of 2,600 euro's (p<0.1), partly participating in an energy management system in a community network (p<0.1), and the management done by volunteers (p<0.01).

Table 15. Results Multinomial logit model.

Attribute	Attributes private	Parameters	Sign.	Attributes community	Parameters	Sign.
Constants	Constant 1	2.16280	***	Constant 2	1.20147	***
Investment	11 panels	0.38482		€1300	0.11730	
	16 panels	0.15497		€2600	-0.18108	*
	16 panels & storage	-0.53979	***	€0	0.06378	
Energy management system	None	0.05081		None	-0.27834	
	Partly	0.00595		Partly	0.19314	*
	Automatic	-0.05676		Automatic	0.08520	
Number of members	7500	-0.04991		7500	0.03217	
	500	-0.01272		500	0.04793	
	200	0.06263		200	-0.08010	
Information provision	Not applicable			Monthly	-0.04782	
				Daily	0.11389	
				Real-time	-0.06607	
Management	Company	-0.02274		Company	0.11142	
	Government	0.01368		Government	0.16380	
	Volunteers	0.00906		Volunteers	-0.27522	***

****;**;* -> Significance at 1%, 5%, 10% level*

Furthermore, the performance of the model is shown in Table 16. McFadden's Rho^2 is 0.227. According to Hensher et al (2015) a value between 0.2 and 0.4 represents an excellent fit. Therefore, it could be concluded that this model has a good fit, and functions better compared to the null model.

Table 16. Goodness of fit of the MNL model

Number of observations	1,206
LL(0)	-1,324.9264
LL(β)	-971.2367
McFadden's Rho^2	0.227
Rho^2 adjusted	0.214

Figure 26 shows the utility scores of all the attribute levels in a visual way. There were only six variables with significant values. These are presented in green in the figure, the grey values represent non-significant values. There are many values which represent only a small impact.

The constants in the model have a high value. This means that the overall impact of the constants is high on the choices made. These values represent the highest impact overall, especially constant 1 has a high influence. This is the constant representing the choice for a private investment. Constant 2 has a lower value, but still has a higher impact on the choices made than any other value. This means that respondent prefer private investments over community investments and that the latter are preferred over no investments at all. The individual attributes will be discussed below.

Investment

Investment was one of the attributes, divided into a private investment or a community investment. The private investment was divided into a small system of 11 panels, a bigger system with 16 panels and a system combining 16 panels with a battery storage. The last two were presented with parameters in the MNL model, the first attribute level is used for estimation and calculated afterwards. Only the PV panels & storage resulted in a significant result. The effect of this variable is -0.54, it could be said that this variable has a negative effect on the choice compared to the none option and other attribute levels. The effect of 16 PV panels was lightly positive with 0.15497 but is not significant (p=0.1101). With these two variables the effect of the third variable could be calculated. The effect of 11 PV panels is positive with 0.38482.

Community investment was divided into an investment of 1,300 euro, 2,600 euro or no investment with using the roof for installation of PV panels. The second level, 2,600 euro with eight shares has a significant effect on the choice made by the respondents ($p<0.1$). This effect is -0.18108, therefore it could be assumed that including this variable in a scenario the none option is more preferred. The second variable estimated by the model, the ‘no investment’ option does not have a significant effect and with a value of 0.06378 it can be ignored. The other level, investment of €1,300, has a positive effect of 0.11730.

Energy management system

The introduction of an EMS is quite new but could have impact on the costs a household pays for electricity. Therefore, the options were no EMS, partly EMS, and an automatic EMS, all presented in the private and joint ownership scenario. The private ownership scenario does not have significant values, and with small values it could be said that this variable does not influence the choice a person made. However, a different pattern is established in the joint investment. A partly EMS has a significant effect of 0.19314 on the choice ($p<0.1$). The presence of a partly EMS affects the choice compared to the none option in a positive manner. An automatic EMS has a small effect of 0.08520 and is not significant. The estimated third variable, no EMS, has a negative effect of -0.27834.

Community members

The size of the community was included in both scenarios. In both cases, there are no significant relations found between this variable and the decision for a certain scenario. The utilities of both the private and community scenario, are negligible small. This is also visible in Figure 26, where the community member attributes are represented, but the utility scores are hardly visible.

Information provision

In a system that is owned privately, normally an actual information system is provided with the system. Therefore, a choice for the respondents is not required. For the community ownership, the billing goes via an external party that organized the investment. The information provision does not show significant results regarding the interval of information given to the customer. While looking at the non-significant values it could be concluded that these are relatively small. The daily information regarding energy use and supply has a utility of 0.11389, but is not significant.

Management

The final variable is the management, in general this can be done by a company, by the government or via volunteers in the community. This variable is presented both in the private and joint scenario. In the private scenario there are no significant values found. However, in the community scenario management by volunteers has a negative impact of -0.27522 on the choice compared to the none option ($p<0.01$). The other management types do not show significant results.

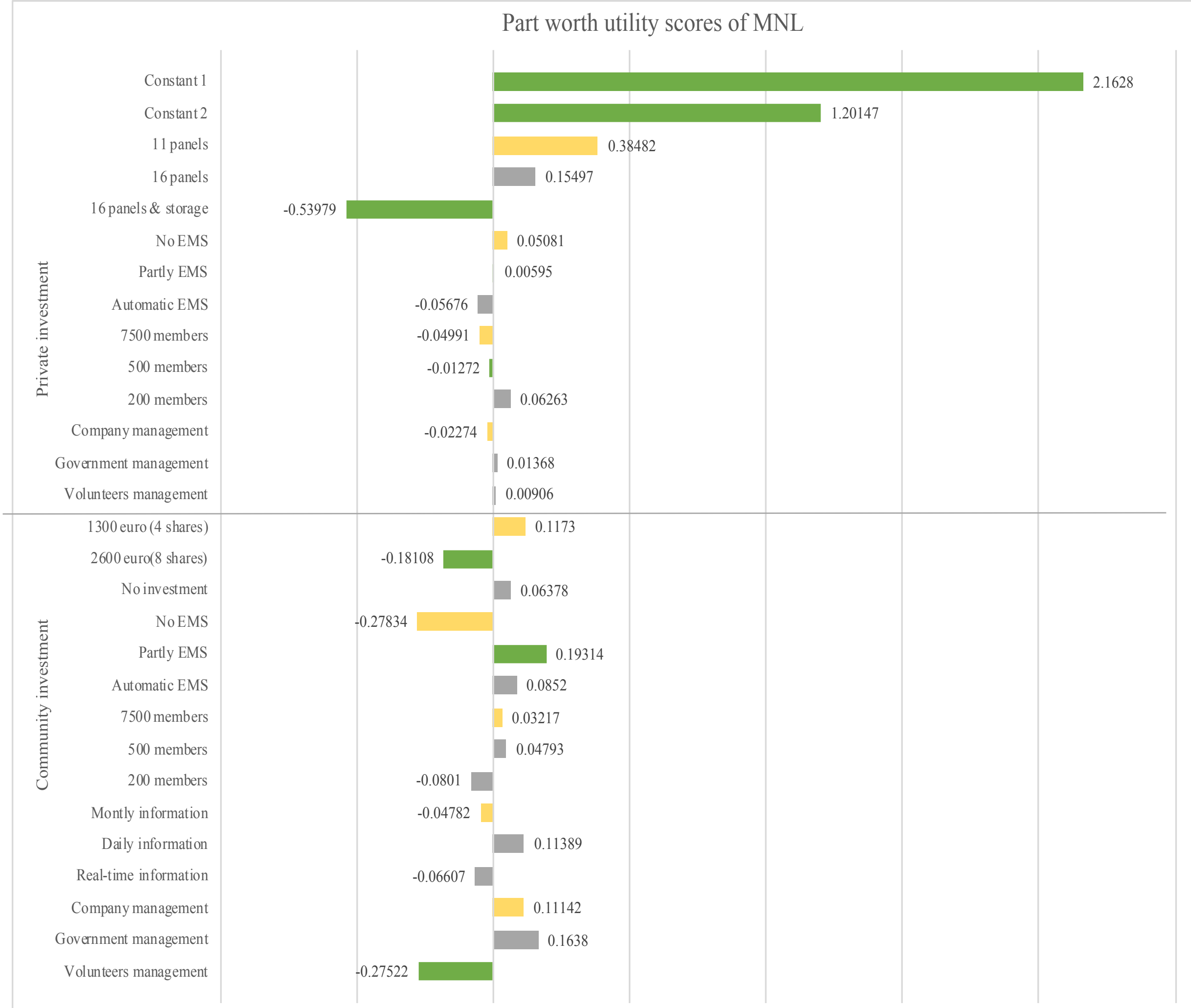


Figure 26. Part Worth Utility of Multinomial Logit model

Relative importance

With the utility scores of the attribute's levels, the relative importance can be calculated. The range of one attribute (the difference between the lowest and highest part worth utility) can be divided by the sum of the ranges of all attributes. The choice is made to include all the utilities, and not only the significant ones since there are only a few of these. Figure 27 shows the total graph of the whole model, where both private and community shares have been included. The lower relative importance, the less influence this attribute has on the decision-making of the respondents. As can be seen in the figure, four attributes are rather important. Especially the height of the investment for private ownership is important. The other relative important attributes are the height of the community investment, the presence of an energy management system for community investments and the community management.

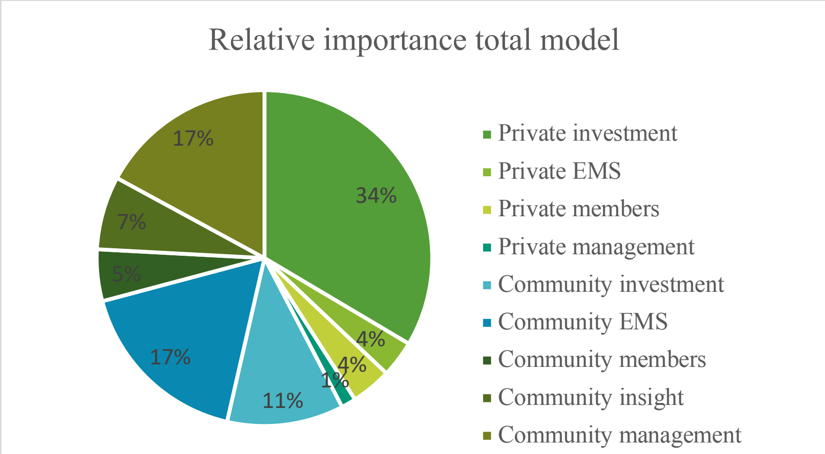


Figure 27. Relative importance total model

The relative importance can also be determined for private ownership or community ownership, to determine the most important decision-making values in these two scenarios. Figure 28 shows the relative importance for the private ownership, as expected from the earlier figure, the investment height is most important in the decision making with 79 per cent. The importance of other attributes is less than 10 per cent. Figure 29 shows the relative importance for the community ownership. The investment height has a relative importance of 19 per cent, presence of an EMS and the management of the community have a relative importance of 30 per cent. Which is quite different from the results from the private ownership. The relative importance of attribute community members is similar to that of private members.

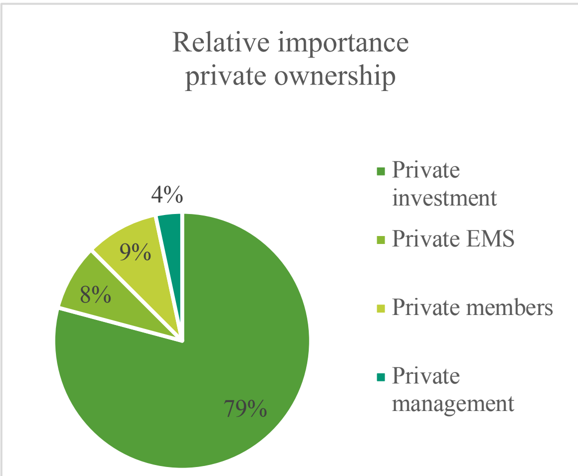


Figure 28. Relative importance private

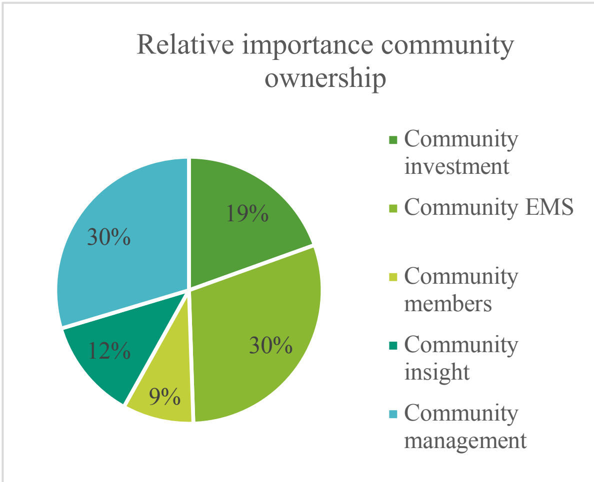


Figure 29. Relative importance community

4.4 Mixed Logit model

In order to estimate the mixed logit model, a number of Halton draws is used. Halton draws give a better estimation of the model compared to random draws (Train, 2000), but there is no stick number of draws that finds the best fitting model. The reason for this efficiency is the more even spread of draws and the filling of empty spaces. Train (2000) finds the best performing model is with 125 draws, mainly the standard deviations are the smallest in this model. Table 17 shows an overview of the results depending on the number of draws. Looking towards the Rho^2, 25 Halton draws give the best results. 50 Halton draws have a slightly lower goodness-of-fit, but have more significant values for both the mean parameters (the β's) as the standard deviations of the corresponding random components. However, extreme values have a relative high impact on the standard deviation it the number of draws a small. According to the current standards, a higher number of Halton draws is requested according to Ellis et al (2019). With a number of 10 random parameters, at least 1000 draws are advised. In this research, 18 random parameters need to be estimated. Therefore, the 1000 Halton draws will be used.

Table 17. Model performance based upon Halton draws

Halton draws	25	50	125	500	1000
LL(β)	-960.096	-962.619	-963.822	-965.695	-965.795
Rho^2	0.2754	0.2735	0.2725	0.2711	0.2711
Significance parameters	5	6	5	5	5
Significant standard dev.	4	5	2	2	2

The mixed logit model estimates not only the mean of the utility parameters, but also the standard deviations. Table 18 shows the estimated parameters, the complete output of the model is visible in Appendix X. Comparing the Rho^2 of 0.2711 to the Rho^2 of the MNL, 0.227, it could be concluded that the ML model performs better. Including the taste variations in the model does increase the model performance. However, there are less significant parameters found in the Mixed Logit model with 1000 draws.

The mixed logit model measures the standard deviation. The standard deviation represents the difference in preferences of respondents. A small standard deviation could be assumed as smaller difference in preference regarding the attribute level under consideration between the respondents. Also, the significance is measured for these standard deviations, if the standard deviation is not significant, tastes can be assumed homogeneous. The attributes EMS, members, management and community information provision do not include significant standard deviations. Therefore, these attributes can be assumed as homogeneous. However, private investment has a significant ($p<0.01$) standard deviation for 16 PV panels and storage (0.6119). Therefore, in this attribute heterogeneity can be assumed in respondents' affinity to this attribute. A less significant ($p<0.05$) standard deviations was found for no investment (0.4328), also this attribute can be assumed as heterogeneous.

Table 18. Mixed logit model results

Attribute	Attributes private	Parameters	Sign.	St.dev	Sign.	Attributes community	Parameters	Sign.	St.dev	Sign.
Constants	Constant 1	2.20962	***			Constant 2	1.17684	***		
Investment	11 panels	0.44651		-		€1300	0.11232		-	
	16 panels	0.11744		0.0094		€2600	-0.16481		0.1335	
	16 panels & storage	-0.56395	***	0.6119	***	€0	0.05249		0.4328	**
Energy management system	None	0.05634		-		None	-0.30878		-	
	Partly	0.00224		0.0237		Partly	0.20943	*	0.2586	
	Automatic	-0.05410		0.2301		Automatic	0.09935		0.0268	
Number of members	7500	-0.04998		-		7500	0.04027		-	
	500	-0.01264		0.0012		500	0.04570		0.0088	
	200	0.06262		0.0009		200	-0.08597		0.0001	
Information provision	Not applicable					Monthly	-0.005759		-	
						Daily	0.11927		0.0002	
						Real-time	-0.06168		0.0035	
Management	Company	-0.02016		-		Company	0.12322		-	
	Government	0.01692		0.0004		Government	0.16188		0.0015	
	Volunteers	-0.00324		0.0234		Volunteers	-0.28510	**	0.0103	

***,**,* -> significance at 1%, 5% or 10%

The comparison between the multinomial logit model and mixed logit model is visible in Figure 30. The directions of the utilities are the same in almost every case. The utility scores in general are nearly the same. Therefore, the explanations of the Multinomial Logit model also hold for the Mixed Logit model. This is also confirmed by the relative importance of the Mixed Logit model. The importance of the attributes are in comparison with the MNL model almost the same, as can be seen in Figure 31. The differences in the model are in the additional standard deviations that are included in the ML model. These standard deviations cause the better performance of the model, in comparison with the MNL model.

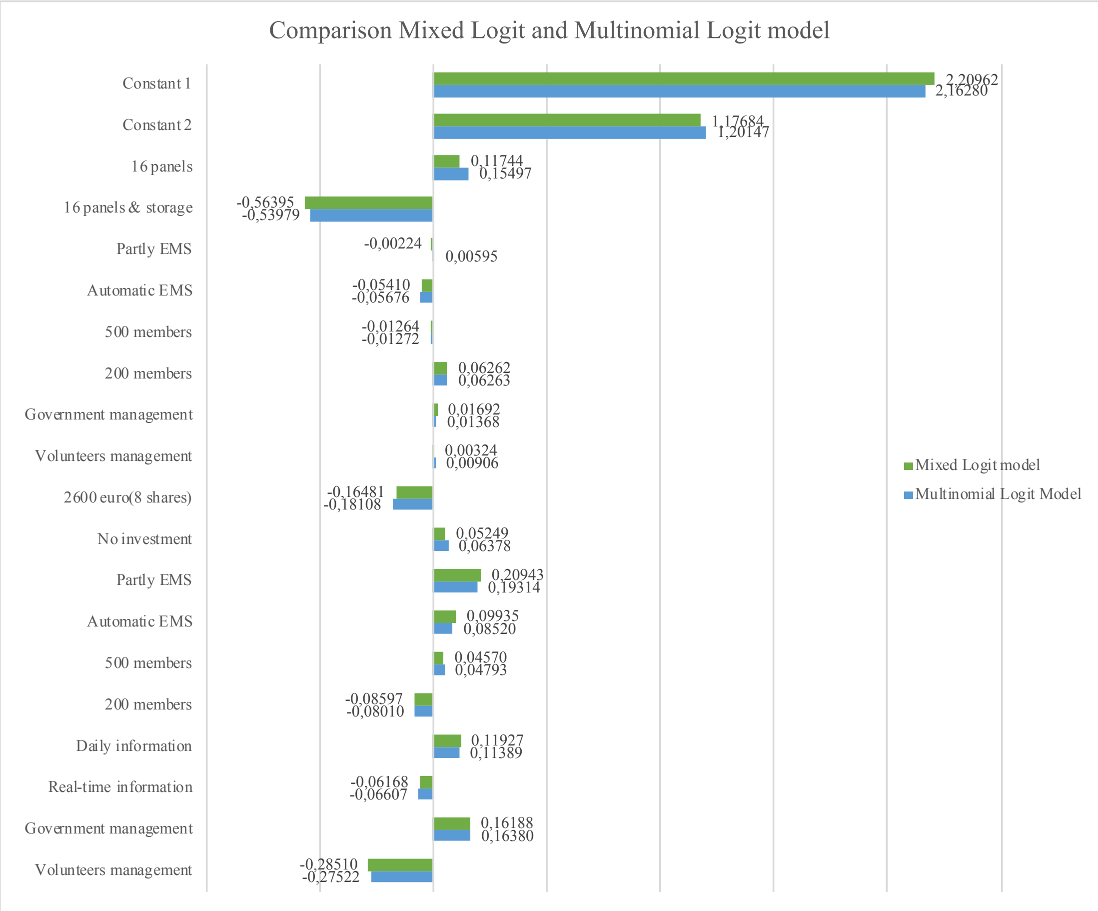


Figure 30. Comparison PWU Multinomial Logit and Mixed Logit

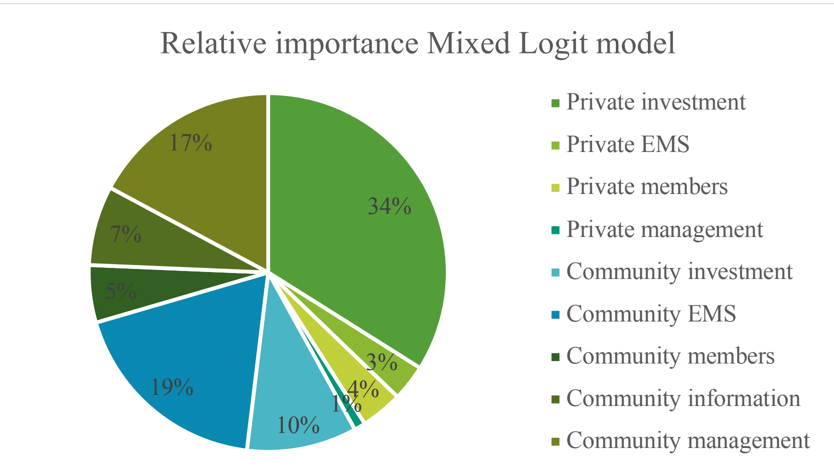


Figure 31. Relative importance mixed logit

4.5 Latent Class model

As final analysis, the Latent Class (LC) model was applied. This model estimates the parameters for a predefined number of classes within the sample. Respondents are clustered into these classes according to their preference structures. It was possible to add socio-demographic characteristics and statements to this model in order to predict to which class each respondent belongs. Different explanatory variables were tested to find a well performing model. The final model is shown in Table 19.

The second part of the LC analysis consisted of a simpler model without predicting class membership probabilities given characteristics of the respondents. Now, for each respondent class membership probabilities were estimated by Nlogit. By assigning each respondent to the class with the highest probability, class membership can be investigated using Chi-square analyses in SPSS. In these LC analyses, two classes are used. A higher number of classes did not result in significant and reasonable values. Therefore, the choice is made not to analyse the number of classes further. The complete models are visible in Appendix XI.

Analysis 1: LC with class membership

In this analysis the socio-demographic characteristics and statements were combined with the latent classes. While looking at class 1 in The performance of the LC model is visible in Table 20. As can be seen, the goodness-of-fit is much higher than for the MNL and ML models with a result of 0.3748.

Table 19, the constants are higher compared to the MNL model. The investment in PV panels & storage still has a negative utility, which means that these influence people's choice in a negative manner. The attribute level 'partly EMS' is also significant, and positive. The final significant value is the presence of volunteers in the choice set, which has a negative influence on the choice. Class 1 can be interpreted as representing the prosumer community. In this class the majority of the choices is made for the first alternative (84.77%). The ones who did not choose explicitly for alternative 1, choose only in 14 per cent of the cases for alternative 2, The none-alternatives has been chosen 1.10 per cent.

Class 2 has fewer high constants, but they remain significant. This means that respondents in class 1 have a higher preference for one of the two alternatives. Another significant value, the investment in both PV panels & storage has a negative, significant utility. The utility in class 2 is more negative than in class 1. In contrast to class 1, class 2 has a significant parameter for the presence of volunteers in the prosumer community scenario. This is a positive utility which is, compared to earlier results, a different outcome. Apart from these two attribute levels there are no other significant parameters. Class 2 can be considered as the hybrid form of an energy community. In 46.54 per cent of the cases alternative 2 has been chosen, and in 35.22 per cent of the cases alternative 1 has been chosen. This class also has a higher percentage of the none option (18.24%). Respondents in this class prefer energy cooperatives over private ownership.

In this model the statements and socio-demographic characteristics were included in the model. The statements are combined in the decision-making variables determined in Chapter 2.5. These were subjective norm, environmental attitude, locus of control, community identity, trust and independency. In the Latent Class model the high scores of these decision-making variables with an average above 4, were included. When the environmental attitude is high, the effect is significantly positive. The statement regarding trust in energy suppliers has an opposite outcome. This outcome can be explained by the overall involvement of companies and governmental agencies being involved in the development. Trust in these organizations was expected to play a role. This results confirm this. Finally, a negative effect of income is estimated, people in the highest income category have a significant higher probability to be member of class 1. The performance of the LC model is visible in Table 20. As can be seen, the goodness-of-fit is much higher than for the MNL and ML models with a result of 0.3748.

Table 19. Latent Class model

		Class 1		**Class 2**	
	Attribute	Parameters	Sign.	Parameters	Sign.
Constants	Constant 1	4.53523	***	0.85504	***
	Constant 2	1.97858	***	1.03172	***
Private Investment	Investment 11 panels	0.06414		0.61582	
	Investment 16 panels	0.52995		0.21276	
	Investment panels and storage	-0.59409	**	-0.82858	***
Private energy management system	No EMS	-0.27900		0.10222	
	Partly EMS	-0.26101		0.03779	
	Automatic EMS	0.54001		-0.14001	
Private members	7500 members	-0.00897		0.05598	
	500 members	-0.18601		0.00996	
	200 members	0.27572		0.04602	
Private management	Company	0.26265		-0.26811	
	Government	0.21673		-0.06228	
	Volunteers	-0.47938		0.33039	*
Community investment	1300 euro	0.19962		0.11576	
	2600 euro	-0.46898		-0.15785	
	No investment	0.26936		0.04210	
Community energy management system	No EMS	-1.35131		0.01467	
	Partly EMS	0.59353	*	0.10955	
	Automatic EMS	0.75778		-0.12422	
Community members	7500 members	-0.18127		0.16839	
	500 members	0.10751		-0.01618	
	200 members	0.07556		-0.15221	
Community insight	Monthly	0.16349		-0.09686	
	Daily	0.11204		0.15574	
	Real time	-0.27553		-0.05888	
Community management	Company	0.25094		0.001651	
	Government	0.21047		0.22554	
	Volunteers	-0.46141	**	-0.24205	
	Subjective norm	0.64645			
	Environmental attitude	1.58933	**		
	Locus of control	-0.21983			
	Community identity	-0.60701			
	Trust	-1.10337	*		
	Independency	0.35547			
	Young people	0.34134			
	Female	-0.51404			
	High education	0.46769			
	Two persons	0.41077			
	No child	-0.28370			
	High income	1.65931	*		

****;**;* -> Significance at 1%, 5%, 10% level*

Table 20. Goodness-of-fit Latent Class model

Log likelihood	-928.32337
Rho^2	0.3748
R^2 adjusted	0.3608

Analysis 2: LC without class membership

This analysis consists of a simpler version of the LC model, but with an analysis in SPSS. In Table 21 the part worth utility scores are visible, also the significance of the model is incorporated. As is shown, there are more significant values estimated in this model. The performance of the model is visible in Table 22. Compared to the MNL model and the ML model, the McFadden's Rho^2 is much higher, indicating that the LC model better fits the observed choice data.

Table 21. Second Latent Class analysis

	Class 1		Class 2	
Constant 1	4.60937	***	0.70753	***
Constant 2	2.25006	***	0.97535	***
Investment 11 panels	0.13850		0.56732	
Investment 16 panels	0.74608	***	0.10246	
Investment panels and storage	-0.88458	***	-0.66978	***
No EMS	-0.11038		0.03355	
Partly EMS	-0.10382		0.03594	
Automatic EMS	0.21420		-0.06949	
7500 members	0.13314		-0.11450	
500 members	-0.20597		0.00969	
200 members	0.07283		0.10481	
Company	0.30154		-0.32538	
Government	0.15675		-0.13587	
Volunteers	-0.45829	**	0.46125	***
1300 euro	0.24098		0.09464	
2600 euro	-0.50524	**	-0.08438	
No investment	0.26426		-0.01026	
No EMS	-0.99558		-0.01595	
Partly EMS	0.47106	**	0.10804	
Automatic EMS	0.52452	**	-0.09209	
7500 members	0.00560		0.13005	
500 members	0.27135		-0.06442	
200 members	-0.27695		-0.06563	
Monthly	-0.05161		-0.06174	
Daily	0.13559		0.13576	
Real time	-0.08398		-0.07402	
Company	0.21424		-0.01966	
Government	0.23418		0.29848	*
Volunteers	-0.44842	*	-0.27882	*
PrbClass 1	0.59442	***		
PrbClass 2	0.40558	***		

****;**;* -> Significance at 1%, 5%, 10% level*

Table 22. Performance of Latent Class model

Log likelihood	-843.11529
Rho^2	0.3637
R^2 adjusted	0.3526

After estimating the LC model, the respondents are assigned to the class with the highest probability. This results in the class descriptions in Table 24, where the socio-demographic characteristics are descripted. At the 5 per cent significant level, there are no significant differences found between the two classes. When looking at the10 per cent significance level, the number of children does have a significant value. No differences are found with having no children, but households with two children are more often assigned to class 2, while having more than 2 children results in a higher probability of being assigned to class 1.

Table 23. Socio-demographic characteristics of Latent Classes

		Complete sample		Class 1		Class 2	
Respondents per class		134		81		53	
Percentage per class		100%		62%		38%	
Gender χ^2 =0.356 p= 0.551	Female	64	48%	37	46%	27	51%
	Male	60	45%	44	54%	26	49%
Age χ^2 =2.008 p= 0.848	20-29	43	32%	26	32%	17	32%
	30-39	20	15%	13	16%	7	13%
	40-49	20	15%	13	16%	7	13%
	50-59	33	25%	19	23%	14	26%
	60-69	17	13%	10	12%	7	13%
	70-79	1	1%	0	0%	1	2%
Education χ^2 =1.1001 p= 0.606	Low	13	10%	9	11%	4	8%
	Middle	28	21%	15	19%	13	25%
	High	93	69%	57	70%	36	68%
Work status χ^2 =3.799 p= 0.284	Student	16	12%	11	14%	5	9%
	Unemployed	1	1%	0	0%	1	2%
	Employed	109	81%	67	83%	42	79%
	Retired	8	6%	3	4%	5	9%
Household income χ^2 =5.967 p= 0.202	<€30,000	16	12%	10	12%	6	11%
	€30,000-50,000	47	35%	26	32%	21	40%
	€50,000-100,000	46	34%	26	32%	20	38%
	>€100,000	22	16%	18	22%	4	8%
	Prefer not to answer	3	2%	1	1%	2	4%
Household size χ^2 =5.967 p= 0.286	1-person	21	16%	10	12%	11	21%
	2-persons	55	41%	36	44%	19	36%
	3-persons	23	17%	14	17%	9	17%
	4-persons	24	18%	12	15%	12	23%
	5 or more persons	5	4%	5	6%	0	0%
	Shared Household	6	4%	4	5%	2	4%
Child	No children	79	59%	47	58%	32	60%

χ^2 =7.383 p= 0.061*	1 child	22	16%	15	19%	7	13%
	2 children	26	19%	12	15%	14	24%
	3 or more children	7	5%	7	9%	0	0%
Home-owner χ^2 =0.096 p= 0.757	Yes	103	77%	63	78%	40	75%
	No, renter	31	23%	18	22%	13	25%

After the descriptive statistics of the socio-demographic characteristics, the statements are used to estimate whether the decision-making variables have an influence on the preferences. The statements are combined into sums and determined to be high or not as described in Chapter 3.3.5. Table 24 shows the results. The first variable, subjective norm, shows significant results. Therefore, the null hypotheses of having no influence can be rejected. In class 1 there is a higher part of the sample which indicates a high subjective norm. In class 2, a higher part of the sample represents the low subjective norm. The second decision-making variable, environmental attitude, shows a significant Chi-Square test as well. This indicates that there are differences in the classes as well. Respondents in the first class agree more upon the statement related to environmental attitude compared to respondents in the second class. Furthermore, locus of control and community identity do not have differences between the groups. In contrast, trust shows a significant effect. Class 1 contains relatively less respondents who attach a high value to trust. The last significant value ($p<0.1$) is independency. People in class 1 find it slightly more important to be independent from the big energy companies in comparison to people in class 2.

Table 24. Statement descriptive latent classes

		Complete sample		**Class 1**		**Class 2**	
Respondents per class		134		81		53	
Percentage per class		100%		62%		38%	
Subjective norm χ^2 = 5.275 p= 0.022**	Low	67	50%	34	42%	33	62%
	High	67	50%	47	58%	20	38%
Environmental attitude χ^2 = 6.630 p= 0.010***	Low	28	21%	11	14%	17	32%
	High	106	79%	70	86%	36	68%
Locus of control χ^2 = 0.093 p= 0.761	Low	56	42%	33	41%	23	43%
	High	78	58%	48	59%	30	57%
Community identity χ^2 = 0.050 p= 0.823	Low	95	71%	58	72%	37	70%
	High	39	29%	23	28%	16	30%
Trust χ^2 = 5.275 p= 0.022**	Low	67	50%	47	58%	20	38%
	High	67	50%	34	42%	33	62%
Independency χ^2 = 2.795 p= 0.095*	Low	35	26%	17	21%	18	34%
	High	99	74%	64	79%	35	66%

Comparing analysis 1 and 2 with the latent class model, some similarities are found as well as differences. In the first analysis, the high-income class has a significant impact, but in analysis two, the chi-square did not represent a significant value. But looking at the representations in the classes, differences in the highest income class are found as well. While the first analysis only gives environmental attitude and trust as significant decision-making variables, class 2 adds subjective norm and independency as well.

4.6 Discussion

In this research 140 complete responses are achieved. Incomplete responses were erased and the persons who answered only 'none' in the SCE were deleted as well. This was done after comparing the fit of the model. A better fitting model is found excluding the none answers (6 in total), which results in a smaller sample of 134. Therefore, the choice was made to exclude these responses. The representativeness of the sample is not good, the only representative variables are gender and number of children. The other characteristics: age, education, work status, household income, household size, and number of children, did not represent the Dutch population. The combination of the small sample with the distribution method could have caused these differences. The respondents were also asked whether they applied sustainable energy measures already. One quarter of the sample mention that they do not do anything to their home. The rest of the respondents mention that they have already applied PV panels (28%), insulation (33%) or one of the other options like heat pumps, solar boilers etc. This is an unexpected high finding since in the Netherland 12.5 per cent of the households apply PV panels (Alphens, 2020).

In the Multinomial logit model and the Mixed logit model the parameters and their significance are estimated. The constants included for both private and community scenarios are significant. This indicates the preference of the respondents for one of the scenarios, no matter what the attribute levels represent. The utility of the choice for scenario 1 is higher. Furthermore, a significant utility score is found for the incorporation of PV panels combined with a storage system. This utility is negatively associated in both private and community scenarios. This can be due to the height of the investment which was 11,000 euro. Despite the fact that benefits of PV panels remain almost stable for the upcoming ten years, it does not influence the respondents in a positive manner. Other investments in a private system do not have significant results. Earlier research concluded that price was the most important decision-making variable in the decision to participate in a P2P community (Lobbe et al., 2020). This is also confirmed by the relative importance of the attributes where 79 per cent of the decision for the private scenario is represented by the investment height. The price component in the joint investment is significant for the investment of 2,600 euro, but also negative. The study design did not provide in a question where the respondent indicated their decision for this attribute level. Therefore, possible reasons could be the height of the investment or benefits associated with this investment. Compared to the private investment in 11 panels, the benefits are much higher.

Furthermore, the presence of an energy management system was included in the models. Where the EMS is most effective for having a private ownership of a system, there are no significant values found. In this research, people do not base their decision upon the presence of an EMS, in order to decrease their yearly energy costs. The utility scores of this variable are very low, so there is no influence of the presence of an EMS. Although no significant impact was found for private investment, there is a significant influence of the factor EMS on the choice for a joint investment. A partly EMS increases the choice for scenario 2, not having an EMS resulted in a negative utility. This could mean that people prefer an EMS when joining an energy community, in order to reduce costs.

The size of the community is considered as well, but in both scenarios this utility is neglectable and not significant. People do not prefer a certain size of a community. Earlier research indicated that people prefer a more local or regional system in a P2P network (Lobbe et al., 2020), but utility scores indicate that the size and location of the members do not matter to the respondents. Also, the information management in the community scenario does not result in significant values and the relative importance is less than 10 per cent in the choice for the community scenario. Gonalves Da Silva et al (2012) concluded that people are more interested in knowing more about their consumption. In this research this was measured in order to estimate to what extent people would like to know more about their consumption, but this does not influence their decision.

The final attribute is the management of the community. In the research the model estimates the influence of a government and volunteers on the decision for scenario 1 or 2. In the private scenario, no influences are found. However, in the second scenario there is a significant difference found. Management by volunteers is not preferred by the sample since the utility score was negative, although this option was cheaper on a yearly basis compared to the other two management options. Management by a government does not significantly influence the decision for scenario 2. Lobbe et al. (2020) found that management by the municipality was most preferred in a P2P network, followed by an energy company. The values representing the management are not significant, but did follow the same pattern as the research of Lobbe et al (2020).

In terms of significant values, the Mixed Logit model increased the performance of the Multinomial logit model. Although the goodness-of-fit of the model increased, the utilities of the model are comparable with the MNL model. The differences occur in the additional standard deviations which are able to measure taste heterogeneity. Only a few significant values were found, therefore, it could be assumed that there is a lot of homogeneity in the sample. The investment height for both private and community investment showed significant standard deviations, and therefore can be considered heterogeneous.

Latent Class model were estimated with two classes. Class 1 has a higher preference for scenario 1, private investment, and class 2 has a higher preference for scenario 2, joint investment. The LC model shows a better performance compared to the MNL and ML model. Membership of the latent classes were investigated by means of the socio-demographic and statements. The only variable influencing the decision for a scenario is the height of the income, the highest income group (above 100,000 euro) has a significant higher probability being a member of class 1. Kalkbrenner & Roosen (2016) have found that higher incomes have a positive effect on the participation in energy projects. In their research, a higher income increases the participation specific in prosumer communities. Other socio-demographic characteristics did not represent significant differences between the groups. This is different compared to other research into the willingness to participate in a local energy project. A higher education was found significantly increasing the participation in a P2P community in Germany (Lobbe et al., 2020; Hackbarth & Lobbe, 2020). Furthermore, larger households were more likely to participate in a local energy market according to Mengelkamp et al (2019) and Hahnel et al (2019). These results are not significantly represented in in this research. A larger sample size could affect these results, since only a small amount of multi-person households participated in the research. No differences are found in gender, however, Kalkbrenner & Roosen (2015) have concluded that being male influences the participation in a community positively. This is also confirmed by Ropuszynska-Surma & Weglar (2019) who found males were more likely to apply RES. Gender was evenly represented in the sample; the finding of no significant preference can be defined as reliable. In contrast to age, with an overrepresentation of younger people, was found not having an impact on the decision-making for a certain scenario. The impact of age on the willingness to participate was already found significant (Hahnel et al., 2019; Hackbarth & Lobbe, 2020).

The behavioural models described in Chapter 2.5 determined the most important decision-making variables that have an influence on the intention to adopt a certain behaviour. One of these decision-making variables was subjective norm, which was measured by combining social norm and descriptive norm. It has a significant impact on the classes. A higher subjective norm increases the intention to participate in a prosumer community, class 1. Kalkbrenner & Roosen found similar results for social norm, a part of subjective norm, to have a positive impact on the participation in community scheme. However, in the latent class model, the higher subjective norm is related to the prosumer community instead of an energy cooperative. Another decision-making variable was the environmental awareness. Earlier research pointed out that a higher environmental awareness increases the intention to apply energy saving measures (Vasseur & Marique, 2019) and participate in a community project (Kalkbrenner & Roosen, 2015). Respondents with a high environmental attitude are more likely to be member of class 1, where the overall preference is for private investments in RES. Locus of control and community identity show no significant differences between class 1 and 2. Community identity was measured by asking how people think about their future energy community, instead of relating to the current community. This can cause differences with other research, since in this research no significant relationships were established. Mengelkamp et al (2018) researched the willingness to participate in a local energy market, where they found a higher community identity positively impacting the willingness to participate. This is in line with the research of Kalkbrenner & Roosen (2015) who also found a non-significant relationship. Trust is also included, where the trust in energy suppliers is measured. Both analysis of LC pointed out that there are significant differences found between class 1 and 2. Class 2 represents a higher share of people with a higher trust. While this is lower in class 1, this can be due to having more control with a private energy system. The willingness to be more independent from suppliers does have a significant relation between the two classes. Scenario 1 is in general more independent from the grid compared to scenario 2, because scenario 2 depends on an external generation location and more involvement of a manager. This is also confirmed by the LC analysis, where people with a higher desire for independency belong to class 1. The willingness to be more independent increases the willingness to participate in a P2P community according to Hackbarth et al (2020), this is in line with the higher representation of a higher independency in class 1 in this research.

4.7 Conclusion

In this chapter the results of the analysis of the questionnaire are discussed. The sample was relatively small with 134 complete, usable responses. The first part of the questionnaire consisted of the socio-demographic questions to test the representativeness of the sample. The sample was not representative. Due to the manner of recruiting respondents (within personal network and small company) these findings are not surprising.

The stated choice experiment was conducted and analysed by three models, the Multinomial logit model, Mixed logit model and the Latent class model. Overall, the multinomial logit model has a Rho^2-value above 0.2. However, the mixed logit model performed better due to inclusion of the standard deviations. The multinomial logit model and mixed logit model estimated the utility scores of the attribute levels. The constants represent a high value, therefore, it could be concluded that respondents have an overall preference for one of the scenarios, no matter what the attribute levels are. From the analyses it could be concluded that the combination of PV panels and storage is not preferred by the respondents. The same holds for an investment of 2,600 euro in community energy shares. Furthermore, the EMS is more preferred in the joint investment scenario, although it is more effective in the private scenario. Respondents who want to invest in the joint scenario, do not prefer the management by volunteers. Information frequency and the number of members do not influence the choice for a scenario. In the multinomial logit and mixed logit model answer is given to the fourth sub question, and conclusions are given on the characteristics important for participation in an energy community.

With the latent class model, the sample was divided in two classes. The first class represents a higher preference for the private scenario and class 2 a higher preference for an energy cooperative. Therefore, it could be concluded that the respondents added to class 1 have a higher preference for a prosumer community, and in class 2 for an energy cooperative. The only personal characteristic influencing the division into these groups is the height of the income. Respondents with a household income above 100,000 euro are more likely to be added to class 1. Gender, education, age, household size and having children do not have a significant impact on the choice for a certain community. The second part of the questionnaire consisted of twelve statements regarding social norm, environmental attitude, locus of control, community identity, trust and independency. These decision-making variables do show different results. The statements were summarized into groups of variables. A high subjective norm, environmental attitude and desire to be independent are overrepresented in class 1. In contrast, a higher trust was found in class 2. The latent class model made it possible to relate the decision-making variables to the preference for a community type, this gives answer to the fifth sub question.

5 Conclusions, managerial implications, and future research

The challenges associated with climate change, and the need to decrease the use of fossil fuels, result in a higher demand for renewable energy sources. The current top-down energy market is designed around electricity generation based on fossil fuels. A transition to local energy systems is an opportunity to enlarge the amount of energy generated by RES. The topic of local energy communities comes into place, where multiple local forms of energy generation are used. These communities can be composed in different ways, and different definitions can be found in the literature. The households are an important stakeholder in this energy transition and the development of energy communities. Yet, why Dutch inhabitants decide to participate in a specific energy community is unknown. Therefore, in this research, the following main question is answered: "What characteristics of energy communities and Dutch households influence the choice of energy communities?"

To answer the first sub-question (What is the current position of households in the energy market?) literature study and orientating interviews were conducted. These pointed out that multiple challenges and possibilities were present regarding the energy market. The position of households in the current energy market is changing. More flexibility of the energy systems is required, due to the weather dependency of RES and the local generation. Dutch energy policies are changing, for instance, the 'salderingsregeling' and the 'Postcoderoosregeling' will affect households financially in the upcoming years. Households will be more actively involved in energy generation, storage, sharing and trade. Therefore, prosumerism becomes relevant. Prosumers can form local energy communities to increase the efficiency and local character of energy generation.

Sub-question two was about the definition of local energy communities and their characteristics. In defining energy communities, many different names arose. In this research was concluded that there are two major different community types regarding households, the energy cooperative and the prosumer community. These two community types were used to present the respondents of the questionnaire with a choice. A prosumer community can be described as a self-producing community, where households produce their own energy and share or store the over-supply. Via a virtual network management can take place, however, the system management is not determined. In a prosumer community households produce their own energy; therefore, financial benefits are created directly. The energy cooperative is based upon a joint investment in either PV panels or windmills, hereby a share of the system is bought. The cooperative makes sure that the energy generation takes place, and investors get a financial benefit on their investment in terms of a tax discount ("Postcoderoosregeling").

Literature review into behaviour change pointed out that there are two types of behaviour change. Curtailment behaviour is about repetitive actions, to save energy for example. Efficiency behaviour is a one-time action that is mainly focussed on an investment. Both behaviour changes are relevant to becoming a member of an energy community because in the first place an investment should be done and after this behaviour change to save energy, and become more actively involved in the sharing and controlling of energy demand and supply. In previous research environmental behavioural models were developed to predict the intention of behaviour change. Multiple behavioural models showed similarities, but also differences. These models were analysed, it was concluded that contextual factors, social influences, attitude and personal characteristics were most convenient in the decision-making for participation. Therefore, the third sub-question (What decision-making variables concerning energy-related behaviour are relevant to participation in energy communities?) could be answered. However, due to the tenuous character of the categories, policy implication, social norms, environmental attitude, socio-demographic characteristics and locus of control were adopted as decision-making variables. Furthermore, to identify the character of the market and community, trust in energy suppliers, independency from the current market and community identity were used as well.

A stated choice experiment was conducted to answer the fourth sub-questions (What characteristics of energy communities are in what way associated with deciding to participate in an energy community?). Literature review and a financial estimation of the benefits of local energy systems concluded the following community characteristics: investment height of a solar system, storages facilities or shares, the presence of an energy management system, community size in terms of the number of members, information provision in terms of frequency, and the system management. Each characteristic (attribute) had three levels and were measured in a questionnaire. Analysis of the results showed that there is an overall higher preference for the prosumer community scenario among the respondents. Significant parameters were found for the presence of a storage system, which influences the choice for a prosumer community negatively. No further significant parameters were estimated in the prosumer scenario. The investment height and management by volunteers in the community scenario showed negative parameters as well. However, the presence of energy management (partly, shifting of household appliances done by household themselves) system showed a positive effect on the choice for the energy cooperative. Furthermore, no significant findings were found. The estimation of the relative importance showed that in the prosumer scenario, investment height affects the majority of the choices. For the energy cooperative, the presence of an energy management system and management showed both one-third of the prediction for the choice. It was concluded that both information provision and the number of members did not impact the choice.

The decision-making variables concluded in sub-question three were used to answer sub-questions five (What is the influence of the decision-making variables on participation in energy communities?). Latent Class modelling showed that two classes can be estimated within the sample. Class 1 represents the respondents preferring a prosumer community and class 2 the preference for an energy cooperative. The class characteristics were estimated and socio-demographic characteristics of households did not impact the choice for one of the community types, except for household income. Class 1 represented a significantly higher share of households with a high income. Furthermore, the decision-making variables based upon the environmental behavioural models were measured in these classes. Households preferring a prosumer community (class 1) had a significantly higher environmental attitude, subjective norm and desire to be more independent. On the other hand, class 2 represented a significantly higher share of households with a higher trust in energy suppliers. Locus of control and community identity did not show a significant impact on the choice between the two community types.

So, the characteristics which influence significantly the choice between a prosumer community and an energy cooperative are investment height, presence of an energy management system and management by volunteers. A prosumer community is chosen by households with a higher income, a higher environmental attitude, a higher subjective norm and a greater desire to be more independent. People preferring an energy cooperative have a higher trust in energy suppliers. This answers the main question of this research.

5.1 Scientific relevance

This research provides evidence on the preferences regarding the selection of an energy community. Therefore, this research is an extension of the previous research especially the number of quantitative researches was minimal on this topic. Both characteristics of the community and the household' characteristics (decision-making variables) were incorporated.

The decision-making variables concluded from environmental behavioural models are coupled to the decision-making for either the choice for a prosumer community or an energy cooperative. Previous research explored only one of the community types or the willingness to participate (Mengelkamp et al., 2018; Hackbarth & Lobbe, 2020; Mengelkamp et al., 2019; Kalkbrenner & Roosen, 2015; Lobbe et al., 2020), but did not look into the influence of environmental behavioural models in order to determine the intention to perform a behavioural change, either on curtailment (investment) or efficiency behaviour (repeated behaviour). The initial start for participation is curtailment behaviour, but in this research a combination is made with efficiency behaviour. Therefore, this research extends the existing literature on energy communities. Preferences regarding different characteristics of a community have been investigated in this research. But also, attribute levels with a low utility could be assumed as non-important, and therefore, not relevant to extent the scientific research about this.

5.2 Societal relevance

The societal relevance is demonstrated by providing insight in the willingness to participate in either one of the energy community types. Respondents have their personal reasoning in participating in a community, where cost decrease or performing sustainable behaviour are the most frequently mentioned reasons. These responses indicate that there is a certain preference to change to a more sustainable electricity network but financial aspects are leading.

This research provides more insight into the preferences of Dutch households. Two scenarios were investigated: scenario 1 concerns private investment in PV panels; scenario 2 concerns a community investment in PV or wind energy. For the decision regarding the development of a prosumer community and energy cooperative, the overall preference is for a prosumer community. However, the willingness to share electricity has not been measured. Nevertheless, subsequent development of prosumer communities could contribute to the transition of the energy market.

Furthermore, the regulation change for the ‘Salderingsregeling’ will have a major impact on the financial benefits people get from their PV system. This benefit change is adopted in the choice experiment, including the possibility to store electricity. This last option is not attractive for most people. In general, incorporating storage in the choice set affects the person’s choice negatively. In the decision-making for incorporating private investment for households, storage seems to be one step to far although it is more efficient in terms of benefits. The overall impact of the financial benefits of the investment are measured and seem to be the most important characteristic in the decision to participate in either one of the scenarios.

Another relevant attribute is the management by volunteers, which is not preferred by respondents. This research found significant relationships between participation in a community type and characteristics of the community, which could be used as knowledge for future developments.

5.3 Recommendation

In this research the recruitment of respondents is done via flyers and the personal network. Due to this approach, the sample is not representative for the Dutch population. However, as most of the sociodemographic variable apparently do not affect choice behaviour, the results may not be valid for the Dutch population. Therefore, a more representative sample is advised. Furthermore, the sample was small with 134 relevant responses, a bigger sample would probably improve the results and representativeness. Also, the sample was focussed on the integration of households in the energy sector. However, households are only using a share of the electricity demand in the Netherlands. Small companies, which are also locally operating, have the possibility to participate in the market. Future research can be done into the possibilities of integration of (small) companies in the local energy market.

The topic in the survey was complex, and the stated choice experiment caused much reading work for the respondent. It is suggested that a less complex experiment is performed. The knowledge regarding the subject is low, but it is important to have more knowledge about the subject in order to make the right choice. Since knowledge is one of the decision-making variables influencing behavioural change, it is recommended to investigate whether knowledge will increase the choice for a certain community or will affect the importance of attribute levels. From a societal point of view, it is recommended to provide more information and simplify regulations on order to stimulate people participating in energy communities.

Sharing electricity is an important component in the prosumer community, due to the complexity of the stated choice experiment, this component was neglected. So, the preference for a prosumer community needs to be investigated in more detail by incorporating sharing in the experiment. This sharing of electricity can be done in multiple ways according to the different system management types of a prosumer community. For a P2P network, platforms have been developed. The participation degree is unknown, it could lead to interesting scientific research in combination with these working platforms whether people are willing to invest more in order to sell their over-supply via these networks. Furthermore, the sharing component can be investigated in terms of the height for the feed-in compensation. Nowadays, the minimal feed-in compensation is determined by law, but the changing 'Salderingsregeling' can cause benefit loss for households. Innovative pricing schemes can positively stimulate people to shift their energy use to other times of the day, in order to shave the peaks of the electricity demand. The possibilities of flexible pricing in the Netherlands should be investigated from a technical viewpoint, but also regarding preferences for energy suppliers, grid operators and households. Sharing electricity via a bi-directional network, where a double meter and real-time information are incorporated, are important components for the development. However, the privacy impact could be important and should be researched on this specific measure prior to implementation.

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Appendix I: Interviews

Company: Brainport Smart District

Date: 21 October 2020

Introduction:

Brainport Smart District (BSD) is an innovative project where living and working will be combined in a village. This village works with seven programs where the future developments are associated with. In the future, 1,500 houses will be built on the site near Helmond. The interview is held according to a semi-structured interview method, especially about the program line “village with energy”.

Summary of the interview:

Brainport Smart District developed a Quality Book with the ambitions in the neighbourhood. This book is developed by the program managers, the university, companies and future inhabitants. In the neighbourhood, 40 lots were available for sale and personal developments (called the “pioneers”), the inhabitants of the neighbourhood have a deputy from the pioneers. Part of the innovations which will be experimented in BSD are initiated by the inhabitants. These pioneers are the ones who develop their own house, very innovative and actively involved in the transition, in consideration these are not representative for the mainstream household that will be living in BSD. The quality book resulted in three principles based on the building code, only with some stricter limits than the rest of the Netherlands. The most important related to energy is the minimal of 50 per cent onsite matching, to reduce the peaks in the energy distribution.

In the design of the energy network, there are two levels. The first is for the houses, which are developed by multiple constructors and therefore, different principles incorporated (called “living labs”). They have to score on two or three program lines excellent, and the others have to be at the minimum levels. The second level is the infrastructure. Currently, they are in the phase where companies are consulted and a building team is developed. In this stage, important choices regarding the energy program will be made. This on the neighbourhood level, but they are looking for a manner where the future inhabitants can be involved.

The starting point of the development of the houses is that home-related energy consumption is generated completely from RES, and the principle of 50% onsite energy matching is achieved. If the developer wants to initiate this on neighbourhood level, BSD is open for different innovations. The interaction between systems is important, the quality team is responsible for making the decision regarding approval or disapproval.

The principle of energy sharing is important. The belief is that the more buildings are coupled via a network, the better the energy matching already works. If this is connected with electrical vehicles (EV), if the loading is smarter the peaks will be minimalized. In BSD, cars cannot be placed near the houses but only on the outer sides of the neighbourhood.

In terms of the energy program, habitual changes are not prescribed. If a household does not want to change their energy use, they should invest in more generation etc. He expects that the habit changes only will be done if high financial benefits can be achieved. But is can be done, automatically with systems.

One of the bottlenecks of the transitions is that people can be aware of the necessities, but cannot link this to their own behaviour, technical solutions are the only option. Action are only done when financial benefits or losses are associated with the behaviour. Currently, in the system there are no behavioural stimuli because of the “salderingsregeling”. This regulation will be phased out, if no matching is done the costs for electricity will be significantly higher. Due to this regulation change, financial benefits can be achieved with changes habits (comparable with the "nachtstroom" from earlier). BSD would like to achieve that inhabitants have insight into their own consumption of energy, especially when "salderen" is not possible anymore and inhabitants have financial consequences from this. This can be solved with battery storage, at this moment storage is less attractive because of the possibility of salderen, but when this is gone investments in battery storage should be done or habits should be changed. EV's are big spenders in this case, if this can be managed a bit more, the financial benefits can be massive.

Another problem with the development of the RES, and not investing in storage. Enexis (grid operator), should invest hundreds of millions in scaling up the distribution network to overcome the peaks, this is not necessary when storage becomes more important. This is mandatory in BSD.

The overall assignment of BSD is also associated with the mix of inhabitants in the neighbourhood, this should almost be representing. Therefore, almost 70% consists of apartments. All kinds of buildings will be applied, to achieve this mix of inhabitants.

Other than the salderingsregeling, to share energy between households, is there another big problem in the legal system; The double payed taxes. In your home, storage, generation and appliances are one system. But, an EV or battery system of the neighbours, is outside of your home-based system (WOZ-object), and therefore, the tax authorities sees the household as an energy supplier and then, taxes have to be paid. If you use energy from your own EV, you pay taxes another time because now the EV is a supplier.

Interview II:

Company: Duurzaam Bouwloket

Date: 4 November 2020

Introduction:

About 10 years ago “Duurzaam Bouwloket” was started, which is a company advising and supporting inhabitants in the Netherlands in the decision for sustainable options for their houses. Furthermore, they are supporting municipalities in their planning for sustainable innovations in their municipality.

Summary of interview:

The company is working with the inhabitants of municipalities, where they can ask questions about sustainable solutions for renovation or building new houses. Where they are able to advice on renewable energy sources, insulation, heating and cooling solutions and how to finance the investments. The height of these investments is the main barrier of people not wanting to do it. People might be willing to invest in certain measures but, are not able to do so. Another barrier where people are struggling with, is the fear of the investments and the constantly changing environment of innovations. This has also to do with the regulations and the ignorance of these people. For example, the changes with the salderingsregeling have fundamental changes for the investors in these measures, but the effects are still not clear for everyone.

While the earlier mentioned barriers are important for people, the market of the sustainable measures is constantly adapting to the supply and demand. There is a shortage of companies being able to install PV panels, heat pumps etc. This shortage has the effect that prices increase for man hours instead of decreasing system costs. Also, small scale projects (houses) are not interesting for installers, and therefore, prices will increase more. This market forces have a negative effect on the perception people having with installation of PV or heat pumps for example. Some investments are subsidizing to stimulate the purchase, companies see this as an opportunity to increase the prices a little, since it is still cheaper for the investors.

The ‘Duurzaam Bouwloket’ can advise municipalities in their strategy for a certain environment to make them completely gas free for example. They are not especially advising to create decentralized communities, but sometimes these initiatives are coming from inhabitants, where the municipality can give financial support for example. In these activities, the Loket is involved as well. The main things that are important for inhabitants in projects is the unburdening for the inhabitants. They are often struggling with being afraid of the investments and whether they are able to manage somethings.

Interview III

Company: Paris Proof Plan

Date: 10 November 2020

Introduction:

A book and website called “Paris Proof Plan” were developed to add more relevant knowledge around sustainability. The website is independent around their beliefs, for increasing the sustainability of homes.

Summary of interview:

The experience with local energy cooperatives is that whenever volunteers organize it, they get tired of organization. Good people are necessary to organize this and grow out to a big PV project. Generally, only 1 per cent of the RES is organized by local, private energy cooperatives. It is out of proportion comparing it to what big developers can achieve, the positive thing about local initiatives is that is locally developed and supplied.

The collective purchasing of PV panels started around 2010-2011. In 2009 municipalities wondered whether they were able to create a local energy company, combined with prosumers which was promising to increase the locality. Unfortunately, the power and knowledge were lacking. The power of the bigger companies in the energy sector is major, therefore, the prosumer is less active as expected because of the intermediate companies.

Developing initiatives together is promising around heat networks and decreasing energy use. Although, there is much friction around gas free living. Trust in the developments, companies is an issue but also the most important aspect in the development. The belief is that no one does not want to do anything to become more sustainable, and everyone has a personal plan. Unconsciously is everyone formulating their opinion about this subject. A behavioural model, where people behaviour can be predicted by goals (Goal Framing Theory) is important. People function around their personal goals.

An important aspect in increasing the sustainability is sealing gabs in houses, and ventilation with heat recovery. Less experience is around this subject, but the importance of indoor climate increases. Related to the goal framing theory, people experience the indoor climate and can relate.

Paris Proof Plan sees potential in analysing initiatives where things went wrong, to learn from this. Instead of developing new things.

Appendix II: Financial model

Private investment

Electricity costs:

The energy costs in the Netherlands are consisting of: delivery charges, network costs, and taxes. The delivery charges are partly depending on variable costs, which are calculated per kWh of electricity, and part on fixed costs which have to be paid to the energy supplier. Network costs are paid for the network operator to distribute and maintain the network. This is a fixed amount per year and set by the network operator. Over the energy costs for both electricity and gas, VAT of 21% need to be paid, energy taxes and taxes for storing sustainable energy (ODE) (Pricewise, n.d.). In Table 25 the variable costs for electricity are shown, for further calculations the most actual price for electricity will be used.

Table 25. Variable energy costs (CBS,2020)

	Delivery charges	ODE	Taxes	Total costs [euro/kWh]
2018	€0.0719	€0.01597	€0.12654	€0.21441
2019	€0.0803	€0.02287	€0.11934	€0.22251
2020 (Nov)	€0.0701	€0.03303	€0.11822	€0.22135

The fixed costs are shown in Table 26. As can be seen in the last column, a tax decrease is given. The reason behind this decrease is that electricity is one of the basic needs for living, therefore part of the energy taxes is given back to every household. This is automatically done by the energy suppliers (Rijksoverheid, 2021).

Table 26. Fixed energy costs (CBS, 2020)

	Fixed delivery charge	Distribution charge	Energy tax decrease
2018	€55.43	€239.09	€-373.33
2019	€66.46	€238.32	€-311.62
2020 (Nov)	€69.44	€241.85	€-527.17

Electricity demand:

The electricity demand of household can be different due to different sizes in housing, but also the number of members of the household have an effect on the demand. For further calculations, the average will be used, but this is only suitable for household of 2 people. Whenever there is an increase of the household size, the electricity demand will increase according to the table. Which will have an effect on the size of the microgeneration system.

Table 27. Electricity demand per household size (Nibud, 2020)

Household size	Electricity demand per year [kWh]
1	1,850
2	2,860
3	3,400
4	3,930
5 or more	4,180
Average	2,832

Explanation of PV panel:

A solar panel has a certain capacity which can be generated by one panel. The Wp per panel has therefore an effect on the size of the system necessary to supply in the energy demand. As can be expected, the higher the capacity, the higher the price. A capacity of 290 Wp is used (Verheij et al., 2020). This can be useful whenever the roof space is not sufficient enough to install the necessary number of panels (Wilt, 2019). Another expected decrease in the amount that can be generated via PV panels, is the orientation.

Costs per panel can be different according to the capacity of the system, the number of panels due to installation costs etc. In calculations by TNO (2020) the costs per Wp are used, their starting point was 1.31 euro/Wp with a bandwidth of 1.16 to 1.46 euro/Wp (Verheij et al., 2020). This price is excluding VAT, this is no problem since there is a government regulation which makes it possible to ask back the VAT on PV panels.

Direct energy use:

According to Verheij et al (2020) the direct energy use can be estimated at 30 per cent during the day. But, a bandwidth between 20 per cent and 40 per cent is also calculated. The direct energy use represents the percentage of the electricity that is directly used, without interference of the electricity grid. Especially for the 'Salderingsregeling' this has an impact, because in 2020 (Salderen = 100 per cent), there is no effect of the percentage on the benefits.

Yearly cost decrease PV panels:

The costs for PV will decrease due to the higher purchase of the product, but also the accelerated development of the product. In the upcoming years it is expected that the purchase value of the PV panels will decrease with 3 per cent every year (Verheij et al., 2020).

Salderingsregeling:

The Salderingsregeling is a regulation that compensated the prosumers with the supply of electricity they deliver, with the electricity demand they have. But this regulation is changing, and the Dutch government estimated a phasing out schedule. Table 28 shows the percentage of compensation per year.

Table 28. Phasing out of Salderingsregeling (Rijksoverheid, 2020)

Year	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031
Percentage phasing out	100%	91%	82%	73%	64%	55%	46%	37%	28%	0%

Table 29. Input variables of private investment

Regular electricity costs[1]	€0.22135
Feed-in tariff (80% of bare electricity costs)[2]	€0.05608
Electricity demand (average)	2,832 kWh
Power per PV panel	290 Wp
Costs per Wp	€1.31
Direct energy use	30%
Yearly cost decrease PV panels	3%

[1] Price level used of November 2020

[2] Feed-in tariff is based upon the bare energy price, and should be minimally 80 per cent

Table 30. Equations for private investment calculations

Necessary PV panels	Electricity demand/(power per PV*0.9)
Electricity supply	Power per PV*Necessary PV panels *0.9
Investment height	Necessary PV*Power per PV*Costs per Wp
Direct energy use	30%*demand=863.3 kWh
Available energy supply for salderen (AS)	(Electricity supply – direct energy use) * salderen
Additional demand (AD)	Electricity demand – Direct energy use-AS
Yearly additional costs (YAD)	AD*Regular electricity costs
Feed-in compensation (Feed-in)	AD*Feed-in compensation + Electricity supply-Electricity demand * Feed-in compensation
Yearly electricity costs (YEC)	YAD-Feed-in
Benefits per year	Regular electricity costs*Electricity demand-YEC

Scenario 1: 11 panels (necessary amount)

Table 31. Calculation of benefits of 11 panels

	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031
Investment	€4,178	€0	€0	€0	€0	€0	€0	€0	€0	€0	€0
Salderen	100%	100%	91%	82%	73%	64%	55%	46%	37%	28%	0%
AS [kWh]	2009.7	2009.7	1828.8	1648.0	1467.1	1286.2	1105.3	924.5	743.6	562.7	0.0
AD [kWh]	0.0	0.0	141.9	322.7	503.6	684.5	865.4	1046.2	1227.1	1408.0	1970.7
YAD [€]	€0	€0	€31.40	€71.44	€111.48	€151.51	€191.55	€231.58	€271.62	€311.66	€436.21
Feed-in [€]	€2.19	€2.19	€10.14	€20.29	€30.43	€40.57	€50.72	€60.86	€71.00	€81.15	€112.70
YEC [€]	€ -2.19	€-2.19	€21.26	€51.15	€81.05	€110.94	€140.83	€170.72	€200.62	€230.51	€323.51
Benefits [€]	€629.05	€629.05	€605.60	€575.71	€545.82	€515.92	€486.03	€456.14	€426.25	€396.35	€303.35

Table 32. Calculation of payback period of 11 panels

Investment*	Year 0**	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Year 7	Year 8	Year 9	Pay-back period
01-2021	€4,179	€3,550	€2,921	€2,315	€1,739	€1,194	€678	€192	€-264	€-691	7.39
01-2022	€4,054	€3,424	€2,819	€2,243	€1,697	€1,181	€695	€239	€-187	€-613	7.52
01-2023	€3,932	€3,326	€2,751	€2,205	€1,689	€1,203	€747	€320	€-76	€-379	7.75
01-2024	€3,814	€3,238	€2,692	€2,177	€1,690	€1,234	€808	€412	€108	€-195	8.27
01-2025	€3,700	€3,154	€2,638	€2,152	€1,696	€1,269	€873	€570	€266	€-37	8.88
01-2026	€3,589	€3,073	€2,587	€2,130	€1,704	€1,308	€1,005	€701	€398	€94	9.31
01-2027	€3,481	€2,995	€2,539	€2,112	€1,716	€1,413	€1,109	€806	€503	€199	9.66
01-2028	€3,376	€2,920	€2,494	€2,098	€1,794	€1,491	€1,188	€884	€581	€278	9.92
01-2029	€3,275	€2,849	€2,453	€2,149	€1,846	€1,543	€1,239	€936	€632	€329	10.08
01-2030	€3,177	€2,781	€2,477	€2,174	€1,871	€1,567	€1,264	€960	€657	€354	10.17
01-2031	€3,082	€2,778	€2,475	€2,172	€1,868	€1,565	€1,262	€958	€655	€351	10.16

*Investment height is decreased by the yearly cost decrease of PV of 3%

** Remaining amount is calculated depending on the base year, and the benefits achievable in that year according to Table 31.

Scenario 2: 16 panels

Table 33. Calculation of benefits of 16 panels

	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031
Investment	€6,078.4	0	0	0	0	0	0	0	0	0	0
Salderen	100%	100%	91%	82%	73%	64%	55%	46%	37%	28%	0%
AS [kWh]	2923.2	2923.2	2660.1	2397.0	2133.9	1870.8	1607.8	1344.7	1081.6	818.5	0.0
AD [kWh]	0.0	0.0	0.0	0.0	0.0	0.0	0.0	234.5	497.6	760.7	1579.2
YAD [€]	€0	€0	€0	€0	€0	€0	€0	€51.91	€110.15	€168.38	€349.56
Feed-in [€]	€75.37	€75.37	€75.37	€75.37	€75.37	€75.37	€75.37	€88.52	€103.28	€118.03	€163.93
YEC [€]	€-75.37	€-75.37	€-75.37	€-75.37	€-75.37	€-75.37	€-75,37	€-36.61	€6.87	€50.35	€185.62
Benefits [€]	€702.23	€702.23	€702.23	€702.23	€702.23	€702.23	€702.23	€663.47	€619.99	€576.51	€441.24

Table 34. Calculation of payback period of 16 panels

	Year 0	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Year 7	Year 8	Year 9	Payback period
01-2021	€6,078	€5,376	€4,674	€3,972	€3,269	€2,567	€1,865	€1,163	€499	€-121	8.75
01-2022	€5,896	€5,194	€4,492	€3,789	€3,087	€2,385	€1,683	€1,019	€399	€-177	8.64
01-2023	€5,719	€5,017	€4,315	€3,612	€2,910	€2,208	€1,545	€925	€348	€-93	8.60
01-2024	€5,548	€4,845	€4,143	€3,441	€2,739	€2,075	€1,455	€879	€437	€-4	€8.99
01-2025	€5,381	€4,679	€3,977	€3,274	€2,611	€1,991	€1,414	€973	€532	€91	9.21
01-2026	€5,220	€4,517	€3,815	€3,152	€2,532	€1,955	€1514	€1,073	€632	€190	9.43
01-2027	€5,063	€4,361	€3,697	€3,077	€2,501	€2,060	€1,618	€1,177	€736	€295	10.67
01-2028	€4,911	€4,248	€3,628	€3,051	€2,610	€2,169	€1,728	€1,286	€845	€404	10.92
01-2029	€4,764	€4,144	€3,567	€3,126	€2,685	€2,244	€1,802	€1,361	€920	€479	11.08
01-2030	€4,621	€4,044	€3,603	€3,162	€2,721	€2,280	€1,838	€1,397	€956	€515	11.17
01-2031	€4,482	€4,041	€3,600	€3,159	€2,717	€2,276	€1,835	€1,394	€952	€511	11.16

*Investment height is decreased by the yearly cost decrease of PV of 3%, therefore, the payback period is stabilizing.

Scenario 3: 20 panels

Table 35. Calculation of benefits 20 panels

	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031
Investment	€7,598.0	0	0	0	0	0	0	0	0	0	0
Salderen	100%	100%	91%	82%	73%	64%	55%	46%	37%	28%	0%
AS [kWh]	3654.0	3654.0	3325.1	2996.3	2667.4	2338.6	2009.7	1680.8	1352.0	1023.1	0.0
AD [kWh]	0	0	0	0	0	0	0	0	0	242.9	1266.0
YAD[€]	€0	€0	€0	€0	€0	€0	€0	€0	€0	€53.76	€280.23
Feed-in[€]	€133.92	€133.92	€133.92	€133.92	€133.92	€133.92	€133.92	€133.92	€133.92	€147.54	€204.92
YEC[€]	€-133.92	€-133.92	€-133.92	€-133.92	€-133.92	€-133.92	€-133.92	€-133.92	€-133.92	€-93.78	€75.31
Benefits [€]	€760.78	€760.78	€760.78	€760.78	€760.78	€760.78	€760.78	€760.78	€760.78	€720.64	€551.55

Table 36. Calculation of payback period 20 panels

	Year 0	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Year 7	Year 8	Year 9	Pay-back period*
01-2021	€7,598	€6,837	€6,076	€5,316	€4,555	€3,794	€3,033	€2,273	€1,512	€751	9.99
01-2022	€7,370	€6,609	€5,848	€5,088	€4,327	€3,566	€2,805	€2,045	€1,284	€563	9.78
01-2023	€7,149	€6,388	€5,627	€4,867	€4,106	€3,345	€2,584	€1,823	€1,103	€551	10.00
01-2024	€6,934	€6,174	€5,413	€4,652	€3,891	€3,131	€2,370	€1,649	€1,098	€546	9.99
01-2025	€6,726	€5,966	€5,205	€4,444	€3,683	€2,923	€2,202	€1,650	€1,099	€547	9.99
01-2026	€6,525	€5,764	€5,003	€4,242	€3,482	€2,761	€2,209	€1,658	€1,106	€555	10.01
01-2027	€6,329	€5,568	€4,807	€4,047	€3,326	€2,774	€2,223	€1,671	€1,120	€568	10.03
01-2028	€6,139	€5,378	€4,617	€3,897	€3,345	€2,794	€2,242	€1,691	€1,139	€588	10.07
01-2029	€5,955	€5,194	€4,473	€3,922	€3,370	€2,819	€2,267	€1,716	€1,164	€613	10.11
01-2030	€5,776	€5,056	€4,504	€3,952	€3,401	€2,849	€2,298	€1,746	€1,195	€643	10.17
01-2031	€5,603	€5,051	€4,500	€3,948	€3,397	€2,845	€2,294	€1,742	€1,191	€639	10.16

*Investment height is decreased by the yearly cost decrease of PV of 3%, therefore, the payback period is stabilizing.

Scenario 4: PV panels including HES

Input:

Costs electricity storage

The costs for electricity are based on the estimates from Milieucentraal(n.d.-c) who determined the price for battery storage between 700 and 1000 euros. Therefore, the average is used as price.

Electricity storage size

The electricity demand per day is 7.76 kWh, where part of the demand is used directly from the solar panels 2.33 kWh. Therefore, a storage size of 6 kWh is used. Furthermore, a bigger system would not have increased the benefits. This would only be interesting if there is a possibility for seasonal storage

Table 37. Input variables for HES

Costs Electricity storage per kWh	€850
Electricity storage size [kWh]	6.0
Electricity demand per day [kWh]	7.76
Direct energy use per day	2.33

Table 38. Equations used for Calculations of HES

Daily energy generation	Electricity supply * monthly energy generation%/days per month
Amount of energy in storage	Daily energy generation – Direct energy use per day (Max electricity storage size)
Remaining demand per day	Electricity demand per day – Direct energy use - Amount in ES
Feed-in compensation	Over-supply * feed-in compensation
Costs/benefits per day	Remaining demand * electricity costs – Feed-in compensation
Investment height	Investment 16 Panels + 850 * 6

*Equations are places in a simple version, the realistic version of the calculations includes if. Else/maximum/minimum options.

Output:

Table 39. Calculations of HES

	Monthly energy generation [%]	Daily energy generation [kWh/day]	Amount of energy in storage [kWh]	Remaining demand per day [kWh]	Feed-in compensated energy [kWh]	Costs/ Benefits per day	Costs/ Benefits per month	Additional feed-in compensation
January	3%	4.04	1.71	3.72	0.00	€0.84	€26.15	€0
February	5%	7.46	5.13	0.30	0.00	€0.07	€1.92	€0
March	8%	10.78	6.00	0.00	2.45	€-0.17	€-5.14	€0.99
April	12%	16.70	6.00	0.00	8.38	€-0.57	€-17.03	€0.96
May	13%	17.51	6.00	0.00	9.18	€-0.62	€-19.29	€0.99
June	13%	18.10	6.00	0.00	9.77	€-0.62	€-19.86	€0.96
July	13%	17.51	6.00	0.00	9.18	€-0.62	€-19.29	€0.99
August	11%	14.82	6.00	0.00	6.49	€-0.44	€-13.63	€0.99
September	10%	13.92	6.00	0.00	5.59	€-0.38	€-11.37	€0.96
October	7%	9.43	6.00	0.00	1.10	€-0.07	€-2.31	€0.99
November	3%	4.18	1.85	3.58	0.00	€0.81	€24.39	€0
December	2%	2.69	0.37	5.06	0.00	€1.15	€35.62	€0
Total		137.14	57.06	12.67	52.15			
Yearly total		4176.00	1733.56	388.19	1592.84	€-0.66	€-19.85	€7.81

Table 40. Results from calculations HES

Investment height	€11,178.40
Yearly energy costs	€-91.81
Yearly benefits	€718.68
Payback period	15.55

Scenario 5: PV panels including community storage

Input:

Table 41. Input variables for CES

Decrease of size with CES	65%
Electricity storage size [kWh]	3.90

Output:

Table 42. Calculation of CES

	Monthly energy generation [%]	Daily energy generation [kWh/day]	Amount of energy in storage [kWh]	Remaining demand per day [kWh]	Feed-in compensated energy [kWh]	Costs/ benefits per day	Costs/benefits per month	Additional feed-in compensation
January	3%	4.04	1.71	3.72	0.00	€0.84	€26,15	-
February	5%	7.46	3.90	1.53	1.23	€0.26	€7,40	-
March	8%	10.78	3.90	1.53	4.55	€0.04	€1,21	-
April	12%	16.70	3.90	1.53	10.48	€-0.36	€-10,87	-
May	13%	17.51	3.90	1.53	11.28	€-0,42	€-12,93	-
June	13%	18.10	3.90	1.53	11.87	€-0,46	€-13,70	-
July	13%	17.51	3.90	1.53	11.28	€-0,42	€-12,93	-
August	11%	14.82	3.90	1.53	8.59	€-0,23	€-7,27	-
September	10%	13.92	3.90	1.53	7.69	€-0,17	€-5,21	-
October	7%	9.43	3.90	1.53	3.20	€0,13	€4,04	-
November	3%	4.18	1.85	3.58	0.00	€0,81	€24,39	-
December	2%	2.69	0.37	5.06	0.00	€1,15	€35,62	-
Total								
Yearly total		4176.00	1184.63	797.77	2141.77		€35.89	-

Table 43. Results from calculations CES

Investment height	€9,393.40
Yearly energy costs	€
Yearly benefits	€718.68
Payback period	15.55

Scenario 6: Joint investment wind energy

The joint investment of wind energy is based on the concept of ‘winddelen’, all input variables are based upon this case (de Windcentrale, n.d.).

Input:

Table 44. Output of joint investment in wind project

Power per share	500 kWh
Price per share	€275
Maximum percentage	85%
Electricity demand	2832 kWh
Reduced electricity tariff	€0.15

Output:

Table 45. Output of joint investment in wind project

Investment height	*€1375*
Yearly energy costs from shares	*€378.13*
Yearly energy costs outside shares	*€73.49*
Total electricity costs	*€451.61*
Yearly benefits compared to no shares	*€175.25*

Scenario 7: Joint investment Solar energy

The joint investment of solar energy is based upon the case of ‘Zon op Nederland’, all input variables are based upon this case (Zon op Nederland, 2020). The price per share is an average off their projects.

Input:

Table 46. Input of joint investment in solar project

Power per share	*270 kWh*
Price per share	*€320*
Maximum percentage	*85%*

Output:

Table 47. Output of joint investment in solar project

Investment height	*€2880*
Yearly energy costs from shares	*€367.54*
Yearly energy costs outside shares	*€88.98*
Total electricity costs	*€456.52*
Yearly benefits compared to no shares	*€170.34*

Scenario 8: Energy management system

In the calculations for the energy management system, the direct energy use is changed. The bandwidth of 20 to 40 per cent is applied on the 11-panel system.

Output:

Table 48. Shift of direct energy use to 20 per cent

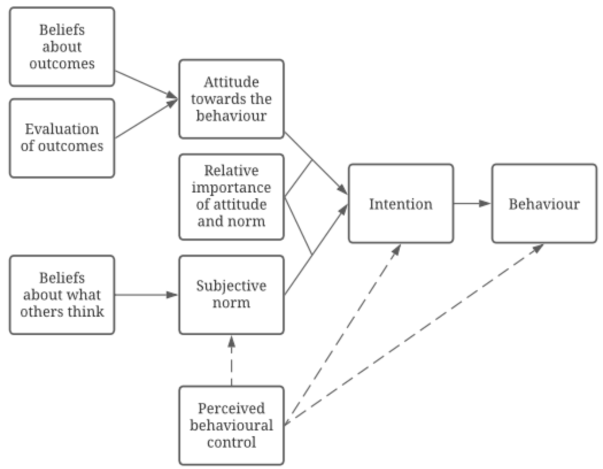
	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031
AS [kWh]	2296.8	2296.8	2090.1	1883.4	1676.7	1470.0	1263.2	1056.5	849.8	643.1	0.0
AD [kWh]	0.0	0.0	167.7	374.4	581.1	787.8	994.6	1201.3	1408.0	1614.7	2257.8
YAD[€]	€-	€-	€37,12	€82,88	€128,63	€174,39	€220,15	€265,90	€311,66	€357,41	€499,76
Feed-in[€]	€2.19	€2.19	€11,59	€23,18	€34,78	€46,37	€57,96	€69,55	€81,15	€92,74	€128,80
YEC[€]	€-2,19	€-2,19	€25,53	€59,69	€93,86	€128,02	€162,18	€196,35	€230,51	€264,67	€370,96
Benefits [€]	€629.05	€629.05	€601,33	€567,17	€533,01	€498,84	€464,68	€430,52	€396,35	€362,19	€255,90

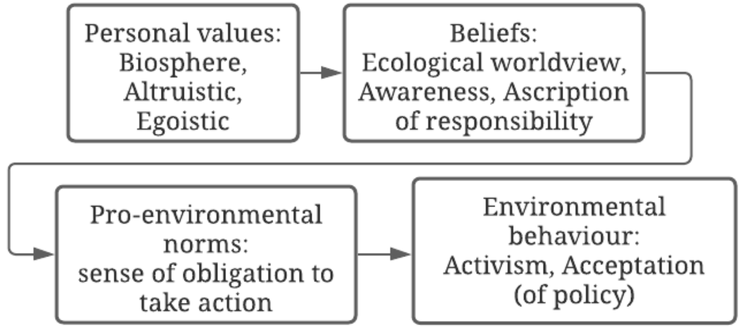
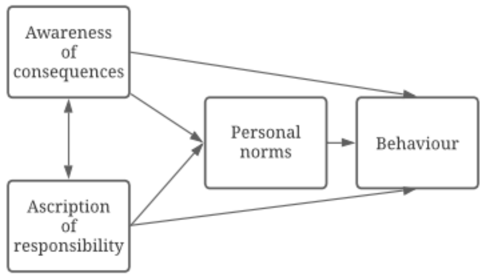
Table 49. Shift of direct energy use to 40 per cent

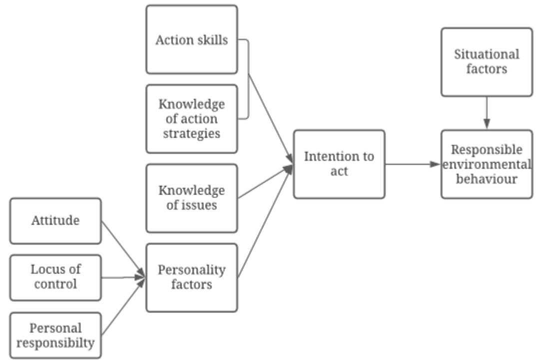
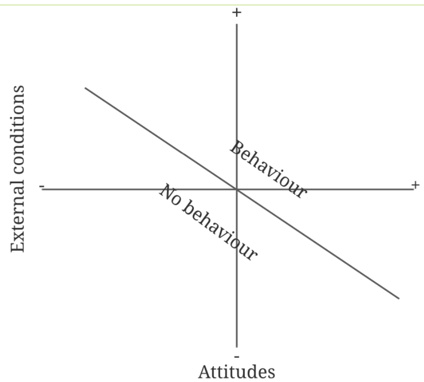
	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031
AS [kWh]	1722.6	1722.6	1567.6	1412.5	1257.5	1102.5	947.4	792.4	637.4	482.3	0.0
AD [kWh]	0.0	0.0	116.0	271.1	426.1	581.1	736.2	891.2	1046.2	1201.3	1683.6
YAD[€]	€-	€-	€25.68	€60.00	€94.32	€128.63	€162.95	€197.27	€231.58	€265.90	€372.66
Feed-in[€]	€2.19	€2.19	€8.69	€17.39	€26.08	€34.78	€43.47	€52.17	€60.86	€69.55	€96.60
YEC[€]	€-2,19	€-2.19	€16.99	€42.61	€68.23	€93.86	€119.48	€145.10	€170.72	€196.35	€276.06
Benefits [€]	€629.05	€629.05	€609.87	€584.25	€558.63	€533.01	€507.38	€481.76	€456.14	€430.52	€350.80

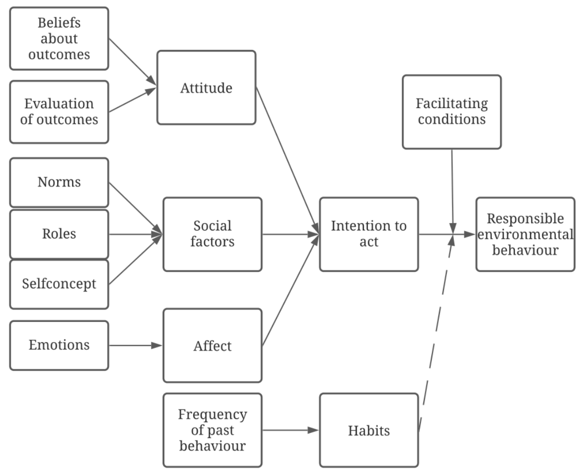
Appendix III: Behavioural models

Table 50. Overview of behavioural models

Behavioural model	Variables	Variable explanation	Explanation	Reason for development	Visual representation of model
Theory of Planned Behaviour (TPB)	Attitude, subjective norm, Perceived Behavioural Control (PBC)	Attitude: reflection of the behavioural change of an individual either being positive or negative. Where in case of TPB, the attitude is influences by beliefs by weighting cost and benefits (Stef &Norlund, 2012). Subjective norm: Belief of other individuals accepting or not accepting the behaviour. PBC: ability to perform a certain behaviour according to the belief of the situation	Widely applied model, which is an extended version of the Theory of Reasoned Action (TRA). TRA is based upon people's intention to perform a certain behaviour, measured by motivational factors (Azjen, 1991). The model assumes that variables influence the intention, and therefore, behaviour will change (Steg & Norlund, 2012).	This model is developed because of the integration of PBC, which explains the belief of an individual about how difficult the behaviour change is (Jackson, 2005).	 Adopted from (Jackson,2005)
Value Belief Norm Theory	Personal values (biosphere, altruistic, egoistic), beliefs (Ecological worldview,	Biosphere: value which is not about the individual, but about nature and environment.	This theory is according to Martiskainen (2007) based on "the principle that pro-social and personal	This model consists of multiple value orientations, in this model the activation of personal norm	

	awareness, ascription of responsibility), pro-environmental norms (sense of obligation to act)	*Altruistic:* value which is about the society. *Egoistic*: value relatable to individuals own situation, possessions, power and status.	moral norms are predictors of pro-environmental behaviour". The theory assumes that egoistic values cause negative perceptions of environmental change. And biosphere and altruistic are most important in encouragement of environmentally friendly behaviour (Bouman & Steg, 2019).	(NAT model) to ecological value.	 Adopted from (Martiskainen, 2007)
Norm activation theory (NAT)	Personal norms, awareness, ascription of responsibility, outcome efficacy, self-efficacy	Personal norms: problem awareness, ascription of responsibility, outcome efficacy and self-efficacy. Outcome efficacy: belief that actions individuals take to overcome the problems in the environment, have positive effect. Self-efficacy: the belief of the ability of individuals to undertake action	The theory is developed around altruistic values, the starting point is personal norms. From social norms awareness and willingness to change can come (Jackson, 2005). Personal norm is used to activate certain sustainable behaviour based on the assumption that people act when they feel morally obliged to a certain situation (Klockner, 2013).	In models as TRA/TPB subjective norm is an important component, but the NAT encounters the concept of personal norm. The belief that behaviour is an expression of personal values, instead of social components (Jackson, 2005)	 Adopted from (Jackson,2005)

		(Steg & Norlund, 2012).			
Model of Responsible Environmental Behaviour (REB)	Action skills, knowledge of action, knowledge of issues, personality factors (attitude, locus of control, personal responsibility), situation factors.	<u>Knowledge of action</u>: knowing how to act to have a lower impact on the environment. <u>Knowledge of issues:</u> overall knowledge of the aspect being a problem. <u>Locus of control:</u> incorporating the belief of being able to change behaviour (Kollmus & Agyeman, 2002)	The TPB is used as starting point for the REB model. In this model knowledge is integrated.	The TPB was used to analyse behaviour, but knowledge of issues and actions, locus of control, attitude, personal responsibility and intention all have a relation with intention to act too. Therefore, they combined this in one complete model (Kollmus & Agyeman, 2002)	 Adopted from (Chao, 2012)
Attitude-Behaviour-Context (ABC) model	Attitude, contextual factors	<u>Contextual factors:</u> Physical, legal, social and financial aspects (Guagnano et al., 1995).	According to Martiskainen (2007, p.16) “the behaviour is an interactive outcome of personal attitudinal variables and contextual factors”. The ABC models assumes that behaviour is a distinction between internal and external factors. If the sum of A (attitude) and C	This model is built around the belief that understanding behaviour is an equation of the individual and the context. The interaction between these two components, is formulated in a graphical representation (Jackson, 2005)	 Adopted from (Guagnano et al., 1995)

			(context) is higher than 0, the behaviour is present. When either A of C is changing, behaviour change is expected (Guagnano et al., 1995).		
Theory of Interpersonal Behaviour (TIB)	Attitude (beliefs, evaluation of outcomes), social factors (norms, roles, self-concept), affect (emotions), habits (frequency of past behaviour), facilitating conditions	<u>Self-concept:</u> perception of yourself, and the behaviour someone participates in	The TIB model is not only driven by intention, but also by current habits, affect and contextual situation.	Previous models neglected the habits of an individual, since some behaviour is driven by an automatic process, of which habits and routines are part of (Russell et al., 2017)	 Adopted from (Jackson, 2005)

Appendix IV: Previous research

Table 51. Previous research about energy communities and sustainable energy measures

Authors	Year	Title	Research method	Attitude	Contextual factors	Social influence	Personal capabilities	Habits	Others variables
E.Mengelkamp, P.Staudt, J.Garttner, C.Weinhardt, J.Huber	2018	Quantifying factors for participation in local electricity markets		-	A lower price does not have significant impact	-	-	-	Community identity seems to be important for increasing the willingness to participate in Local energy market The affinity to (new) technologies seems to be the most important influencing factor in the local energy market
A. Hackbarth, S.Lobbe	2020	Attitudes, benefits and intentions of German households concerning participation in peer-to-peer electricity trading.	Survey, regression analysis about openness towards P2P electricity trading	The current attitude towards participation in a P2P network is positive	-	-	More knowledge increases the willingness to participate. Age and a higher education increase willingness to participate in a p2p model, income is significant too.	-	Desire to be more independent increases the willingness. Technical affinity increases the willingness to participate
E.Mengelkamp, T. Schönland a,J.Hubert,	2019	The value of local electricity - a choice experiment among	Choice based study to examine the importance of design	-	The German electricity customer is willing to pay 5 euros/month more for more flexibility and control over	-	Larger households seem to be more willing to participate in LEMs, than their smaller counterparts in the	-	-

C.Weinhardt		German residential customers	parameters for LEM		electricity suppliers		Allgäu survey in this research		
S.Lobbe, A. Hackbarth, T.Stillahn, L.Pfeiffer, G. Rohbogner	2020	Customer participation in P2P trading: a German energy community case study	Case study and survey into willingness to participate in a P2P community	-	Participants prefer not to pay extra compared to their current contracts. Respondents rate the price as most important aspect	-	Home-owners and higher educated people are more willing to participate	-	The vast majority prefers local or regional communities, People are most willing to participate if it is operated by the municipality, followed by regional energy company
B. J. Kalkbrenner, J.Roosen	2015	Willingness to participate in local renewable energy projects: The role of community and trust in Germany	Survey into willingness to take part in community energy schemes	Environmental concern, significantly associated with willingness for community participation	-	Social norms positive significant relation, highest impact on willingness to engage in community-energy project	Being male increases and a higher income increases	-	Community identity does not have a significant impact but trust does.
U.J.J. Hahnel, M. Herberz, A.Pena-Bello, D.Parra, T. Brosch	2019	Becoming prosumer: Revealing trading preferences and decision-making strategies in peer-to-peer	Survey, analysing homeowners' trading decisions in simulated P2P electricity trading scenarios	-	-	-	Younger age groups are generally more likely to support renewable energy concepts, significant differences were found in education level higher	-	-

		energy communities					educated people are more likely to become prosumers. This also holds for larger households.		
H.Saele, T.L. Cherry	2016	Attitudes and perceptions of being a prosumer	Survey about Norwegians that are willing to become a prosumer with a PV system. Eventually the group is divided into two; willing to install PV and not willing to install.	Awareness of impact of PV is very low. The three most cited reasons are: installing a PV system is too expensive (34.6%), satisfied with current system (28.5%), and do not know about the possibility of a PV system (25.5%).	Price of PV systems: main reason to pay are cost saving and environmental concern; main reason not to pay: uncertainty. Negative relation (price increases, people willingness decreases)	-	Less than 5% of respondents indicated a quite good or very good knowledge about the regulatory framework. Knowledge also is limited among those considering a PV system.	-	-
E Ruokamo & M. Kopsakangas-Savolainen	2016	Key elements and attributes affecting prosumers	Choice experiment, evaluation of households' acceptance for hypothetical flexibility contracts and services in Finland.	-	Flexible pricing is negative perception and users want to be compensated in order to use it	-	The interaction between household's gross income and choosing the status quo was statistically significant	-	-

P.Goncalves Da Silva, S. Karnouskos, D. Ilic	2012	A Survey Towards Understanding Residential Prosumers in Smart Grid Neighbourhoods	Survey with 5 categories: willingness to change, energy monitoring and understanding, automated control. Value-added services and privacy	Willingness to change, 2/3 of the prosumers seem positive towards participating in shared groups	Willingness to pay for green energy is between 70 and 80 per cent	About half of the participants are willing to provide information about their energy-usage to third parties	-	-	The percentage of participants that would like to know more about their consumption behaviour is between 90 and 100 percent. Willingness for sharing information on social networks is low, but benefits increase the willingness
E.Ropuszyńska-Surma and M.Węglarz	2019	Social acceptance of small-scale renewable energy in Lower Silesia in Poland	Survey into the willingness to apply renewable energy sources.	-	-		Willingness of age groups to integrate RES, groups between 30-49 are most likely; males are more willing; smaller households less likely and with a bigger ground floor surface are more likely	--	
E. Sardianou, P. Genoudi	2013	Which factors influence the willingness to adopt renewable energy sources	Empirical analysis willingness to adopt renewable energies, binary probit	-	Consumers who consider energy tax deductions and energy subsidies as incentives to adopt renewable energies are more	-	Education level explains the adoption, younger people are less likely to pay more for RES, a higher income increases	-	-

			regression model.		likely to be willing to adopt them		the probability to apply		
N.Komendantova, M.Yazdanpanah	2016	Impact of human factors on willingness to use renewable energy sources in Iran and Morocco	Case study between Iran and Morocco (major differences)	Awareness about impacts is major influence for energy policies; awareness has influence on public acceptance and willingness to use RES	-	Moral norms seem to have the biggest influence on willingness to install RES. This could be explained by: moral norms have large influence on individual intentions	-	-	-
V. Vasseur and A. Marique	2019	Households' Willingness to Adopt Technological and Behavioural Energy Savings Measures	Survey into willingness to install boiler, led, PV, insulation and behavioural change	Environmental concerns (values and attitudes) offer little explanation in the adoption of technical energy saving measures	The majority of the people not willing to install (80%) said they could not afford the investment costs	-	Males are more likely to apply sustainable measures, and having your own home makes it more likely	-	-

Appendix V: Experimental design

Generic candidate design

```
        Design Summary
    Number of
    Levels        Frequency
         3             9
```

```
Saturated      = 19
Full Factorial = 19,683
Some Reasonable                       Cannot Be
   Design Sizes        Violations     Divided By
             27 *               0
             36 *               0
             45 *               0
             54 *               0
             21                36      9
             24                36      9
             30                36      9
             33                36      9
             39                36      9
             42                36      9
             19 S              45      3 9
* - 100% Efficient design can be made with the MktEx macro.
S - Saturated Design - The smallest design that can be made.
    Note that the saturated design is not one of the
    recommended designs for this problem.  It is shown
    to provide some context for the recommended sizes.
```

Create candidate design

Obs	x1	x2	x3	x4	x5	x6	x7	x8	x9
1	1	2	3	2	1	1	3	1	1
2	3	2	2	3	2	1	3	2	3
3	3	2	2	2	3	2	1	3	1
4	3	3	3	1	3	1	2	2	1
5	2	3	2	2	1	1	2	3	3
6	1	3	1	1	1	3	1	3	1
7	3	3	3	3	1	2	3	3	2
8	1	3	1	3	2	1	2	1	2
9	3	1	1	3	3	3	3	1	1
10	2	2	1	3	1	2	1	1	3
11	2	3	2	1	2	2	3	1	1
12	1	1	2	3	1	2	2	2	1
13	1	2	3	1	2	2	1	2	2
14	3	1	1	1	2	2	2	3	3
15	2	1	3	1	1	3	3	2	3
16	2	3	2	3	3	3	1	2	2
17	2	1	3	2	3	2	2	1	2
18	1	2	3	3	3	3	2	3	3
19	3	3	3	2	2	3	1	1	3
20	1	1	2	2	2	3	3	3	2
21	3	2	2	1	1	3	2	1	2
22	3	1	1	2	1	1	1	2	2
23	2	1	3	3	2	1	1	3	1
24	1	3	1	2	3	2	3	2	3
25	2	2	1	1	3	1	3	3	2
26	1	1	2	1	3	1	1	1	3
27	2	2	1	2	2	3	2	2	1

›

Appendix VI: Choice sets

	Alternative 1	Alternative 2		Alternative 1	Alternative 2
Survey 1	18	17	Survey 4	18	13
	10	6		17	1
	7	9		2	20
	24	24		6	12
	12	27		5	26
	13	15		22	14
	4	23		11	16
	3	1		15	21
	11	5		25	18
Survey 2	12	13	Survey 5	15	14
	9	3		9	12
	19	10		8	27
	16	20		1	26
	22	17		23	16
	1	6		20	7
	25	7		21	8
	5	2		5	11
	21	4		6	24
Survey 3	2	5	Survey 6	10	2
	14	3		4	15
	17	4		14	18
	26	8		8	22
	24	25		3	19
	20	10		19	23
	7	9		26	11
	13	22		16	21
	27	19		27	25

Appendix VII: Questionnaire

✱What is your age category?

❗ Choose one of the following answers

- ◯ 19 years or younger
- ◯ 20-29 years
- ◯ 30-39 years
- ◯ 40-49 years
- ◯ 50-59 years
- ◯ 60-69 years
- ◯ 70-79 years
- ◯ 80 years or older
- ◯ no answer

What is your gender?

♀ Female	♂ Male	◯ No answer

✱What is your highest level of education?

❗ Choose one of the following answers

- ◯ Primary education
- ◯ Secondary school
- ◯ VMBO or MBO
- ◯ Bachelor or master
- ◯ Other: ______

✱What is your current work status?

❗ Choose one of the following answers

- ◯ Student
- ◯ Unemployed
- ◯ Employed

- Retired
- Other:

✱What is your gross household income on a yearly basis?

❶ Choose one of the following answers

- < 30.000 euro
- 30.000-50.000 euro
- 50.000-100.000 euro
- >100.000 euro
- no answer

✱What is the size of your household?

❶ Choose one of the following answers

- 1 person
- 2 persons
- 3 persons
- 4 persons
- 5 or more persons
- Shared household (e.g. dorm)

✱How many children are there in your household?

❶ Choose one of the following answers

- 0
- 1
- 2
- 3
- 4
- 5 or more
- no answer

Data policy

✱Suppose you (and your household members) are moving to a new neighborhood where you can join a community with the main goal to produce and consume electri locally. You are the owner of the property and will be living there for a longer time. Below, you will be presented 12 different statements where you can agree on or disa Fill in what fits you the best.

	Strongly disagree	Disagree	Neutral	Agree	Strongly agre
In general, people who are important to me would support my efforts to conserve energy for environmental reasons	○	○	○	○	○
In general, people who are important to me think I should conserve energy for environmental reasons	○	○	○	○	○
In my environment, many people are actively involved in applying environmentally friendly measures	○	○	○	○	○
I am concerned with the environmental problems	○	○	○	○	○
I am concerned with the use of fossil fuels and its effects	○	○	○	○	○
My personal actions can make a difference in the environment	○	○	○	○	○
My decision now, can protect the environment in the future	○	○	○	○	○
I think it is important to feel attached to the proposed energy community	○	○	○	○	○
I think it is important to feel pride about the proposed energy community	○	○	○	○	○
I think it is important to have friends within the proposed energy community	○	○	○	○	○
I trust energy suppliers and third parties to manage my energy conservation safely	○	○	○	○	○
I think it is important to be more independent from the current energy producers	○	○	○	○	○

Still suppose you are moving to another neighborhood. In the following 9 questions you will be asked to choose between two alternatives. The alternatives are:

- Alternative 1: The members of the energy community invest in their own solar panels and storage system. The energy community exchanges energy between its members.
- Alternative 2: The members of the energy community invest in a common microgeneration system by buying ‘shares’ and exchange electricity for lower prices.

These situations are different in their characteristics; we ask you to choose the option you prefer. However, if you think both options are unacceptable, you can choose ‘ of these options’.

You will answer the questions under the assumption that the electricity that you need is 2800 kWh per year and the costs for electricity are 630 euro per year if you do n join the energy community (based on a tariff of 0,22 euro/kWh)

This is an EXAMPLE

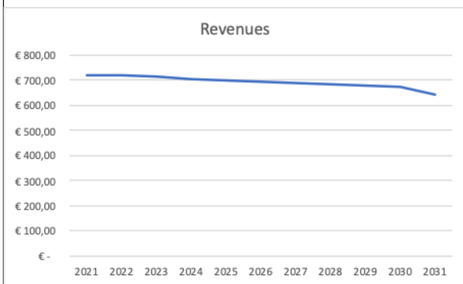
Below you will see two alternatives:

- Alternative 1: Investing in private solar panels (lifespan of 25 years for solar panels, 15 years for battery)
- Alternative 2: Iinvesting in shares of renewable energy (e.g. wind or solar energy at another location)

The different characteristics of the alternatives can vary:

- Energy management system 1) no energy management system 2) you will save energy by using household appliances (washing machine, dryer, dishwasher) duri the day 3) You will save more energy through an automatic management system for your household appliances
- Members of the community: 1) every household in the postal code area can be a member 2) max 500 households can participate 3) max 200 households can participate
- Contract information (only regarding Alternative 2); the information you receive regarding your demand and supply on a 1) monthly, 2) daily, or 3) real-time with f back about saving more energy
- Management of the community; 1) company, 2) government, or 3) voluntary community members

Decrease in costs are on yearly basis

Community characteristics	Alternative 1	Alternative 2
Investment	16 panels and storage Investment: €11.000 Revenue range 10 years: €650-725,- per year Payback period: 15 years  	4 shares of wind or solar energy Investment: €1300,- Revenues: €80,- per year Duration: 15 years
Energy management systen	Energy management system automatically aligning use of household appliances Cost decrease per year: up to €50,- per year	No energy management system
Community members	A community of only close streets, consisting of a maximum of 200 households	Every household in the postal code area can be a member (+/-7500 households)
Contract information	Always real-time information about demand and supply, including actual feedback	Real-time information about demand and supply, including actual feedback
Management of the community	Company, Additional yearly fee: €25,-	Company, Additional yearly fee: €25,-

❓ Alternative 1 will always be presented with the payback period and the revenues for the upcoming years. For the same period, the revenues will be presented in a gra For alternative 2 the height of the investment will be presented, including the revenues and contract duration

If you have no preference, or none are making sense. You can select the "none of these" option.

On the next pages we will ask you to make the choice 9 times.

What would be your main goal which you would like to achieve in the energy community?

❗ Check all that apply

- [ ] None, I do not want to participate in any form
- [ ] Net-zero of your home
- [ ] Net-zero of the community
- [ ] Cost decrease
- [ ] Good investment of money
- [ ] Sustainability in the neighborhood
- [ ] Local energy production
- [ ] Other: ______

✱What is your current living situation?

❗ Choose one of the following answers

- ○ Renter
- ○ Home-owner
- ○ Other: ______

Did you apply measures to your current home to reduce energy use?

❗ Check all that apply

- [ ] None
- [ ] PV panels
- [ ] Solar boiler
- [ ] Heat pump
- [ ] Energy storage system
- [ ] Extra insulation
- [ ] Other: ______

Appendix VIII: Cross-tabs statements

Statement 1: In general, people who are important to me would support my efforts to conserve energy for environmental reasons

Table 52. Cross-tabs statement 1

Statement 1		Strongly disagree	Disagree	Neutral	Agree	Strongly agree	Total
Age	20-29	0	3	8	22	14	47
	%	0%	6%	17%	47%	30%	100%
	30-39	0	0	3	14	5	22
	%	0%	0%	14%	64%	23%	100%
	40-49	0	1	3	14	3	21
	%	0%	5%	14%	67%	14%	100%
	50-59	1	3	4	22	6	36
	%	3%	8%	11%	61%	17%	100%
	60-69	0	0	3	13	3	19
	%	0%	0%	16%	68%	16%	100%
	70-79	0	0	0	1	0	1
	%	0%	0%	0%	100%	0%	100%
Gender	Female	0	3	9	42	17	71
	%	0%	4%	13%	59%	24%	100%
	Male	1	4	13	43	14	75
	%	1%	5%	17%	57%	19%	100%
Education	Secondary school	0	1	4	7	4	16
	%	0%	6%	25%	44%	25%	100%
	VMBO/MBO	0	2	6	18	2	28
	%	0%	7%	21%	64%	7%	100%
	HBO/WO	1	4	12	60	25	102
	%	1%	4%	12%	59%	25%	100%
Work status	Student	0	0	2	11	5	18
	%	0%	0%	11%	61%	28%	100%
	Unemployed	0	0	1	0	0	1
	%	0%	0%	100%	0%	0%	100%
	Employed	1	7	17	68	26	119
	%	1%	6%	14%	57%	22%	100%
	Retired	0	0	2	6	0	8
	%	0%	0%	25%	75%	0%	100%
Household income	< 30,000	0	0	4	14	2	20
	%	0%	0%	20%	70%	10%	100%
	30,000-50,000	0	1	10	25	11	47
	%	0%	2%	21%	53%	23%	100%
	50,000-100,000	0	5	8	28	11	52
	%	0%	10%	15%	54%	21%	100%
	>100,000	1	1	0	15	6	23
	%	4%	4%	0%	65%	26%	100%
	No answer	0	0	0	3	1	4
	%	0%	0%	0%	75%	25%	100%
Household size	1	0	1	4	14	5	24
	%	0%	4%	17%	58%	21%	100%
	2	1	4	9	34	13	61

	%	2%	7%	15%	56%	21%	100%
	3	0	1	6	12	5	24
	%	0%	4%	25%	50%	21%	100%
	4	0	1	2	14	8	25
	%	0%	4%	8%	56%	32%	100%
	5 or more	0	0	1	4	0	5
	%	0%	0%	20%	80%	0%	100%
	Shared	0	0	0	7	0	7
	%	0%	0%	0%	100%	0%	100%
Number of children	No children	1	5	13	52	18	89
	%	1%	6%	15%	58%	20%	100%
	With children	0	2	9	33	13	57
	%	0%	4%	16%	58%	23%	100%
House ownership	Renter	0	2	6	15	8	31
	%	0%	6%	19%	48%	26%	100%
	Homeowner	1	5	16	64	23	109
	%	1%	5%	15%	59%	21%	100%

	Chi-square	**df**	**Significance**
Age	16.926	20	0.658
Gender	2.064	4	0.724
Education level	7.524	8	0.481
Work status	10.675	12	0.557
Household income	18.136	16	0.316
Household size	12.804	20	0.886
Number of children	13.65	16	0.625
Home-Ownership	6.006	8	0.647

Statement 2: In general, people who are important to me think I should conserve energy for environmental reasons

Table 53. Cross-tabs Statement 2

Statement 2		**Strongly disagree**	**Disagree**	**Neutral**	**Agree**	**Strongly agree**	**Total**
Age	20-29	1	9	14	22	1	47
	%	2%	19%	30%	47%	2%	100%
	30-39	1	4	6	10	1	22
	%	5%	18%	27%	45%	5%	100%
	40-49	0	2	6	10	3	21
	%	0%	10%	29%	48%	14%	100%
	50-59	1	5	6	22	2	36
	%	3%	14%	17%	61%	6%	100%
	60-69	0	1	3	11	4	19
	%	0%	5%	16%	58%	21%	100%
	70-79	0	0	1	0	0	1
	%	0%	0%	100%	0%	0%	100%
Gender	Female	0	10	19	37	5	71
	%	0%	14%	27%	52%	7%	100%
	Male	3	11	17	38	6	75
	%	4%	15%	23%	51%	8%	100%
Education	Secondary school	0	5	2	6	3	16
	%	0%	31%	13%	38%	19%	100%
	VMBO/MBO	0	5	5	18	0	28
	%	0%	18%	18%	64%	0%	100%
	HBO/WO	3	11	29	51	8	102
	%	3%	11%	28%	50%	8%	100%
Work status	Student	0	3	6	9	0	18
	%	0%	17%	33%	50%	0%	100%
	Unemployed	0	0	0	1	0	1
	%	0%	0%	0%	100%	0%	100%
	Employed	3	17	27	62	10	119
	%	3%	14%	23%	52%	8%	100%
	Retired	0	1	3	3	1	8
	%	0%	13%	38%	38%	13%	100%
Household income	< 30,000	0	2	6	12	0	20
	%	0%	10%	30%	60%	0%	100%
	30,000-50,000	0	7	17	22	1	47
	%	0%	15%	36%	47%	2%	100%
	50,000-100,000	1	9	9	27	6	52
	%	2%	17%	17%	52%	12%	100%
	>100,000	2	3	4	11	3	23
	%	9%	13%	17%	48%	13%	100%
	Prefer not to answer	0	0	0	3	1	4
	%	0%	0%	0%	75%	25%	100%
Household size	1	1	2	7	13	1	24
	%	4%	8%	29%	54%	4%	100%
	2	1	10	16	31	3	61
	%	2%	16%	26%	51%	5%	100%

	3	1	2	4	14	3	24
	%	4%	8%	17%	58%	13%	100%
	4	0	3	5	13	4	25
	%	0%	12%	20%	52%	16%	100%
	5 or more	0	2	0	3	0	5
	%	0%	40%	0%	60%	0%	100%
	Shared	0	2	4	1	0	7
	%	0%	29%	57%	14%	0%	100%
Number of children	No children	2	13	26	44	4	89
	%	2%	15%	29%	49%	4%	100%
	With children	1	8	10	31	7	57
	%	2%	14%	18%	54%	12%	100%
House ownership	Renter	0	7	8	15	1	31
	%	0%	23%	26%	48%	3%	100%
	Homeowner	3	14	24	58	10	109
	%	3%	13%	22%	53%	9%	100%

	Chi-square	**df**	**Significance**
Age	18.649	20	0.545
Gender	3.156	4	0.532
Education level	14.025	8	0.081
Work status	5.02	12	0.957
Household income	20.922	16	0.182
Household size	19.133	20	0.513
Number of children	11.843	16	0.755
House ownership	10.238	8	0.249

Statement 3: In my environment, many people are actively involved in applying environmentally friendly measures

Table 54. Cross-tabs Statement 3

Statement 3		**Strongly disagree**	**Disagree**	**Neutral**	**Agree**	**Strongly agree**	**Total**
Age	20-29	3	5	9	25	5	47
	%	6%	11%	19%	53%	11%	100%
	30-39	0	4	4	13	1	22
	%	0%	18%	18%	59%	5%	100%
	40-49	0	4	3	12	2	21
	%	0%	19%	14%	57%	10%	100%
	50-59	0	1	8	23	4	36
	%	0%	3%	22%	64%	11%	100%
	60-69	0	0	6	8	5	19
	%	0%	0%	32%	42%	26%	100%
	70-79	0	0	0	1	0	1
	%	0%	0%	0%	100%	0%	100%
Gender	Female	2	7	13	42	7	71
	%	3%	10%	18%	59%	10%	100%
	Male	1	7	17	40	10	75
	%	1%	9%	23%	53%	13%	100%
Education	Secondary school	1	3	4	6	2	16
	%	6%	19%	25%	38%	13%	100%
	VMBO/MBO	0	4	7	13	4	28
	%	0%	14%	25%	46%	14%	100%
	HBO/WO	2	7	19	63	11	102
	%	2%	7%	19%	62%	11%	100%
Work status	Student	1	1	5	11	0	18
	%	6%	6%	28%	61%	0%	100%
	Unemployed	0	1	0	0	0	1
	%	0%	100%	0%	0%	0%	100%
	Employed	2	12	22	66	17	119
	%	2%	10%	18%	55%	14%	100%
	Retired	0	0	3	5	0	8
	%	0%	0%	38%	63%	0%	100%
Household income	< 30,000	2	3	3	12	0	20
	%	10%	15%	15%	60%	0%	100%
	30,000-50,000	0	7	8	28	4	47
	%	0%	15%	17%	60%	9%	100%
	50,000-100,000	1	4	14	25	8	52
	%	2%	8%	27%	48%	15%	100%
	>100,000	0	0	5	14	4	23
	%	0%	0%	22%	61%	17%	100%
	Prefer not to answer	0	0	0	3	1	4
	%	0%	0%	0%	75%	25%	100%
Household size	1	0	3	4	16	1	24
	%	0%	13%	17%	67%	4%	100%
	2	2	5	14	31	9	61
	%	3%	8%	23%	51%	15%	100%

	3	0	0	5	15	8	28
	%	0%	0%	18%	54%	29%	100%
	4	0	5	6	11	3	25
	%	0%	20%	24%	44%	12%	100%
	5 or more	0	0	0	5	0	5
	%	0%	0%	0%	100%	0%	100%
	Shared	1	1	1	4	0	7
	%	14%	14%	14%	57%	0%	100%
Number of children	No children	3	9	19	49	9	89
	%	3%	10%	21%	55%	10%	100%
	With children	0	5	11	33	8	57
	%	0%	9%	19%	58%	14%	100%
House ownership	Renter	2	5	3	17	4	31
	%	6%	16%	10%	55%	13%	100%
	Homeowner	1	9	25	61	13	109
	%	1%	8%	23%	56%	12%	100%

	Chi-square	**df**	**Significance**
Age	21.787	20	0.352
Gender	1.336	4	0.855
Education level	7.670	8	0.466
Work status	17.56	12	0.130
Household income	20.607	16	0.194
Household size	21.804	20	0.351
Number of children	14.887	16	0.533
House ownership	9.325	8	0.316

Statement 4: I am concerned with the environmental problems

Table 55. Cross-tabs Statement 4

Statement 4		Strongly disagree	Disagree	Neutral	Agree	Strongly agree	Total
Age	20-29	0	2	7	26	12	47
	%	0%	4%	15%	55%	26%	100%
	30-39	0	2	6	7	7	22
	%	0%	9%	27%	32%	32%	100%
	40-49	0	1	3	11	6	21
	%	0%	5%	14%	52%	29%	100%
	50-59	0	1	4	17	14	36
	%	0%	3%	11%	47%	39%	100%
	60-69	0	0	0	11	8	19
	%	0%	0%	0%	58%	42%	100%
	70-79	0	0	0	1	0	1
	%	0%	0%	0%	100%	0%	100%
Gender	Female	0	1	10	34	26	71
	%	0%	1%	14%	48%	37%	100%
	Male	0	5	10	39	21	75
	%	0%	7%	13%	52%	28%	100%
Education	Secondary school	0	0	2	9	5	16
	%	0%	0%	13%	56%	31%	100%
	VMBO/MBO	0	2	7	12	7	28
	%	0%	7%	25%	43%	25%	100%
	HBO/WO	0	4	11	52	35	102
	%	0%	4%	11%	51%	34%	100%
Work status	Student	0	1	2	10	5	18
	%	0%	6%	11%	56%	28%	100%
	Unemployed	0	0	0	1	0	1
	%	0%	0%	0%	100%	0%	100%
	Employed	0	5	18	56	40	119
	%	0%	4%	15%	47%	34%	100%
	Retired	0	0	0	6	2	8
	%	0%	0%	0%	75%	25%	100%
Household income	< 30,000	0	1	4	10	5	20
	%	0%	5%	20%	50%	25%	100%
	30,000-50,000	0	1	9	26	11	47
	%	0%	2%	19%	55%	23%	100%
	50,000-100,000	0	3	5	25	19	52
	%	0%	6%	10%	48%	37%	100%
	>100,000	0	1	2	9	11	23
	%	0%	4%	9%	39%	48%	100%
	Prefer not to answer	0	0	0	3	1	4
	%	0%	0%	0%	75%	25%	100%
Household size	1	0	2	3	11	8	24
	%	0%	8%	13%	46%	33%	100%
	2	0	2	7	35	17	61
	%	0%	3%	11%	57%	28%	100%
	3	0	0	3	12	9	24

	%	0%	0%	13%	50%	38%	100%
	4	0	1	5	10	9	25
	%	0%	4%	20%	40%	36%	100%
	5 or more	0	0	1	2	2	5
	%	0%	0%	20%	40%	40%	100%
	Shared	0	1	1	3	2	7
	%	0%	14%	14%	43%	29%	100%
Number of children	No children	0	5	10	48	26	89
	%	0%	6%	11%	54%	29%	100%
	With children	0	1	10	25	21	57
	%	0%	2%	18%	44%	37%	100%
House ownership	Renter	0	2	4	17	8	31
	%	0%	6%	13%	55%	26%	100%
	Homeowner	0	4	12	54	39	109
	%	0%	4%	11%	50%	36%	100%

	Chi-square	df	Significance
Age	9.288	15	0.862
Gender	2.977	3	0.395
Education level	7.941	6	0.242
Work status	4.770	9	0.854
Household income	10.352	12	0.585
Household size	10.413	15	0.793
Number of children	5.488	3	0.139
House ownership	1.297	3	0.730

Statement 5: I am concerned with the use of fossil fuels and its effects

Table 56. Cross-tabs Statement 5

Statement 5		Strongly disagree	Disagree	Neutral	Agree	Strongly agree	Total
Age	20-29	1	4	5	26	11	47
	%	2%	9%	11%	55%	23%	100%
	30-39	1	4	4	9	4	22
	%	5%	18%	18%	41%	18%	100%
	40-49	0	2	3	10	6	21
	%	0%	10%	14%	48%	29%	100%
	50-59	0	3	7	20	6	36
	%	0%	8%	19%	56%	17%	100%
	60-69	0	1	0	12	6	19
	%	0%	5%	0%	63%	32%	100%
	70-79	0	0	0	1	0	1
	%	0%	0%	0%	100%	0%	100%
Gender	Female	0	6	9	34	22	71
	%	0%	8%	13%	48%	31%	100%
	Male	2	8	10	44	11	75
	%	3%	11%	13%	59%	15%	100%
Education	Secondary school	0	4	1	9	2	16
	%	0%	25%	6%	56%	13%	100%
	VMBO/MBO	1	3	7	13	4	28
	%	4%	11%	25%	46%	14%	100%
	HBO/WO	1	7	11	56	27	102
	%	1%	7%	11%	55%	26%	100%
Work status	Student	0	3	0	11	4	18
	%	0%	17%	0%	61%	22%	100%
	Unemployed	0	0	0	1	0	1
	%	0%	0%	0%	100%	0%	100%
	Employed	2	11	19	59	28	119
	%	2%	9%	16%	50%	24%	100%
	Retired	0	0	0	7	1	8
	%	0%	0%	0%	88%	13%	100%
Household income	< 30,000	0	3	3	12	2	20
	%	0%	15%	15%	60%	10%	100%
	30,000-50,000	0	5	9	22	11	47
	%	0%	11%	19%	47%	23%	100%
	50,000-100,000	2	4	5	28	13	52
	%	4%	8%	10%	54%	25%	100%
	>100,000	0	2	2	13	6	23
	%	0%	9%	9%	57%	26%	100%
	Prefer not to answer	0	0	0	3	1	4
	%	0%	0%	0%	75%	25%	100%
Household size	1	1	2	2	12	7	24
	%	4%	8%	8%	50%	29%	100%
	2	0	6	7	36	12	61
	%	0%	10%	11%	59%	20%	100%
	3	0	0	5	14	5	24

	%	0%	0%	21%	58%	21%	100%
	4	1	3	4	10	7	25
	%	4%	12%	16%	40%	28%	100%
	5 or more	0	0	1	2	2	5
	%	0%	0%	20%	40%	40%	100%
	Shared	0	3	0	4	0	7
	%	0%	43%	0%	57%	0%	100%
Number of children	No children	1	10	8	51	19	89
	%	1%	11%	9%	57%	21%	100%
	With children	1	4	11	27	14	57
	%	2%	7%	19%	47%	25%	100%
House ownership	Renter	0	6	2	18	5	31
	%	0%	19%	6%	58%	16%	100%
	Homeowner	2	8	14	57	28	109
	%	2%	7%	13%	52%	26%	100%

	Chi-square	df	Significance
Age	13.823	20	0.839
Gender	7.690	4	0.104
Education level	12.100	8	0.147
Work status	9.207	12	0.685
Household income	14.735	16	0.544
Household size	26.884	20	0.139
Number of children	7.207	4	0.125
House ownership	7.367	4	0.118

Statement 6: My personal actions can make a difference in the environment

Table 57. Cross-tabs Statement 6

Statement 6		Strongly disagree	Disagree	Neutral	Agree	Strongly agree	Total
Age	20-29	1	3	4	29	10	47
	%	2%	6%	9%	62%	21%	100%
	30-39	1	2	5	11	3	22
	%	5%	9%	23%	50%	14%	100%
	40-49	0	2	6	11	2	21
	%	0%	10%	29%	52%	10%	100%
	50-59	1	3	7	19	6	36
	%	3%	8%	19%	53%	17%	100%
	60-69	0	2	7	6	4	19
	%	0%	11%	37%	32%	21%	100%
	70-79	0	0	1	0	0	1
	%	0%	0%	100%	0%	0%	100%
Gender	Female	0	5	12	45	9	71
	%	0%	7%	17%	63%	13%	100%
	Male	3	7	18	31	16	75
	%	4%	9%	24%	41%	21%	100%
Education	Secondary school	0	2	4	6	4	16
	%	0%	13%	25%	38%	25%	100%
	VMBO/MBO	1	4	7	13	3	28
	%	4%	14%	25%	46%	11%	100%
	HBO/WO	2	6	19	57	18	102
	%	2%	6%	19%	56%	18%	100%
Work status	Student	0	0	2	12	4	18
	%	0%	0%	11%	67%	22%	100%
	Unemployed	0	1	0	0	0	1
	%	0%	100%	0%	0%	0%	100%
	Employed	3	10	24	61	21	119
	%	3%	8%	20%	51%	18%	100%
	Retired	0	1	4	3	0	8
	%	0%	13%	50%	38%	0%	100%
Household income	< 30,000	0	3	4	11	2	20
	%	0%	15%	20%	55%	10%	100%
	30,000-50,000	1	6	7	27	6	47
	%	2%	13%	15%	57%	13%	100%
	50,000-100,000	1	1	15	22	13	52
	%	2%	2%	29%	42%	25%	100%
	>100,000	1	2	4	13	3	23
	%	4%	9%	17%	57%	13%	100%
	Prefer not to answer	0	0	0	3	1	4
	%	0%	0%	0%	75%	25%	100%
Household size	1	1	4	3	13	3	24
	%	4%	17%	13%	54%	13%	100%
	2	0	6	15	32	8	61
	%	0%	10%	25%	52%	13%	100%

	3	0	0	7	9	8	24
	%	0%	0%	29%	38%	33%	100%
	4	2	2	5	11	5	25
	%	8%	8%	20%	44%	20%	100%
	5 or more	0	0	0	5	0	5
	%	0%	0%	0%	100%	0%	100%
	Shared	0	0	0	6	1	7
	%	0%	0%	0%	86%	14%	100%
Number of children	No children	1	9	18	49	12	89
	%	1%	10%	20%	55%	13%	100%
	With children	2	3	12	27	13	57
	%	4%	5%	21%	47%	23%	100%
House ownership	Renter	0	5	3	18	5	31
	%	0%	16%	10%	58%	16%	100%
	Homeowner	3	7	26	53	20	109
	%	3%	6%	24%	49%	18%	100%

	Chi-square	**df**	**Significance**
Age	18.369	20	0.563
Gender	8.599	4	0.072
Education level	6.540	8	0.587
Work status	21.254	12	0.047
Household income	14.819	16	0.538
Household size	25.560	20	0.181
Number of children	3.511	4	0.476
House ownership	5.147	4	0.273

Statement 7: My decision now, can protect the environment in the future

Table 58. Cross-tabs statement 7

Statement 7		Strongly disagree	Disagree	Neutral	Agree	Strongly agree	Total
Age	20-29	0	10	9	17	11	47
	%	0%	21%	19%	36%	23%	100%
	30-39	0	2	3	13	4	22
	%	0%	9%	14%	59%	18%	100%
	40-49	0	3	6	11	1	21
	%	0%	14%	29%	52%	5%	100%
	50-59	0	1	10	17	8	36
	%	0%	3%	28%	47%	22%	100%
	60-69	0	1	7	7	4	19
	%	0%	5%	37%	37%	21%	100%
	70-79	0	0	0	1	0	1
	%	0%	0%	0%	100%	0%	100%
Gender	Female	0	7	16	36	12	71
	%	0%	10%	23%	51%	17%	100%
	Male	0	10	19	30	16	75
	%	0%	13%	25%	40%	21%	100%
Education	Secondary school	0	3	5	4	4	16
	%	0%	19%	31%	25%	25%	100%
	VMBO/MBO	0	6	9	9	4	28
	%	0%	21%	32%	32%	14%	100%
	HBO/WO	0	8	21	53	20	102
	%	0%	8%	21%	52%	20%	100%
Work status	Student	0	5	6	3	4	18
	%	0%	28%	33%	17%	22%	100%
	Unemployed	0	1	0	0	0	1
	%	0%	100%	0%	0%	0%	100%
	Employed	0	10	26	60	23	119
	%	0%	8%	22%	50%	19%	100%
	Retired	0	1	3	3	1	8
	%	0%	13%	38%	38%	13%	100%
Household income	< 30,000	0	6	7	4	3	20
	%	0%	30%	35%	20%	15%	100%
	30,000-50,000	0	6	11	25	5	47
	%	0%	13%	23%	53%	11%	100%
	50,000-100,000	0	5	11	24	12	52
	%	0%	10%	21%	46%	23%	100%
	>100,000	0	0	5	11	7	23
	%	0%	0%	22%	48%	30%	100%
	Prefer not to answer	0	0	1	2	1	4
	%	0%	0%	25%	50%	25%	100%
Household size	1	0	4	6	10	4	24
	%	0%	17%	25%	42%	17%	100%
	2	0	6	17	28	10	61
	%	0%	10%	28%	46%	16%	100%
	3	0	0	8	8	8	24

	%	0%	0%	33%	33%	33%	100%
	4	0	3	2	15	5	25
	%	0%	12%	8%	60%	20%	100%
	5 or more	0	1	0	4	0	5
	%	0%	20%	0%	80%	0%	100%
	Shared	0	3	2	1	1	7
	%	0%	43%	29%	14%	14%	100%
Number of children	No children	0	13	25	36	15	89
	%	0%	15%	28%	40%	17%	100%
	With children	0	4	10	30	13	57
	%	0%	7%	18%	53%	23%	100%
House ownership	Renter	0	8	5	10	8	31
	%	0%	26%	16%	32%	26%	100%
	Homeowner	0	8	29	52	20	109
	%	0%	7%	27%	48%	18%	100%

	Chi-square	**df**	**Significance**
Age	15.211	15	0.436
Gender	0.728	3	0.867
Education level	10.370	6	0.110
Work status	16.343	9	0.060
Household income	20.127	12	0.065
Household size	20.912	15	0.140
Number of children	5.387	3	0.146
House ownership	10.425	3	0.015

Statement 8: I think it is important to feel attached to the proposed energy community

Table 59. Cross-tabs statement 8

Statement 8		Strongly disagree	Disagree	Neutral	Agree	Strongly agree	Total
Age	20-29	3	9	11	21	3	47
	%	6%	19%	23%	45%	6%	100%
	30-39	0	2	8	11	1	22
	%	0%	9%	36%	50%	5%	100%
	40-49	0	6	6	9	0	21
	%	0%	29%	29%	43%	0%	100%
	50-59	1	4	11	15	5	36
	%	3%	11%	31%	42%	14%	100%
	60-69	0	0	6	11	2	19
	%	0%	0%	32%	58%	11%	100%
	70-79	0	0	0	1	0	1
	%	0%	0%	0%	100%	0%	100%
Gender	Female	2	7	27	33	2	71
	%	3%	10%	38%	46%	3%	100%
	Male	2	14	15	35	9	75
	%	3%	19%	20%	47%	12%	100%
Education	Secondary school	2	1	7	3	3	16
	%	13%	6%	44%	19%	19%	100%
	VMBO/MBO	1	2	9	12	4	28
	%	4%	7%	32%	43%	14%	100%
	HBO/WO	1	18	26	53	4	102
	%	1%	18%	25%	52%	4%	100%
Work status	Student	2	1	5	9	1	18
	%	11%	6%	28%	50%	6%	100%
	Unemployed	0	0	1	0	0	1
	%	0%	0%	100%	0%	0%	100%
	Employed	2	20	36	51	10	119
	%	2%	17%	30%	43%	8%	100%
	Retired	0	0	0	8	0	8
	%	0%	0%	0%	100%	0%	100%
Household income	< 30,000	1	2	6	11	0	20
	%	5%	10%	30%	55%	0%	100%
	30,000-50,000	0	5	14	25	3	47
	%	0%	11%	30%	53%	6%	100%
	50,000-100,000	3	9	13	23	4	52
	%	6%	17%	25%	44%	8%	100%
	>100,000	0	5	6	8	4	23
	%	0%	22%	26%	35%	17%	100%
	Prefer not to answer	0	0	3	1	0	4
	%	0%	0%	75%	25%	0%	100%
Household size	1	1	5	8	9	1	24
	%	4%	21%	33%	38%	4%	100%
	2	0	7	18	30	6	61
	%	0%	11%	30%	49%	10%	100%
	3	2	2	7	11	2	24

	%	8%	8%	29%	46%	8%	100%
	4	0	6	5	12	2	25
	%	0%	24%	20%	48%	8%	100%
	5 or more	0	1	2	2	0	5
	%	0%	20%	40%	40%	0%	100%
	Shared	1	0	2	4	0	7
	%	14%	0%	29%	57%	0%	100%
Number of children	No children	2	12	25	44	6	89
	%	2%	13%	28%	49%	7%	100%
	With children	2	9	17	24	5	57
	%	4%	16%	30%	42%	9%	100%
House ownership	Renter	1	7	5	15	3	31
	%	3%	23%	16%	48%	10%	100%
	Homeowner	3	14	34	50	8	109
	%	3%	13%	31%	46%	7%	100%

Age	Chi-square	df	Significance
Age	19.517	20	0.488
Gender	8.547	4	0.078
Education level	21.848	8	0.005
Work status	19.512	12	0.077
Household income	14.918	16	0.513
Household size	16.679	20	0.674
Number of children	0.734	4	0.947
House ownership	3.855	4	0.426

Statement 9: I think it is important to feel pride about the proposed energy community

Table 60. Cross-tabs statement 9

Statement 9		Strongly disagree	Disagree	Neutral	Agree	Strongly agree	Total
Age	20-29	3	6	17	17	4	47
	%	6%	13%	36%	36%	9%	100%
	30-39	0	3	9	9	1	22
	%	0%	14%	41%	41%	5%	100%
	40-49	1	4	11	4	1	21
	%	5%	19%	52%	19%	5%	100%
	50-59	1	5	19	8	3	36
	%	3%	14%	53%	22%	8%	100%
	60-69	0	0	9	8	2	19
	%	0%	0%	47%	42%	11%	100%
	70-79	0	0	1	0	0	1
	%	0%	0%	100%	0%	0%	100%
Gender	Female	1	8	33	26	3	71
	%	1%	11%	46%	37%	4%	100%
	Male	4	10	33	20	8	75
	%	5%	13%	44%	27%	11%	100%
Education	Secondary school	1	2	10	2	1	16
	%	6%	13%	63%	13%	6%	100%
	VMBO/MBO	1	1	14	9	3	28
	%	4%	4%	50%	32%	11%	100%
	HBO/WO	3	15	42	35	7	102
	%	3%	15%	41%	34%	7%	100%
Work status	Student	0	3	8	6	1	18
	%	0%	17%	44%	33%	6%	100%
	Unemployed	0	0	1	0	0	1
	%	0%	0%	100%	0%	0%	100%
	Employed	5	15	54	35	10	119
	%	4%	13%	45%	29%	8%	100%
	Retired	0	0	3	5	0	8
	%	0%	0%	38%	63%	0%	100%
Household income	< 30,000	0	3	9	8	0	20
	%	0%	15%	45%	40%	0%	100%
	30,000-50,000	0	3	24	15	5	47
	%	0%	6%	51%	32%	11%	100%
	50,000-100,000	5	8	18	18	3	52
	%	10%	15%	35%	35%	6%	100%
	>100,000	0	4	12	4	3	23
	%	0%	17%	52%	17%	13%	100%
	Prefer not to answer	0	0	3	1	0	4
	%	0%	0%	75%	25%	0%	100%
Household size	1	1	2	13	8	0	24
	%	4%	8%	54%	33%	0%	100%
	2	2	4	25	24	6	61
	%	3%	7%	41%	39%	10%	100%

	3	1	4	12	4	3	24
	%	4%	17%	50%	17%	13%	100%
	4	1	6	10	6	2	25
	%	4%	24%	40%	24%	8%	100%
	5 or more	0	1	2	2	0	5
	%	0%	20%	40%	40%	0%	100%
	Shared	0	1	4	2	0	7
	%	0%	14%	57%	29%	0%	100%
Number of children	No children	3	7	40	34	5	89
	%	3%	8%	45%	38%	6%	100%
	With children	2	11	26	12	6	57
	%	4%	19%	46%	21%	11%	100%
House ownership	Renter	2	4	15	7	3	31
	%	6%	13%	48%	23%	10%	100%
	Homeowner	3	14	50	34	8	109
	%	3%	13%	46%	31%	7%	100%

	Chi-square	**df**	**Significance**
Age	13.919	20	0.835
Gender	3.650	4	0.455
Education level	5.411	8	0.713
Work status	7.552	12	0.819
Household income	16.746	16	0.402
Household size	13.802	20	0.840
Number of children	6.266	4	0.180
House ownership	2.525	4	0.640

Statement 10: I think it is important to have friends within the proposed energy community

Table 61. Cross-tabs statement 10

Statement 10		**Strongly disagree**	**Disagree**	**Neutral**	**Agree**	**Strongly agree**	**Total**
Age	20-29	5	8	20	13	1	47
	%	11%	17%	43%	28%	2%	100%
	30-39	0	7	6	8	1	22
	%	0%	32%	27%	36%	5%	100%
	40-49	3	3	6	8	1	21
	%	14%	14%	29%	38%	5%	100%
	50-59	2	4	19	11	0	36
	%	6%	11%	53%	31%	0%	100%
	60-69	0	0	10	9	0	19
	%	0%	0%	53%	47%	0%	100%
	70-79	0	0	1	0	0	1
	%	0%	0%	100%	0%	0%	100%
Gender	Female	4	11	32	23	1	71
	%	6%	15%	45%	32%	1%	100%
	Male	6	11	30	26	2	75
	%	8%	15%	40%	35%	3%	100%
Education	Secondary school	1	5	6	4	0	16
	%	6%	31%	38%	25%	0%	100%
	VMBO/MBO	1	3	8	15	1	28
	%	4%	11%	29%	54%	4%	100%
	HBO/WO	8	14	48	30	2	102
	%	8%	14%	47%	29%	2%	100%
Work status	Student	1	4	9	4	0	18
	%	6%	22%	50%	22%	0%	100%
	Unemployed	0	0	1	0	0	1
	%	0%	0%	100%	0%	0%	100%
	Employed	9	18	49	40	3	119
	%	8%	15%	41%	34%	3%	100%
	Retired	0	0	3	5	0	8
	%	0%	0%	38%	63%	0%	100%
Household income	< 30,000	2	3	8	7	0	20
	%	10%	15%	40%	35%	0%	100%
	30,000-50,000	0	7	17	21	2	47
	%	0%	15%	36%	45%	4%	100%
	50,000-100,000	7	8	23	13	1	52
	%	13%	15%	44%	25%	2%	100%
	>100,000	1	4	11	7	0	23
	%	4%	17%	48%	30%	0%	100%
	Prefer not to answer	0	0	0	3	1	4
	%	0%	0%	0%	75%	25%	100%
Household size	1	3	3	8	10	0	24
	%	13%	13%	33%	42%	0%	100%
	2	3	6	29	22	1	61
	%	5%	10%	48%	36%	2%	100%
	3	2	5	8	7	2	24

	%	8%	21%	33%	29%	8%	100%
	4	1	6	12	6	0	25
	%	4%	24%	48%	24%	0%	100%
	5 or more	0	1	1	3	0	5
	%	0%	20%	20%	60%	0%	100%
	Shared	1	1	4	1	0	7
	%	14%	14%	57%	14%	0%	100%
Number of children	No children	7	10	38	33	1	89
	%	8%	11%	43%	37%	1%	100%
	With children	3	12	24	16	2	57
	%	5%	21%	42%	28%	4%	100%
House ownership	Renter	3	4	13	10	1	31
	%	10%	13%	42%	32%	3%	100%
	Homeowner	6	18	47	36	2	109
	%	6%	17%	43%	33%	2%	100%

	Chi-square	**df**	**Significance**
Age	22.465	20	0.316
Gender	0.293	4	0.990
Education level	13.551	8	0.094
Work status	9.855	12	0.629
Household income	13.311	16	0.650
Household size	19.526	20	0.488
Number of children	4.482	4	0.344
House ownership	1.326	4	0.857

Statement 11: I trust energy suppliers and third parties to manage my energy conservation safely

Table 62. Cross-tabs statement 11

Statement 11		Strongly disagree	Disagree	Neutral	Agree	Strongly agree	Total
Age	20-29	0	7	17	18	5	47
	%	0%	15%	36%	38%	11%	100%
	30-39	1	9	4	8	0	22
	%	5%	41%	18%	36%	0%	100%
	40-49	1	4	6	10	0	21
	%	5%	19%	29%	48%	0%	100%
	50-59	3	8	6	18	1	36
	%	8%	22%	17%	50%	3%	100%
	60-69	0	1	7	10	1	19
	%	0%	5%	37%	53%	5%	100%
	70-79	0	0	1	0	0	1
	%	0%	0%	100%	0%	0%	100%
Gender	Female	0	17	19	32	3	71
	%	0%	24%	27%	45%	4%	100%
	Male	5	12	22	32	4	75
	%	7%	16%	29%	43%	5%	100%
Education	Secondary school	1	1	5	8	1	16
	%	6%	6%	31%	50%	6%	100%
	VMBO/MBO	3	3	7	15	0	28
	%	11%	11%	25%	54%	0%	100%
	HBO/WO	1	25	29	41	6	102
	%	1%	25%	28%	40%	6%	100%
Work status	Student	0	5	5	6	2	18
	%	0%	28%	28%	33%	11%	100%
	Unemployed	0	0	0	1	0	1
	%	0%	0%	0%	100%	0%	100%
	Employed	5	24	33	52	5	119
	%	4%	20%	28%	44%	4%	100%
	Retired	0	0	3	5	0	8
	%	0%	0%	38%	63%	0%	100%
Household income	< 30,000	0	7	3	8	2	20
	%	0%	35%	15%	40%	10%	100%
	30,000-50,000	1	6	17	23	0	47
	%	2%	13%	36%	49%	0%	100%
	50,000-100,000	2	8	15	23	0	48
	%	4%	17%	31%	48%	0%	100%
	>100,000	2	8	5	7	1	23
	%	9%	35%	22%	30%	4%	100%
	Prefer not to answer	0	0	1	3	0	4
	%	0%	0%	25%	75%	0%	100%
Household size	1	0	7	6	11	0	24
	%	0%	29%	25%	46%	0%	100%
	2	2	9	21	27	2	61
	%	3%	15%	34%	44%	3%	100%
	3	1	5	6	10	2	24

	%	4%	21%	25%	42%	8%	100%
	4	2	6	5	11	1	25
	%	8%	24%	20%	44%	4%	100%
	5 or more	0	0	1	4	0	5
	%	0%	0%	20%	80%	0%	100%
	Shared	0	2	2	1	2	7
	%	0%	29%	29%	14%	29%	100%
Number of children	No children	1	18	28	38	4	89
	%	1%	20%	31%	43%	4%	100%
	With children	4	11	13	26	3	57
	%	7%	19%	23%	46%	5%	100%
House ownership	Renter	0	6	12	11	2	31
	%	0%	19%	39%	35%	6%	100%
	Homeowner	5	20	28	51	5	109
	%	5%	18%	26%	47%	5%	100%

	Chi-square	**df**	**Significance**
Age	24.590	20	0.218
Gender	5.066	4	0.281
Education level	18.336	8	0.019
Work status	8.000	12	0.785
Household income	17.287	16	0.367
Household size	23.271	20	0.267
Number of children	5.540	4	0.236
House ownership	3.436	4	0.488

Statement 12: I think it is important to be more independent form the current energy producers

Table 63. Cross-tabs statement 12

Statement 12		Strongly disagree	Disagree	Neutral	Agree	Strongly agree	Total
Age	20-29	1	4	7	30	5	47
	%	2%	9%	15%	64%	11%	100%
	30-39	0	3	3	8	8	22
	%	0%	14%	14%	36%	36%	100%
	40-49	0	1	6	12	2	21
	%	0%	5%	29%	57%	10%	100%
	50-59	0	2	4	18	12	36
	%	0%	6%	11%	50%	33%	100%
	60-69	0	2	5	9	3	19
	%	0%	11%	26%	47%	16%	100%
	70-79	0	0	0	1	0	1
	%	0%	0%	0%	100%	0%	100%
Gender	Female	0	8	10	45	8	71
	%	0%	11%	14%	63%	11%	100%
	Male	1	4	15	33	22	75
	%	1%	5%	20%	44%	29%	100%
Education	Secondary school	0	4	1	7	4	16
	%	0%	25%	6%	44%	25%	100%
	VMBO/MBO	0	0	6	16	6	28
	%	0%	0%	21%	57%	21%	100%
	HBO/WO	1	8	18	55	20	102
	%	1%	8%	18%	54%	20%	100%
Work status	Student	0	3	2	11	2	18
	%	0%	17%	11%	61%	11%	100%
	Unemployed	0	0	1	0	0	1
	%	0%	0%	100%	0%	0%	100%
	Employed	1	9	19	63	27	119
	%	1%	8%	16%	53%	23%	100%
	Retired	0	0	3	4	1	8
	%	0%	0%	38%	50%	13%	100%
Household income	< 30,000	0	4	4	10	2	20
	%	0%	20%	20%	50%	10%	100%
	30,000-50,000	0	3	8	30	6	47
	%	0%	6%	17%	64%	13%	100%
	50,000-100,000	1	4	8	27	12	52
	%	2%	8%	15%	52%	23%	100%
	>100,000	0	1	3	10	9	23
	%	0%	4%	13%	43%	39%	100%
	Prefer not to answer	0	0	2	1	1	4
	%	0%	0%	50%	25%	25%	100%
Household size	1	0	0	8	11	5	24
	%	0%	0%	33%	46%	21%	100%
	2	1	7	8	35	10	61
	%	2%	11%	13%	57%	16%	100%
	3	0	1	5	11	7	24

	%	0%	4%	21%	46%	29%	100%
	4	0	0	4	14	7	25
	%	0%	0%	16%	56%	28%	100%
	5 or more	0	1	0	3	1	5
	%	0%	20%	0%	60%	20%	100%
	Shared	0	3	0	4	0	7
	%	0%	43%	0%	57%	0%	100%
Number of children	No children	1	9	16	48	15	89
	%	1%	10%	18%	54%	17%	100%
	With children	0	3	9	30	15	57
	%	0%	5%	16%	53%	26%	100%
House ownership	Renter	1	2	3	20	5	31
	%	3%	6%	10%	65%	16%	100%
	Homeowner	0	10	21	56	22	109
	%	0%	9%	19%	51%	20%	100%

	Chi-square	**df**	**Significance**
Age	19.272	20	0.504
Gender	11.016	4	0.026
Education level	9.577	8	0.296
Work status	12.207	12	0.429
Household income	22.855	16	0.118
Household size	32.544	20	0.038
Number of children	4.521	4	0.340
House ownership	5.873	4	0.209

Appendix IX: Multinomial Logit model

```
|-> DISCRETECHOICE;Lhs=CHOSEN;Choices=1,2,3;Rhs=CONST1,CONST2,X11,X12,X21,X22
    ,X31,X32,X41,X42,X51,X52,X61,X62,X71,X72,X81,X82,X91,X92$
Iterative procedure has converged
Normal exit:   6 iterations. Status=0, F=    .9712367D+03

-----------------------------------------------------------------------
Discrete choice (multinomial logit) model
Dependent variable              Choice
Log likelihood function      -971.23670
Estimation based on N =    1206, K =  20
Inf.Cr.AIC  =   1982.5 AIC/N =    1.644
------------------------------------
           Log likelihood R-sqrd R2Adj
Constants only  -1001.3891  .0301 .0220
Note: R-sqrd = 1 - logL/Logl(constants)
Warning:  Model does not contain a full
set of ASCs. R-sqrd is problematic. Use
model setup with ;RHS=one to get LogL0.
------------------------------------
Response data are given as ind. choices
Number of obs.=  1206, skipped    0 obs
--------+--------------------------------------------------------------
```

CHOSEN	Coefficient	Standard Error	z	Prob. |z|>Z*	95% Confidence Interval	
CONST1	2.16280***	.11084	19.51	.0000	1.94555	2.38005
CONST2	1.20147***	.11817	10.17	.0000	.96987	1.43307
X11	.15497	.09700	1.60	.1101	-.03515	.34510
X12	-.53979***	.09234	-5.85	.0000	-.72078	-.35881
X21	.00595	.09288	.06	.9489	-.17609	.18800
X22	-.05676	.09252	-.61	.5395	-.23809	.12457
X31	-.01272	.09545	-.13	.8940	-.19980	.17436
X32	.06263	.09588	.65	.5136	-.12530	.25056
X41	.01368	.09878	.14	.8899	-.17993	.20728
X42	.00906	.09864	.09	.9268	-.18427	.20240
X51	-.18108*	.10358	-1.75	.0804	-.38410	.02193
X52	.06378	.09905	.64	.5196	-.13035	.25791
X61	.19314*	.10281	1.88	.0603	-.00837	.39465
X62	.08520	.10015	.85	.3950	-.11110	.28149
X71	.04793	.10434	.46	.6459	-.15656	.25243
X72	-.08010	.09824	-.82	.4149	-.27263	.11244
X81	.11389	.10412	1.09	.2740	-.09017	.31795
X82	-.06607	.10064	-.66	.5115	-.26333	.13119
X91	.16380	.10233	1.60	.1094	-.03676	.36435
X92	-.27522***	.10524	-2.62	.0089	-.48149	-.06894

Appendix X: Mixed Logit model

```
Iterative procedure has converged
Normal exit:  51 iterations. Status=0, F=    .9657950D+03

-----------------------------------------------------------------------------
Random Parameters Multinom. Logit Model
Dependent variable                CHOSEN
Log likelihood function       -965.79504
Restricted log likelihood    -1324.92642
Chi squared [ 38](P= .000)     718.26277
Significance level               .00000
---------------------------------------------------------------------------------------------------------
McFadden Pseudo R-squared       .2710576
Estimation based on N =    1206, K =  38
Inf.Cr.AIC  =    2007.6 AIC/N =     1.665
--------------------------------------
           Log likelihood R-sqrd R2Adj
No coefficients -1324.9264  .2711 .2594
Constants only  -1001.3891  .0355 .0201
At start values  -971.2367  .0056-.0103
Note: R-sqrd = 1 - logL/Logl(constants)
Warning:  Model does not contain a full
set of ASCs. R-sqrd is problematic. Use
model setup with ;RHS=one to get LogL0.
--------------------------------------
Response data are given as ind. choices
Replications for simulated probs. =1000
Used Halton sequences in simulations.
RPL model with panel has      134 groups
Fixed number of obsrvs./group=        9
Number of obs.=  1206, skipped    0 obs
--------+----------------------------------------------------------------
        |                 Standard           Prob.      95% Confidence
  CHOSEN|  Coefficient       Error      z   |z|>Z*          Interval
--------+----------------------------------------------------------------
        |Random parameters in utility functions..............................
     X11|     .11744        .10189    1.15  .2491     -.08227    .31715
     X12|    -.56395***      .11144   -5.06  .0000     -.78237   -.34554
     X21|    -.00224        .09896    -.02  .9819     -.19620    .19172
     X22|    -.05410        .10024    -.54  .5894     -.25058    .14237
     X31|    -.01264        .10103    -.13  .9004     -.21065    .18537
     X32|     .06262        .10196     .61  .5391     -.13722    .26246
     X41|     .01692        .10464     .16  .8715     -.18817    .22202
     X42|     .00324        .10536     .03  .9755     -.20326    .20974
     X51|    -.16481        .11133   -1.48  .1388     -.38301    .05339
     X52|     .05249        .11346     .46  .6436     -.16989    .27487
     X61|     .20943*       .11147    1.88  .0603     -.00905    .42790
     X62|     .09935        .10720     .93  .3540     -.11076    .30947
     X71|     .04570        .11103     .41  .6806     -.17192    .26332
     X72|    -.08597        .10411    -.83  .4090     -.29002    .11809
     X81|     .11927        .11012    1.08  .2788     -.09657    .33510
     X82|    -.06168        .10749    -.57  .5661     -.27236    .14901
     X91|     .16188        .10838    1.49  .1353     -.05055    .37431
     X92|    -.28510**      .11279   -2.53  .0115     -.50616   -.06405
        |Nonrandom parameters in utility functions..........................
  CONST1|    2.20962***      .11525   19.17  .0000    1.98373   2.43551
  CONST2|    1.17684***      .12230    9.62  .0000     .93713   1.41655
        |Distns. of RPs. Std.Devs or limits of triangular....................
   NsX11|     .00940        .28555     .03  .9737     -.55027    .56907
   NsX12|     .61192***      .14186    4.31  .0000      .33388    .88996
   NsX21|     .02373        .31296     .08  .9396     -.58965    .63712
   NsX22|     .23010        .31345     .73  .4629     -.38425    .84446
   NsX31|     .00117        .11900     .01  .9921     -.23206    .23440
   NsX32|     .00089        .14481     .01  .9951     -.28293    .28472
   NsX41|     .00041        .11042     .00  .9971     -.21601    .21682
   NsX42|     .02341        .26523     .09  .9297     -.49644    .54326
   NsX51|     .13352        .58865     .23  .8206    -1.02022   1.28726
   NsX52|     .43281**       .19349    2.24  .0253      .05358    .81203
   NsX61|     .25855        .29792     .87  .3855     -.32536    .84245
```

NsX62	.02680	.24451	.11	.9127	-.45243	.50603
NsX71	.00875	.14899	.06	.9532	-.28325	.30076
NsX72	.73092D-04	.20499	.00	.9997	-.40171	.40185
NsX81	.00015	.14659	.00	.9992	-.28716	.28745
NsX82	.00354	.16642	.02	.9830	-.32264	.32973
NsX91	.00151	.21366	.01	.9944	-.41725	.42027
NsX92	.01033	.15187	.07	.9458	-.28733	.30799

ınnnn.D-xx or D+xx => multiply by 10 to -xx or +xx.
'**, **, * ==> Significance at 1%, 5%, 10% level.
ʌodel was estimated on Mar 16, 2021 at 05:12:24 PM

Appendix XI: Latent Class model

Analysis 1:

```
|-> NLOGIT;LHS=Chosen;Choices=
1,2,3;Rhs=Const1,Const2,X11,X12,X21,X22,X31,X32,X41,X42,X51,X52,X61,X62,X71,X72,X81,X82,X91,X9
2;lcm=SUBJEC,ATTITUDE,LOCUS,IDENTITY,TRUST,INDEPEND,YOUNG,Female,HIGHEDU,NOCHILD,H
IGHINC,TWOPERSO;pds=9;pts=2 $
Iterative procedure has converged
Normal exit:   6 iterations. Status=0, F=    .9712367D+03

-----------------------------------------------------------------------
Discrete choice (multinomial logit) model
Dependent variable              Choice
Log likelihood function      -971.23670
Estimation based on N =    1206, K =  20
Inf.Cr.AIC  =    1982.5 AIC/N =    1.644
----------------------------------------
           Log likelihood R-sqrd R2Adj
Constants only  -1001.3891  .0301 .0083
Note: R-sqrd = 1 - logL/Logl(constants)
Warning:  Model does not contain a full
set of ASCs. R-sqrd is problematic. Use
model setup with ;RHS=one to get LogL0.
----------------------------------------
Response data are given as ind. choices
Number of obs.=  1206, skipped    0 obs
--------+--------------------------------------------------------------
        |                 Standard            Prob.      95% Confidence
  CHOSEN|  Coefficient       Error       z   |z|>Z*         Interval
--------+--------------------------------------------------------------
CONST1|1|    2.16280***     .11084    19.51  .0000     1.94555  2.38005
CONST2|1|    1.20147***     .11817    10.17  .0000      .96987  1.43307
   X11|1|     .15497        .09700     1.60  .1101     -.03515   .34510
   X12|1|    -.53979***     .09234    -5.85  .0000     -.72078  -.35881
   X21|1|     .00595        .09288      .06  .9489     -.17609   .18800
   X22|1|    -.05676        .09252     -.61  .5395     -.23809   .12457
   X31|1|    -.01272        .09545     -.13  .8940     -.19980   .17436
   X32|1|     .06263        .09588      .65  .5136     -.12530   .25056
   X41|1|     .01368        .09878      .14  .8899     -.17993   .20728
   X42|1|     .00906        .09864      .09  .9268     -.18427   .20240
   X51|1|    -.18108*       .10358    -1.75  .0804     -.38410   .02193
   X52|1|     .06378        .09905      .64  .5196     -.13035   .25791
   X61|1|     .19314*       .10281     1.88  .0603     -.00837   .39465
   X62|1|     .08520        .10015      .85  .3950     -.11110   .28149
   X71|1|     .04793        .10434      .46  .6459     -.15656   .25243
   X72|1|    -.08010        .09824     -.82  .4149     -.27263   .11244
   X81|1|     .11389        .10412     1.09  .2740     -.09017   .31795
   X82|1|    -.06607        .10064     -.66  .5115     -.26333   .13119
   X91|1|     .16380        .10233     1.60  .1094     -.03676   .36435
   X92|1|    -.27522***     .10524    -2.62  .0089     -.48149  -.06894
--------+--------------------------------------------------------------
***, **, * ==>  Significance at 1%, 5%, 10% level.
Model was estimated on Mar 02, 2021 at 10:30:34 AM
-----------------------------------------------------------------------

Iterative procedure has converged
Normal exit:  57 iterations. Status=0, F=    .8283234D+03

-----------------------------------------------------------------------
Latent Class Logit Model
```

```
Dependent variable             CHOSEN
Log likelihood function      -828.32337
Restricted log likelihood   -1324.92642
Chi squared [ 53](P= .000)    993.20610
Significance level              .00000
McFadden Pseudo R-squared       .3748156
Estimation based on N =   1206, K =  53
Inf.Cr.AIC  =   1762.6 AIC/N =    1.462
-----------------------------------
           Log likelihood R-sqrd R2Adj
No coefficients -1324.9264  .3748 .3608
Constants only  -1001.3891  .1728 .1542
At start values  -971.1953  .1471 .1279
Note: R-sqrd = 1 - logL/Logl(constants)
Warning:  Model does not contain a full
set of ASCs. R-sqrd is problematic. Use
model setup with ;RHS=one to get LogL0.
-----------------------------------
Response data are given as ind. choices
Number of latent classes =           2
Average Class Probabilities
     .559  .441
LCM model with panel has      134 groups
Fixed number of obsrvs./group=       9
BHHH estimator used for asymp. variance
Number of obs.=  1206, skipped    0 obs
--------+-------------------------------------------------------------
        |                  Standard            Prob.      95% Confidence
  CHOSEN|  Coefficient       Error       z    |z|>Z*         Interval
--------+-------------------------------------------------------------
        |Random utility parameters in latent class -->>  1..................
CONST1|1|    4.53523***      .58127     7.80  .0000     3.39597   5.67449
CONST2|1|    1.97858***      .62298     3.18  .0015      .75757   3.19959
   X11|1|     .52995         .36936     1.43  .1514     -.19398   1.25388
   X12|1|    -.59409**       .30048    -1.98  .0480    -1.18302   -.00515
   X21|1|    -.26101         .33938     -.77  .4419     -.92619    .40417
   X22|1|     .54001         .38713     1.39  .1630     -.21875   1.29876
   X31|1|    -.18601         .39750     -.47  .6398     -.96509    .59307
   X32|1|     .27572         .35315      .78  .4350     -.41645    .96789
   X41|1|     .21673         .37996      .57  .5684     -.52799    .96144
   X42|1|    -.47938         .32661    -1.47  .1422    -1.11952    .16075
   X51|1|    -.46898         .36134    -1.30  .1943    -1.17719    .23923
   X52|1|     .26936         .28965      .93  .3524     -.29834    .83707
   X61|1|     .59353*        .35801     1.66  .0973     -.10815   1.29522
   X62|1|     .75778         .47079     1.61  .1075     -.16495   1.68052
   X71|1|     .10751         .42447      .25  .8000     -.72444    .93946
   X72|1|     .07556         .36813      .21  .8374     -.64596    .79707
   X81|1|     .11204         .35529      .32  .7525     -.58432    .80840
   X82|1|    -.27553         .52068     -.53  .5967    -1.29605    .74499
   X91|1|     .21047         .34430      .61  .5410     -.46434    .88528
   X92|1|    -.46141         .43216    -1.07  .2857    -1.30843    .38562
        |Random utility parameters in latent class -->>  2..................
CONST1|2|     .85504***      .16876     5.07  .0000      .52427   1.18581
CONST2|2|    1.03172***      .09744    10.59  .0000      .84073   1.22270
   X11|2|     .21276         .25832      .82  .4102     -.29354    .71907
   X12|2|    -.82858***      .23578    -3.51  .0004    -1.29070   -.36646
   X21|2|     .03779         .20556      .18  .8542     -.36511    .44068
```

```
 X22|2|  -.14001     .18546   -.75  .4503   -.50350   .22348
 X31|2|   .00996     .21099    .05  .9623   -.40357   .42349
 X32|2|   .04602     .20029    .23  .8183   -.34653   .43857
 X41|2|  -.06228     .20378   -.31  .7599   -.46169   .33713
 X42|2|   .33039*    .18587   1.78  .0755   -.03392   .69469
 X51|2|  -.15785     .23195   -.68  .4962   -.61246   .29676
 X52|2|   .04210     .19895    .21  .8324   -.34783   .43203
 X61|2|   .10955     .23575    .46  .6421   -.35251   .57162
 X62|2|  -.12422     .23631   -.53  .5991   -.58737   .33893
 X71|2|  -.01618     .27010   -.06  .9522   -.54556   .51320
 X72|2|  -.15221     .21478   -.71  .4785   -.57317   .26875
 X81|2|   .15574     .20961    .74  .4575   -.25508   .56656
 X82|2|  -.05888     .21297   -.28  .7822   -.47630   .35854
 X91|2|   .22554     .20012   1.13  .2597   -.16669   .61778
 X92|2|  -.24205     .21436  -1.13  .2588   -.66218   .17807
     |This is THETA(01) in class probability model........................
 _ONE|1|  -1.18464    1.12932  -1.05  .2942  -3.39808  1.02879
_SUBJE|1|   .64645     .59306   1.09  .2757   -.51593  1.80883
_ATTIT|1|  1.58933**   .76197   2.09  .0370    .09590  3.08276
_LOCUS|1|  -.21983     .57449   -.38  .7020  -1.34580   .90614
_IDENT|1|  -.60701     .64452   -.94  .3463  -1.87025   .65623
_TRUST|1| -1.10337*    .63001  -1.75  .0799  -2.33818   .13143
_INDEP|1|   .35547     .60925    .58  .5596   -.83864  1.54958
_YOUNG|1|   .34134     .64907    .53  .5990   -.93081  1.61349
_FEMAL|1|  -.51404     .56556   -.91  .3634  -1.62253   .59444
_HIGHE|1|   .46769     .73138    .64  .5225   -.96579  1.90117
_NOCHI|1|  -.28370     .79887   -.36  .7225  -1.84945  1.28206
_HIGHI|1|  1.65931*    .92031   1.80  .0714   -.14446  3.46307
_TWOPE|1|   .41077     .71991    .57  .5683  -1.00022  1.82177
     |This is THETA(02) in class probability model........................
 _ONE|2|     0.0   .....(Fixed Parameter).....
_SUBJE|2|    0.0   .....(Fixed Parameter).....
_ATTIT|2|    0.0   .....(Fixed Parameter).....
_LOCUS|2|    0.0   .....(Fixed Parameter).....
_IDENT|2|    0.0   .....(Fixed Parameter).....
_TRUST|2|    0.0   .....(Fixed Parameter).....
_INDEP|2|    0.0   .....(Fixed Parameter).....
_YOUNG|2|    0.0   .....(Fixed Parameter).....
_FEMAL|2|    0.0   .....(Fixed Parameter).....
_HIGHE|2|    0.0   .....(Fixed Parameter).....
_NOCHI|2|    0.0   .....(Fixed Parameter).....
_HIGHI|2|    0.0   .....(Fixed Parameter).....
_TWOPE|2|    0.0   .....(Fixed Parameter).....
--------+--------------------------------------------------------------
***, **, * ==>  Significance at 1%, 5%, 10% level.
Fixed parameter ... is constrained to equal the value or
had a nonpositive st.error because of an earlier problem.
Model was estimated on Mar 02, 2021 at 10:30:39 AM
-----------------------------------------------------------------------
```

Analysis 2:

```
|-> NLOGIT;LHS=Chosen;Choices=
1,2,3;Rhs=Const1,Const2,X11,X12,X21,X22,X31,X32,X41,X42,X51,X52,X61,X62,X71,X72,X81,X82,X91,X9
2;lcm;pds=9;pts=2 $
Iterative procedure has converged
Normal exit:   6 iterations. Status=0, F=    .9712367D+03

-----------------------------------------------------------------------------
Discrete choice (multinomial logit) model
Dependent variable              Choice
Log likelihood function      -971.23670
Estimation based on N =   1206, K =  20
Inf.Cr.AIC  =   1982.5 AIC/N =    1.644
-----------------------------------
           Log likelihood R-sqrd R2Adj
Constants only  -1001.3891  .0301 .0133
Note: R-sqrd = 1 - logL/Logl(constants)
Warning:  Model does not contain a full
set of ASCs. R-sqrd is problematic. Use
model setup with ;RHS=one to get LogL0.
-----------------------------------
Response data are given as ind. choices
Number of obs.=  1206, skipped    0 obs
--------+--------------------------------------------------------------------
        |                 Standard            Prob.      95% Confidence
  CHOSEN|  Coefficient       Error      z    |z|>Z*         Interval
--------+--------------------------------------------------------------------
CONST1|1|    2.16280***     .11084    19.51  .0000      1.94555   2.38005
CONST2|1|    1.20147***     .11817    10.17  .0000       .96987   1.43307
   X11|1|     .15497        .09700     1.60  .1101      -.03515    .34510
   X12|1|    -.53979***     .09234    -5.85  .0000      -.72078   -.35881
   X21|1|     .00595        .09288      .06  .9489      -.17609    .18800
   X22|1|    -.05676        .09252     -.61  .5395      -.23809    .12457
   X31|1|    -.01272        .09545     -.13  .8940      -.19980    .17436
   X32|1|     .06263        .09588      .65  .5136      -.12530    .25056
   X41|1|     .01368        .09878      .14  .8899      -.17993    .20728
   X42|1|     .00906        .09864      .09  .9268      -.18427    .20240
   X51|1|    -.18108*       .10358    -1.75  .0804      -.38410    .02193
   X52|1|     .06378        .09905      .64  .5196      -.13035    .25791
   X61|1|     .19314*       .10281     1.88  .0603      -.00837    .39465
   X62|1|     .08520        .10015      .85  .3950      -.11110    .28149
   X71|1|     .04793        .10434      .46  .6459      -.15656    .25243
   X72|1|    -.08010        .09824     -.82  .4149      -.27263    .11244
   X81|1|     .11389        .10412     1.09  .2740      -.09017    .31795
   X82|1|    -.06607        .10064     -.66  .5115      -.26333    .13119
   X91|1|     .16380        .10233     1.60  .1094      -.03676    .36435
   X92|1|    -.27522***     .10524    -2.62  .0089      -.48149   -.06894
--------+--------------------------------------------------------------------
***, **, * ==>  Significance at 1%, 5%, 10% level.
Model was estimated on Mar 02, 2021 at 10:33:18 AM
-----------------------------------------------------------------------------

Iterative procedure has converged
Normal exit:  47 iterations. Status=0, F=    .8431153D+03

-----------------------------------------------------------------------------
Latent Class Logit Model
Dependent variable              CHOSEN
```

```
Log likelihood function      -843.11529
Restricted log likelihood   -1324.92642
Chi squared [ 41](P= .000)    963.62226
Significance level              .00000
McFadden Pseudo R-squared      .3636512
Estimation based on N =   1206, K =  41
Inf.Cr.AIC  =   1768.2 AIC/N =    1.466
-----------------------------------
          Log likelihood R-sqrd R2Adj
No coefficients -1324.9264  .3637 .3526
Constants only  -1001.3891  .1581 .1435
At start values  -971.1953  .1319 .1169
Note: R-sqrd = 1 - logL/Logl(constants)
Warning:  Model does not contain a full
set of ASCs. R-sqrd is problematic. Use
model setup with ;RHS=one to get LogL0.
-----------------------------------
Response data are given as ind. choices
Number of latent classes =           2
Average Class Probabilities
    .594  .406
LCM model with panel has     134 groups
Fixed number of obsrvs./group=       9
Number of obs.=  1206, skipped    0 obs
--------+--------------------------------------------------------
        |               Standard            Prob.      95% Confidence
  CHOSEN|  Coefficient      Error       z    |z|>Z*         Interval
--------+--------------------------------------------------------
        |Random utility parameters in latent class -->> 1..................
CONST1|1|    4.60937***     .44362    10.39  .0000     3.73988   5.47886
CONST2|1|    2.25006***     .43924     5.12  .0000     1.38917   3.11095
   X11|1|     .74608***     .27857     2.68  .0074      .20010   1.29207
   X12|1|    -.88458***     .22527    -3.93  .0001    -1.32611   -.44306
   X21|1|    -.10382        .21125     -.49  .6231     -.51787    .31022
   X22|1|     .21420        .23623      .91  .3645     -.24880    .67720
   X31|1|    -.20597        .22615     -.91  .3624     -.64922    .23728
   X32|1|     .07283        .22594      .32  .7472     -.37000    .51566
   X41|1|     .15675        .22387      .70  .4838     -.28203    .59553
   X42|1|    -.45829**      .19982    -2.29  .0218     -.84993   -.06666
   X51|1|    -.50524**      .24264    -2.08  .0373     -.98080   -.02967
   X52|1|     .26426        .21179     1.25  .2121     -.15084    .67937
   X61|1|     .47106**      .23884     1.97  .0486      .00295    .93918
   X62|1|     .52452**      .22587     2.32  .0202      .08182    .96723
   X71|1|     .27135        .21001     1.29  .1963     -.14027    .68297
   X72|1|    -.27695        .24772    -1.12  .2636     -.76247    .20856
   X81|1|     .13559        .21267      .64  .5238     -.28124    .55242
   X82|1|    -.08398        .22786     -.37  .7125     -.53058    .36263
   X91|1|     .23418        .22909     1.02  .3067     -.21483    .68319
   X92|1|    -.44842*       .23444    -1.91  .0558     -.90791    .01106
        |Random utility parameters in latent class -->> 2..................
CONST1|2|     .70753***     .17097     4.14  .0000      .37243   1.04264
CONST2|2|     .97535***     .13566     7.19  .0000      .70947   1.24124
   X11|2|     .10246        .15544      .66  .5098     -.20220    .40712
   X12|2|    -.66978***     .17276    -3.88  .0001    -1.00838   -.33118
   X21|2|     .03594        .14904      .24  .8095     -.25618    .32806
   X22|2|    -.06949        .14579     -.48  .6336     -.35524    .21625
   X31|2|     .00969        .15124      .06  .9489     -.28673    .30611
```

X32|2|	.10481	.15743	.67	.5056	-.20374	.41337
X41|2|	-.13587	.16275	-.83	.4038	-.45485	.18310
X42|2|	.46125***	.16428	2.81	.0050	.13927	.78323
X51|2|	-.08438	.15046	-.56	.5749	-.37928	.21052
X52|2|	-.01026	.15200	-.07	.9462	-.30818	.28766
X61|2|	.10804	.14638	.74	.4605	-.17887	.39494
X62|2|	-.09209	.13854	-.66	.5062	-.36363	.17945
X71|2|	-.06442	.14507	-.44	.6570	-.34874	.21991
X72|2|	-.06563	.13849	-.47	.6356	-.33708	.20581
X81|2|	.13675	.14817	.92	.3560	-.15365	.42716
X82|2|	-.07402	.14406	-.51	.6074	-.35637	.20833
X91|2|	.29848*	.15377	1.94	.0522	-.00290	.59986
X92|2|	-.27882*	.14542	-1.92	.0552	-.56384	.00619
|Estimated latent class probabilities................................						
PrbCls1|	.59442***	.04990	11.91	.0000	.49660	.69223
PrbCls2|	.40558***	.04990	8.13	.0000	.30777	.50340

***, **, * ==> Significance at 1%, 5%, 10% level.
Model was estimated on Mar 02, 2021 at 10:33:23 AM

Cross-tabs analysis 2:

Case Processing Summary

	Cases					
	Valid		Missing		Total	
	N	Percent	N	Percent	N	Percent
sub_results * Group_LCM	134	100,0%	0	0,0%	134	100,0%
EA_results * Group_LCM	134	100,0%	0	0,0%	134	100,0%
LC_results * Group_LCM	134	100,0%	0	0,0%	134	100,0%
CI_results * Group_LCM	134	100,0%	0	0,0%	134	100,0%
tr_results * Group_LCM	134	100,0%	0	0,0%	134	100,0%
ind_results * Group_LCM	134	100,0%	0	0,0%	134	100,0%

sub_results * Group_LCM

Crosstab

			Group_LCM		
			1	2	Total
sub_results	Low	Count	34	33	67
		% within sub_results	50,7%	49,3%	100,0%
	High	Count	47	20	67
		% within sub_results	70,1%	29,9%	100,0%
Total		Count	81	53	134
		% within sub_results	60,4%	39,6%	100,0%

Chi-Square Tests

	Value	df	Asymptotic Significance (2-sided)	Exact Sig. (2-sided)	Exact Sig. (1-sided)
Pearson Chi-Square	5,275[a]	1	,022		
Continuity Correction[b]	4,495	1	,034		
Likelihood Ratio	5,317	1	,021		
Fisher's Exact Test				,034	,017
Linear-by-Linear Association	5,236	1	,022		
N of Valid Cases	134				

a. 0 cells (0,0%) have expected count less than 5. The minimum expected count is 26,50.

b. Computed only for a 2x2 table

EA_results * Group_LCM

Crosstab

			Group_LCM		
			1	2	Total
EA_results	Low	Count	11	17	28
		% within EA_results	39,3%	60,7%	100,0%
	High	Count	70	36	106
		% within EA_results	66,0%	34,0%	100,0%
Total		Count	81	53	134
		% within EA_results	60,4%	39,6%	100,0%

Chi-Square Tests

	Value	df	Asymptotic Significance (2-sided)	Exact Sig. (2-sided)	Exact Sig. (1-sided)
Pearson Chi-Square	6,630[a]	1	,010		
Continuity Correction[b]	5,558	1	,018		
Likelihood Ratio	6,502	1	,011		
Fisher's Exact Test				,016	,010
Linear-by-Linear Association	6,581	1	,010		
N of Valid Cases	134				

a. 0 cells (0,0%) have expected count less than 5. The minimum expected count is 11,07.

b. Computed only for a 2x2 table

LC_results * Group_LCM

Crosstab

			Group_LCM		
			1	2	Total
LC_results	Low	Count	33	23	56
		% within LC_results	58,9%	41,1%	100,0%
	High	Count	48	30	78
		% within LC_results	61,5%	38,5%	100,0%
Total		Count	81	53	134
		% within LC_results	60,4%	39,6%	100,0%

Chi-Square Tests

	Value	df	Asymptotic Significance (2-sided)	Exact Sig. (2-sided)	Exact Sig. (1-sided)
Pearson Chi-Square	,093[a]	1	,761		
Continuity Correction[b]	,016	1	,900		
Likelihood Ratio	,093	1	,761		
Fisher's Exact Test				,858	,449
Linear-by-Linear Association	,092	1	,761		
N of Valid Cases	134				

a. 0 cells (0,0%) have expected count less than 5. The minimum expected count is 22,15.

b. Computed only for a 2x2 table

CI_results * Group_LCM

Crosstab

			Group_LCM 1	2	Total
CI_results	Low	Count	58	37	95
		% within CI_results	61,1%	38,9%	100,0%
	High	Count	23	16	39
		% within CI_results	59,0%	41,0%	100,0%
Total		Count	81	53	134
		% within CI_results	60,4%	39,6%	100,0%

Chi-Square Tests

	Value	df	Asymptotic Significance (2-sided)	Exact Sig. (2-sided)	Exact Sig. (1-sided)
Pearson Chi-Square	,050[a]	1	,823		
Continuity Correction[b]	,001	1	,977		
Likelihood Ratio	,050	1	,823		
Fisher's Exact Test				,848	,486
Linear-by-Linear Association	,050	1	,824		
N of Valid Cases	134				

a. 0 cells (0,0%) have expected count less than 5. The minimum expected count is 15,43.

b. Computed only for a 2x2 table

tr_results * Group_LCM

Crosstab

			Group_LCM 1	2	Total
tr_results	Low	Count	47	20	67
		% within tr_results	70,1%	29,9%	100,0%
	High	Count	34	33	67
		% within tr_results	50,7%	49,3%	100,0%
Total		Count	81	53	134
		% within tr_results	60,4%	39,6%	100,0%

Chi-Square Tests

	Value	df	Asymptotic Significance (2-sided)	Exact Sig. (2-sided)	Exact Sig. (1-sided)
Pearson Chi-Square	5,275[a]	1	,022		
Continuity Correction[b]	4,495	1	,034		
Likelihood Ratio	5,317	1	,021		
Fisher's Exact Test				,034	,017
Linear-by-Linear Association	5,236	1	,022		
N of Valid Cases	134				

a. 0 cells (0,0%) have expected count less than 5. The minimum expected count is 26,50.

b. Computed only for a 2x2 table

ind_results * Group_LCM

Crosstab

			Group_LCM 1	2	Total
ind_results	Low	Count	17	18	35
		% within ind_results	48,6%	51,4%	100,0%
	High	Count	64	35	99
		% within ind_results	64,6%	35,4%	100,0%
Total		Count	81	53	134
		% within ind_results	60,4%	39,6%	100,0%

Chi-Square Tests

	Value	df	Asymptotic Significance (2-sided)	Exact Sig. (2-sided)	Exact Sig. (1-sided)
Pearson Chi-Square	2,795[a]	1	,095		
Continuity Correction[b]	2,163	1	,141		
Likelihood Ratio	2,755	1	,097		
Fisher's Exact Test				,110	,071
Linear-by-Linear Association	2,774	1	,096		
N of Valid Cases	134				

a. 0 cells (0,0%) have expected count less than 5. The minimum expected count is 13,84.

b. Computed only for a 2x2 table