MASTER THESIS

A FINANCIAL MODEL FOR THE COMMERCIALIZATION OF THE HOME BATTERY

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Preface

I have conducted this research at Zonneplan, an integrated energy company, as the final assignment before obtaining a Master's degree in Financial Engineering and Management. This study is part of the specialization track in Industrial Engineering and Management Master at the University of Twente.

First, I would like to thank Zonneplan for the opportunity to carry out this graduation assignment at their company. The company and especially the finance department welcomed me with warm hospitality. Additionally, they helped me gain a lot of knowledge about the energy sector, for which I am very grateful. A special thank you to Roman Lukaschuk for challenging me and participating in insightful discussions, contributing to achieving the best results.

Second, I would like to thank my supervisor B. Roorda for his guidance and time during the recurrent meetings of the research. I would also like to thank my second supervisor R.A.M.G. Joosten, for his time and clear feedback at the end of the research.

Finally, I want to express my gratitude to my family, friends, and housemates who have supported me throughout my entire study at the University of Twente and during this final research.

Hopefully, you enjoy reading my Master's thesis.

Meike Kruger

Enschede, February 2024

Management Summary

An upcoming topic in the integrated energy sector is the home battery. We explore the commercialization options of these batteries, which can help the Netherlands achieve a 55% reduction in CO_2 emissions by 2030. An increased adoption of the home battery could support this ambition.

Literature studies, conducted as part of our research, indicate that home batteries can effectively contribute to the overloaded main grid and the Netherlands' climate ambitions. If all households with solar panels adopt home batteries, estimates suggest a peak load reduction of 10 to 15 percent. Additionally, the CO_2 emissions of a household significantly reduce when a home battery is purchased. A home battery, combined with solar energy storage and other green technologies, achieves the highest CO_2 reduction, estimated at 160 kg per year.

Within our research context, the primary focus is on developing a financial model that will be attractive to customers, Zonneplan, and potential investors. This model aims to provide an overview of the various home battery applications and the corresponding cash flows for the customer and Zonneplan.

A target group analysis, conducted by Zonneplan, shows that 51.4% of all the participants indicate the intention to purchase a home battery in the long run. Among all the participants with a purchase intention, 58.6% indicate that the main motivation for investing in a battery is to become independent of the main grid. The most interested target group comprises men with a high educational level aged between 30 and 39 years.

There are three types of applications for the home battery: solar energy, day-ahead prices, and the imbalance market. With netting, the excess of self-generated solar energy can be fed back to the main grid. The battery's ability to store solar energy becomes financially attractive only when the existing netting agreement is either canceled or reduced. The current full netting arrangement makes it more profitable to feed all the generated electricity back to the main grid rather than storing it in a home battery.

The second application is a managed battery with day-ahead prices. This application is currently not financially viable with one cycle a day. Optimizing the software to enable the battery to undergo more cycles per day could make this application worth investing in.

The last application is the imbalance market. This application is not included in the financial model, due to a lack of publicly available data. This market consists of more extreme prices than the day-ahead market, which can make this application profitable. However, households cannot trade on this market. Therefore, if a company is allowed to trade on this market, it needs to investigate for itself if this application is a viable option.

Based on the financial model, Zonneplan should sell the home batteries for €5000 with a profit-sharing ratio of 90 to 10. Customers should consider investing in a solar energy application of the home battery when full netting is lifted. Taking out a loan from Warmtefonds, especially with a zero-interest option for an annual total income below 60,000 euros, positively influences the investment. These types of sustainability loans and subsidies ensure that low-income households have an opportunity to invest in the home battery as well, which will contribute to the widespread participation in the transition to sustainable energy solutions.

Table of Contents

Introduction **1**

Chapter 1 Research Methodology **2**

1.1 Problem definition 2

1.1.1 Problem cluster 2

1.1.2 Research problem 3

1.1.3 Research questions 3

1.2 Research design 4

1.3 Literature review 4

1.3.1 Definition of the research question 4

1.3.2 Key findings 5

Chapter 2 The Current Situation **7**

2.1 The current position of the Netherlands regarding the transition to renewable energy ... 7

2.1.1 The climate goals of the Netherlands 7

2.1.2 The different sources used for energy production in the Netherlands 8

2.1.3 The current regulations regarding renewable energy 9

2.1.4 Future regulations regarding renewable energy 9

2.2 General specifications of the home battery 10

2.3 The perspectives on the home battery 12

2.3.1 The home battery on the Dutch household market 12

2.3.2 The perspective of the Dutch households on the home battery 12

2.3.3 Assessing the attractiveness of the home battery investment 13

2.4 Summary 14

Chapter 3 The Applications of the Home Battery **16**

3.1 Solar energy 16

3.1.1 Netting agreement 16

3.1.2 Feed-in-fee solar energy 17

3.1.3 Benefits of the solar energy functionality 17

3.2 Dynamic energy contracts and day-ahead prices 17

3.2.1 Forecast of the EPEX spot market 18

3.2.2 Benefits of the day-ahead functionality of the home battery 18

3.3 Imbalance market 19

3.4 Summary 19

Chapter 4 Description of the Financial Model **20**

4.1 Structure financial model 20

4.2 Financial statements 22

4.2.1 The profit and loss statement ... 22
4.2.2 Cash flow overview Zonneplan ... 23
4.2.3 Cash flow customer ... 24
4.3 Financing methods of the home battery ... 25
4.3.1 Buying the home battery ... 26
4.3.2 Take out a loan ... 26
4.3.3 Financial lease ... 27
4.3.4 Net operational lease ... 27
4.3.5 Payment in installments ... 28
4.4 Summary ... 28
Chapter 5 Results of the Financial Model ... 29
5.1 The different scenarios ... 29
5.1.1 The profit-share ratio ... 30
5.2 The output variables of the model ... 30
5.3 The results of the financial model ... 31
5.3.1 The results for the customer ... 31
5.3.2 The results for Zonneplan ... 33
5.4 Summary ... 34
Chapter 6 The impact of the Home Battery ... 35
6.1 The effects of the home battery on the main grid ... 35
6.2 The contribution of the home battery to the $CO2$ reduction ... 35
6.3 The social impact of the home battery ... 36
6.4 Summary ... 37
Chapter 7 Discussion and Conclusion ... 38
7.1 Discussion ... 38
7.2 Conclusion ... 39
Bibliography ... 42
Appendix A: Detailed Description of the Literature Review ... 46
Appendix B: Benefit Statements for the Home Battery ... 49
Appendix B.1: Solar energy benefit statement for the home battery ... 49
Appendix B.2: Day-ahead benefit statement for the home battery ... 49
Appendix C: The Financial Model ... 51
Appendix C.1: The benefits of the applications of the home battery ... 51
Appendix C.2: The input parameters sheet ... 52
Appendix C.3: The Profit and Loss statement ... 53
Appendix C.4: Cash flow overview Zonneplan ... 54

Appendix C.5: Cash flow overview customer 54
Appendix D: The Financing Methods 55
Appendix D.1: Take out a loan 55
Appendix D.2: Financial lease 55
Appendix D.3: Net operational lease 55
Appendix D.4: Payment in installments 56

Introduction

An upcoming topic in the integrated energy sector is the home battery. This type of battery can help with the electrification of the Netherlands, which is the transition from fossil to renewable electrical energy. This transition aligns with the sustainable development goals of the Netherlands. The home battery can be implemented in various ways. Currently, many Dutch households view the home battery primarily as a storage solution for solar energy. However, the home battery has other possible applications as well.

The home battery can become a managed battery using day-ahead prices. It can load energy when prices are low and sell energy when prices are high. Another potential functionality is participating in the imbalance market, where the home battery can help relieve the pressure of the main grid. Selecting the right functionality is essential to make the home battery most attractive to Dutch households.

My Master's assignment is executed at the company Zonneplan, a major player in the integrated energy sector. It is currently the number one market leader in residential solar panels. In addition to solar panels, Zonneplan offers dynamic energy contracts and charging stations. They are focusing on the electrification of the Netherlands and with that, making the transition to durable energy easier.

The scope of this assignment encompasses the commercialization of the home battery, which will play a crucial role in allowing the Netherlands to meet its climate ambitions. To meet these ambitions, the home battery needs to gain more traction. Within this scope, the focus is on finding a financial model attractive to the customer, Zonneplan, and future investors. This financial model aims to provide an overview of the different applications of the home battery and the corresponding cash flows for the customer and Zonneplan.

To construct the financial model, I apply revenue management, billing, and customer financing models. External factors such as marketing, product development, and energy trading markets are out of scope for this assignment. The objective of this research is to formulate a decision support statement for Zonneplan, addressing the main research question:

'How can the commercialization of the home battery contribute to the Netherlands' climate ambitions, and what measures should be implemented to proceed?'

Chapter 1 Research Methodology

Our objective is to formulate a decision support statement regarding the commercialization of the home battery. We use the Managerial Problem-Solving Method (MPSM) to guide the research process (Heerkens & Winden, 2017). First, we define the problem. Second, we form the research design and at last, we carry out a literature review.

1.1 Problem definition

As a component of the national circular economy program, the Netherlands aims to achieve full circularity by the year 2050 (Rijksoverheid, 2023). However, the current way of operating is insufficient to meet this ambitious goal. One of the main reasons for the slow transition is the lacking capacity for storage of green energy. Most of the generated green energy from wind turbines and solar panels should be used immediately, as any surplus tends to go to waste. Therefore, the main action problem is: 'The energy transition to become fully circular in the Netherlands is going too slow'.

1.1.1 Problem cluster

The action problem can be extended to a global level, with the primary problem 'global warming'. The main contribution to global warming is the consistent use of vast quantities of raw materials. To mitigate global warming, each country first needs to improve its performance. Therefore, the focus of the main action problem is at national level, emphasizing that the transition toward full circularity is progressing too slowly in the Netherlands.

Within the context of this master's assignment, the focus shifts to a corporate level. The problem revolves around the insufficient offer of storage for green energy. While wind turbines and solar panels can generate a large amount of the required energy, not all produced energy is immediately used. The lack of storage capacity results in the loss of generated green energy. Various factors contribute to this storage deficiency, with the major obstacle being the current high purchasing costs of energy storage solutions. When using storage solely for the solar energy produced by one household, the investment payback time will be long and not financially viable. Another contributing factor is the lack of customer interest in energy storage. This lack of interest is often due to a lack of knowledge on the subject.

A visual representation of the problems and their causes across three different levels is provided in the problem cluster, as depicted in Figure 1. The problems are denoted in the squares, while the ovals state the associated causes.

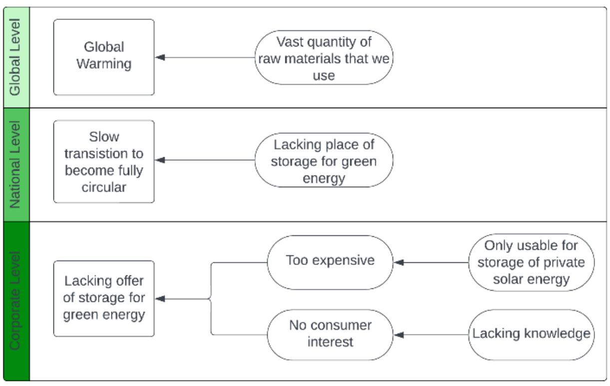

Figure 1: Problem cluster on a three-level overview.

1.1.2 Research problem

I executed this research at the company Zonneplan, a company that is already actively contributing to the electrification of the Netherlands. Zonneplan wants to focus on the commercialization of the home battery, to gain increased attention for this technology. This can play an essential role in the climate goals of the Netherlands. The research question of this master thesis is:

'How can the commercialization of the home battery contribute to the Netherlands' climate ambitions, and what measures should be implemented to proceed?'

To address this question, we aim to construct a financial model that will be attractive to the customer, Zonneplan, and eventual investors. This model will include a cash flow statement for Zonneplan, and the customers. A profit and loss overview should be formed for Zonneplan as well.

1.1.3 Research questions

To answer the main question, various research questions can be formulated. By addressing each of these research questions, the answer to the main questions can be derived.

1. *What is the current position of the Netherlands regarding the transition to renewable energy?*
    a. *Which are the climate goals for the Netherlands?*
    b. *Which sources are used for energy production in the Netherlands?*
    c. *What are the current regulations regarding renewable energy?*
2. *What are the perspectives on the home battery?*
    a. *Is there already such a product on the Dutch household market?*
    b. *What are the specifications of the home battery?*
    c. *What is the perspective of the Dutch households on the home battery?*
3. *What will the applications of the home battery be?*
    a. *Will the home battery only store the self-generated solar energy of households?*
    b. *How can the battery be used with the dynamic energy contracts and day-ahead prices?*
    c. *How can the battery be used with the current imbalance market?*
4. *What will be the structure of the financial model for the home battery?*
    a. *How does the profit and loss statement look like?*
    b. *How do the cash flows for the different applications look like?*
    c. *Which types of financing can Zonneplan apply to the home battery?*
5. *Which financial model should Zonneplan use to bring the home battery to the Dutch household market?*
    a. *Which are the different scenarios?*
    b. *Which are the output variables of the model?*
    c. *What are the results of the financial model?*
6. *What are the implications of the commercialization of the home battery?*
    a. *What are the effects of the home battery on the main grid?*
    b. *What will the* CO_2 *reduction be when implementing the home battery?*
    c. *What will the social impact of the home battery be?*

External factors are left out of the scope, to stay within the time limit of finishing a master's thesis. These factors are processes related to marketing, product development, and energy market research. The costs of the processes are considered, but the process itself is excluded since most decisions are already made within these processes.

1.2 Research design

We use different data methods, with data collection encompassing strategies for acquiring information throughout the thesis assignment. There are three types of research studies: exploratory, descriptive, and explanatory (Creswell, 2023).

Our study is an exploratory, explanatory research. The exploratory aspect involves extensive literature reviews to enhance understanding across the different subjects. Zonneplan has also conducted a survey, contributing valuable insights into the target group for home batteries.

The explanatory research is based on developing a financial model for the commercialization of the home battery. The optimal solution is going to be selected based on different scenarios. These scenarios are based on variables that are not fixed yet and still need to be determined, including the selling price, the benefits, financing options, and the different applications of the home battery.

The research subject is Zonneplan, which is the main stakeholder. Other stakeholders are the customers, the Netherlands, and potential investors. The commercialization of the home battery directly impacts customers as they are the end-users. The transition to renewable energy is stimulated, which will help the Netherlands get closer to the climate goals. Furthermore, the profitability will affect the potential investors. Therefore, Zonneplan, the customers, and potential investors will be the stakeholders of this research.

1.3 Literature review

The goal of this research is to produce a decision support statement of a financial model that will help with the commercialization of the home battery. The home battery is a relatively new subject, which means that not a lot of literature has been executed on this subject. To get an overview of the research that is already executed, we conducted a literature review. The following steps are executed:

1. *Definition of the research question.*
2. *Defining inclusion and exclusion criteria.*
3. *Defining which database to use.*
4. *Describing the search terms and the belonging strategy.*
5. *Listing the number of searches found.*
6. *Create a conceptual matrix of the articles found.*
7. *State the key findings of the articles.*

A detailed overview of these steps and execution can be found in Appendix A.

1.3.1 Definition of the research question

The research question is defined in Section 1.1.2 and is stated below:

'How can the commercialization of the home battery contribute to the Netherlands' climate ambitions, and what measures should be implemented to proceed?'.

There are already existing research papers on the home battery and its implementation in the Dutch household market. Additionally, we need to acquire knowledge on renewable energy and climate goals for our research. Therefore, the research question for the literature review is:

'How will the home battery help the Netherlands transfer to renewable energy to meet the climate goals?'.

1.3.2 Key findings

The literature review resulted in five relevant articles. All five articles are related to renewable energy and the home battery since these were the search terms used for this literature review.

In the first article (Kloppenburg, Smale, & Verkade, 2019), five different ways of implementing the home battery are presented. Individual energy autonomy is the first way of implementing the home battery. With this configuration, households can store their self-generated solar energy with the home battery and use this energy when needed. The second configuration is the local energy community. Here, one 'neighborhood battery' is used to store the renewable energy of a whole community which allows everyone in that community to use the energy when needed. The third solution is the smart grid integration. This implementation uses the home battery of households to balance the grid, this can be done with the use of dynamic energy prices. The fourth solution is a virtual energy community. Instead of a real neighborhood as in the second solution, a virtual neighborhood is created with the use of smart meters. A neighborhood could for example be a group of friends that want to share their produced renewable energy with each other. The fifth configuration is the electricity market integration, in which the imbalance market is entered to purchase and sell electricity and store it in the home battery. From these five different solutions, we will focus on the solutions with separate households because a shared grid is outside of this scope. The local energy community and the virtual energy community are both focusing on multiple households combining their electricity storage through one battery. It will be very difficult to analyze the financial effects for each household separately when they use a common battery. Therefore, these solutions are not treated during our research.

The second article (Dzikowski & Olek, 2017) covers the functionality of the home battery as well. This article proposes five applications: electricity demand is fully covered by the grid, only solar panels are installed and used, the home battery is used only to store solar energy, some part of the battery is used for solar energy and another part of the storage is used for financial benefits, and scenario four is modified in such a way that the home battery generates profit. Only the last scenario is an economically beneficial investment for a household. According to the article, there are still households that invest in one of the other scenarios even though it is not profitable. Nowadays, the social impact of having a home battery and becoming self-sufficient is of big influence in making an investment decision next to the profits. When starting the commercialization of the home battery it is good to keep in mind that households want more than just economic benefits when purchasing a home battery. However, the main share of the households is persuaded to invest only when there is an economic benefit.

In the third article (Meuris, et al., 2018), the primary aim is to obtain the highest possible direct consumption of the generated renewable energy in the Belgian electricity system. The Belgian system is quite similar to the Netherlands, which makes this article relevant. The article concludes that to achieve the highest direct renewable energy consumption, households should exclusively use a home battery for storing renewable energy. Using the home battery for other applications, such as day-ahead prices, leads to lower renewable energy usage.

In the fourth article (Zakeri, Samuel, Dodds, & Gissey, 2021), the main result is that a home battery should be used for dynamic electricity tariffs to maximize the profitability of the home battery storage systems. It states that it is not profitable to use the home battery only for solar energy storage, which is also assumed in our research. The fifth article (Moshövel, Kairies, Magnor, Leuthold, & Bost, 2015), concludes this as well. A strategy that includes dynamic energy tariffs or day-ahead EPEX prices, will lead to a grid relief of 70%.

From our literature review, it becomes clear that the home battery can be used for different applications. To determine which functionality is the best fit for a household, the motivation to purchase a home battery needs to be determined. To obtain the highest direct renewable energy consumption, households should use a home battery only for storing self-generated energy (Meuris, et al., 2018). This is the best fit for households that want a home battery to become more sustainable. When a household wants a home battery to obtain economic benefit, a different functionality should be chosen. According to Zakeri (2021), the optimal choice is to use the home battery for dynamic electricity tariffs to maximize profits. No matter which functionality is used, the home battery always helps the transfer to renewable energy. The main part of households only want to invest in the home battery if it has economic benefit (Dzikowski & Olek, 2017), which makes the functionality of using dynamic electricity tariffs and EPEX prices the best option for the implementation of the home battery.

Chapter 2 The Current Situation

In this chapter, we answer the first two research questions. Both these questions belong to the exploratory research and are answered by executing literature studies.

2.1 The current position of the Netherlands regarding the transition to renewable energy

The home battery is created to help with the stimulation of the electrification of the Netherlands. 'Electrification is the transition from fossil to renewable electrical energy.' (Institute for sustainable process technology, 2023). To obtain a realistic assessment of the utility of the home battery, it is essential to analyze the current position of the Netherlands in the transition to renewable energy.

2.1.1 The climate goals of the Netherlands

The Netherlands is a prosperous country that wants to be part of the most progressive countries in Europe regarding electrification. Therefore, the Dutch cabinet created a policy program based on the European climate plans (Ministery of Economic Affairs and Climate Policy, 2022).

The original climate law aims to achieve a 49% reduction in CO_2emissions by 2030 compared to 1990, to reach a 95% reduction by 2050. However, the Dutch cabinet has updated these targets to a 55% reduction by 2030 and a complete reduction to zero by 2050.

Fit for 55 package

'Fit for 55 refers to the EU's target of reducing net greenhouse gas emissions by at least 55% by 2030' (European Council, 2023). It is a comprehensive package outlining how the EU intends to translate climate goals into law, encompassing 14 different topics. These are:

- *Reform of the EU emissions trading system.*
- *Reaching climate goals in the land use and forestry sectors.*
- *How does the EU intend to address the emissions outside of the EU?*
- *Increasing the uptake of greener fuels in the aviation and maritime sectors.*
- *Why the EU is toughening* CO_2*emission standards for cars and vans.*
- *How the EU plans to boost renewable energy.*
- *Reducing emissions from transport, buildings, agriculture, and waste.*
- *Towards more sustainable transport.*
- *A fund to support the most affected citizens and businesses.*
- *Regulation on methane emissions reduction explained.*
- *How the EU plans to revise energy taxation.*
- *How the EU will become more energy efficient.*
- *Shifting from fossil gas to renewable and low-carbon gases.*
- *Making buildings in the EU greener.*

The topics *'How the EU plans to boost renewable energy'*, and *'How the EU will become more energy-efficient'* are the most important topics related to the electrification of the Netherlands.

Renewable energy emits less carbon dioxide compared to fossil fuels. Additionally, fossil fuel resources can become scarce, while renewable energy is generated from free and abundant natural resources. The EU initially set a goal that 32% of the energy consumed in 2030 should come from renewable sources. However, this target was later updated to a more ambitious share of 42.5% (European Council, 2023). Furthermore, the EU aims to reduce the final energy consumption by 11.7% in 2030.

2.1.2 The different sources used for energy production in the Netherlands

The Netherlands generates energy in approximately ten different ways. In Figure 2, all the energy production over the years is depicted. Renewable energy sources include wind, solar, bioenergy, and other smaller renewables. It is evident from the figure that renewable energy production has been increasing from 2018 to now. The figure highlights a decreasing trend in gas production, while the production of wind and solar is rapidly increasing.

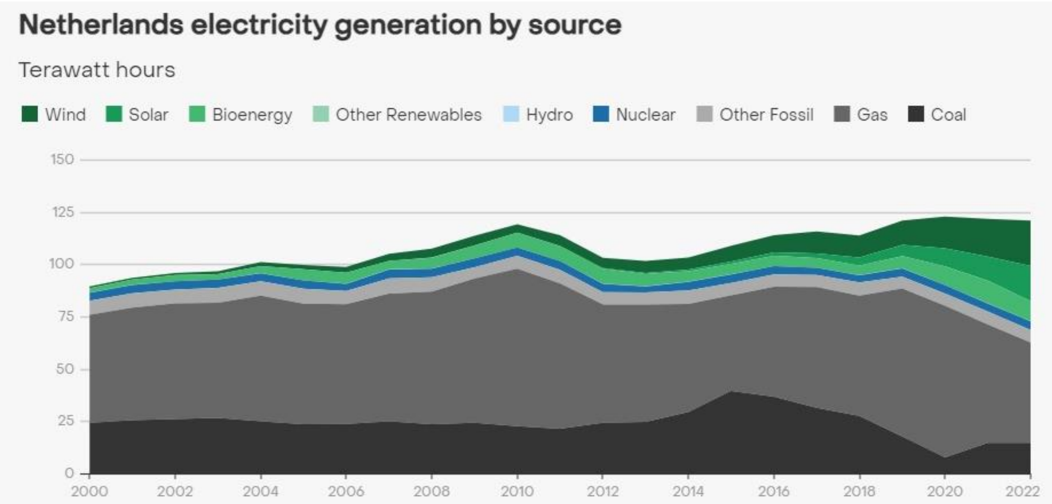

Figure 2: An overview of the Netherlands electricity generation by source from 2000 until 2022 (Ember, 2023).

The transition to renewable energy is expected to lead to a reduction in CO_2 emissions. Figures 3 and 4 illustrate the emissions in the power sector for 'wind and solar' and 'gas' respectively. As of 2019, emissions of wind and solar energy are increasing, corresponding to the increased usage of these energy sources. The scale of the y-as for the solar and wind energy ranges from 0 to 0.2 Megatons of CO_2. The y-as of the gas graph has a scale from 0 to 4 Megatons of CO_2, which is twenty times higher than that of wind and solar. A glance at the graphs might suggest that gas emissions are relatively low compared to wind and solar emissions. However, considering the ratios reveals that wind and solar emissions are significantly lower than those from gas. The wind and solar emissions are primarily related to the manufacturing and maintenance of wind turbines and solar panels respectively. Once operational, the CO_2 emissions of both energy sources are low to non-existent, as they do not rely on fossil fuels.

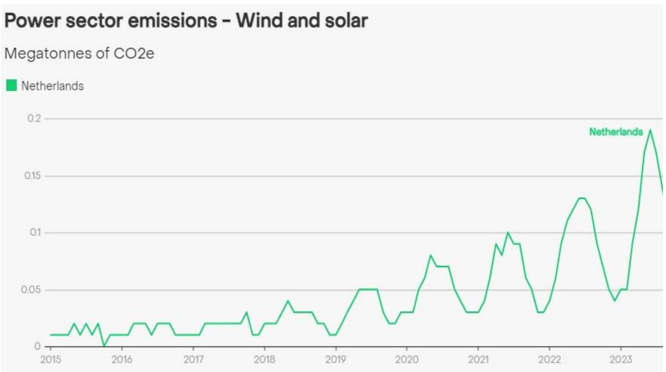

Figure 3: The power section emissions of wind and solar energy in the Netherlands (Ember, 2023).

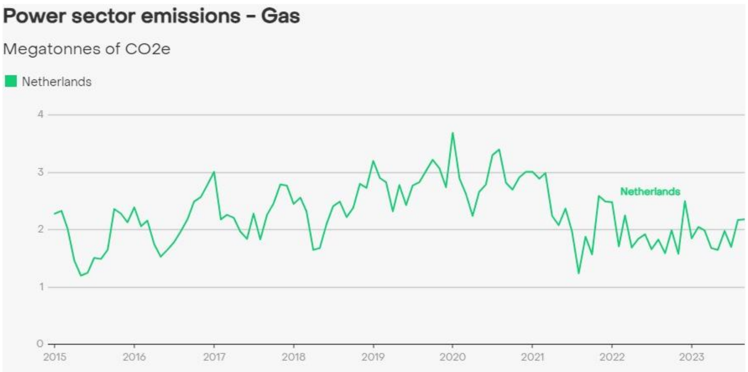

Figure 4: The power section emissions of gas in the Netherlands (Ember, 2023).

Other forms of renewable energy, next to wind and solar energy, are biomass energy, geothermal heat, and hydropower. Biomass energy is received from renewable organic material of plants and animals. The most common way to produce biomass energy is to burn the organic material (Rinkesh, 2023). Another renewable energy source is geothermal energy. This energy originates from the heat within the earth. As heat is consistently generated within the Earth, it can be considered a renewable energy source (U.S. Energy Information Administration, 2023). Biomass and geothermal heat energy are often associated with fire, while hydropower is linked to water. With this method, energy is generated through the force of moving water in a river or other body of water (Energy efficiency and renewable energy, 2023). The process of solar and wind energy is relatively simple compared to other renewable energy sources, making them easier to expand. As a result, wind and solar energy are the most common renewable energy sources in the Netherlands.

2.1.3 The current regulations regarding renewable energy

To stimulate electrification, the government and the EU created new regulations regarding renewable energy. One of these regulations is the climate goals, discussed in Section 2.1.1. Other regulations are an SDE++ subsidy, the Offshore Wind Energy Act, energy agreements, and net metering. We elaborate on the purpose of these regulations in this section.

To stimulate companies to become more sustainable, the government introduced the 'Stimulation of Sustainable Energy Production and Climate Transition Subsidy', commonly known as the SDE++ subsidy (Agency, 2023). This operating subsidy is received during the operating period of a project. Companies can apply for this subsidy if they aim to generate renewable energy or reduce carbon dioxide emissions.

The Offshore Wind Energy Act was created to facilitate the development of offshore wind energy farms on a large scale (Noordzeeloket, 2023). The government introduced a subsidy specifically for wind farms at sea, aiming to enable the operationalization of the new wind farm within four years of receiving the subsidy. This regulation is designed to expedite the transition to renewable energy by increasing the share of wind energy.

The Dutch government is working on national energy agreements in collaboration with the industry, environmental organizations, and trade unions. These agreements are stated in the 'Energy Agreement for Sustainable Growth' (Ministry of Economic Affairs and Climate Policy, 2023), and are created to outline the energy transition strategy.

The final regulation concerning renewable energy is net metering. In the Netherlands, net metering policies are in place for households. Customers generating renewable energy can feed excess electricity back into the grid at the current electricity prices. This regulation has persuaded a majority of households to invest in solar panels, thereby contributing to the electrification efforts.

2.1.4 Future regulations regarding renewable energy

In addition to existing regulations, there are also forecasted regulations. Annually, during 'Prinsjesdag', the Dutch cabinet presents the Dutch Budget Memorandum for the upcoming year to the House of Representatives. In the Netherlands, this memorandum is known as the 'Miljoenennota'. It includes proposed amendments regarding energy costs.

At the beginning of 2023, the Dutch cabinet implemented a price ceiling on electricity and gas usage. Energy suppliers were restricted to charging a maximum of €0.40 per kWh and €1.45 per m^3 when customers did not exceed 2900 kWh of electricity and 1200 m^3 of gas usage (Campenhout, 2023). This arrangement is scheduled to end in 2024. Currently, the impact is not immediately noticeable as most of the energy contracts already fall below the specified maximum prices. However, if prices rise, the consequences could be significant. In particular gas prices are under pressure, due to the persistent scarcity of gas.

In addition to the price ceiling, the Dutch Budget Memorandum also incorporates a change in the energy taxes. As of the 1st of January 2024, there will be a transition in the energy taxes for electricity and gas. The taxes on electricity will decrease, while those on gas will increase. This adjustment is intended to reduce gas usage and encourage customers to transition to gas-free alternatives (Campenhout, 2023).

The expectations were for taxes on electricity to decrease more rapidly than the rates published in the Memorandum. Consequently, the new energy rates have positive impacts for customers with solar panels. When the electricity taxes decrease, the customer price for electricity also decreases, potentially extending the payback time for solar panels. Although the decrease in the electricity tax is not as substantial as anticipated, customers with solar panels can still benefit from the netting agreement and their investment in solar panels (Gastel, 2023).

2.2 General specifications of the home battery

The home battery can come with different specifications. The five most important are the size, price, lifespan, installation costs, and compatibility with solar panels.

The most common home batteries vary between 5 to 20 kWh. The smaller 5 kWh home battery is best suited for small households with low energy consumption. This battery can be convenient during temporary power cuts. The 10 kWh home battery provides more storage for solar energy and can be configured as a managed battery, which can lead to a higher profit compared to a 5 kWh battery. Additionally, many converters have a limit of 10 kWh, meaning that a larger battery cannot charge and discharge faster than a 10 kWh battery. Finally, there are home batteries with a capacity of 20 kWh, suitable for large households or small companies. However, a drawback of this size is that the converter's limit of 10 kWh prevents the battery from being used at full capacity. In addition, the price of these batteries is relatively high.

The optimal size option for households is often the 10 kWh battery. The price is an important specification as well as it will significantly influence customer behavior. A 10 kWh battery typically costs between €5000 and €8000.

Another specification is the lifespan. Most batteries have a lifespan ranging from ten to fifteen years. Customers should research the lifespan of the offered home battery and the associated guarantee. For instance, the Zonneplan battery comes with a guarantee of around 6000 cycles. The actual duration of the guarantee depends on the number of cycles per year. If there is one cycle a day, the guarantee is 16 years.

Installation costs can vary depending on the company. The complexity of the installation and the different tariffs of installers contribute to significant differences in total costs. Some houses may require a converter or an upgrade to their fuse box, incurring additional expenses.

A home battery can be installed anywhere in the house, provided there is a 30 cm clearance around the battery. The wall to which the battery is attached must be constructed from fire-resistant material. Consequently, the battery can be installed in various locations such as the basement, attic, garden house, technical room, or garage. It may also be placed outside under a shelter, although it is preferable for the battery to be situated in a dry area.

The last specification of the battery is its compatibility with solar panels. Customers need to be aware that not every battery will integrate into their current solar energy system. Therefore, customers should inquire with the selling company about the compatibility of the home battery with their solar energy system. If needed, they may have to consider a different battery or adjust their system.

The specifications of Zonneplan's battery can be found in the figure below. The selling price is not fixed and will vary within different scenarios, as detailed later in Chapter 5. The cycles per year are currently based on one cycle a day but can also be adjusted to twice a day, reducing the guarantee in years to eight. The estimated installation costs are approximately €300. Costs to train installers are not included in these installation costs as educational costs are a long-term investment for the company itself.

Battery Specifications	
Battery selling price	€ 5,000.00
Charge volume in kWh	10
Cycles per year	365
Guaranty in cycles	6000
Guarantee in years	16
Residual value after 10 years	€ 1,000.00
Annual drop in earnings due to battery wear and tear	1%
Installation	€ 300.00

Figure 5: The specifications of the home battery of Zonneplan. The orange cells are input cells, and the yellow cell is a dropdown list.

There are two types of battery that Zonneplan can sell: the all-in-one battery and the component-built battery. The component-built battery consists of multiple components that can be added or removed, allowing to make it easier to switch between different capacities. In contrast, the all-in-one battery has a fixed capacity and cannot change in specifications. This battery was the first to enter the home battery market, and most of the software created by energy companies is based on this type of battery. The component-built battery is a newer type of battery that is not yet widely used in the market. Therefore, it is challenging for companies to create software for this battery, as it is relatively new and still needs a lot of testing. Zonneplan will start using the all-in-one battery but is going to transfer to the component-built battery as soon as possible. The first batteries released will be the all-in-one and these will switch to the component-built battery within half a year.

Figure 6: The component-built home battery.

Figure 7: The all-in-one home battery.

2.3 The perspectives on the home battery

Our goal is to help the commercialization of the home battery, by making a financial model. Before the financial model is formed, we need to execute research on the current perspectives on the home battery.

2.3.1 The home battery on the Dutch household market

Whilst neighboring countries such as Germany have already adopted the home battery, the Netherlands is still behind in the integration of this technology. There are a few home batteries released in the last years but the level of interest from households has been limited due to their lack of profitability. Home batteries often offer a low kWh capacity and come with a relatively high price, only enabling the storage of self-generated renewable energy. As a result, households find more financial benefits in the netting agreement than investing in a home battery. Consequently, the market share of home batteries in Dutch households remains relatively low. However, the attractiveness of home batteries is expected to increase if the netting agreement is repealed.

Zonneplan is exploring different possibilities for the applications of the home battery. Instead of only storing solar energy, it could also store energy from the grid. This energy can then be sold during peak hours when dynamic energy prices are high. Implementing such functionality could make the home battery more profitable and appealing to the Dutch household market. All the possible applications of the home battery are explained in Chapter 3.

The current market can be divided into three types of home batteries: '*Only buying the battery itself*', '*Installed battery to store self-generated solar energy*', and '*An installed managed battery*'. With the first option, the customer solely purchases the battery. How the battery is installed in the house and what the functionality is going to be, should be determined by the customer itself. This type of battery is not commonly chosen, as it requires the customer to possess substantial knowledge and conduct their research on how the battery operates and should be installed. Larger companies like Huawei and Tesla offer these types of batteries. The second option involves a battery installed by the company and this battery can store self-generated energy. Smaller companies in the sustainable energy market are now starting to sell these batteries. Soly and Sessy are currently the market leaders for this type of battery (Sessy, 2023). The market for this type of battery is relatively small, mainly due to the netting agreement, which will take away the added economic value of the battery. The third and last type of battery is a managed battery. This battery determines when to store and discharge the energy based on dynamic prices. This type holds the most promise for adoption in the Dutch household market as it is considered the most profitable. Bliq was among the first companies to introduce such a battery. The Bliq battery was released in the first quarter of 2023 and is therefore still relatively new to the market (Bliq, 2023).

Several rumors suggest that more companies will enter the home battery market in the upcoming year. However, the specifications of these home batteries remain unclear. For now, there are still a lot of opportunities for new companies to enter the market.

2.3.2 The perspective of the Dutch households on the home battery

Zonneplan conducted a target group analysis for the home battery, as outlined in the research design. The analysis involved two different groups: 244 Zonneplan's customers and 2002 randomized Dutch households (Zonneplan, 2023).

Young adults are showing the highest purchase intention for a home battery. This intention is decreasing from the age of 40 and older. The age group of 30 to 39 years is the group with the highest purchasing intention. Moreover, the analysis reveals a gender difference, with men expressing more interest in home batteries compared to women. Specifically, 21% of the participating men there is intention to purchase a home battery within five years, whereas for women, this is only 12% (Zonneplan, 2023). Additionally, individuals with higher education levels show greater interest in the home battery. Based on these insights, the target group will be men with a high educational level aged between 30 and 39 years.

The main reason that customers want to get a home battery is to reduce dependency on the main grid. Among all the participants with a purchase intention, 58.6% cited this as their main motivation. Another big reason to invest in a home battery is to increase the usage of self-generated solar energy. By storing self-generated energy, households can decrease their dependency on the main grid, leading to an increase in satisfaction with their solar panels.

The most important question of the survey was: '*To what extent do Dutch households expect to get a home battery?*'. The results, shown in Figure 8, reveal that 29.2% of the participants do want to get a home battery or already have one, while 46.4% do not plan to get a home battery. Additionally, 22.2% want a home battery but are uncertain in which time frame. Therefore, a total of 51.4% of the participants indicate an intention to get a home battery in the long run.

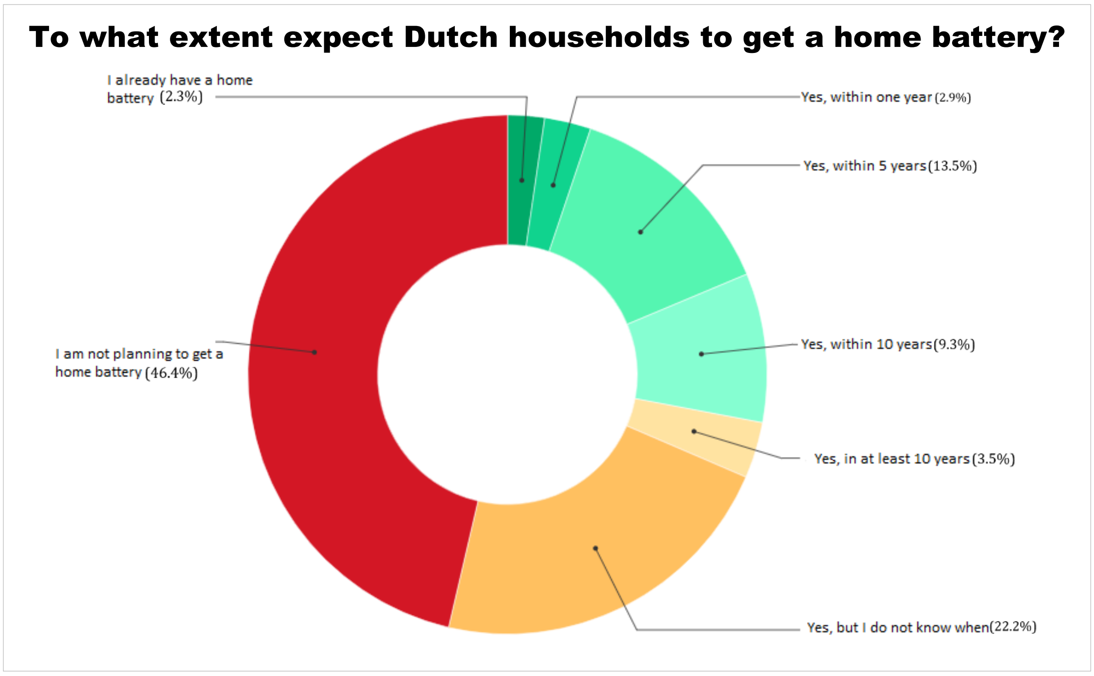

Figure 8: The extent to which Dutch households expect to purchase a home battery. It is based on a customer's research of 2000 Dutch households (Zonneplan, 2023).

The Netherlands has around 4.6 million owner-occupied properties. Analyzing the percentages from Figure 8, 910,800 households will have a home battery within the next five years. This indicates significant potential and expected growth in the battery market from now until 2028.

2.3.3 Assessing the attractiveness of the home battery investment

As mentioned in the previous section, the main reason to purchase a home battery is to become less dependent on the main net. Of all the participants in the target analysis, 58.6%

stated that as the main reason and 34.1% wanted to purchase a home battery to have a backup in case of a power outage (Zonneplan, 2023). When a power outage occurs at a household with solar panels, the Photovoltaics (PV) installation is turned off. The generated solar energy cannot be used during this outage due to safety reasons, resulting in a loss of energy. When a household invests in a home battery, the stored energy can cover the power outage and the self-generated energy can be stored on the battery. A 10 kWh battery can provide a household with approximately 35 hours of electricity during a complete blackout, which is equal to one and a half days (Zonneplan, 2023). It is not possible to become completely independent of the main grid yet. However, a home battery can address potential blackouts and enhance a household's adaptability to its energy usage.

Certain companies choose to deactivate the battery during a power outage, a decision often made for safety considerations. In this scenario, the stored energy in the battery remains preserved and can be used once the power is restored. However, it is important to note that during the power outage, the battery is inactive, leading to a loss of generated energy from the solar panels. Therefore, when considering the adoption of the home battery, customers should carefully consider the reasons driving their decision.

Currently, the payback period for solar panels is on average between 7 to 9 years. Depending on the netting agreement, the payback period can be enlarged (Vattenfall, 2023). A household will only be attracted to the home battery if the investment is favorable. Therefore, the payback period for the home battery should be similar to the solar panels. A payback period of 10 years and higher is not attractive to the customer.

Additional to the payback period, it is crucial for the Return on Investment (ROI) to be positive to make the investment financially attractive for the customer. If the ROI falls below zero or remains at zero, the return on investment is either negative or at a break-even point. A positive ROI indicates the investment's profitability, providing motivation for the customer to seriously consider investing in the battery.

It is not necessary to have solar panels when investing in a home battery. However, without solar panels, the attractiveness of the home battery will decrease. The battery will store only energy from the main net, depending on the day-ahead prices, and this will lead to a more cost-effective use of the electricity. The benefits will not be very high, which will make it hard to pay back the investment within 10 years. Therefore, it is more attractive to invest in a home battery if a household uses solar panels.

2.4 Summary

According to the Dutch climate goals, a 55% reduction in CO_2 emissions is targeted by 2030, with a further aim of zero emissions by 2050. To achieve these reductions, the EU has introduced the Fit for 55 package. Analyzing the electricity generation landscape in the Netherlands reveals a growing importance of wind and solar energy, accompanied by a decline in gas production. To stimulate sustainable energy, the government has introduced multiple subsidies that will stimulate the electrification of the Netherlands.

In the current battery market, the capacities range from 5 to 20 kWh. For customers evaluating the price-capacity ratio, a 10 kWh battery appears to be the most favorable investment. Battery prices vary from €5000 to €8000, with an additional installation cost of approximately €300.

The Netherlands is still behind on the integration of the home battery, compared to neighboring countries. The few batteries that were released can only be used to store self-generated energy. There are rumors of more companies entering the home battery market but specifics about their products remain unclear. This leaves a lot of opportunities for new companies to enter the market.

Zonneplan conducted a target group analysis, revealing that the target group will be men with a high educational level that is between 30 and 39 years old. A total of 51.4% of the participants stated that they want to have a home battery in the long run. This shows that the market will have a lot of potential and growth.

The main reason for a household to invest in a home battery is to become less dependent on the main net. When a power outage occurs, households can provide up to 35 hours of electricity with a home battery of 10 kWh. To make the investment attractive, we imply that the payback time should be within 10 years and the ROI should be positive. Furthermore, solar panels are not a necessity when purchasing a home battery. However, it will decrease the generated benefits from the battery.

Chapter 3 The Applications of the Home Battery

As mentioned in the earlier chapters, a home battery can serve several applications. It can be used to store self-generated solar energy, or the battery can be managed. A managed battery, often referred to as a 'smart' battery, can store and discharge energy at different moments in time, depending on the specifications of the software. The battery can store energy when prices are low, and discharge it when prices are high, resulting in a profit. We will elaborate on these different applications and calculate their monetary benefits.

3.1 Solar energy

The most obvious reason for households to invest in a home battery is to use it as a storage solution for their self-generated solar energy. Households equipped with solar panels can currently return excess energy to the grid when they generate more than they consume. However, the existing netting agreement, which is currently more profitable than purchasing a home battery, is expected to disappear in the future.

3.1.1 Netting agreement

The Dutch cabinet has established a netting agreement for solar panels. From 2025 until 2031, this agreement is scaled down. Under this arrangement, households and small companies can feed their self-produced solar energy to the main grid. This energy returned can then be offset against their energy usage, a practice known as netting.

Currently, 100% of the energy returned to the main net can be netted. However, according to the cabinet's netting agreement, this percentage is reduced to zero by 2031 (Minister of Economic Affairs and Climate, 2023). The current framework for this agreement is detailed in the figure below.

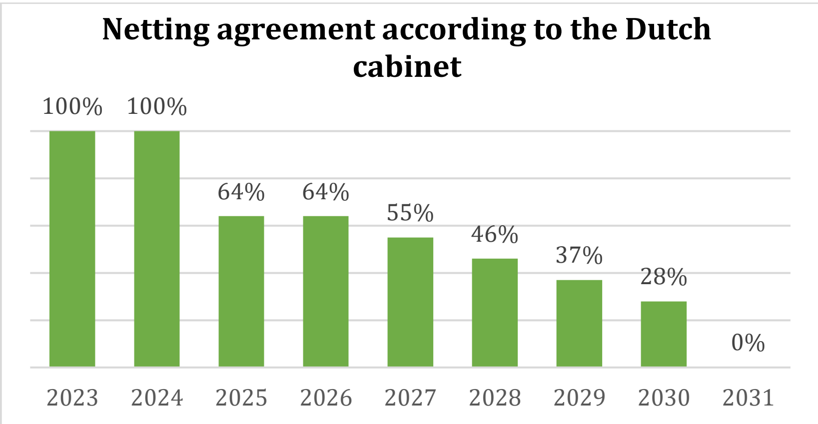

Figure 9: Overview of the netting agreement of the Dutch cabinet.

The cabinet aims to transition away from the netting agreement, believing that investing in solar panels will remain appealing for households even in the absence of this agreement. Currently, the electricity used for netting is tax-free, resulting in reduced tax income for the government. Under the existing netting agreement, energy suppliers incur extra costs to return the excess energy to the main grid. These costs are passed on in the total costs for the customers, impacting households with solar panels as well. By moving away from the netting agreement, the cabinet wants to counter this effect (Minister of Economic Affairs and Climate, 2023).

3.1.2 Feed-in-fee solar energy

When the netting percentage is reduced, households still have the option to contribute solar energy to the main grid. Instead of netting the energy, a feed-in fee is applied. This fee is paid for each kWh returned to the main grid and varies among energy suppliers. Customers of Zonneplan, who have a dynamic energy contract, experience a feed-in fee equivalent to the energy price during the hour in which the kWh is fed into the main grid (Pierik, 2023).

3.1.3 Benefits of the solar energy functionality

To gain a comprehensive understanding of the actual benefits of this functionality, I created a cash flow statement. This statement is based on the average number of solar panels in a Dutch household, which is twelve solar panels. According to Zonneplan, the annual yield of these panels is 4231 kWh (Zonneplan, 2023). The average electricity price for a kWh is €0.40 (Market, 2023).

Without a home battery, a household typically uses 30% of its self-generated power and feeds back the remaining 70% to the main grid. However, with a home battery, this self-generated energy consumption increases to 70%, marking a significant 40% increase (Zonneplan, 2023). The feed-in fee is set at €0.095 per kWh (Pure Energie, 2023). These input variables serve as the foundation for the benefit overview outlined in Figure 10.

Solar Energy Benefit									
Year	**2023**	**2024**	**2025**	**2026**	**2027**	**2028**	**2029**	**2030**	**2031**
Netting Agreement	100%	100%	64%	64%	55%	46%	37%	28%	0%
Feed-in-fee	0%	0%	36%	36%	45%	54%	63%	72%	100%
Benefit home battery	€ 676.96	€ 676.96	€ 720.37	€ 720.37	€ 731.22	€ 742.08	€ 752.93	€ 763.78	€ 797.54

Figure 10: A benefit overview of the solar energy storage functionality. This overview is based on the netting agreement. The figure is based on the total solar energy benefits and does not include a profit-share ratio.

The benefit formula begins by calculating the increase in self-generated energy consumption facilitated by the home battery. This value is then multiplied by the average energy bill, representing the annual savings on the energy bill due to the use of the home battery. Subsequently, the formula calculates the profit from the energy fed back to the main grid, based on the feed-in-fee. The sum of these two calculations yields the total benefit, as depicted in Figure 10. As the figure illustrates, the lower the netting agreement percentage, the greater the benefit for the home battery.

The situation surrounding the netting agreement remains uncertain, pending a decision by the Dutch cabinet. Given the fall of the cabinet, a post-election debate will determine the future of the netting agreement. Consequently, two additional variations are considered in the benefit statement: one where the netting agreement remains at 100% and another where there is no netting at all. These variations are detailed in Appendix B.

3.2 Dynamic energy contracts and day-ahead prices

In addition to storing self-generated solar energy, the home battery can function as a managed battery as well. One of the applications is that this battery is integrated with dynamic energy contracts and day-ahead prices. Equipped with software to manage energy storage and discharge energy, the battery analyzes day-ahead prices and schedules energy loading and release accordingly. When prices are low, the battery loads energy, and when prices are high, it feeds energy back into the main grid for a higher price. The difference between these prices is the profit of the home battery.

To estimate the eventual benefits of this functionality, the battery undergoes testing to estimate its profitability. If the battery undergoes one cycle of loading and discharging a day, the number of cycles is equivalent to the number of days in a month. The average profit per kWh is then calculated and multiplied by the number of cycles in a month. This results in an average annual profit of €445.80, based on data from 2022 and the first half year of 2023.

3.2.1 Forecast of the EPEX spot market

The dynamic energy market relies on the EPEX spot market, revealing energy prices 24 hours in advance, termed as day-ahead prices. These prices are expected to revert to a baseline level, with lower prices during periods of lower average usage and higher prices during peak usage times. For example, peak energy usage occurs between eight to ten in the morning as households wake up for school or work, resulting in higher spot prices. Conversely, during the afternoon, when fewer people are home and the energy usage is low, the spot prices will be low.

The day-ahead prices fluctuate a lot, as illustrated in Figure 11, displaying the hourly progress over multiple years (GroB, 2022). The prices spiked during the Ukrainian and Russian war in 2022. While researchers anticipate a return to lower prices at the beginning of 2024, forecasting EPEX prices remains challenging due to market instability, especially in the context of global conflicts (Cornwall Insight, 2023). This expected drop is visualized in Figure 12. As shown in the figure, the average was around €50 before the war. During the war, prices rose extremely high, and researchers forecast that the prices will fall back to €130 around 2024. A table with the exact numbers of the forecast is stated in the appendix.

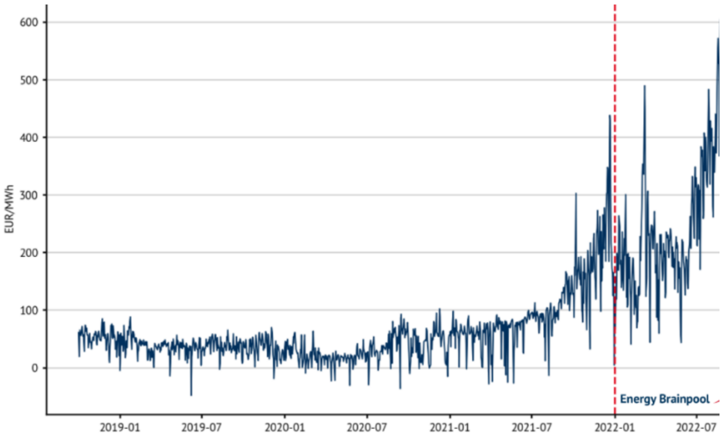

Figure 11: The hourly day-ahead prices from 2019 to 2022 (GroB, 2022)

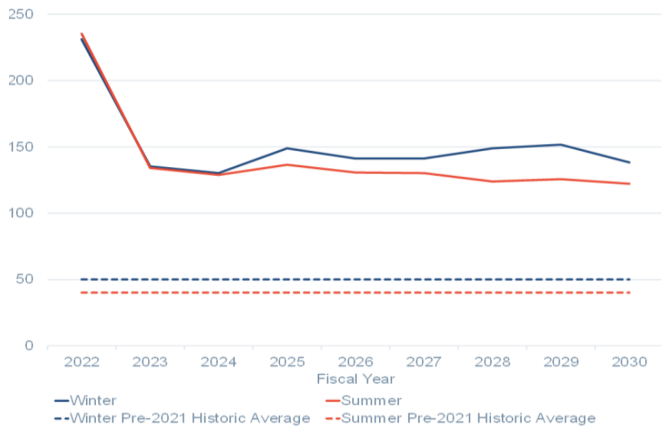

Figure 12: The EPEX spot price market forecast per year (Cornwall Insight, 2023). The prices are based on an average year price.

3.2.2 Benefits of the day-ahead functionality of the home battery

Figure 13 presents the benefit statement for the day-ahead functionality, based on one cycle a day, resulting in approximately 365 cycles per year. Although the home battery was tested with the scenario of two cycles per year, this is not considered realistic due to the time constraint involved in loading and discharging energy.

Given the difficulty of long-term spot price forecasting, as discussed in the previous section, the statement relies on the same prices as in the years 2022 and 2023. The benefits, detailed in the appendix, reflect the forecasted prices explained in Section 3.2.1. As depicted in the figure, the benefit equals €445.80 per year.

Day-ahead benefits									
Year	**2023**	**2024**	**2025**	**2026**	**2027**	**2028**	**2029**	**2030**	**2031**
Cycles per year	365	365	365	365	365	365	365	365	365
EPEX original	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%
Benefit home battery	**€ 445.80**	**€ 445.80**	**€ 445.80**	**€ 445.80**	**€ 445.80**	**€ 445.80**	**€ 445.80**	**€ 445.80**	**€ 445.80**

Figure 13: Benefit statement of the day-ahead functionality of the home battery. The figure is based on the total benefits of day-ahead prices and does not include a profit-share ratio.

3.3 Imbalance market

A third functionality of the home battery involves a managed battery based on the imbalance market. The main electricity grid in the Netherlands is monitored by the national grid operator TenneT. They monitor the electricity grid to maintain balance, which is between the ranges 49.5 and 40.5 Hertz and 195.5 and 253 Volt (PVNED, 2023). The imbalance, which is the difference between production and consumption every 15 minutes, is addressed by TenneT using forecasting models. However, the forecast will never be perfect, leading to an imbalance solved by TenneT adjusting the electricity flow by switching it on or off (PVNED, 2023).

When TenneT adds too little energy to the main grid, causing an energy shortage, electricity may be switched off from a high consuming facility like a farmer's greenhouse. Conversely, if too much energy is added, it needs to be sold to energy suppliers to balance the main grid. While the purchasing and selling of energy in this market are based on imbalance prices, only energy suppliers, not households, can participate. However, a managed home battery allows energy suppliers to purchase and store the energy in home batteries. When the grid has a shortage of energy, the energy suppliers can sell the energy back to TenneT and the home battery can discharge the energy. The difference in prices is the profit of the home battery (Zonneplan, 2023).

Despite the potential for higher benefits than the day-ahead functionality due to more extreme prices, the lack of public disclosure of the imbalance market makes it challenging to predict the exact benefits of the home battery. As a result, the financial model will focus solely on the solar energy and day-ahead functionality of the home battery.

3.4 Summary

There are three types of applications for the home battery: solar energy, dynamic energy, and the imbalance market. With the solar energy application, the battery stores self-generated energy, considering different netting arrangements and the feed-in fee as the netting agreement diminishes. The battery can also function as a managed battery, analyzing day-ahead prices in the dynamic energy market to optimize energy loading and release based on fluctuating prices. The last application is the imbalance market. However, the imbalance prices are not public to customers, which makes it difficult to predict the corresponding benefits. Therefore, we do not include the imbalance market in the financial model.

Chapter 4 Description of the Financial Model

An essential aspect of this thesis is the development of a financial model to analyze the various home battery applications and their associated benefits. I constructed this financial model using Excel, which incorporates a profit and loss (P&L) statement, a cash flow statement for Zonneplan, and a cash flow statement for the customer. It also includes built-in scenarios based on different input parameters. The fourth research question is answered in this chapter. First, we will explain the input sheets of the financial model. Second, we present the different financial statements. Finally, we will list various financing methods for the customer.

4.1 Structure financial model

I built the financial model in Excel, and it consists of several sheets, including input sheets, output sheets, and data sheets. The data sheets contain extra data used to define input parameters for the model. The input sheets, colored orange, encompasses all the input parameters that are used in the output sheets. The output sheets, colored blue, include the P&L statement, the cash flow overview for Zonneplan, and the cash flow overview for the customer. A legend is provided for different cells and sheets. To analyze different input parameters, I created multiple scenarios, which can be recognized by the yellow cells.

Input
Output
Drop down list

Figure 14: Legend of the different styles of cells.

The input sheets serve as the foundation of the model. First, I calculated the benefits of the applications of the home battery, as explained in Chapter 3. An overview of all the benefits is represented in the sheet 'Benefits overview home battery', which is stated in Appendix B. The first cash flow considers the benefits overview for Zonneplan, calculated quarterly for the years 2024 to 2026. Due to the relatively new nature of the battery market, making predictions for a longer period becomes more uncertain. Therefore, I have chosen to make a forecast until 2026 for Zonneplan. However, for the customers is it more convenient to forecast for a longer period as it allows the calculation of the payback period, which is multiple years. Therefore, the customer benefits were forecasted from 2024 until 2038.

Another input sheet is the 'FTE Input' sheet, used for calculating department costs to create a P&L statement for Zonneplan. With Zonneplan already functioning as a company with multiple departments, introducing the home battery to their product line will increase workload and extend several departments. The department costs are calculated based on the full-time equivalent (FTE) costs, where one FTE is equivalent to the monthly costs of an employee working a 40-hour workweek. The total cost per FTE for extending Zonneplan's departments is influenced by the occupier cost index. This index represents the extra costs that a company needs to pay per FTE alongside the salary. These were on average €9,152.00 per year (Colliers, 2022). Additionally, the average salary for each department is calculated. Development, finance, marketing, and the additional running costs are based on fixed additional numbers of FTEs. Sales, operations, installer, and customer support costs are variable and are based on the number of sales or installations. Both the fixed and variable numbers of FTEs are based on estimations from Zonneplan. The costs per FTE for each department, are based on the average salaries that can be found on (Jooble, 2023), and (National professions guide, 2023). The 'FTE

Input' sheet provides an overview of the total cost per FTE for each department and is illustrated below.

Department costs	Number of FTE's	Cost per FTE	Occupier cost index per month	Total cost per FTE
Sales	1 FTE per 5.000 sales	€ 4,225.00	€ 762.67	€ 4,987.67
Development	6	€ 4,166.00	€ 762.67	€ 4,928.67
Operations	1 FTE per 10.000 sales	€ 5,950.00	€ 762.67	€ 6,712.67
Operations 'Installers	1 FTE per 450 installations	€ 5,950.00	€ 762.67	€ 6,712.67
Customer Support	1 FTE per 10.000 sales	€ 3,400.00	€ 762.67	€ 4,162.67
Finance	2	€ 4,750.00	€ 762.67	€ 5,512.67
Additional running cost	3	€ 5,750.00	€ 762.67	€ 6,512.67
Marketing cost	4	€ 4,750.00	€ 762.67	€ 5,512.67
Occupier cost index per FTE for one year	€ 9,152.00			

Figure 15: An overview of the FTE Input sheet. The total costs per FTE are calculated for the different departments that need to be expanded when the home battery is added to the product line of Zonneplan. The orange cells are input cells. When the input cell is changed, all the connected cells are adjusted as well.

The 'input parameters' sheet is the last input sheet. The first parameters are related to the battery specifications, as detailed in Section 2.2, including the associated costs. Subsequently, additional parameters for Zonneplan are outlined, such as upfront development costs, annual running costs, and an annual dropout rate of five percent. The up-front development costs are the initial investment and are estimated at 4.7 million, which is based on the software development, employee costs, and department budgets. The operational parameters are related to the marketing cost, where each marketing lead costs an average of €25.00. The conversion to sale rate is set at 15%, indicating that 15% of all leads will result in a product sale. All these parameters are derived from information provided by Zonneplan.

Another important input parameter is the profit-share ratio. This ratio shows which percentage of the home battery benefits is allocated to the customer and Zonneplan. A discount rate of 5% is used for the calculations within the financial model, which is based on the recommendations of the Committee on Climate Change (Committee on Climate Change, 2017).

Lastly, payment term parameters are established. One payment parameter relates to the customer, which shows in which month the product is paid. For the customer, this parameter is one since the customer pays after the installation of the home battery. For Zonneplan, the payment term signifies the month in which the company pays its suppliers. An overview of these input parameters is presented in Figure 16.

Battery Specifications		**Cost Zonneplan**	
Battery selling price	€ 5,000.00	Up-front development costs	€ 4,700,000.00
Charge volume in kWh	10	Annual running costs proposition	€ 1,200,000.00
Cycles per year	365		
Guaranty in cycles	6000	**Annual customer churn rate (dropout rate)**	5%
Guarantee in years	16		
Residual value after 10 years	€ 1,000.00	**Operational costs**	
Annual drop in earnings due to battery wear and tear	1%	Lead costs	€ 25.00
		Conversion to sale	15%
Cost specifications all-in-one			
Hardware	€ 4,146.00	**Profit-share**	
Connect - SGN	€ 25.00	Zonneplan profit share	10%
Installation	€ 300.00	Customer profit share	90%
Refurbishing costs		**Payment term**	
Cost per kWh	€ 160.00	Customer Home battery payment term in months	1
		Payment term Zonneplan to suppliers in months	3
Cost specifications component-build			
DMEGC battery packs	€ 1,800.00		
AME bi-directional 3-phases converter	€ 1,500.00		
Connect - SGN	€ 25.00		
Installation	€ 300.00		

Figure 16: An overview of the input parameters on the 'Input parameters' sheet. These input parameters can be changed for different scenarios.

The last input parameters are associated with the number of sales, equivalent to the number of battery installations in that year. This number is a forecast based on estimations from Zonneplan. Running batteries present the number of installed batteries subtracted from the churn rate. The cumulative number of batteries is equal to the total running batteries. An overview of these input parameters is depicted below. The number of installations can vary based on the scenario that is chosen, as explained later in this chapter.

Year	Month	Battery installations	Battery sold	Running batteries	Total Running Batteries
2024	Q1	1,875	All in one	1,781	1,781
	Q2	1,875	All in one	1,781	3,563
	Q3	1,875	Component	1,781	5,344
	Q4	1,875	Component	1,781	7,125
2025	Q1	3,750	Component	3,563	10,688
	Q2	3,750	Component	3,563	14,250
	Q3	3,750	Component	3,563	17,813
	Q4	3,750	Component	3,563	21,375
2026	Q1	7,500	Component	7,125	28,500
	Q2	7,500	Component	7,125	35,625
	Q3	7,500	Component	7,125	42,750
	Q4	7,500	Component	7,125	49,875

Figure 17: An overview of the number of battery sales for each quarter.

The complete 'Input parameters' sheet is stated in Appendix C. These parameters form the basis of the P&L statement and the two cash flow overviews.

4.2 Financial statements

Now that I established the structure of the financial model, the financial statements can be generated. As mentioned earlier, these statements include a P&L statement for Zonneplan and a cashflow overview for both the customer and Zonneplan. The statements are based on the 'buying' financing method, where the customer purchases the product directly from Zonneplan, and no external financing company is involved. Other financing methods are discussed in Section 4.3.

4.2.1 The profit and loss statement

A P&L statement is a tool to assess whether the home battery project will result in a profit or loss for Zonneplan. If the statement indicates that Zonneplan generates losses over the forecasted years, it may not be favorable to continue with the project. Conversely, if it indicates a profit, Zonneplan receives the confirmation that the home battery is indeed a project worth investing in.

The P&L statement consists of several components: revenue, costs of goods sold, operating costs, and operating income. Revenue includes the amount Zonneplan receives from selling the battery and the percentage of benefits it gains. Costs of goods sold encompass different battery-related costs, including hardware, the connecter, and the installation costs. The gross margin is calculated using the following formula:

$$Gross\ Margin = Revenue - Total\ Cost\ of\ Goods\ Sold$$

Operating costs include initial investment costs and additional department costs. To calculate the operating income, the operating costs are summed to calculate the total operating costs. The operating income is calculated with the formula below.

$$Operating\ income = Gross\ Margin - Total\ Operating\ Costs$$

To calculate the net income quarterly, the formula represented below is applied.

$$Net\ Income = Operating\ income - Provision\ for\ Income\ Tax$$

The P&L statement starts with the year 2023, the year that Zonneplan started investing in the home battery. The figure below illustrates only the year 2024. The statement is created for the applications solar energy and dynamic energy prices. The complete profit and loss statement can be found in appendix C.3.

P&L Statement

	2023	2024			
Revenue		***Q1***	***Q2***	***Q3***	***Q4***
Sales home battery		€ 9,375,000.00	€ 9,375,000.00	€ 9,375,000.00	€ 9,375,000.00
Benefits PV		€ 31,732.50	€ 31,732.50	€ 31,732.50	€ 31,732.50
Net Sales		**€ 9,406,732.50**	**€ 9,406,732.50**	**€ 9,406,732.50**	**€ 9,406,732.50**
Costs Of Goods Sold					
All in one					
Hardware		€ 7,773,750.00	€ 7,773,750.00	-	-
Connect - SGN		€ 46,875.00	€ 46,875.00	-	-
Installation Costs		€ 562,500.00	€ 562,500.00	-	-
Component					
DMEGC battery packs				€ 3,375,000.00	€ 3,375,000.00
AME bi-directional 3-phases converter		-	-	€ 2,812,500.00	€ 2,812,500.00
Connect - SGN		-	-	€ 46,875.00	€ 46,875.00
Installation Costs		-	-	€ 562,500.00	€ 562,500.00
Total Costs of Goods Sold		**€ 8,383,125.00**	**€ 8,383,125.00**	**€ 6,796,875.00**	**€ 6,796,875.00**
Refurbishing costs		**€ -**	**€ -**	**€ -**	**€ -**
Gross margin		**€ 1,023,607.50**	**€ 1,023,607.50**	**€ 2,609,857.50**	**€ 2,609,857.50**
Operating Costs					
Initital investment	€ -4,700,000.00				
Department costs					
Sales		€ 22,444.50	€ 22,444.50	€ 22,444.50	€ 22,444.50
Development		€ 88,716.00	€ 88,716.00	€ 88,716.00	€ 88,716.00
Operations		€ 11,089.50	€ 11,089.50	€ 11,089.50	€ 11,089.50
Operations 'Installers'		€ 246,433.33	€ 246,433.33	€ 246,433.33	€ 246,433.33
Customer Support		€ 9,366.00	€ 9,366.00	€ 9,366.00	€ 9,366.00
Finance		€ 33,076.00	€ 33,076.00	€ 33,076.00	€ 33,076.00
Additional running cost		€ 58,614.00	€ 58,614.00	€ 58,614.00	€ 58,614.00
Marketing cost per lead		€ 312,500.00	€ 312,500.00	€ 312,500.00	€ 312,500.00
Marketing campaign costs		€ 30,000.00	-	-	-
Marketing department		€ 66,152.00	€ 66,152.00	€ 66,152.00	€ 66,152.00
Total Operating Costs		**€ 878,391.33**	**€ 848,391.33**	**€ 848,391.33**	**€ 848,391.33**
Operating Income	**€ -4,700,000.00**	**€ 145,216.17**	**€ 175,216.17**	**€ 1,761,466.17**	**€ 1,761,466.17**
Provision For Income Tax		€ 37,465.77	€ 45,205.77	€ 454,458.27	€ 454,458.27
Net Income	**-€ 4,700,000.00**	**€ 107,750.40**	**€ 130,010.40**	**€ 1,307,007.90**	**€ 1,307,007.90**

Figure 18: A part of the P&L statement for Zonneplan. This figure only contains the years 2023 and 2024, whilst the figure in Appendix C, contains the complete profit and loss statement.

The most important indicators in the profit and loss statement are the net incomes for each quarter. A positive net income indicates a profit for Zonneplan, while a negative net income signifies a loss. As shown in Figure 18, each quarter has a positive net income, except for 2023. Given that 2023 represents the initial investment only, it is logical that this net income is negative. However, all the other quarters are positive, which suggests that Zonneplan will indeed receive profit. This P&L statement confirms that investing in the home battery will lead to a profit for Zonneplan.

4.2.2 Cash flow overview Zonneplan

A P&L statement indicates whether Zonneplan has made a profit or loss during a quarter, providing insight into the project's overall profitability. However, a P&L statement will not show if the investment is earned back over time. Therefore, I created a cash flow overview alongside the P&L statement. This cash flow statement takes into account the initial investment at the end of each quarter.

Cash flow Zonneplan

	2023	2024			
Quarters		*1*	*2*	*3*	*4*
Initital investment	**€ -4,700,000.00**				
Revenue		€ 9,406,732.50	€ 9,406,732.50	€ 9,406,732.50	€ 9,406,732.50
Total Costs of Goods Sold		-€ 8,383,125.00	-€ 8,383,125.00	-€ 6,796,875.00	-€ 6,796,875.00
Operation Cost		-€ 878,391.33	-€ 848,391.33	-€ 848,391.33	-€ 848,391.33
EBIT		**€ 145,216.17**	**€ 175,216.17**	**€ 1,761,466.17**	**€ 1,761,466.17**
Taxes		-€ 37,465.77	-€ 45,205.77	-€ 454,458.27	-€ 454,458.27
Net Cash Flow	€ -4,700,000.00	€ 107,750.40	€ 130,010.40	€ 1,307,007.90	€ 1,307,007.90
Discounted Net Cash Flow	**€ -4,700,000.00**	**€ 102,619.42**	**€ 117,923.26**	**€ 1,129,042.56**	**€ 1,075,278.63**
Start of quarter cashflow		€ -4,700,000.00	€ -4,597,380.58	€ -4,479,457.31	€ -3,350,414.75
End of quarter cashflow		€ -4,597,380.58	€ -4,479,457.31	€ -3,350,414.75	€ -2,275,136.12

Figure 19: The cash flow overview of Zonneplan. The cash flow is based on the 10 to 90 profit-share ratio and the lowest selling price for Zonneplan.

The start and end cash flows represent the amount of money that Zonneplan has at the end of the balance. When negative, Zonneplan has a loss, and if positive, a profit is made. From the figure above, it becomes clear that with the current input parameters, Zonneplan will earn back its investment in the last quarter of 2024. The cash flow in Figure 19 is based on the application's dynamic energy prices, but I have also created a cash flow for the solar energy application. In Chapter 5, we elaborate on the different scenarios with various input parameters, and we present the results.

Working Capital

In addition to a cash flow overview, is it also important for a company to analyze its working capital. This is the difference between the current assets and liabilities of the company. It represents the capital that is available for day-to-day operations and equals the amount of money that a company needs to cover its short-term expenses. It is important that Zonneplan has an overview of their working capital. A negative working capital indicates that Zonneplan may need to find a way to cover its liabilities, such as obtaining a short-term loan. An overview of the working capital is stated in Appendix C. We analyze the working capital with the different scenarios in Chapter 5.

4.2.3 Cash flow customer

I created a cash flow overview for the customer as well. This overview will indicate if the home battery is a favorable investment for the customer. The cash flow overview is forecasted from 2023, when the product is purchased, until 2038. This extended period allows for the calculation of the payback time for the investment.

Cash flow Customer

	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034
Initial investment	**€ -5,000.00**											
Benefits PV		€ 717.79	€ 717.79	€ 717.79	€ 717.79	€ 717.79	€ 717.79	€ 717.79	€ 717.79	€ 717.79	€ 717.79	€ 717.79
Net Cash Flow	€ -5,000.00	€ 717.79	€ 717.79	€ 717.79	€ 717.79	€ 717.79	€ 717.79	€ 717.79	€ 717.79	€ 717.79	€ 717.79	€ 717.79
Discounted Net Cash Flow	€ -5,000.00	€ 683.61	€ 651.06	€ 620.05	€ 590.53	€ 562.41	€ 535.63	€ 510.12	€ 485.83	€ 462.69	€ 440.66	€ 419.68
Start of year cashflow		€ -5,000.00	€ -4,316.39	€ -3,665.34	€ -3,045.28	€ -2,454.76	€ -1,892.35	€ -1,356.72	€ -846.60	€ -360.78	€ 101.92	€ 542.58
End of year cashflow		€ -4,316.39	€ -3,665.34	€ -3,045.28	€ -2,454.76	€ -1,892.35	€ -1,356.72	€ -846.60	€ -360.78	€ 101.92	€ 542.58	€ 962.25

Figure 20: Cash flow overview for the customer. The original overview is from 2023 to 2038. This is only a snapshot of the first 10 years. An overview of the complete cash flow can be found in the Appendix. This cash flow is based on the benefits of the PV installation, a 10 to 90 profit-share ratio, and the 'Low selling price, Low demand' scenario.

A part of the cash flow overview, based on the PV benefits, is presented above. The initial investment is the price of the home battery for the customer. The benefits are the yearly benefits of the home battery application, and the start and end year cash flow indicates whether the customer has a negative or positive total balance. Different scenarios will yield different outputs, which we analyze in the next chapter.

4.3 Financing methods of the home battery

The foundation of the model, as explained in the previous section, is based on the financing method where the customer purchases the home battery directly from Zonneplan. However, there are different ways of financing a product beyond direct purchasing. A customer can take a loan, pay in multiple terms, or lease the product. These types of financing methods can make it more appealing for a customer to purchase a home battery, as they eliminate the need for an upfront investment. In the financial model, I have incorporated five different financing methods and Figure 21 provides a visual representation of these methods.

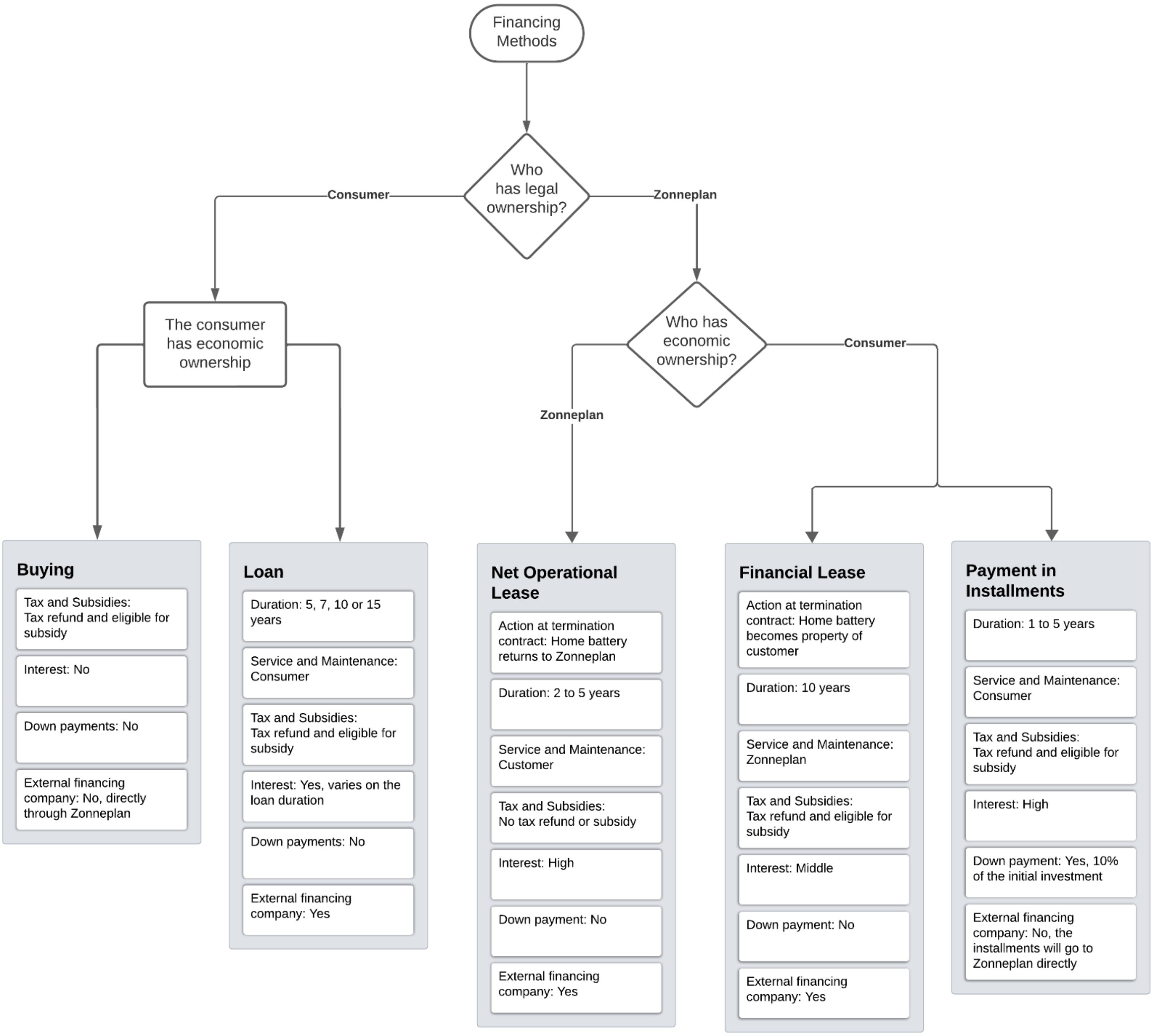

Figure 21: A decision tree that contains all the five financing methods that can be applied to the customer. The characteristics of the methods are depicted in the figure as well.

4.3.1 Buying the home battery

The most common method of purchasing a product is to buy it directly from the company. Buying is a straightforward financing approach, involving only the company and the customer in the transaction. The customer makes a direct payment of the product price to Zonneplan, and no external financing company is required in the process. Customers who choose this method can apply for tax refunds and potential subsidies.

However, a notable drawback is that the customer needs to pay the entire investment upfront. Some customers may not have the full amount in their bank account or may find it challenging to make such a significant investment. Therefore, offering different financing methods can expand the customer base, enabling more individuals to access and utilize the product.

When a customer purchases the home battery, the cash flow overview will reflect an initial investment in 2023. In the subsequent years, the cash flow will include only the benefits derived from using the battery, with no additional costs for the home battery after the initial investment.

4.3.2 Take out a loan

Another financing option is a loan. The customer can apply for a loan at an external financing company. Such an external company can be a bank or the National Warmtefonds, which offers energy savings loans. One advantage of a loan is that the customer retains legal ownership of the home battery, and the initial investment is spread across monthly loan payments. Additionally, the customer can still apply for a tax refund and subsidies. However, a disadvantage of a loan is the presence of interest. Interest payments are required in addition to the loan payments, resulting in a higher overall investment compared to a direct purchase of the home battery.

The National Warmtefonds offers loans for 7, 10, and 15 years. For households with a total income lower than €60,000, the interest rate is zero. For households with higher incomes, the interest will vary based on the loan duration. The interest is fixed, and an overview of the interest is depicted in Figure 22 (Warmtefonds, 2023). Alternatively, customers could take a loan at the bank. This will result in a higher interest rate than the National Warmtefonds. Bank loans can differ in duration from 5 to 15 years and the interest rate is fixed over the entire period (Actual interest rates, 2023). The interest rates are depicted in Figure 22 as well.

Information on loans scenario	
Warmtefonds	
Interest 7 years	4.5%
Interest 10 years	4.5%
Interest 15 years	4.8%
Interest if total income<60K	0.0%
Consumer loan	
Interest 5 years	8.9%
Interest 7 years	8.9%
Interest 10 years	8.9%
Interest 15 years	11.6%

Figure 22: The different interest rates for the National Warmtefonds and a customer loan at a bank. The customer loan interest rates are based on the bank that offers the lowest rate, which can be found on the Dutch actual interest rates website (Actual interest rates, 2023).

The interest rates for customer loans are higher than those from the National Warmtefonds, as they aim to incentivize households to invest in the sustainability of their homes. However, the National Warmtefonds does not include the home battery in their options for a loan yet. They offer loans for a heat pump, solar panels, isolation, and floor heating. However, given the expected entry of home batteries into the Dutch household market, we may anticipate that the National Warmtefonds will incorporate the home battery into its loan options in the future. Therefore, the option for the National Warmtefonds is included in the model. An overview of the cash flow when a customer takes a loan is stated in Appendix D.

4.3.3 Financial lease

I also have created financing methods in which Zonneplan retains legal ownership of the home battery, such as leasing and payment in installments. Leasing can be divided into two types: financial lease and net operational lease. This section will elaborate on the financial lease.

In a financial lease arrangement, Zonneplan is the legal owner of the battery, while the customer is the economic owner. As the economic owner, the customer can still apply for a tax refund or subsidies. It is common for the product to become the property of the customer after the contract terminates. Therefore, I assume that the customer will purchase the home battery at its residual value if the contract ends.

The duration of the contract is set at 10 years since the financial lease should cover a substantial period of the battery's useful life, which is 16 years. After 10 years, the residual value of the home battery is around €1000, which will be the purchase value. The financial lease is executed by an external company. Zonneplan will receive the purchase price for the battery at the start of the financial lease, and the interest is directed to the financial company. This financing method will not change the income stream of Zonneplan. However, the customer is going to pay more than the initial purchase price due to the interest. The interest rate is equal to the rate for a 10-year customer loan, which is 8.9%. The cash flow overview resulting from this financing method is stated in Appendix D.2.

4.3.4 Net operational lease

In addition to a financial lease, a net operational lease is also a viable option. A net operational lease is a financing method where both the legal and economic ownership belong to Zonneplan. When the contract is terminated, the battery returns to Zonneplan. Since Zonneplan is the economic owner, the customer cannot apply for tax refunds or subsidies. Furthermore, the customer bears the service and maintenance costs. The duration of a net operational lease contract is relatively short, and I have used the duration of 2 to 5 years in the financial model.

Moreover, the interest rate for a net operational lease is relatively high compared to the other financing method, namely 11%. The leasing contract is facilitated through an external financing company. Similar to the financial lease, Zonneplan will receive the full price at the beginning of the contract, and the interest will go to the external company. After the termination of the contract, the battery is returned to Zonneplan and refurbished for use. The estimated cost to refurbish a home battery is €160 per kWh (Gartner, 2022). For a Zonneplan home battery, which is 10 kWh, the total refurbishing cost for one battery will be €1600. These are costs that Zonneplan need to pay when a customer wants to net operational lease the battery.

The customer will also incur additional costs at the termination of the contract. The battery needs to be deinstalled, equivalent to the installation cost of €300. These costs are the customer's responsibility and are paid with the final installment of the leasing contract. An overview is added to the appendix.

4.3.5 Payment in installments

The last financing method that I included in this model is payment in installments. Payment in installments is a method in which Zonneplan has legal ownership, but the customer holds economic ownership. Its duration is short-term and can vary between one to five years. This method carries higher risks since there is a chance that the customer may not pay in time or at all. The elevated risks contribute to a high interest rate of 14% (ING, 2024). When the home battery is recognized as a sustainability investment of a house, it becomes feasible to deduct the interest from taxes. This makes payment in installments an interesting option to explore, even with the high interest rate.

Furthermore, the customer needs to make a downpayment of ten percent of the purchase price. There is no external financing company involved, and the payments go directly to Zonneplan. This holds that both the interest and the downpayment is directed to Zonneplan itself. This arrangement creates a shift in the cash flow overview of Zonneplan and its working capital. An overview of the working capital for Zonneplan and the cash flow for the customer is provided in Appendix D.

4.4 Summary

The financial model consists of input and output sheets. The input sheets contain all the necessary input parameters, including department costs, battery specifications, and additional costs. The output sheets are a P&L statement for Zonneplan and a cash flow overview for both Zonneplan and the customer.

The customer can choose different financing methods for the home battery. The methods that are included in this model are: buying, taking out a loan, net operational lease, financial lease, and payment in installments.

Chapter 5 Results of the Financial Model

In this chapter we introduce the different scenarios that are incorporated into the financial model. Each scenario will generate different results, which we analyze in the second part of this chapter. The fifth research question is addressed in this chapter is.

5.1 The different scenarios

The scenarios are displayed in a dropdown list within the model, formatted as 'yellow' cells. Figure 23 provides an overview of the scenarios and the corresponding dropdown lists.

Scenario analyses	
Application Battery	Benefits Day-Ahead
Netting	Netting Agreement
Different scenario's: sell price, and installations	Original scenario
Forecast EPEX volatility	EPEX original
Financing methods	Buying

Figure 23: The different scenarios and dropdown lists as created in the financial model.

The cells 'Application battery', 'Netting', and 'Forecast EPEX volatility' are related to the applications of the battery as explained in Chapter 3. The application battery includes the options 'Benefits day-ahead' and 'Benefits PV'. With netting, there is the option to follow the netting agreement or apply no netting or complete netting throughout all the years. The forecast EPEX volatility has the EPEX original option, where the volatility remains constant over the years, or the forecast volatility, which assumes that the EPEX prices will drop to a lower but stable level. Additionally, the different financing methods can be chosen from the last row.

I have created a dropdown list with four different scenarios that modify the selling price and the number of sales. These scenarios are: *'High selling price, High demand', 'Low selling price, Low demand', 'Moderate selling price, Moderate demand',* and *'Moderate selling price, Low demand'.* These scenarios do not apply to the law of demand, in which the demand for a product change inversely to its price, all else being equal. However, the home battery market is still in the formation progress, and there is limited information available on the market conditions. Therefore, Zonneplan wanted to implement various scenarios with different prices. Given the developing and undefined nature of the home battery market, Zonneplan wanted scenarios reflecting diverse conditions. The scenario *'High selling price, High demand'* acknowledges the potential for premium pricing in emerging markets, while *'Low selling price, Low demand'* addresses the uncertainties.

For Zonneplan, the *'High selling price, High demand'* is the most favorable scenario. However, from the customer's perspective, this scenario is considered the most negative, as it corresponds to the highest selling price. The '*Moderate selling price, Moderate demand'* is an in-between scenario, lying between the high and low selling price and the high and low demand. The *'Moderate selling price, Low demand'* scenario is the original scenario used to build the financial model. The scenarios are presented in Figure 24.

List with different scenarios name	Selling Price	Installations 2024	Installations 2025	Installations 2026
High selling price, High demand	€ 6,000.00	30,000	33,000	35,000
Low selling price, Low demand	€ 5,000.00	7,500	15,000	30,000
Moderate selling price, Moderate demand	€ 5,500.00	15,000	22,000	30,000
Moderate selling price, Low demand	€ 5,500.00	7,500	15,000	30,000

Figure 24: List with the different scenarios related to the selling price and number of sales.

The selling price should exceed the production costs of the battery, estimated at around €4500. Literature suggests that the profit margins for the battery businesses typically range from 10% to 30% (Ryzhkov, 2023). Therefore, the selling price varies in the scenarios, ranging from €5000 to €6000.

The second variable that varies for each scenario, is the number of installations. The low demand is based on the sales that Zonneplan obtained when they released the charging stations for an electrical vehicle. Conversely, the high demand is based on the addressable market, encompassing all households with solar panels. This is equal to two million households. Assuming Zonneplan captures one percent of the market share, it would sell 30.000 home batteries in the first year. The moderate scenario is based on the average values of the low and high demand.

5.1.1 The profit-share ratio

Different scenarios will emerge based on varying profit-share ratios. This ratio indicates the percentage of the home battery benefits allocated to the customer and Zonneplan. The ratio should be structured to provide Zonneplan with a profit share that makes their investment appealing, while also offering customers a profit share that enhances the attractiveness of investing in the home battery.

Profit-share	
Zonneplan profit share	10%
Customer profit share	90%

Figure 25: The profit-share input parameters in the financial model. In this figure, Zonneplan receives 10% of the total benefits of the home battery, and the customer 90%.

The profit-share ratio will vary between 0 and 30 percent for Zonneplan. The ratios will generate different results. We will elaborate on these results in Section 5.3.

5.2 The output variables of the model

To analyze the various scenarios, output values are calculated based on the cash flow of both the customer and Zonneplan. These values are presented below the cash flows itself.

Output Values Customer

- *IRR.*
- *NPV.*
- *PVI.*
- *Payback time in years.*
- *ROI.*

Output Values Zonneplan

- *IRR.*
- *NPV.*
- *PVI.*
- *Payback time in years.*

The first output value is the Internal Rate of Return (IRR), a metric that estimates the profitability of potential investments. A higher IRR indicates a more favorable investment. The IRR formula is calculated with the formula represented below, where t represents the number of periods, CF stands for cash flow, and C_0 is the initial investment.

$$0 = NPV = \sum_{t=1}^{T} \frac{CF_t}{(1 + IRR)^t} - C_0$$

The second value is the Net Present Value (NPV), which calculates the difference between the present value of cash inflows compared to the present value of cash outflows. A positive NPV suggests the project is worth investing in. The NPV is calculated with the following formula:

$$NPV = -C_0 + \frac{CF_1}{1 + r} + \frac{CF_2}{(1 + r)^2} + \cdots + \frac{CF_T}{(1 + r)^T}$$

Third, the Present Value Index (PVI) is calculated, equivalent to the profitability index. It measures the project attractiveness by dividing the present value of forecasted cash flows by the initial investment. A PVI greater than one indicates that the project is worth investing in. We used the following formula for the PVI:

$$PVI = \frac{PV\ of\ future\ cash\ flows}{C_0}$$

Fourth, the payback time is calculated. For the customer, the payback time is the time in which the initial investment is paid back, and for Zonneplan is it the time in which the investment of the project is paid back. The same payback time formula is applied to both the customer and Zonneplan, which is:

$$Payback\ time = Years\ before\ full\ recovery + \frac{Unrecovered\ cost\ at\ start\ of\ the\ year}{Cash\ flow\ during\ the\ year}$$

The fifth and last output value is the Return On Investment (ROI), calculated exclusively for the customer. ROI assesses the profitability of an investment, independent of the initial investment, by comparing the gains or losses from a project relative to the costs. The formula that we use to calculate the ROI is expressed below:

$$ROI = \left(\frac{Total\ revenue - Total\ costs}{Total\ costs}\right) * 100\%$$

The financing methods that do not have an initial investment, which are loan and lease contracts, cannot calculate the IRR, PVI, and payback time. Therefore, the ROI metric is calculated as well to get a comprehensive overview of the different scenarios and their profitability.

5.3 The results of the financial model

For each scenario, the output variables are calculated for both the customer and Zonneplan. Comparing these scenarios will provide us with insights into which options we need to choose to make the investment in the home battery the most favorable.

5.3.1 The results for the customer

Nearly every scenario influences the output values for the customer, except for the *'Moderate selling price, Low demand'* scenario. This scenario is equivalent to the *'Moderate selling price, Moderate demand'* scenario, as the demand does not influence the customer's output values.

As mentioned in Section 2.3.3, the investment in the home battery is considered financially attractive when the payback time does not exceed nine years and the ROI is higher than 100 percent. All the scenarios meeting these conditions are summarized in two Excel sheets, one for the PV application and one for the day-ahead application.

PV application

Three types of financing methods yield attractive output values when comparing the different scenarios from the PV application. These financing methods are buying, loan Warmtefonds, and payment in installments. All output values are based on a forecast of 15 years, as explained in the customer cash flow in Section 4.2.2.

All scenarios that are financially attractive when the home battery is bought are visualized in Figure 26. The figure illustrates that it is only attractive to purchase the home battery when there is no netting or a netting agreement. If the netting agreement is 100 percent, it is not attractive for a customer to purchase the product. Additionally, the battery is only worth investing in when Zonneplan sells it for €5000 or €5500, which corresponds to the low and moderate selling prices. The profit share runs from 70 to 100 percent for the customer. When the profit share for the customer increases, the output values become more positive. This can be logically derived as it implies that the customer can retain a larger share of the generated profits from the home battery. As shown in Figure 26, the profit share greater or equal to 89 percent will give a payback time of nine years or less.

Financing Method	Netting	Different scenario's	Profit Share Customer	IRR	NPV	PVI	Payback Time	ROI
Buying	No Netting	Low Selling Price, Low Demand for Zonneplan	89	11%	€2,367.62	1.47	8.9	113%
Buying	Netting Agreement	Low Selling Price, Low Demand for Zonneplan	89	10%	€2,005.56	1.4	9.73	104%
Buying	No Netting	Low Selling Price, Low Demand	90	12%	€2,450.41	1.49	8.78	115%
Buying	Netting Agreement	Low Selling Price, Low Demand	90	10%	€2,084.27	1.42	9.6	107%
Buying	No Netting	Low Selling Price, Low Demand for Zonneplan	91	12%	€2,533.19	1.51	8.66	118%
Buying	Netting Agreement	Low Selling Price, Low Demand for Zonneplan	91	11%	€2,162.99	1.43	9.47	109%
Buying	No Netting	Moderate Selling Price, Moderate Demand	91	10%	€2,033.19	1.37	9.77	98%
Buying	No Netting	Low Selling Price, Low Demand for Zonneplan	92	12%	€2,615.97	1.52	8.54	120%
Buying	Netting Agreement	Low Selling Price, Low Demand for Zonneplan	92	11%	€2,241.70	1.45	9.35	111%
Buying	No Netting	Moderate Selling Price, Moderate Demand	92	10%	€2,115.97	1.38	9.63	100%
Buying	No Netting	Low Selling Price, Low Demand for Zonneplan	93	12%	€2,698.75	1.54	8.43	123%
Buying	Netting Agreement	Low Selling Price, Low Demand for Zonneplan	93	11%	€2,320.41	1.46	9.23	114%
Buying	No Netting	Moderate Selling Price, Moderate Demand	93	10%	€2,198.75	1.4	9.5	102%
Buying	No Netting	Low Selling Price, Low Demand for Zonneplan	94	12%	€2,781.54	1.56	8.32	125%
Buying	Netting Agreement	Low Selling Price, Low Demand for Zonneplan	94	11%	€2,399.13	1.48	9.12	116%
Buying	No Netting	Moderate Selling Price, Moderate Demand	94	11%	€2,281.54	1.41	9.37	104%
Buying	No Netting	Low Selling Price, Low Demand for Zonneplan	95	13%	€2,864.32	1.57	8.21	127%
Buying	Netting Agreement	Low Selling Price, Low Demand for Zonneplan	95	11%	€2,477.84	1.5	9	118%
Buying	No Netting	Moderate Selling Price, Moderate Demand	95	11%	€2,364.32	1.43	9.25	107%
Buying	No Netting	Low Selling Price, Low Demand for Zonneplan	96	13%	€2,947.10	1.59	8.1	130%
Buying	Netting Agreement	Low Selling Price, Low Demand for Zonneplan	96	12%	€2,556.56	1.51	8.9	121%
Buying	No Netting	Moderate Selling Price, Moderate Demand	96	11%	€2,447.10	1.44	9.12	109%
Buying	No Netting	Low Selling Price, Low Demand for Zonneplan	97	13%	€3,029.88	1.61	8	132%
Buying	Netting Agreement	Low Selling Price, Low Demand for Zonneplan	97	12%	€2,635.27	1.53	8.79	123%
Buying	No Netting	Moderate Selling Price, Moderate Demand	97	11%	€2,529.88	1.46	9	111%
Buying	No Netting	Low Selling Price, Low Demand for Zonneplan	98	13%	€3,112.66	1.62	7.9	134%
Buying	Netting Agreement	Low Selling Price, Low Demand for Zonneplan	98	12%	€2,713.98	1.54	8.69	125%
Buying	No Netting	Moderate Selling Price, Moderate Demand	98	11%	€2,612.66	1.48	8.89	113%
Buying	No Netting	Low Selling Price, Low Demand for Zonneplan	99	13%	€3,195.45	1.64	7.81	137%
Buying	Netting Agreement	Low Selling Price, Low Demand for Zonneplan	99	12%	€2,792.70	1.56	8.59	127%
Buying	No Netting	Moderate Selling Price, Moderate Demand	99	12%	€2,695.45	1.49	8.78	115%
Buying	No Netting	Low Selling Price, Low Demand for Zonneplan	100	14%	€3,278.23	1.66	7.71	139%
Buying	Netting Agreement	Low Selling Price, Low Demand for Zonneplan	100	12%	€2,871.41	1.57	8.49	130%
Buying	No Netting	Moderate Selling Price, Moderate Demand	100	12%	€2,778.23	1.51	8.67	118%

Figure 26: Scenarios based on the financing method buying. The scenarios are sorted from lowest to highest profit share.

Taking out a Warmtefonds loan is only attractive when the annual income of the household does not exceed 60,000 euros. In such circumstances, the loan will carry zero interest. Similar to the method of buying, taking out a Warmtefonds loan is only attractive when there is no 100 percent netting, and the lowest selling price is applied. Moreover, as the duration of the loan period extends, the investment becomes more beneficial. The scenarios related to the Warmtefonds loan are depicted in Figure 27.

Financing Method	Netting	Different scenario's	Duration	Interest	Profit Share Customer	NPV	ROI
Loan Warmtefonds	No Netting	Low Selling Price, Low Demand	15	0.0%	89	€3,907.74	113%
Loan Warmtefonds	No Netting	Low Selling Price, Low Demand	10	0.0%	89	€3,506.76	113%
Loan Warmtefonds	No Netting	Low Selling Price, Low Demand	7	0.0%	89	€3,234.50	113%
Loan Warmtefonds	No Netting	Low Selling Price, Low Demand	5	0.0%	89	€3,038.15	113%
Loan Warmtefonds	Netting Agreement	Low Selling Price, Low Demand	15	0.0%	89	€3,545.67	104%
Loan Warmtefonds	Netting Agreement	Low Selling Price, Low Demand	10	0.0%	89	€3,144.69	104%
Loan Warmtefonds	Netting Agreement	Low Selling Price, Low Demand	7	0.0%	89	€2,872.43	104%
Loan Warmtefonds	Netting Agreement	Low Selling Price, Low Demand	5	0.0%	89	€2,676.08	104%
Loan Warmtefonds	No Netting	Low Selling Price, Low Demand	15	0.0%	90	€3,990.52	115%
Loan Warmtefonds	No Netting	Low Selling Price, Low Demand	10	0.0%	90	€3,589.54	115%
Loan Warmtefonds	No Netting	Low Selling Price, Low Demand	7	0.0%	90	€3,317.28	115%
Loan Warmtefonds	No Netting	Low Selling Price, Low Demand	5	0.0%	90	€3,120.93	115%
Loan Warmtefonds	Netting Agreement	Low Selling Price, Low Demand	15	0.0%	90	€3,624.38	107%
Loan Warmtefonds	Netting Agreement	Low Selling Price, Low Demand	10	0.0%	90	€3,223.40	107%
Loan Warmtefonds	Netting Agreement	Low Selling Price, Low Demand	7	0.0%	90	€2,951.15	107%
Loan Warmtefonds	Netting Agreement	Low Selling Price, Low Demand	5	0.0%	90	€2,754.79	107%
Loan Warmtefonds	No Netting	Low Selling Price, Low Demand	15	0.0%	91	€4,073.30	118%
Loan Warmtefonds	No Netting	Low Selling Price, Low Demand	10	0.0%	91	€3,672.32	118%
Loan Warmtefonds	No Netting	Low Selling Price, Low Demand	7	0.0%	91	€3,400.06	118%
Loan Warmtefonds	No Netting	Low Selling Price, Low Demand	5	0.0%	91	€3,203.71	118%

Figure 27: Scenario overview for the financing method 'Loan Warmtefonds'.

The final financing method is payment in installments. However, this method is only considered attractive when the profit-share ratio for the customer is 100 percent. This implies that Zonneplan does not receive any share of the generated benefits, which is not a viable argument. Therefore, payment in installments is not a feasible option.

Analyzing the profit-share ratios across all potential scenarios establishes that the profit-share for the customers should be at least 82 percent. Nevertheless, the investment must also be appealing to Zonneplan. Therefore, we set the profit-share ratio at 90 to 10 for the customer and Zonneplan, respectively. Figure 28 displays all the financially attractive scenarios when the profit-share ratio for the customer is set at 90 percent.

Financing Method	Netting	Different scenario's	Duration	Interest	Profit Share Customer	IRR	NPV	PVI	Payback Time	ROI
Buying	No Netting	Low Selling Price, Low Demand	-	-	90	12%	€2,450.41	1.49	8.78	115%
Buying	Netting Agreement	Low Selling Price, Low Demand	-	-	90	10%	€2,084.27	1.42	9.6	107%
Loan Warmtefonds	No Netting	Low Selling Price, Low Demand	15	0.0%	90		€3,990.52			115%
Loan Warmtefonds	No Netting	Low Selling Price, Low Demand	10	0.0%	90		€3,589.54			115%
Loan Warmtefonds	No Netting	Low Selling Price, Low Demand	7	0.0%	90		€3,317.28			115%
Loan Warmtefonds	No Netting	Low Selling Price, Low Demand	5	0.0%	90		€3,120.93			115%
Loan Warmtefonds	Netting Agreement	Low Selling Price, Low Demand	15	0.0%	90		€3,624.38			107%
Loan Warmtefonds	Netting Agreement	Low Selling Price, Low Demand	10	0.0%	90		€3,223.40			107%
Loan Warmtefonds	Netting Agreement	Low Selling Price, Low Demand	7	0.0%	90		€2,951.15			107%
Loan Warmtefonds	Netting Agreement	Low Selling Price, Low Demand	5	0.0%	90		€2,754.79			107%

Figure 28: Scenario overview with all the 90 to 10 profit-share ratios.

According to Figure 28, it is evident that purchasing the home battery is not advisable if there is complete netting. However, when the netting agreement is active or there is no netting at all, the recommended selling price to make the investment viable is €5000.

Day-ahead application

In addition to the PV application, the battery can also be used with the day-ahead application. When we analyze the scenarios based on 365 cycles a year, none of them are attractive to invest in. The payback time extends to 10 years or more and the ROI is below 100 percent, sometimes even turning negative.

However, if we double the number of cycles to twice a day, totaling 730 cycles, attractive scenarios emerge. Buying, taking out a Warmtefonds loan, and payment in installments are now viable financing methods that will result in positive output values. The various scenarios available for customers are outlined in the figure below.

Financing Method	Forecast EPEX volatility	Different scenario's	Duration	Interest	Profit Ratio Customer	IRR	NPV	PVI	Payback Time	ROI
Buying	Epex original	Low Selling Price, Low Demand	-	-	90	14%	€3,329.08	1.67	7.66	141%
Buying	Epex original	Moderate Selling Price, Moderate Demanc	15	0.0%	90	12%	€2,829.08	1.51	8.61	119%
Loan warmtefonds	Epex original	Moderate Selling Price, Moderate Demanc	10	0.0%	90		€4,523.21			119%
Loan warmtefonds	Epex original	Moderate Selling Price, Moderate Demanc	10	0.0%	90		€4,082.13			119%
Loan warmtefonds	Epex original	Moderate Selling Price, Moderate Demanc	7	0.0%	90		€3,782.64			119%
Loan warmtefonds	Epex original	Moderate Selling Price, Moderate Demanc	5	0.0%	90		€3,566.66			119%
Loan warmtefonds	Epex original	Low Selling Price, Low Demand	15	0.0%	90		€4,869.19			141%
Loan warmtefonds	Epex original	Low Selling Price, Low Demand	7	0.0%	90		€4,195.96			141%
Loan warmtefonds	Epex original	Low Selling Price, Low Demand	10	0.0%	90		€4,468.21			141%
Loan warmtefonds	Epex original	Low Selling Price, Low Demand	5	0.0%	90		€3,999.60			141%
Loan warmtefonds	Epex original	Low Selling Price, Low Demand	7	4.5%	90		€3,419.30			103%
Payment in Installments	Epex original	Low Selling Price, Low Demand	2	14.0%	90	11%	€2,747.68	4.98	9.88	102%

Figure 29: Scenario overview for the day-ahead application. The profit-share ratio is fixed at 90 percent.

Despite the appealing output values, it is currently unrealistic for a home battery to execute more than one cycle a day. The processes of loading and discharging energy consume too much time to facilitate two cycles a day. Therefore, the day-ahead application is currently unattractive for investment from a financial perspective. However, if running multiple cycles a day becomes feasible in the future, the application holds potential, and customers can then consider the options that we outlined in the figure above.

5.3.2 The results for Zonneplan

From the customer's results, it is evident that currently, only the PV application is financially attractive. Furthermore, the profit-share percentage for Zonneplan should be set to 10 percent and the selling price should be equal to €5000.

In the case of a customer taking out a Warmtefonds loan, Zonneplan will not encounter a difference compared to a direct purchase. The customer pays the same amount of money for the battery but lends money instead of their capital. Therefore, we focus the analysis on the financing methods buying and payment in installments. The output values are based on the Zonneplan cash flow created for three years.

As depicted in the figure below, all options are financially attractive for Zonneplan. Whether the home battery is acquired with own capital or a Warmtefonds loan, the IRR is 31%, and the payback time is within one and a half years. When the home battery is paid in installments, the IRR is 55%, and the payback time is approximately a half year. Both options demonstrate financially strong output values, suggesting that the home battery is a worthwhile investment from a corporate viewpoint.

Input Parameters						
Application Battery	Benefits PV	Benefits PV	Benefits PV	Benefits PV	Benefits PV	Benefits PV
Netting	Netting Agreement	No Netting	Complete Netting	Netting Agreement	No Netting	Complete Netting
Forecast EPEX						
Financing Method	Buying	Buying	Buying	Payment in Installments	Payment in Installments	Payment in Installments
Output Variables						
IRR	**31%**	**31%**	**31%**	**55%**	**55%**	**55%**
NPV	**€ 19,772,351.04**	**€ 19,828,652.51**	**€ 19,749,046.89**	**€ 45,270,956.69**	**€ 45,327,258.16**	**€ 45,247,652.54**
PVI	**5.21**	**5.22**	**5.20**	**10.63**	**10.64**	**10.63**
Payback Time	**1.5**	**1.5**	**1.5**	**0.6**	**0.6**	**0.6**

Figure 30: Scenario overview for Zonneplan. The scenarios are based on a 10 percent profit-share for Zonneplan, and all output values are based on the 'Low Selling Price, Low Demand' scenario.

However, payment in installments will lead to a change in working capital. The full selling price is not paid at once, which results in fewer assets compared to simply purchasing the product. As represented in Figure 31, the working capital is negative for all three forecasted years, reaching extremes such as minus 10 million in the second quarter of 2026. A negative working capital can limit the financial flexibility of Zonneplan. It can become challenging to fulfill all supplier payments and can make Zonneplan more vulnerable to unexpected changes in cash flows. Considering this effect, the payment in installments method is not a favorable option for Zonneplan.

Working capital	**2024**				**2025**				**2026**			
Current Assets	*1*	*2*	*3*	*4*	*1*	*2*	*3*	*4*	*1*	*2*	*3*	*4*
Debtors (customers)	€ 1,281,001.75	€ 2,562,003.50	€ 3,843,005.26	€ 5,124,007.01	€ 7,686,010.51	€ 10,248,014.02	€ 12,810,017.52	€ 15,372,021.03	€ 19,215,026.29	€ 23,058,031.54	€ 26,901,036.80	€ 30,744,042.06
Current liabilities												
Creditors (Zonneplan to suppliers)	€ 0.00	-€ 8,383,125.00	-€ 8,383,125.00	-€ 6,796,875.00	-€ 6,796,875.00	-€ 13,593,750.00	-€ 13,593,750.00	-€ 13,593,750.00	-€ 13,593,750.00	-€ 27,187,500.00	-€ 27,187,500.00	-€ 27,187,500.00
Taxes	-€ 506,036.69	-€ 513,776.69	-€ 923,029.19	-€ 923,029.19	-€ 1,909,670.35	-€ 1,909,670.35	-€ 1,909,670.35	-€ 1,909,670.35	-€ 3,882,952.67	-€ 3,882,952.67	-€ 3,882,952.67	-€ 3,882,952.67
Operation Cost	-€ 878,391.33	-€ 848,391.33	-€ 848,391.33	-€ 848,391.33	-€ 1,450,224.67	-€ 1,450,224.67	-€ 1,450,224.67	-€ 1,450,224.67	-€ 2,653,891.33	-€ 2,653,891.33	-€ 2,653,891.33	-€ 2,653,891.33
Working capital	**-€ 103,426.28**	**-€ 7,183,289.52**	**-€ 6,311,540.27**	**-€ 3,444,288.52**	**-€ 2,470,759.51**	**-€ 6,705,631.00**	**-€ 4,143,627.50**	**-€ 1,581,623.99**	**-€ 915,567.72**	**-€ 10,666,312.46**	**-€ 6,823,307.20**	**-€ 2,980,301.95**

Figure 31: The working capital of Zonneplan when the customer is paying in installments. The overview is based on the 90 to 10 profit-share ratio and the 'Low selling price, Low demand' scenario.

5.4 Summary

Analyzing various scenarios along with their corresponding output values provides valuable insights to determine the viability of investing in a home battery for both Zonneplan and the customer. Zonneplan should base the application choice on the most positive scenarios for the customer, equivalent to selling the home battery for €5000. Furthermore, the profit-share ratio will be 90 to 10, for the customer and Zonneplan, respectively.

Currently, the day-ahead application is financially unattractive for investment. However, the PV application yields positive returns in certain scenarios. If the customer purchases the home battery for €5000, the investment is earned back within 9 years, with an ROI of 115 percent. Additionally, if the customer has an annual income below 60,000 euros, taking a Warmtefonds loan is a feasible option. The customer should base their decision on the financial validity of their household.

Zonneplan's scenarios are consistently positive, indicating that investing in the home battery is a promising project for the company. When customers purchase the product, the payback time for Zonneplan's investment is one and a half years. When the payment is divided into installments, the payback time is approximately half a year. However, the decreasing working capital with this financing method makes it less attractive for Zonneplan to invest in.

Chapter 6 The impact of the Home Battery

We provided a comprehensive overview of the current climate scenario, the diverse applications of the battery, and the financial implications for both customers and Zonneplan. In this chapter we delve into the impact of implementing the battery in Dutch households, addressing the sixth research question. The analysis encompasses three distinct topics: the effect on the main grid, the contribution to CO_2 reductions, and the social implications associated with the utilization of the home battery.

6.1 The effects of the home battery on the main grid

The Dutch main grid is currently facing significant challenges due to the escalating demand for electricity and the frequent oversupply of solar energy. This pressure is exacerbated by the growing adoption of solar panels, heat pumps, and electric vehicle chargers in households, along with firms transitioning from gas to electricity. The necessary expansion of the main grid to accommodate this new supply and demand of electricity is a lengthy project, spanning multiple years (Central Government, 2023). However, an immediate solution is required to alleviate the current pressure on the overloaded main grid.

Home batteries can be used to reduce the peak load effectively. If all the households equipped with solar panels utilize home batteries, the estimated peak load could be reduced by 10 to 15 percent (Cappellen, et al., 2023). This reduction could potentially postpone the need for grid expansion in various regions of the Netherlands, depending on the number of households and the share of home batteries.

There are two methods by which home batteries can contribute to lowering the peak load. First, a battery can be used to decrease the peak load within the household itself. By storing self-generated solar energy, households can utilize the battery during periods of high electricity demand. This will relieve pressure of the main grid, and households will not need to upgrade their grid connection to accommodate higher demand (Cappellen, et al., 2023). Second, a battery can be used to release the grid congestion in the main grid. Through congestion management, households can receive compensation for adjusting their energy consumption patterns. A home battery can be used in this market to prevent congestion in other parts of the main grid (Cappellen, et al., 2023).

However, it is important to note that the impact of home batteries on the main grid is not always positive. When operating based on day-ahead prices, there is a potential increase in electricity demand on the main grid, leading to an increase in the peak load. In instances of low prices, the battery stores electricity, contributing to a potential increase of 5 to 25 percent in the peak load (Schöne, 2024). When a significant amount of wind and solar energy is generated, the grid load increases. Moreover, if the prices are low during periods of high grid load, the battery continues to charge energy despite the already high demand from households, exacerbating the overloaded main grid. Therefore, the usage of home batteries will not always have a positive impact on the main grid.

6.2 The contribution of the home battery to the CO_2 reduction

Investing in a home battery not only provides benefits for the household but also contributes significantly to CO_2 reduction. An average household consuming 4,500 kWh and having a PV system capacity of 7.5kW can achieve a 45% reduction in CO_2 emissions through the installation of solar panels alone. However, this reduction increases to 79% percent when a home battery is added, representing an increase of 34% (Diermann, 2021).

Home batteries can reduce CO_2 emissions when operating based on day-ahead prices. In this scenario, the battery charges during periods of low electricity prices and supplies electricity to the household during peak price periods. It is notable that the charging moments coincide with low CO_2 emission moments (Cappellen, et al., 2023). This correlation is attributed to the high production of wind- or solar energy during these moments, which are CO_2 neutral sources of electricity. Therefore, home batteries working with day-ahead prices contribute to a reduction in CO_2 emissions.

Figure 32 provides an overview of the CO_2 reduction potential for home batteries, as analyzed by the University of Delft (Cappellen, et al., 2023). The most substantial CO_2 reduction occurs when households invest in an electric vehicle, a heating pump, and solar panels. Additionally, when the battery operates with day-ahead prices and stores solar energy, it achieves the highest level of CO_2 reduction. The reduction depicted in Figure 32 is calculated based on the one-year reduction per kWh. When a 10 kWh home battery is used with a combination of solar energy and day-ahead prices, the CO_2 reduction amounts 130 kg for a household with a PV installation and increases to 160 kg when there is an additional heating pump and electrical vehicle. From the target group analysis, it became evident that approximately 910,800 households aim to invest in a home battery within the next 5 years. Multiplying this with the CO_2 reduction illustrates that the widespread adoption of the home battery has the potential to reduce millions of CO_2 emissions in a year.

CO2 reduction per year by usage of the home battery	Application: Solar energy	Application: Solar energy and Day-ahead prices
	CO2 reduction per kWh battery capacity per year	CO2 reduction per kWh battery capacity per year
Housholds with PV installation	10 kg CO2/kWh	13 kg CO2/kWh
Households with PV installation, EV and Heating pump	12 kg CO2/kWh	16 kg CO2/kWh

Figure 32: Overview of the CO_2 reduction of the home overview from (Cappellen, et al., 2023).

6.3 The social impact of the home battery

The concept of sustainability relies on three pillars: economic, environmental, and social (Move to impact, 2024). The economic pillar is related to the financial added value of the battery and the profit for the company. The environmental pillar represents the added value of the battery to the climate goals. Finally, the social pillar stands for equal rights among all households in the Netherlands.

More than 900,000 households spend a relatively large portion of their income on energy (Middelkoop, et al., 2019). When the Netherlands transitions to sustainable energy, there is a risk that these households may struggle to pay their energy bills, in particular those with low incomes. They face challenges in investing in solar panels or a home battery due to the associated high investment. Additionally, many of these households reside in rented homes. In such cases, the households must either bear the costs of sustainable options or the property owner can make the investments, resulting in a potential increase in monthly rent. Unfortunately, low-income households often cannot afford these investments, hindering their ability to adopt more sustainable practices.

To ensure the applicability of all three pillars to the home battery, it is essential to provide equal opportunities for all types of households, regardless of income. To achieve this, subsidies should be established to reduce the costs of batteries for lower-income households. This financial support can make sustainable energy options more accessible to a broader range of individuals.

There are already several subsidies for sustainable solutions, such as solar panels. Since 2023, solar panels are exempt from VAT when installed on the household's premises. Furthermore, Warmtefonds provides a loan, as elaborated on in Chapter 4. For households with a total income below 60,000 euros, the interest rate is equal to zero (Warmtefonds, 2023). This implies that the loan is essentially interest-free, and only the principal amount needs to be repaid without any additional interest. Next to Warmtefonds, a significant number of Dutch municipalities also provide sustainability loans (Drabbe, 2023). These loans can be used to enhance the sustainability of a house through investments in insulation, a heat pump, solar panels, or other sustainable innovations. The interest rate on this loan is typically 1.6% in most municipalities, with a maximum amount of €25,000. These loans simplify the journey toward sustainability for households with lower incomes.

Furthermore, for the households residing in rented homes, partnerships and agreements with social housing providers should be established. These collaborations can facilitate the implementation of sustainable solutions, such as home batteries, making it easier for households to adopt environmentally friendly products.

Housing corporations are currently focusing on renovating existing houses, while new constructions are being built with a greater emphasis on sustainability. Existing houses are undergoing sustainable renovations that include improvements in insulation, the installation of energy-efficient systems, and sustainable innovations such as solar panels. Additionally, housing corporations are actively promoting awareness among renters regarding energy-saving practices and sustainable behavior. For new constructions, the trend is to build houses without gas connections and to implement heat pump systems. These newly constructed houses are designed to be self-sufficient, contributing to a more sustainable and eco-friendly approach in the housing sector.

By addressing the financial barriers associated with both low-income and rental households, the three pillars of sustainability can be effectively incorporated into the adoption of home batteries.

6.4 Summary

In conclusion, this chapter expanded the multifaceted impact of implementing home batteries in Dutch households, addressing key aspects such as the effects on the main grid, contributions to CO_2 reduction, and the social implications. Home batteries prove beneficial in relieving pressure on the main grid and contribute significantly to CO_2 reduction when combined with solar panels. Despite the challenges related to financial accessibility, various subsidies and initiatives aim to ensure equal opportunities for households of all income levels.

Collaborative efforts, such as forming partnerships with social housing providers and renovating housing corporations, show a complete approach that fits with the three sustainability pillars: economic, environmental, and social.

Chapter 7 Discussion and Conclusion

This chapter serves as the final segment of this research, encompassing both the discussion and conclusion. The discussion begins by highlighting the limitations of our research and proposing recommendations for further studies. Subsequently, the conclusion provides a summary of our key findings and insights.

7.1 Discussion

The Netherlands is still behind on the integration of the home battery compared to neighboring countries such as Germany. While a few home batteries have been released, their low capacity and relatively high price have led to limited interest from households. Consequently, the market share of home batteries in Dutch households remains relatively low. However, with the current uncertainty of the netting agreement, the attractiveness of the home battery is expected to increase. Therefore, the Dutch home battery market displays significant potential for growth. On the other hand, it remains an upcoming market with uncertainties, making it hard to determine the optimal application for Zonneplan and its customers.

When we analyze the scenarios of the day-ahead application based on 365 cycles a year, none of them are attractive to invest in. The payback time extends to 10 years or more and the ROI is below 100 percent, which sometimes even turns negative. However, it becomes an appealing investment when the battery runs two cycles a day. The existing software requires optimization to efficiently run two cycles a day. If this optimization occurs, the day application could become a worthwhile investment.

The PV application, yielding positive returns in various scenarios, faces challenges. Its attractiveness depends on the status of the netting agreement. The PV application is favorable when there is no netting or a netting agreement. Currently, with complete netting, households can feed back their self-generated solar energy for the netting price. This makes it more favorable to use the netting agreement instead of storing the energy in the home battery. However, the uncertainty of the Dutch government's decision on the netting agreement, delayed by the elections, adds uncertainty to the business case for the home battery with the PV application.

The imbalance market application, which is not thoroughly discussed in the financial model due to limited public information on corresponding prices, presents an intriguing option. The imbalance, which is the difference between production and consumption every 15 minutes, is addressed by TenneT using forecasting models. The potentially extreme prices in this market may lead to higher benefits, but only energy suppliers can trade on this market. When an energy supplier wants to start selling home batteries, it can consider making the home battery a managed battery working on the imbalance market. If a company intends to participate in this market, conducting further research is essential to create a detailed financial model analyzing the feasibility and potential benefits of this application.

An additional limitation is the lack of research on the effect of home batteries on spot price markets. There is a possibility that widespread adoption of home batteries could contribute to more balanced prices. If these batteries are managed consistently, with a stabilizing strategy for charging and discharging, it could help balance the shortage and overload of the main grid. For instance, during periods of excess electricity, all batteries will charge, reducing the available electricity. Conversely, during electricity shortages, the batteries will discharge energy to the main grid, increasing the available electricity. This could potentially lead to a more balanced main grid, resulting in less extreme day-ahead and imbalance prices. Further research is needed to analyze the actual effect of the adoption of managed batteries.

Another limitation of the upcoming home battery market is the absence of subsidies specifically designated for the battery. Existing loans from organizations like Warmtefonds or municipalities are created to support sustainable improvements in a house. Currently, heat pumps, improving insulation, and solar panels are stated as sustainable improvements. The home battery is a sustainable improvement as well. However, it is still an upcoming product that is not included in most loan criteria yet. Nevertheless, as the market for home batteries expands, we anticipate that the home batteries are going to be included in these loans soon. This development will provide an opportunity for households across all income groups to integrate the battery as a sustainable improvement.

The final limitation of this research is related to the contribution of the home battery to the CO_2 reduction. When a home battery is used in a household, the CO_2 reduction equals 130 kg. Additionally, if households invest in an electrical vehicle, a heating pump, and solar panels, the CO_2 reduction increases to 160 kg. However, it is important to acknowledge that the production of the home battery itself generates CO_2 emissions. The exact amount of these emissions remains unclear, as limited research has been conducted on this aspect, and opinions among researchers vary significantly. While some researchers argue that the overall effects of the home battery remain positive, others state that the home battery may end up generating more emissions than it reduces, challenging its status as a sustainable improvement. To accurately assess the emissions during the production process, further research is necessary.

7.2 Conclusion

The objective of this research was to formulate a decision support statement for Zonneplan, addressing the main research question: *'How can the commercialization of the home battery contribute to the Netherlands' climate ambitions, and what measures should be implemented to proceed?'.* We formulated several sub-questions to systematically address this question. By addressing each of these sub-questions, we can answer the primary question.

First, the current position of the Netherlands regarding the transition to renewable energy was analyzed by executing a literature review. The Netherlands actively pursues renewable energy goals, increasing the 49% reduction in CO_2 emissions by 2030 to a more ambitious 55%. The 'Fit for 55' EU package outlines strategies for these goals. The topics *'How the EU plans to boost renewable energy'*, and *'How the EU will become more energy-efficient'* are the most important topics related to the electrification of the Netherlands. Renewable sources, including wind, solar, and bioenergy, are key components of the new energy mix, contributing to a steady increase in renewable energy production. To stimulate electrification, the government and the EU created new regulations. Net metering is a regulation created for Dutch households. Customers generating renewable energy can feed excess electricity back into the grid at the current electricity prices. This regulation has persuaded a majority of households to invest in solar panels, thereby contributing to the electrification efforts.

Additionally, a second literature review on the perspectives on the home battery is executed. The Netherlands is falling behind on the adoption, as the existing batteries can only be used to store self-generated energy, which is not profitable with the current netting agreement.

There are rumors of more companies entering the home battery market but specifics about their products remain unclear, which leaves a lot of opportunities for new companies to enter the market. Zonneplan conducted a target group analysis, revealing that the target group will be men with a high educational level between 30 and 39 years old. A total of 51.4% of the participants stated that they want to have a home battery in the long run. This shows that the market will have a lot of potential and growth.

The third step is to analyze the different applications of the home battery. There are three types of applications for the home battery: solar energy, dynamic energy, and the imbalance market. The solar energy application, also known as the PV application, is the most straightforward application. The home battery serves as a storage solution for the self-generated solar energy. However, the Netherlands has an active netting agreement, allowing households to feed all the produced solar energy back into the main grid. In case the netting percentage is reduced, households still have the option to contribute their produced solar energy to the main grid. Instead of netting the energy, a feed-in-fee is applied. The PV application has three scenarios: no netting, complete netting, and the netting agreement as formed by the government. The battery can become a managed battery as well. When this battery is used in the dynamic energy market, it will analyze the day-ahead prices and make a schedule to charge and discharge energy depending on the dynamic prices. The dynamic energy market relies on the EPEX spot market, which reveals energy prices 24 hours in advance. Forecasting the EPEX prices remains challenging due to the market instability. Therefore, we defined two different scenarios: a forecasted EPEX spot market, and the historical EPEX spot market. The third application is the imbalance market, but the prices are not public to customers, which makes that this application is not used in the financial model.

The financial model created in the fourth step consists of a P&L statement for Zonneplan and a cash flow overview for both Zonneplan and the customer. Customers can choose different financing methods for the home battery. The methods that are included in this model are: buying, taking out a loan, net operational lease, financial lease, and payment in installments.

The fifth step discusses the results of the financial model. Zonneplan should sell the home battery for €5000, along with a profit-share ratio of 90 to 10 for the customer and Zonneplan respectively. Currently, the day-ahead application is financially unattractive for investment because the netting agreement is more profitable than purchasing a home battery. However, the PV application yields positive returns when the netting agreement is partially or completely lifted. If the customer purchases the home battery for €5000, the investment is earned back within 9 years, with an ROI of 115 percent. Additionally, if the customer has an annual income below 60,000 euros, taking a Warmtefonds loan is a feasible option. The customer should base their decision on the financial validity of their household. Zonneplan's scenarios are consistently positive, indicating that investing in the home battery is a promising project for the company. When customers purchase the product, the payback time for Zonneplan's investment is one and a half years. When the payment is divided into installments, the payback time is approximately half a year. However, this financing method leads to a decrease in working capital for Zonneplan. A negative working capital can limit the financial flexibility of Zonneplan, which can make them more vulnerable to unexpected changes in cashflows. Therefore, this method is not recommended.

In the last and sixth step, the implications of the commercialization of the home battery are discussed, addressing key aspects such as the effects on the main grid, contributions to CO_2 reduction, and the social implications. Home batteries prove beneficial in relieving pressure on the main grid and contribute significantly to CO_2 reduction when combined with solar panels. Despite the challenges related to financial accessibility, various subsidies and initiatives aim to ensure equal opportunities for households of all income levels. Collaborative efforts, such as forming partnerships with social housing providers and renovating housing corporations, show a complete approach that fits with the three sustainability pillars: economic, environmental, and social. The interaction between these pillars highlights the importance of a comprehensive strategy in realizing sustainable energy solutions in the Netherlands.

Summarizing all these steps answers the research question. Zonneplan should implement the home battery with a 90 to 10 profit-share ratio, for a selling price of €5000. It contributes to the Netherlands' climate ambitions by lifting the pressure of the main grid. Furthermore, the widespread implementation of the home battery will lead to a CO_2 reduction of 160 kg when implemented in the most optimal way, which can contribute to the Dutch climate goals.

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Appendix A: Detailed Description of the Literature Review

The following steps are executed:

1. *Definition of the research question.*
2. *Defining inclusion and exclusion criteria.*
3. *Defining which database to use.*
4. *Describing the search terms and the belonging strategy.*
5. *Listing the number of searches found.*
6. *Create a conceptual matrix of the articles found.*
7. *State the key findings of the articles.*

The first and last steps are already explained in Chapter 1. Therefore, only step two to six are elaborated on in this appendix.

Step 2: Inclusion and exclusion criteria

To answer this research question, inclusion and exclusion criteria must be defined to limit the number of hits in the databases. First, the inclusion criteria are determined. The first two criteria are the search terms entered in the database. Next to the search terms, the papers should have a relevant outcome and similar design compared to this research. Only scientific papers are considered. Language is the first exclusion criterion. Only English papers are considered in this literature review since this is the main language of this research. Furthermore, is this topic very up to date which means that old research can be outdated quickly. Therefore, only papers from 2015 until now are considered. An overview of the criteria is depicted in Table 1.

Table 1: Inclusion and exclusion criteria of the literature review.

Criteria	Defined
Inclusion	Renewable Energy, Home Battery, Outcome of the paper (The paper should be relevant for our research), Research design of the paper (Should be like our research to use), Scientific articles
Exclusion	Language (English), Date (>2015)

Step 3: Databases

The number of databases that I will search is between two and four to let the articles not originate from only one database (Ewald, 2022). A database should be relevant to the research, match the information needed, and should add something unique.

Search engines will not be used during this literature review, since they will give millions of results which does not focus on scientific articles. To get the best results, domain-specific databases and multidisciplinary databases are being searched. The domain-specific database will be IEEE Xplore and the multidisciplinary database will be Scopus.

Step 4: Search terms and strategy

The search strategy is based on the context, intervention, mechanism, and outcome strategy (CIMO). The strategy and the related search terms are visualized in Table 2.

Table 2: CIMO search strategy (Doyle, 2019).

CIMO	Constructs	Related terms	Broader terms	Narrower terms
Context	Households	Houses, homes, residential	Customers, users	Residential users
Intervention	Home battery	Energy Storage	Storage systems, households' storage	Home battery energy storage

Mechanism	Renewable energy	Energy transition	Electrification	-
Outcomes	Financial Model	-	-	P&L statement, Cash flow overview, Revenue management

Step 5: Searching articles

In this step, the databases can be searched. From the search terms and strategy, 22 articles are found in Scopus and 17 in IEEE Xplore. In the table below, an overview can be found of the final articles that are used for the literature review.

Table 3: Overview of search progress.

Search Date	Description	Hits
20-09-2023	*Total articles in Scopus*	22
20-09-2023	*Total articles in IEEE Xplore*	17
	Total articles	**39**
	Duplicates removed	-7
	Total selected for review	**32**
	Removed after reading the abstract	-27
	Total useful articles	**5**

Step 6: Conceptual matrix

In total, five articles are valued as useful. These articles are read, and the key findings are represented in a conceptual matrix.

Table 4: Conceptual matrix of five articles.

Title	Core topics	Key findings
Capacity sharing – Economic analysis of home battery systems **(Dzikowski & Olek, 2017)**	Economic viability, home battery, sharing capacity	This article reviews if it can be profitable for a customer with solar panels and a home battery to share their capacity. The financial calculations are based on five different scenarios: **1.** No green energy installation **2.** Only solar panels are installed **3.** A separate home battery is combined with solar panels **4.** Part of the battery capacity is shared, and additional financial benefits are obtained **5.** Modify scenario four until profits are obtained.
Managing PV power injection and storage, enabling a larger direct consumption of renewable energy: A case study for the Belgian electricity system **(Meuris, et al., 2018)**	Distributed storage system, grid injection limit, self-consumption	This article focuses on the potential of wind and solar energy to transform the Belgian electricity system towards renewables at a minimal social cost. The main goal is to obtain the highest possible direct consumption of the generated wind and solar power electricity.
Analysis of the maximal possible grid relief from PV-peak-power impacts by using storage systems for increased self-consumption	Home storage system, Battery management strategy	This article creates a model to analyze the potential of private home battery storage systems to reduce stress on the power supply system. The conclusion is that with a forecast algorithm, a higher grid relief is

(Moshövel, Kairies, Magnor, Leuthold, & Bost, 2015)		obtained compared to a self-consumption-only strategy.
Policy options for enhancing economic profitability of residential solar photovoltaic with battery energy storage **(Zakeri, Samuel, Dodds, & Gissey, 2021)**	Energy policy, Renewable energy market, Cost-benefit analysis, electrical energy storage	This article proposes a few new storage policies that aim to reward the operation of residential storage for increasing solar PV self-consumption, peak shaving, and load leveling.
Technologies of engagement: How battery storage technologies shape householder participation in energy transitions **(Kloppenburg, Smale, & Verkade, 2019)**	Battery storage technologies, public participation, households, socio-technical transitions	This article explores the potential ways in which home batteries can enable households to become engaged in the transition towards low-carbon energy systems. It discusses five socio-technical configurations: **1.** Individual energy autonomy **2.** Local energy community **3.** Smart grid integration **4.** Virtual energy community **5.** Electricity market integration.

Appendix B: Benefit Statements for the Home Battery

Appendix B.1: Solar energy benefit statement for the home battery

As mentioned in Section 3.1, there are two more alternatives for the netting agreement: the netting agreement will fully disappear or will stay for 100%. These two alternatives are visualized in Figures 33 and 34.

Solar Energy Benefit									
Year	**2023**	**2024**	**2025**	**2026**	**2027**	**2028**	**2029**	**2030**	**2031**
No netting	0%	0%	0%	0%	0%	0%	0%	0%	0%
Feed-in-fee	100%	100%	100%	100%	100%	100%	100%	100%	100%
Benefit home battery	€ 797.54	€ 797.54	€ 797.54	€ 797.54	€ 797.54	€ 797.54	€ 797.54	€ 797.54	€ 797.54

Figure 33: Solar energy benefits for the home battery. This statement is based on the scenario where there is no netting agreement.

The netting agreement fully disappeared in the figure above. This holds that all the energy that is fed back to the main grid will fall under the feed-in fee.

Solar Energy Benefit									
Year	**2023**	**2024**	**2025**	**2026**	**2027**	**2028**	**2029**	**2030**	**2031**
Complete netting	100%	100%	100%	100%	100%	100%	100%	100%	100%
Feed-in-fee	0%	0%	0%	0%	0%	0%	0%	0%	0%
Benefit home battery	€ 676.96	€ 676.96	€ 676.96	€ 676.96	€ 676.96	€ 676.96	€ 676.96	€ 676.96	€ 676.96

Figure 34: Solar energy benefits for the home battery. This statement is based on the scenario where there is a netting agreement of 100%.

In the statement above, the netting agreement is 100% active. All the energy that is fed back into the main grid will fall under the netting agreement and the feed-in-fee will not be used.

The benefits of the home battery are calculated with a combination of two calculations. The first part calculated the savings on the annual energy bill, when a home battery is used. The second part calculated the benefits of the self-generated solar energy that is fed back into the main grid. These two calculations summed, will give the total benefit per year. The calculations are represented below:

$$Savings\ on\ annual\ energy\ bill = (\Delta\ in\ solar\ energy\ usage\ with\ and\ without\ home\ battery) * annual\ yield\ PV * \ electricity\ price$$

$$Benefits\ from\ fed\ back\ energy = (1 - \%\ solar\ energy\ usage\ with\ battery) * annual\ yield\ in\ kWh * (feed\ in\ fee * \%\ feed\ in\ fee)$$

Appendix B.2: Day-ahead benefit statement for the home battery

In the figure below, the calculations for the average profit of the home battery is calculated based on the day-ahead prices of the dynamic energy market. The number of cycles is based on one cycle a day, so the battery loads and discharges energy once a day. The total monthly profit is based on the monthly profit per kWh multiplied by the number of kWh of a home battery. 2022 Has a total profit of €600.18 and the six months of 2023 have a total profit of €145.71. The average per year is based on these two numbers and is therefore €445.80.

Year	Month	Days in month	Cycles	Average profit per kWh	Monthly profit per kWh	Total monthly profit	
2022	1	31	31	€ 0.12	€ 3.60	€ 32.36	
	2	29	29	€ 0.15	€ 4.21	€ 37.85	
	3	31	31	€ 0.15	€ 4.50	€ 40.46	
	4	30	30	€ 0.15	€ 4.59	€ 41.31	
	5	31	31	€ 0.13	€ 4.12	€ 37.11	
	6	30	30	€ 0.17	€ 4.95	€ 44.55	
	7	31	31	€ 0.26	€ 8.06	€ 72.54	
	8	31	31	€ 0.31	€ 9.49	€ 85.37	
	9	30	30	€ 0.31	€ 9.24	€ 83.16	
	10	31	31	€ 0.17	€ 5.21	€ 46.87	
	11	30	30	€ 0.13	€ 3.96	€ 35.64	**Total 2022**
	12	31	31	€ 0.15	€ 4.77	€ 42.97	€ 600.18
2023	1	31	31	€ 0.09	€ 2.82	€ 25.39	
	2	28	28	€ 0.08	€ 2.32	€ 20.92	
	3	31	31	€ 0.09	€ 2.79	€ 25.11	
	4	30	30	€ 0.10	€ 2.88	€ 25.92	
	5	31	31	€ 0.10	€ 2.95	€ 26.51	**Total until 7-2023**
	6	30	30	€ 0.08	€ 2.43	€ 21.87	€ 145.71
							Average per year
							€ 445.80

Figure 35: An overview of the profit calculations of the day-ahead prices on the dynamic energy market.

The figure below shows the forecast of the EPEX spot prices. The EPEX forecast volatility states how much the EPEX will increase or decrease on average per year and the EPEX original assumes that the EPEX will remain the same as it is now.

Year	Base	Base Difference	EPEX forecast volatility	EPEX original
2022	235.40	-42.65%	100.00%	100%
2023	135.00	-3.70%	-42.65%	100%
2024	130.00	10.58%	-3.70%	100%
2025	143.75	-4.35%	10.58%	100%
2026	137.50	-1.09%	-4.35%	100%
2027	136.00	1.10%	-1.09%	100%
2028	137.50	0.36%	1.10%	100%
2029	138.00	-3.80%	0.36%	100%
2030	132.75	0.00%	-3.80%	100%
2031	132.75	-100.00%	0.00%	100%

Figure 36: An overview of the EPEX forecast volatility of the upcoming years.

Figure 37 shows the benefits of the day-ahead functionality of the home battery when the EPEX forecast is used. The benefits are lower than with the 'original EPEX', since the forecast is that the prices will drop from 2023 to 2024.

Day-ahead benefits									
Year	**2023**	**2024**	**2025**	**2026**	**2027**	**2028**	**2029**	**2030**	**2031**
Cycles per year	365	365	365	365	365	365	365	365	365
EPEX forecast volatility	-42.65%	-3.70%	-3.70%	10.58%	-4.35%	-1.09%	1.10%	0.36%	-3.80%
Benefit home battery	**€ 344.20**	**€ 331.45**	**€ 319.18**	**€ 352.93**	**€ 337.59**	**€ 333.91**	**€ 337.59**	**€ 338.82**	**€ 325.93**

Figure 37: Benefits of the day-ahead functionality of the home battery, based on the EPEX forecast volatility.

Appendix C: The Financial Model

Appendix C.1: The benefits of the applications of the home battery

Zonneplan's benefits

	2024				2025				2026			
	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4
Benefits PV	€ 31,732.50	€ 31,732.50	€ 31,732.50	€ 31,732.50	€ 63,465.00	€ 63,465.00	€ 63,465.00	€ 63,465.00	€ 126,930.00	€ 126,930.00	€ 126,930.00	€ 126,930.00
Benefits Day-Ahead	€ 19,852.10	€ 39,704.20	€ 59,556.29	€ 79,408.39	€ 119,112.59	€ 158,816.78	€ 198,520.98	€ 238,225.18	€ 317,633.57	€ 397,041.96	€ 476,450.35	€ 555,858.75

Customers benefits (per customer)

	2024				2025				2026			
	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4
Benefits PV	€ 152.32	€ 152.32	€ 152.32	€ 152.32	€ 152.32	€ 152.32	€ 152.32	€ 152.32	€ 152.32	€ 152.32	€ 152.32	€ 152.32
Benefits Day-Ahead	€ 100.31	€ 100.31	€ 100.31	€ 100.31	€ 100.31	€ 100.31	€ 100.31	€ 100.31	€ 100.31	€ 100.31	€ 100.31	€ 100.31

Customer benefits longer time period

	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038
Benefits PV	€ 609.26	€ 609.26	€ 609.26	€ 609.26	€ 609.26	€ 609.26	€ 609.26	€ 609.26	€ 609.26	€ 609.26	€ 609.26	€ 609.26	€ 609.26	€ 609.26	€ 609.26
Benefits Day-Ahead	€ 401.22	€ 401.22	€ 401.22	€ 401.22	€ 401.22	€ 401.22	€ 401.22	€ 401.22	€ 401.22	€ 401.22	€ 401.22	€ 401.22	€ 401.22	€ 401.22	€ 401.22

Figure 38: Overview of the benefits of the applications of the home battery. The first cash flow is based on the benefits of Zonneplan, the second is based on the customer benefits and the last is also the customer's benefits but over a longer period. All the cashflows are based on a 10 to 90 profit-share ratio.

Appendix C.2: The input parameters sheet

Battery Specifications		
Battery selling price	€	5,000.00
Charge volume in kWh		10
Cycles per year		365
Guaranty in cycles		6000
Guarantee in years		16
Residual value after 10 years	€	1,000.00
Annual drop in earnings due to battery wear and tear		1%
Cost specifications all-in-one		
Hardware	€	4,146.00
Connect - SGN	€	25.00
Installation	€	300.00
Refurbishing costs		
Cost per kWh	€	160.00
Cost specifications component-build		
DMEGC battery packs	€	1,800.00
AME bi-directional 3-phases converter	€	1,500.00
Connect - SGN	€	25.00
Installation	€	300.00
Profit		
annual benefits day-ahead		
2024	€	445.80
2025	€	445.80
2026	€	445.80
annual benefits PV		
2024	€	676.96
2025	€	676.96
2026	€	676.96
Cost Zonneplan		
Up-front development costs	€	4,700,000.00
Annual running costs proposition	€	1,200,000.00

Annual customer churn rate (dropout rate)	5%
Operational costs	
Lead costs	€ 25.00
Conversion to sale	15%
Profit-share	
Zonneplan profit share	10%
Customer profit share	90%
Payment term	
Customer Home battery payment term in months	1
Payment term Zonneplan to suppliers in months	3
Financing Methods	
Netto Operational Lease	
Duration	5
Interest Lease	11%
Financial Lease	
Duration Lease (years)	10
Interest Lease	8.9%
Payment installments with benefits	
Payment installments (years)	2
Interest payment installments	14%
Deposit	10%
Loan	
Duration Loan (years)	7
Interest Loan	NA
Scenario analyses	
Application Battery	Benefits PV
Netting	Complete netting
Different scenario's: sell price,benefits and	Low selling price, Low demand
Forecast EPEX volatility	EPEX original
Financing methods	Payment in Installments

Year	Month	Battery installations	Battery sold	Running batteries	Total Running Batteries
2024	Q1	1875	All in one	1781	1781
	Q2	1875	All in one	1781	3563
	Q3	1875	Component	1781	5344
	Q4	1875	Component	1781	7125
2025	Q1	3750	Component	3563	10688
	Q2	3750	Component	3563	14250
	Q3	3750	Component	3563	17813
	Q4	3750	Component	3563	21375
2026	Q1	7500	Component	7125	28500
	Q2	7500	Component	7125	35625
	Q3	7500	Component	7125	42750
	Q4	7500	Component	7125	49875

Output Customer		**Output Zonneplan**	
IRR	7%	IRR	55%
NPV	€ 742.55	NPV	€ 45,247,652.54
PVI	2.49	PVI	10.63
Payback Time	12.56	Payback Time in years	0.57
ROI	53%		

Input
Output
Drop down list

Figure 39: The 'Input parameters' sheet.

Appendix C.3: The Profit and Loss statement

P&L Statement													
	2023	2024				2025				2026			
Revenue		*Q1*	*Q2*	*Q3*	*Q4*	*Q1*	*Q2*	*Q3*	*Q4*	*Q1*	*Q2*	*Q3*	*Q4*
Sales home battery		€ 9,375,000.00	€ 9,375,000.00	€ 9,375,000.00	€ 9,375,000.00	€ 18,750,000.00	€ 18,750,000.00	€ 18,750,000.00	€ 18,750,000.00	€ 37,500,000.00	€ 37,500,000.00	€ 37,500,000.00	€ 37,500,000.00
Benefits PV		€ 31,732.50	€ 31,732.50	€ 31,732.50	€ 31,732.50	€ 63,465.00	€ 63,465.00	€ 63,465.00	€ 63,465.00	€ 126,930.00	€ 126,930.00	€ 126,930.00	€ 126,930.00
Net Sales		**€ 9,406,732.50**	**€ 9,406,732.50**	**€ 9,406,732.50**	**€ 9,406,732.50**	**€ 18,813,465.00**	**€ 18,813,465.00**	**€ 18,813,465.00**	**€ 18,813,465.00**	**€ 37,626,930.00**	**€ 37,626,930.00**	**€ 37,626,930.00**	**€ 37,626,930.00**
Costs Of Goods Sold													
All in one													
Hardware		€ 7,773,750.00	€ 7,773,750.00	-	-	-	-	-	-	-	-	-	-
Connect - SGN		€ 46,875.00	€ 46,875.00	-	-	-	-	-	-	-	-	-	-
Installation Costs		€ 562,500.00	€ 562,500.00	-	-	-	-	-	-	-	-	-	-
Component													
DMEGC battery packs				€ 3,375,000.00	€ 3,375,000.00	€ 6,750,000.00	€ 6,750,000.00	€ 6,750,000.00	€ 6,750,000.00	€ 13,500,000.00	€ 13,500,000.00	€ 13,500,000.00	€ 13,500,000.00
AME bi-directional 3-phases converter		-	-	€ 2,812,500.00	€ 2,812,500.00	€ 5,625,000.00	€ 5,625,000.00	€ 5,625,000.00	€ 5,625,000.00	€ 11,250,000.00	€ 11,250,000.00	€ 11,250,000.00	€ 11,250,000.00
Connect - SGN		-	-	€ 46,875.00	€ 46,875.00	€ 93,750.00	€ 93,750.00	€ 93,750.00	€ 93,750.00	€ 187,500.00	€ 187,500.00	€ 187,500.00	€ 187,500.00
Installation Costs		-	-	€ 562,500.00	€ 562,500.00	€ 1,125,000.00	€ 1,125,000.00	€ 1,125,000.00	€ 1,125,000.00	€ 2,250,000.00	€ 2,250,000.00	€ 2,250,000.00	€ 2,250,000.00
Total Costs of Goods Sold		**€ 8,383,125.00**	**€ 8,383,125.00**	**€ 6,796,875.00**	**€ 6,796,875.00**	**€ 13,593,750.00**	**€ 13,593,750.00**	**€ 13,593,750.00**	**€ 13,593,750.00**	**€ 27,187,500.00**	**€ 27,187,500.00**	**€ 27,187,500.00**	**€ 27,187,500.00**
Refurbishing costs		**€ -**	**€ -**	**€ -**	**€ -**	**€ -**	**€ -**	**€ -**	**€ -**	**€ -**	**€ -**	**€ -**	**€ -**
Gross margin		**€ 1,023,607.50**	**€ 1,023,607.50**	**€ 2,609,857.50**	**€ 2,609,857.50**	**€ 5,219,715.00**	**€ 5,219,715.00**	**€ 5,219,715.00**	**€ 5,219,715.00**	**€ 10,439,430.00**	**€ 10,439,430.00**	**€ 10,439,430.00**	**€ 10,439,430.00**
Operating Costs													
Initital investment	€ -4,700,000.00												
Department costs													
Sales		€ 22,444.50	€ 22,444.50	€ 22,444.50	€ 22,444.50	€ 44,889.00	€ 44,889.00	€ 44,889.00	€ 44,889.00	€ 89,778.00	€ 89,778.00	€ 89,778.00	€ 89,778.00
Development		€ 88,716.00	€ 88,716.00	€ 88,716.00	€ 88,716.00	€ 88,716.00	€ 88,716.00	€ 88,716.00	€ 88,716.00	€ 88,716.00	€ 88,716.00	€ 88,716.00	€ 88,716.00
Operations		€ 11,089.50	€ 11,089.50	€ 11,089.50	€ 11,089.50	€ 22,179.00	€ 22,179.00	€ 22,179.00	€ 22,179.00	€ 44,358.00	€ 44,358.00	€ 44,358.00	€ 44,358.00
Operations 'Installers'		€ 246,433.33	€ 246,433.33	€ 246,433.33	€ 246,433.33	€ 492,866.67	€ 492,866.67	€ 492,866.67	€ 492,866.67	€ 985,733.33	€ 985,733.33	€ 985,733.33	€ 985,733.33
Customer Support		€ 9,366.00	€ 9,366.00	€ 9,366.00	€ 9,366.00	€ 18,732.00	€ 18,732.00	€ 18,732.00	€ 18,732.00	€ 37,464.00	€ 37,464.00	€ 37,464.00	€ 37,464.00
Finance		€ 33,076.00	€ 33,076.00	€ 33,076.00	€ 33,076.00	€ 33,076.00	€ 33,076.00	€ 33,076.00	€ 33,076.00	€ 33,076.00	€ 33,076.00	€ 33,076.00	€ 33,076.00
Additional running cost		€ 58,614.00	€ 58,614.00	€ 58,614.00	€ 58,614.00	€ 58,614.00	€ 58,614.00	€ 58,614.00	€ 58,614.00	€ 58,614.00	€ 58,614.00	€ 58,614.00	€ 58,614.00
Marketing cost per lead		€ 312,500.00	€ 312,500.00	€ 312,500.00	€ 312,500.00	€ 625,000.00	€ 625,000.00	€ 625,000.00	€ 625,000.00	€ 1,250,000.00	€ 1,250,000.00	€ 1,250,000.00	€ 1,250,000.00
Marketing campaign costs		€ 30,000.00	-	-	-	-	-	-	-	-	-	-	-
Marketing department		€ 66,152.00	€ 66,152.00	€ 66,152.00	€ 66,152.00	€ 66,152.00	€ 66,152.00	€ 66,152.00	€ 66,152.00	€ 66,152.00	€ 66,152.00	€ 66,152.00	€ 66,152.00
Total Operating Costs		**€ 878,391.33**	**€ 848,391.33**	**€ 848,391.33**	**€ 848,391.33**	**€ 1,450,224.67**	**€ 1,450,224.67**	**€ 1,450,224.67**	**€ 1,450,224.67**	**€ 2,653,891.33**	**€ 2,653,891.33**	**€ 2,653,891.33**	**€ 2,653,891.33**
Operating Income	***€ -4,700,000.00***	**€ 145,216.17**	**€ 175,216.17**	**€ 1,761,466.17**	**€ 1,761,466.17**	**€ 3,769,490.33**	**€ 3,769,490.33**	**€ 3,769,490.33**	**€ 3,769,490.33**	**€ 7,785,538.67**	**€ 7,785,538.67**	**€ 7,785,538.67**	**€ 7,785,538.67**
Provision For Income Tax		€ 37,465.77	€ 45,205.77	€ 454,458.27	€ 454,458.27	€ 972,528.51	€ 972,528.51	€ 972,528.51	€ 972,528.51	€ 2,008,668.98	€ 2,008,668.98	€ 2,008,668.98	€ 2,008,668.98
Net Income	**-€ 4,700,000.00**	**€ 107,750.40**	**€ 130,010.40**	**€ 1,307,007.90**	**€ 1,307,007.90**	**€ 2,796,961.83**	**€ 2,796,961.83**	**€ 2,796,961.83**	**€ 2,796,961.83**	**€ 5,776,869.69**	**€ 5,776,869.69**	**€ 5,776,869.69**	**€ 5,776,869.69**

Figure 40: The profit and loss statement for Zonneplan.

Appendix C.4: Cash flow overview Zonneplan

Cash flow Zonneplan

	2023	2024				2025				2026			
Quarters		1	2	3	4	1	2	3	4	1	2	3	4
Initial investment	**€ -4,700,000.00**												
Revenue		€ 9,406,732.50	€ 9,406,732.50	€ 9,406,732.50	€ 9,406,732.50	€ 18,813,465.00	€ 18,813,465.00	€ 18,813,465.00	€ 18,813,465.00	€ 37,626,930.00	€ 37,626,930.00	€ 37,626,930.00	€ 37,626,930.00
Total Costs of Goods Sold		-€ 8,383,125.00	-€ 8,383,125.00	-€ 6,796,875.00	-€ 6,796,875.00	-€ 13,593,750.00	-€ 13,593,750.00	-€ 13,593,750.00	-€ 13,593,750.00	-€ 27,187,500.00	-€ 27,187,500.00	-€ 27,187,500.00	-€ 27,187,500.00
Operation Cost		-€ 878,391.33	-€ 848,391.33	-€ 848,391.33	-€ 848,391.33	-€ 1,450,224.67	-€ 1,450,224.67	-€ 1,450,224.67	-€ 1,450,224.67	-€ 2,653,891.33	-€ 2,653,891.33	-€ 2,653,891.33	-€ 2,653,891.33
EBIT		**€ 145,216.17**	**€ 175,216.17**	**€ 1,761,466.17**	**€ 1,761,466.17**	**€ 3,769,490.33**	**€ 3,769,490.33**	**€ 3,769,490.33**	**€ 3,769,490.33**	**€ 7,785,538.67**	**€ 7,785,538.67**	**€ 7,785,538.67**	**€ 7,785,538.67**
Taxes		-€ 37,465.77	-€ 45,205.77	-€ 454,458.27	-€ 454,458.27	-€ 972,528.51	-€ 972,528.51	-€ 972,528.51	-€ 972,528.51	-€ 2,008,668.98	-€ 2,008,668.98	-€ 2,008,668.98	-€ 2,008,668.98
Net Cash Flow	€ -4,700,000.00	€ 107,750.40	€ 130,010.40	€ 1,307,007.90	€ 1,307,007.90	€ 2,796,961.83	€ 2,796,961.83	€ 2,796,961.83	€ 2,796,961.83	€ 5,776,869.69	€ 5,776,869.69	€ 5,776,869.69	€ 5,776,869.69
Discounted Net Cash Flow	**€ -4,700,000.00**	**€ 102,619.42**	**€ 117,923.26**	**€ 1,129,042.56**	**€ 1,075,278.63**	**€ 2,191,492.78**	**€ 2,087,135.98**	**€ 1,987,748.55**	**€ 1,893,093.86**	**€ 3,723,821.71**	**€ 3,546,496.87**	**€ 3,377,616.06**	**€ 3,216,777.20**
Start of quarter cashflow		€ -4,700,000.00	€ -4,597,380.58	€ -4,479,457.31	€ -3,350,414.75	€ -2,275,136.12	€ -83,643.34	€ 2,003,492.64	€ 3,991,241.19	€ 5,884,335.05	€ 9,608,156.76	€ 13,154,653.62	€ 16,532,269.69
End of quarter cashflow		€ -4,597,380.58	€ -4,479,457.31	€ -3,350,414.75	€ -2,275,136.12	€ -83,643.34	€ 2,003,492.64	€ 3,991,241.19	€ 5,884,335.05	€ 9,608,156.76	€ 13,154,653.62	€ 16,532,269.69	€ 19,749,046.89

Working capital

		2024				2025				2026			
Current Assets		1	2	3	4	1	2	3	4	1	2	3	4
Debtors (customers)		€ 6,250,000.00	€ 9,375,000.00	€ 9,375,000.00	€ 9,375,000.00	€ 15,625,000.00	€ 18,750,000.00	€ 18,750,000.00	€ 18,750,000.00	€ 31,250,000.00	€ 37,500,000.00	€ 37,500,000.00	€ 37,500,000.00
Current liabilities													
Creditors (Zonneplan to suppliers)		€ 0.00	-€ 8,383,125.00	-€ 8,383,125.00	-€ 6,796,875.00	-€ 6,796,875.00	-€ 13,593,750.00	-€ 13,593,750.00	-€ 13,593,750.00	-€ 13,593,750.00	-€ 27,187,500.00	-€ 27,187,500.00	-€ 27,187,500.00
Taxes		-€ 37,465.77	-€ 45,205.77	-€ 454,458.27	-€ 454,458.27	-€ 972,528.51	-€ 972,528.51	-€ 972,528.51	-€ 972,528.51	-€ 2,008,668.98	-€ 2,008,668.98	-€ 2,008,668.98	-€ 2,008,668.98
Operation Cost		-€ 878,391.33	-€ 848,391.33	-€ 848,391.33	-€ 848,391.33	-€ 1,450,224.67	-€ 1,450,224.67	-€ 1,450,224.67	-€ 1,450,224.67	-€ 2,653,891.33	-€ 2,653,891.33	-€ 2,653,891.33	-€ 2,653,891.33
Working capital		**€ 5,334,142.90**	**€ 98,277.90**	**-€ 310,974.60**	**€ 1,275,275.40**	**€ 6,405,371.83**	**€ 2,733,496.83**	**€ 2,733,496.83**	**€ 2,733,496.83**	**€ 12,993,689.69**	**€ 5,649,939.69**	**€ 5,649,939.69**	**€ 5,649,939.69**

Figure 41: The cash flow for Zonneplan, including an overview of the working capital.

Appendix C.5: Cash flow overview customer

Cash flow Customer

	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038
Initial investment	**€ -5,000.00**															
Benefits PV		€ 609.26	€ 648.33	€ 648.33	€ 658.10	€ 667.87	€ 677.63	€ 687.40	€ 717.79	€ 717.79	€ 717.79	€ 717.79	€ 717.79	€ 717.79	€ 717.79	€ 717.79
Net Cash Flow	€ -5,000.00	€ 609.26	€ 648.33	€ 648.33	€ 658.10	€ 667.87	€ 677.63	€ 687.40	€ 717.79	€ 717.79	€ 717.79	€ 717.79	€ 717.79	€ 717.79	€ 717.79	€ 717.79
Discounted Net Cash Flow	€ -5,000.00	€ 580.25	€ 588.06	€ 560.05	€ 541.42	€ 523.29	€ 505.66	€ 488.52	€ 485.83	€ 462.69	€ 440.66	€ 419.68	€ 399.69	€ 380.66	€ 362.53	€ 345.27
Start of year cashflow		€ -5,000.00	€ -4,419.75	€ -3,831.69	€ -3,271.64	€ -2,730.22	€ -2,206.92	€ -1,701.26	€ -1,212.74	€ -726.91	€ -264.22	€ 176.44	€ 596.12	€ 995.81	€ 1,376.47	€ 1,739.00
End of year cashflow		€ -4,419.75	€ -3,831.69	€ -3,271.64	€ -2,730.22	€ -2,206.92	€ -1,701.26	€ -1,212.74	€ -726.91	€ -264.22	€ 176.44	€ 596.12	€ 995.81	€ 1,376.47	€ 1,739.00	€ 2,084.27

Figure 42: The cash flow overview for the customer.

Appendix D: The Financing Methods

Appendix D.1: Take out a loan

If the customer is getting a loan, the cash flow will change into the structure illustrated in the figure below. The loan payments are calculated with the PMT function of Excel and are based on the interest rate, duration of the loan, and the initial price of the product. After the loan ends, the home battery will only generate benefits and there are no additional costs. There is no initial investment since this financing method does not require a downpayment.

Cash flow Customer

	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038
Loan payments		€ -848.51	€ -848.51	€ -848.51	€ -848.51	€ -848.51	€ -848.51	€ -848.51	€ -	€ -	€ -	€ -	€ -	€ -	€ -	€ -
Benefits PV		€ 609.26	€ 648.33	€ 648.33	€ 658.10	€ 667.87	€ 677.63	€ 687.40	€ 717.79	€ 717.79	€ 717.79	€ 717.79	€ 717.79	€ 717.79	€ 717.79	€ 717.79
Net Cash Flow	€ -	€ -239.24	€ -200.17	€ -200.17	€ -190.41	€ -180.64	€ -170.87	€ -161.11	€ 717.79	€ 717.79	€ 717.79	€ 717.79	€ 717.79	€ 717.79	€ 717.79	€ 717.79
Discounted Net Cash Flow	€ -	€ -227.85	€ -181.56	€ -172.92	€ -156.65	€ -141.54	€ -127.51	€ -114.49	€ 485.83	€ 462.69	€ 440.66	€ 419.68	€ 399.69	€ 380.66	€ 362.53	€ 345.27
Start of year cashflow		€ -	€ -227.85	€ -409.41	€ -582.33	€ -738.98	€ -880.52	€ -1,008.02	€ -1,122.52	€ -636.69	€ -174.00	€ 266.66	€ 686.34	€ 1,086.03	€ 1,466.69	€ 1,829.22
End of year cashflow		€ -227.85	€ -409.41	€ -582.33	€ -738.98	€ -880.52	€ -1,008.02	€ -1,122.52	€ -636.69	€ -174.00	€ 266.66	€ 686.34	€ 1,086.03	€ 1,466.69	€ 1,829.22	€ 2,174.49

Figure 43: The customer cash flow for a loan. This overview is for a loan from the National Warmtefonds for seven years, with an interest rate of 4.5%.

Appendix D.2: Financial lease

When the customer wants to financial lease the home battery, the duration will be ten years. The home battery will become the property of the customer after the termination of the contract. To become the legal owner of the battery, the customer needs to pay an additional amount during the last payment. This amount is equal to the residual value of the battery after ten years, which is €1000. After the financial lease contract, the battery will only generate benefits and no additional costs will occur.

Cash flow Customer

	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038
Lease payments		€ -709.54	€ -709.54	€ -709.54	€ -709.54	€ -709.54	€ -709.54	€ -709.54	€ -709.54	€ -709.54	€ -1,709.54	€ -	€ -	€ -	€ -	€ -
Benefits PV		€ 609.26	€ 648.33	€ 648.33	€ 658.10	€ 667.87	€ 677.63	€ 687.40	€ 717.79	€ 717.79	€ 717.79	€ 717.79	€ 717.79	€ 717.79	€ 717.79	€ 717.79
Net Cash Flow	€ -	€ -100.28	€ -61.21	€ -61.21	€ -51.44	€ -41.67	€ -31.90	€ -22.14	€ 8.25	€ 8.25	€ -991.75	€ 717.79	€ 717.79	€ 717.79	€ 717.79	€ 717.79
Discounted Net Cash Flow	€ -	€ -95.50	€ -55.52	€ -52.87	€ -42.32	€ -32.65	€ -23.81	€ -15.73	€ 5.58	€ 5.32	€ -608.85	€ 419.68	€ 399.69	€ 380.66	€ 362.53	€ 345.27
Start of year cashflow		€ -	€ -95.50	€ -151.02	€ -203.89	€ -246.21	€ -278.86	€ -302.67	€ -318.40	€ -312.82	€ -307.50	€ -916.35	€ -496.67	€ -96.98	€ 283.68	€ 646.21
End of year cashflow		€ -95.50	€ -151.02	€ -203.89	€ -246.21	€ -278.86	€ -302.67	€ -318.40	€ -312.82	€ -307.50	€ -916.35	€ -496.67	€ -96.98	€ 283.68	€ 646.21	€ 991.48

Figure 44: Cash flow overview of the customer for the financial lease. The financial lease is 10 years and with the last payment, the residual value is added as well.

Appendix D.3: Net operational lease

The operational lease construction can vary between two and five years. The figure below shows a statement for three years. The last payment of the net operational lease contract will have an additional €300 because the battery needs to be deinstalled from the house which is equal to the installation costs. After the termination of the contract, the battery will return to Zonneplan and be refurbished. Therefore, the battery will not generate any benefits or costs after the contract has ended.

Cash flow Customer	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038
Renting payments		€ -1,352.85	€ -1,352.85	€ -1,352.85	€ -1,352.85	€ -1,652.85	€ -	€ -	€ -	€ -	€ -	€ -	€ -	€ -	€ -	€ -
Benefits PV		€ 609.26	€ 648.33	€ 648.33	€ 658.10	€ 667.87	€ -	€ -	€ -	€ -	€ -	€ -	€ -	€ -	€ -	€ -
Net Cash Flow	€ -	€ -743.59	€ -704.52	€ -704.52	€ -694.75	€ -984.98	€ -	€ -	€ -	€ -	€ -	€ -	€ -	€ -	€ -	€ -
Discounted Net Cash Flow	€ -	€ -708.18	€ -639.02	€ -608.59	€ -571.57	€ -771.76	€ -	€ -	€ -	€ -	€ -	€ -	€ -	€ -	€ -	€ -
Start of year cashflow		€ -	€ -708.18	€ -1,347.20	€ -1,955.79	€ -2,527.36	€ -3,299.12	€ -3,299.12	€ -3,299.12	€ -3,299.12	€ -3,299.12	€ -3,299.12	€ -3,299.12	€ -3,299.12	€ -3,299.12	€ -3,299.12
End of year cashflow		€ -708.18	€ -1,347.20	€ -1,955.79	€ -2,527.36	€ -3,299.12	€ -3,299.12	€ -3,299.12	€ -3,299.12	€ -3,299.12	€ -3,299.12	€ -3,299.12	€ -3,299.12	€ -3,299.12	€ -3,299.12	€ -3,299.12

Figure 45: Cash flow overview for net operational lease. In this example, the contract is five years, and the interest equals 11%.

Appendix D.4: Payment in installments

The payment in installments is directly linked to Zonneplan and there is no external financing company in between. To cover the risks, a downpayment of ten percent is paid at the beginning of the contract in 2023. The payments are equal for each term and when the payments are finished, the battery will only generate benefits.

Cash flow Customer	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038
Payment in Installments	**€ -500.00**	€ -2,732.80	€ -2,732.80	€ -	€ -	€ -	€ -	€ -	€ -	€ -	€ -	€ -	€ -	€ -	€ -	€ -
Benefits PV		€ 609.26	€ 648.33	€ 648.33	€ 658.10	€ 667.87	€ 677.63	€ 687.40	€ 717.79	€ 717.79	€ 717.79	€ 717.79	€ 717.79	€ 717.79	€ 717.79	€ 717.79
Net Cash Flow	€ -500.00	€ -2,123.54	€ -2,084.47	€ 648.33	€ 658.10	€ 667.87	€ 677.63	€ 687.40	€ 717.79	€ 717.79	€ 717.79	€ 717.79	€ 717.79	€ 717.79	€ 717.79	€ 717.79
Discounted Net Cash Flow	€ -500.00	€ -2,022.42	€ -1,890.68	€ 560.05	€ 541.42	€ 523.29	€ 505.66	€ 488.52	€ 485.83	€ 462.69	€ 440.66	€ 419.68	€ 399.69	€ 380.66	€ 362.53	€ 345.27
Start of year cashflow		€ -500.00	€ -2,522.42	€ -4,413.10	€ -3,853.04	€ -3,311.62	€ -2,788.33	€ -2,282.67	€ -1,794.14	€ -1,308.31	€ -845.62	€ -404.96	€ 14.72	€ 414.41	€ 795.07	€ 1,157.60
End of year cashflow		€ -2,522.42	€ -4,413.10	€ -3,853.04	€ -3,311.62	€ -2,788.33	€ -2,282.67	€ -1,794.14	€ -1,308.31	€ -845.62	€ -404.96	€ 14.72	€ 414.41	€ 795.07	€ 1,157.60	€ 1,502.87

Figure 46: Cash flow overview for 2 installments.

Not only the cash flow overview for the customer change, but the working capital will also change. The customers will pay in installments, and this will influence the current assets of Zonneplan. As illustrated in the figure below, the working capital is negative, which means that Zonneplan does not have enough current assets to pay off its current liabilities.

Working capital		2024				2025				2026			
Current Assets		*1*	*2*	*3*	*4*	*1*	*2*	*3*	*4*	*1*	*2*	*3*	*4*
Debtors (customers)		€ 1,281,001.75	€ 2,562,003.50	€ 3,843,005.26	€ 5,124,007.01	€ 7,686,010.51	€ 10,248,014.02	€ 12,810,017.52	€ 15,372,021.03	€ 19,215,026.29	€ 23,058,031.54	€ 26,901,036.80	€ 30,744,042.06
Current liabilities													
Creditors (Zonneplan to suppliers)		€ 0.00	-€ 8,383,125.00	-€ 8,383,125.00	-€ 6,796,875.00	-€ 6,796,875.00	-€ 13,593,750.00	-€ 13,593,750.00	-€ 13,593,750.00	-€ 13,593,750.00	-€ 27,187,500.00	-€ 27,187,500.00	-€ 27,187,500.00
Taxes		-€ 504,578.39	-€ 512,318.39	-€ 921,570.89	-€ 921,570.89	-€ 1,907,803.72	-€ 1,907,803.72	-€ 1,907,803.72	-€ 1,907,803.72	-€ 3,879,219.40	-€ 3,879,219.40	-€ 3,879,219.40	-€ 3,879,219.40
Operation Cost		-€ 878,391.33	-€ 848,391.33	-€ 848,391.33	-€ 848,391.33	-€ 1,450,224.67	-€ 1,450,224.67	-€ 1,450,224.67	-€ 1,450,224.67	-€ 2,653,891.33	-€ 2,653,891.33	-€ 2,653,891.33	-€ 2,653,891.33
Working capital		**-€ 101,967.97**	**-€ 7,181,831.22**	**-€ 6,310,081.96**	**-€ 3,442,830.21**	**-€ 2,468,892.87**	**-€ 6,703,764.37**	**-€ 4,141,760.86**	**-€ 1,579,757.36**	**-€ 911,834.45**	**-€ 10,662,579.20**	**-€ 6,819,573.94**	**-€ 2,976,568.68**

Figure 47: The working capital when the customer pays in installments.