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A Collaborative Business Model for Local Energy Storage: The Case of Groningen, the Netherlands

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Date: 30.11.2021
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Contents

List of abbreviations

EV	Electric vehicle
PED	Positive Energy District
PV	Photovoltaic
BIPV	Building Integrated Photovoltaic
BESS	Battery Electric Storage System
IRENA	International Renewable Energy Agency
CES	Community Energy Storage
CAPEX	Capital Expenditure
OPEX	Operational Expenditure
BMC	Business Model Canvas
ESCo	Energy Service Company
DSO	Distribution System Operator
TSO	Transmission System Operator
BRP	Balancing Responsible Party
USEF	Universal Smart Energy Framework
DSF	Demand Side Flexibility
FCR	Frequency Containment Reserve
DNO	Distribution Network Operator
ICT	Information Communication Technology
NPV	Net Present Value
PP	Payback Period
ROI	Return on Investment

Developing a Collaborative Business Model for Local Energy Storage in Groningen

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1. Introduction

1.1. The Changing Energy System

The climate is changing due to human emissions and this is already having drastic consequences such as floods, droughts, wildfires, and other extreme weather events [1]. To reduce the effects of climate change, emissions will have to be cut in all sectors. This also includes the energy sector that is still contributing to these emissions with its immense, centralized, fossil fuel-based power plants [1]. Especially in the Netherlands the producers of heat and electricity still hold the highest share of CO2 emissions [2]. But the energy system is changing [3–6]. It is moving away from a centralized approach towards a combination of bottom-up and top-down systems where citizen and local communities are included to a greater extent [4]. The decline of solar prices, increasing residential electricity prices, favorable public opinion, and government support make solar panels more interesting for single households and small communities [6]. But the increasing share of such intermittent generation from solar and wind is forcing the system to adapt to increased fluctuations on the grid [5–9]. To reach the goal of net-zero emissions by 2050 did the Dutch government announce that by 2023 wind and solar generation should exceed 32% in the mix of electricity production [10].

Transmission and distribution grids face difficulties more often since the intermittent supply does not always match demand [4]. Overproduction during noon that overlaps with little consumption also causes congestion and voltage problems [11]. Moreover, there are new peak loads due to increased market penetration of electric vehicles (EV) and increased electrification of other sectors which the Distribution System Operator (DSO) has to deal with [12–14]. A traditional solution would be to upgrade the grid but this is very cost and time-intensive [15]. This would increase the costs for the customers and since would cause resistance from the citizen, this would slow down the energy transition. Until the grid is upgraded, new renewable sources will have problems to dispatch due to bottleneck effects. An attractive alternative could be using the grid more efficiently through ancillary and flexibility services to ensure reliable operation [3, 16]. For this reason, energy storage technologies are getting more attention in recent years since they can offer these kinds of services [17].

1.2. The Case and the Research Question

"Making-City" is a 60-month Horizon 2020 project and was launched in 2018. It uses the concept of Positive Energy Districts (PED) to move forward the transition of urban areas towards a sustainable future. A PED is defined as a *"district with annual net*-zero energy import and net-zero carbon emissions, working towards an annual local surplus *production of renewable energy"* [18]. The project includes two lighthouse cities that are testing several new technologies and systems which will then be replicated in six follower cities.

Groningen is one of the two lighthouse cities and within Groningen, two districts are the focus of the project. The northern district (PED-North) includes, among others, an apartment building owned by the company Nijestee with ca. 108 apartments which will install >15kWp Building Integrated Photovoltaic Panels (BIPV).

Figure 1 Nijestee building - The picture on the right shows the house wall where the BIPV are being installed

They also consider installing two EV charging stations. A special aspect of this case is the fact that the building has two elevators which require an extra grid connection. These two elevators have a 3*16A connection each. An elevator is used rather infrequently but when it is used, it can have power peaks up to 7kW. Energy storage could make this extra elevator grid connection for new buildings in a future PED obsolete. This could make the case described above more profitable since it would save the apartment owners the costs for this extra grid connection. But since the storage will be used only to a limited extent, other services will be considered to make the battery economically viable. The goal of this thesis is to find a viable business model that would be for new houses and homeowners in a PED. But also more complex scenarios will be considered that include additional stakeholders such as the grid operators on the distribution as well as transmission level and local aggregators.

Since this research is based on a specific case study, there are two main research questions. One general question that will focus on is the development of a concept for business models for local energy storage. And one specific research question that is tailored to the use case of the Making City project:

1. How can a business model for energy storage be designed and become beneficial for all stakeholders in the context of the Making City project?
2. How could such a business model be generalized so it can be used as a framework in other cases?

To answer these questions, the literature review discusses academic proposals for such a business model and summarizes different possible revenue streams as well as ownership structures. Additionally, legal and economic barriers are analyzed to what factors impede such a business model. And finally, other pilot projects and cases will be presented before the literature gap is defined.

The literature review leads to the design of a conceptual business model, which was implemented in a technical and financial model where it could be analyzed how different storage capacities affect the business case and under which conditions the conceptualized business model for energy storage can be profitable. The result is a technical analysis that discusses the consumption and production profiles and to which degree a storage device could improve self-consumption. The results from the technical analysis are used in a financial model that gives insights into the profitability of each scenario.

2. Literature Review

The literature defines the terminology for this research and discusses the value of energy storage as well as different business models that were already analyzed by other scholars. This will be used as a basis for the conceptualization of the three different scenarios described in section 1.2.

2.1. Definitions

Since the case owner is mainly interested in Battery Electric Storage Systems (BESS) as a solution, this will be the main focus of this study. However, the terminology BESS implies a rather narrow focus and since the goal of this research is to develop a model that is capable to simulate different energy storage technologies, the term energy storage will be used. Energy storage is defined as a device that is able to absorb and store energy until it is instructed to discharge and deliver this energy back.

The terminology for this device is purposely not narrowly defined in this study, since several energy storage technologies with different storage mechanisms will be analyzed that are not all based on battery electric systems.

2.2. The Value of Energy Storage

According to Ugarte [19], energy storage permits better management of intermittent electricity supply and increases the flexibility of the system. The International Renewable Energy Agency (IRENA) argues that electricity storage will be at the heart of the energy transition and will be able to rapidly drive decarbonisation [3]. Furthermore, *a report of the Horizon2020 project "STORY"*[2] indicated that electricity storage can improve self-sufficiency and self-consumption, decrease network losses and mitigate the impact of renewables on the grid [20].

[2] STORY is a European project researching new energy storage technologies and their benefits in distribution systems

Several studies already analyzed in-depth different applications for energy storage. Local storage can help to utilize the full potential of PV installations that would otherwise suffer limitations due to grid capacity [21]. By increasing the amount of electricity delivered to the customer, batteries also have the potential to lower emissions [22] and save owner-related compliance costs [23]. It can offer services like frequency control and capacity or voltage support which improves the stress-resistance of the electricity grid as well as its reliability, security, and responsiveness [9].

These storage systems are also implemented in an energy community context where one storage installation covers several households. These community energy storage systems (CES) accelerate the development towards a more decentralized energy system since they allow to increase the self-consumption of neighborhoods [4]. Community-scale storage usually offers a capacity of 100kW-500kW and creates benefits by reducing costs for the customer, peak shaving, and increased network hosting for non-dispatchable generation such as solar rooftops [24].

Several authors agreed that especially batteries are interesting since they can also offer flexibility to the grid within milliseconds [6, 7, 25]. These services cannot be offered by storage technologies with a longer ramp-up/down rate like pumped hydro storage. Thus, battery storage has been recognized as well in the Netherlands as a promising technology which led to the development of a national strategy to accelerate battery use [26]. Moreover, the Dutch association for electricity and gas network operators formulated in its vision for 2050 that the electricity system needs new flexibility means [27].

Ramos *et al.* [28] claim that flexibility offered by battery energy storage will be one of the core elements of the future energy system. This has the opportunity to generate new revenue streams for energy storage and thus allow to cover the considerably high capital expenditures (CAPEX) of energy storage systems [17]. Since multiple services can be considered, new business models for such local energy storage systems are possible [3, 4].

In summary, the academic literature indicates that energy storage has an added value for the energy system. There is a need for energy storage systems and new storage technologies that could combine different flexibility services. But concepts for the monetization for such systems are still under investigation with researchers arguing that the development of viable business models still is a challenge [29]. Thus, the next chapter will analyze different business models for energy storage that were proposed by other scholars.

2.3. Business Models

Batteries will become increasingly competitive since the costs for emerging technologies continue to fall and multiple service batteries will have new additional revenue streams [3]. This causes dynamics in terms of new actors (such as prosumers), new market design as well as novelle business models [4]. *"A business model describes how a company plans to create value for its customers and capture a portion of the value it creates"* [28]. How this value is generated can be conceptualized using the Business Model Canvas (BMC). Mir Mohammadi and Davis [29] developed a theoretical business model based on six components of the BMC: Customers, value proposition, channels, revenue streams, resources, and costs. This research will focus on the revenue streams and costs for the collaborating organizations and will analyze the value proposition for each stakeholder

The grid operator is not allowed to interact with the markets, but end-consumer and energy companies could also become a customer for electricity as a commodity. The energy storage owner/operator can offer services to end-consumer, energy companies, and the grid operator. These services are a main part of the value proposition but they are very diverse and complex which is why their exact mechanisms will be explained in detail in the next chapter. The channels in the case of energy storage can be the wholesale market, retail market, balancing, and ancillary services [29]. Concerning the revenue streams did Mir Mohammadi and Davis [29] identify five different options:

Table 1 Different revenue streams for ESS according to (Mohammidi & Davis, 2018)

Revenue stream	**Explanation**	**Example**
Asset sale	Transferring ownership of physical goods such as energy	day-ahead market
Usage fee	Payment for use of specific service	reserve capacity
Subscription fee	Payment to obtain access to services of ESS	End-consumer uses behind-the-meter ESS from ESCo
Renting/ lending/ leasing	One party exclusive right for using its ESS to another party	ESCo owning ESS but allowing other energy companies to use it
Broker fees	Intermediation service	shared savings arrangements between ESCo and end-consumers

Concerning the costs of energy storage, the authors include CAPEX in terms of annual debt payment and fixed operation/ maintenance costs while the operational expenditures cover the variable operation/ maintenance costs as well as charging costs [29].

Several studies looked at different characteristics of possible strategies for new business models. Parra *et al.* [30] summarized studies that looked into different controlling strategies for PV plus battery systems, Lombardi and Schwabe [7] analyzed battery flexibility services (peak-shaving, self-consumption increase, and day-ahead market participation), as well as a sharing-economy approach and Shaw [24] did research on different ownership structures and how they affect the profitability of community batteries.

First studies estimate an Internal Rate of Return (IRR) between 11% and 40% by 2025 for sharing battery operations [7]. However, the profitability of energy storage is very case-dependent [31] and several strategic decisions concerning the ownership structure and the offered flexibility services have to be made.

For scenario 3 different ownership strategies were analyzed (appendix 8.2). This paper will follow the approach of Shaw [24] who concluded in his research that a third-party-owned battery is the most profitable. Additionally, different flexibility services were examined (appendix 8.1) and since in the north of the Netherlands local grid congestion is an increasing problem [32], congestion management for the DSO will be the focus of this study.

Several pilot projects and cases were studied (appendix 8.3) to analyze the current status of practical cases. Only a few of those cases are profitable, but one case in Finland managed to be a positive business case [14]. Here services for the local DSO were combined with activity on the FCR market. Following this strategy, this research will focus on a combination of DSO congestion management and FCR markets.

To conclude, scenario 3 will focus on a value stacking approach. The exact priorities and logic of the flexible service structure are explained in chapter 3.1.4.

2.4. Barriers

2.4.1. Regulatory Framework

When discussing the legal framework for energy storage of the Netherlands, four main aspects are important to consider [26, 29, 33–36]:

1. Net metering scheme
2. Double Taxation
3. Lack of subsidies
4. Limitations for DSO & TSO to own storage assets

The net metering scheme serves as an incentive to promote renewable energy production. It allows to subtract the locally produced energy from the electricity bill and thus delivers a financial incentive for PV owners to produce renewable energy. However, this disincentivizes behind-the-meter energy storage because prosumers have no benefit in shifting their load to off-peak periods [26, 29, 33–36]. The government is now phasing out this scheme by reducing the amount of PV electricity that can be net metered by 9% every year [37]. A lower or not-existing net metering scheme would be beneficial for the business case of energy storage since storing the electricity and using it at a later point in time is more profitable for the PV owner than just dispatching at all times.

The double taxation, lack of subsidies, and limitations for the DSO all root in one common problem: The lack of a definition of energy storage in the legal framework. Due to this gap in the legal context, the business case of energy storage suffers from the fact that it has to pay taxes when it charges and when it discharges. This doubled operational expenditure has a considerable negative effect on the revenue. However, this policy will phase out by January 2022. [38]

Similar problems arise when applying for subsidies. Several support schemes like the SDE++ or the ISDE are in place that have the goal to increase renewable energy production and improve residential energy efficiency. But they do not include energy storage as one of the potential technologies that could apply for financial support. And lastly, the DSO has an interest in developing energy storage to assure grid stability even if intermittent generation will increase in the future. However, since the DSO is legally not allowed to engage in commercial activities, it is also not possible to own energy storage since this would include trading the commodity [26, 29, 33–36]. Additionally, there is also no regulatory framework for the DSO and the TSO through which they can be supported by services from third parties that own energy storage [29].

2.4.2. Economic Barriers

One of the main barriers is still the relatively high investment costs for storage. When compared to the curtailment of renewable sources, the installation costs of energy storage systems are still too high as stated by Hossain *et al.* [39]. The same authors argue that business models for battery electric storage systems lack markets and price signals. With this, they mean that often the compensation of storage services is not adequate or is very complicated to determine for different ancillary services. Value stacking is an approach that allows improving the business case of aggregators but is also highly complex due to conflicting products, different timing for flexibility trading, or a lack of markets and framework, as in the case for constraint management on DSO level [16].

These complexities bear inherent economic risks for battery business models. Additionally, are those business models economically dependent on the demand of ancillary services to be profitable. With more storage facilities in the market, those services will be less profitable and could lead to a financial collapse of individual installations [39].

2.5. Research Gap

International Renewable Energy Agency (IRENA) [3] assumes electricity storage to be a crucial part of a sustainable energy system despite the economic uncertainties for local energy storage. For this reason, this study will look closer into the Making-City case in Groningen to investigate possible new business models for energy storage. The research will include a technical as well as a financial model. Moreover, the different expectations of the stakeholder will also be analyzed in terms of cost-benefit distribution, roles, and responsibilities since Proka *et al.* [9] already found this to be an important factor for a collaborative business model.

Implementation of energy storage might benefit from new energy policy as well as new legislation. These could be tariffs structures such as time of use tariffs, where electricity prices are defined for certain periods of the day with a specific demand profile [40], and location-based net metering where a local meter runs backward and imports, as well as exports, are both valued at the retail price [41]. New organization and business models as well as coordination and interaction among community and energy system actors have to be developed for local energy storage [4]. Additionally, studies indicated that the question of ownership should be further investigated and that hybrid actors, like the DSO, are of special interest in this context [9].

Energy storage devices are likely to be provided by housebuilders, PV installers, utilities, and DSOs (or third parties supplying them storage as a service): some benefits will accrue to householders through lower bills or reduced service charges. However, the battery owners and DSOs will also wish to see financial benefits. The business models have yet to be fully developed, but some of the biggest challenges lie around accessing and monetizing the multiple value streams. It is also important to ensure that all parties are able to clearly see the value, and pay and be remunerated for the benefits local storage brings [17]. A fair distribution of the benefits between the stakeholders seems to be challenging [15]. Recent scholars found that one problem is especially the difference in perceived benefits of a neighborhood battery for different stakeholders. Proka *et al.* [9] tried to develop a collaborative business model that aligns different expectations but failed. They could only map some preliminary ideas about it which this study will build upon.

Over the last years, only few business models seemed to be attractive to investors and in most of these cases, storage was only used for one use case such as primary control reserve [7]. Multiple-service batteries are already investigated and showed first successful attempts to implement a system that offered collective self-consumption, ancillary services, and local grid support [42]. Additionally, there was a pilot project in Finland that developed a business model where a battery system delivered services to the DSO. Here an aggregator company made the investment, offered services to the DSO, and used the battery for primary frequency regulation services when there was no flexibility demand by the DSO. However, *this is only a feasible business case if the occurrence and duration of the DSO's needs are very limited [14]. Additional research is needed to determine to which degree flexibility services can be used to avoid increasing difficulties on the grid [15].*

Mir Mohammadi and Davis [29] developed a theoretical business model for electricity storage systems in the Netherlands. They based their work on the Business Model Canvas approach and defined customers, value proposition, channels, revenues streams, resources, and costs of ESS in the context of the Netherlands. However, this *paper only dealt with a theoretical model and the authors themselves wrote that "the business models need to be tested and evaluated"* [29]. Thus, this research will use the insights from Proka *et al.* [9], Mir Mohammadi and Davis [29], and the projects described above [14, 42] to develop a collaborative business model for a BESS that is beneficial to all stakeholders in the Making City project and can serve as a blueprint for other regions.

3. Method: The Hybrid Approach

This research applies a hybrid method consisting of modeling and semi-structured interviews.[3] In the context of this research, it allows us to analyze different scenarios for the specific case in the Making-City project and via the expert interviews we can be assured that the developed model is realistic and feasible. Moreover, the interviews allow us to include analyze the perspectives and expectations of all stakeholders which is crucial according to Proka *et al.* [9].

3.1. Modeling

3.1.1. Theoretical Framework

Models are the ideal tool to design systems, for the development of system operating policies, and for research to develop system understandings [43]. As shown in several studies, modeling is an adequate approach to design and investigate hybrid photovoltaic-storage systems [44–47].

[3] The python code and an explanation sheet of the financial model can be found in appendix 7.1 and 7.2. The interviews are currently being transcribed.

To assure a valid modeling process, this study followed the approach of Sargent [43].

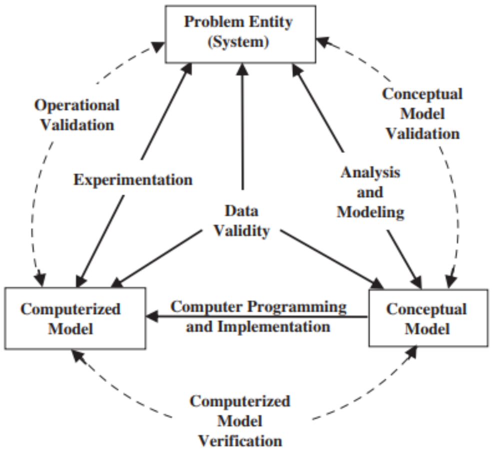

Figure 3 Sargent et al. - Modelling Process

The problem entity was described in 1.2. where the case of the Making-City project was explained in more detail. This problem entity is conceptualized in 3.1.3. as can be seen in Figures 5-6. The computerized model is explained in appendix 7.1.-7.3. where the python code, as well as the logics of the programme and the financial analysis in excel, are explained. The validation and verification of the model are explained in section 3.1.5.

3.1.2. Python and Excel

This research follows a dual approach using python for the technical model and Microsoft excel for the financial model. The reason for this dual modeling is the fact that the pandas library in python can handle datasets with several thousand single datapoints, which would be energy and time-consuming in Microsoft excel. Thus, python was used to model the *storage's* state of charge depending on demand and production profiles as well as calculate the self-sufficiency and self-consumption for different storage sizes. The logic and the decisions paths of the program are explained in appendix 7.3. Furthermore, python already proved to be adequate in other studies that investigated photovoltaic and battery systems [48–52]. The results of this technical model will be automatically integrated into the financial model, which is implemented in excel. Excel has problems handling large datasets but is the ideal tool for displaying, analyzing, and manipulating financial data and conducting financial assessments [53–55]. Thus, the technical model and raw data calculations are done in python and the financial model including Net Present Value (NPV), CAPEX, OPEX, subsidies as well other financial specifications such as the equity structure is implemented in Microsoft excel.

To build the model on solid ground, three scenarios will be compared to a base case scenario:

Base case scenario: Apartment building with BIPV

Alternative scenarios:

1. Apartment building with BIPV and battery (60-70 kWh)
2. Apartment building with BIPV, battery (60-70 kWh), and two EV charging stations
3. Apartment building with BIPV, two EV charging stations, and battery with community-scale capacity (400-600 kWh)

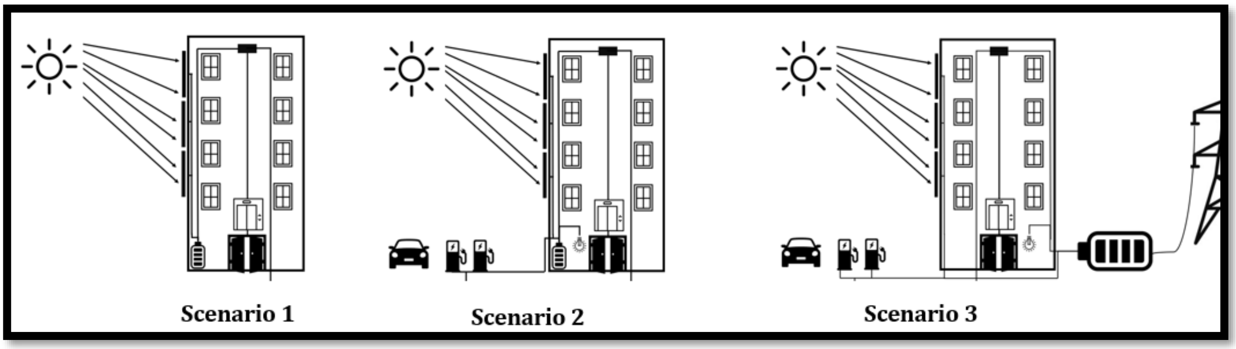

Figure 4 The three scenarios

This will allow the researcher to evaluate the business model in different contexts. In each scenario, the main goal of the battery is to cover the demand of the elevator in the building. These models will first be built on a conceptual level to define the roles and responsibilities. This is especially important to illustrate the different benefits and multiple revenue streams which is crucial as pointed out by Parra (2017) and Fonteijn (2019). This schematic business model will be the framework for the calculations in the technical and financial model. For details on these calculations see appendix 7.1.

3.1.3. Conceptual Model of the three Scenarios

Following the framework of [43], before building the computerized model in python and excel, the three scenarios were conceptualized to get an overview. The project is described in 1.2. was split into three scenarios with increasing complexity. In scenarios 1 & 2 the battery focuses on the building and has the main goal to power the elevator.

The difference between the two scenarios is that in scenario 2 we also add 2 EV charging stations in the business model (see Figure 5).

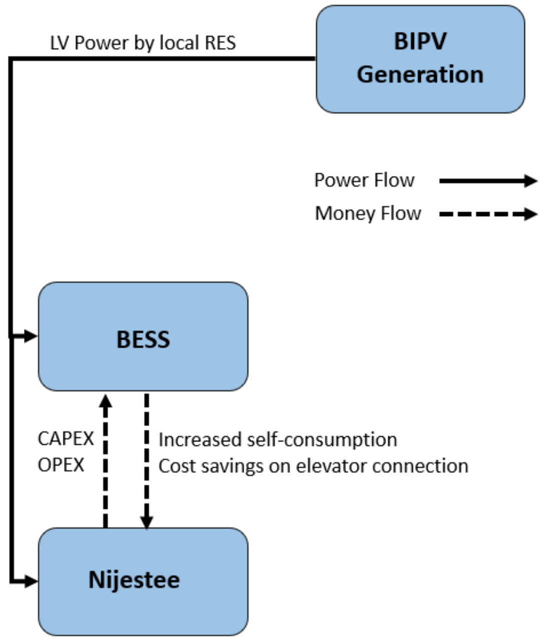

Figure 5 Scenario 1 - Concept

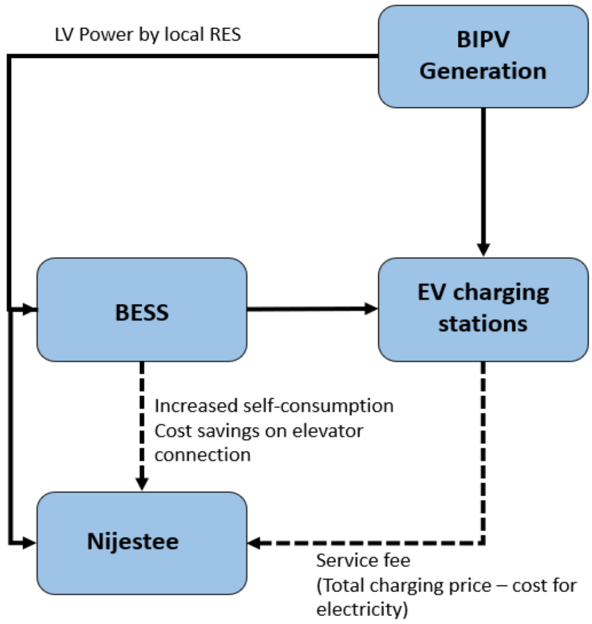

Figure 6 Scenario 2 - Concept

The third scenario (Figure 7) assumed a more complex case where the battery has a community scale capacity (400-600 kWh) and also offers flexibility to the DSO and the TSO. The system would thus have multiple revenue streams: Battery capacity would be rented out to the Nijestee corporation, while the DSO and TSO pay a usage fee for the storage service (see table 1). The conceptual model was based on the review of other storage projects (appendix 8.3.4) and especially on the results of [14]. The roles and responsibilities are based on the USEF framework [16] as laid out in section 2.2. Following this framework, Nijestee takes the role as an active customer and works together with a local aggregator that can then deliver services to BRP, TSO, and DSO. For the reasons given in 2.2.2. the aggregator would be responsible for operating the battery. The aggregator and Nijestee are combined in a single market party as defined in the integrated aggregator model of the USEF framework [16]. For this model, it is assumed that we can pool our storage resources through the aggregator with other assets and thus fulfill the requirement of 1 MW capacity to participate in the imbalance and FCR market.

As mentioned in 2.2. are TSO and DSO are trying to avoid expensive grid upgrades and would thus participate in a business model to support the grid. The DSO would have a higher priority and would have the right to reserve a certain capacity of the battery that can be used to relieve the grid (for more details see appendix 7.3.). The TSO has a secondary priority. As shown by [14], bidding on the FCR market can be a profitable strategy. For this study the technical model also allows using data from the imbalance market, to see whether it could be another option parallel to services for the DSO.

In the 3rd scenario, the high CAPEX of the large-scale BESS is a shared investment of the Nijestee cooperation and the aggregator since it was assumed that a housing corporation will not invest several hundred thousand euros in a storage device. It will also be analyzed whether a local energy cooperative can take the role of the aggregator. As for scenarios 1 and 2, it is the goal in this scenario to cover the demand of the elevator. But in this case, the additional capacity will be used to relieve grid congestion on the local grid and support the TSO via an aggregator that takes the role of a BSP (see Figure 7).

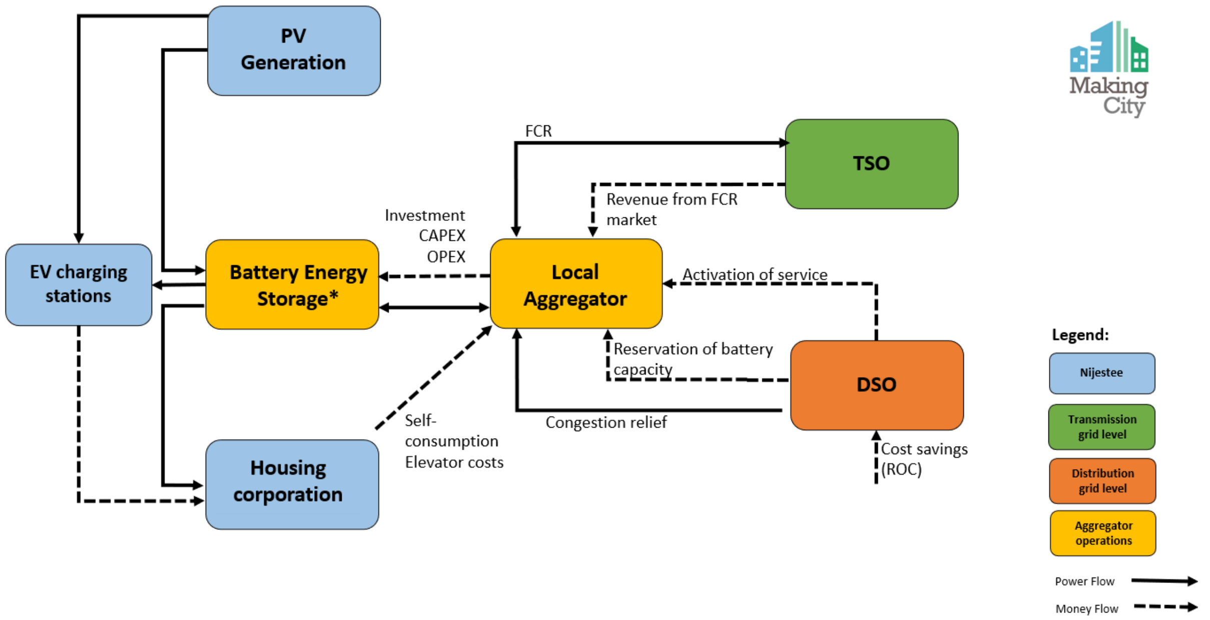

Figure 7 Scenario 3 - Concept

These models will be used as a framework for the computerized model in python and excel.

3.1.4. Computerized Model

The computerized model combines consumption as well as production profiles where the main goal is that the peak power of the elevator is always covered. Thus, the profiles will be analyzed in terms of energy consumption in kWh but also power consumption in kW. The outcome of the technical model is the amount of BIPV energy self-consumed, how much energy was sold to the grid as well as the self-consumption. The self-consumption rate is defined as:

$$\text{Self-consumption} = \frac{\text{Energy consumed from BIPV generation}}{\text{Total BIPV generation}}$$

Equation 1 Definition of self-consumption

Moreover, the technical model calculates the battery capacity that is needed to cover the peak-power demand of the elevator. The outcome from the technical model is used in the financial model to calculate the Net Present Value (NPV), the Internal Rate of Return (IRR) as well as the Payback Period (PP). The NPV is ideal to compare the profitability of certain investment decisions [56]. The IRR is calculated to compare the findings of Lombardi and Schwabe [7] mentioned in 2.3.

The calculations for scenarios 1 and 2 follow a decision tree design, where based on certain conditions (for instance the elevator is used and there is PV generation) the state of charge is calculated based on the given conditions. The algorithm is rather simple and is explained in more detail in appendix 8.5. This chapter focuses on the simulation of the flexibility services for scenario 3.

For the third scenario the priorities are the following:

1. Elevator peak-shaving
2. DSO congestion
3. FCR market
4. Self-consumption

The algorithm calculates an elevator reserve, which is a capacity that will not be used by the other two services. This assures, that the elevator can always be covered.

The reservation mechanism for the DSO blocks FCR services so that the battery delivers its service to relieve grid congestion. This simulates the DSO reserving capacity in advance. In Figure 8 one can see that while the storage is reserved for the DSO, no bid will be made on the FCR markets. This is even the case if we assume that all our bids get activated. If the DSO reserves the storage it is blocked for all other services.

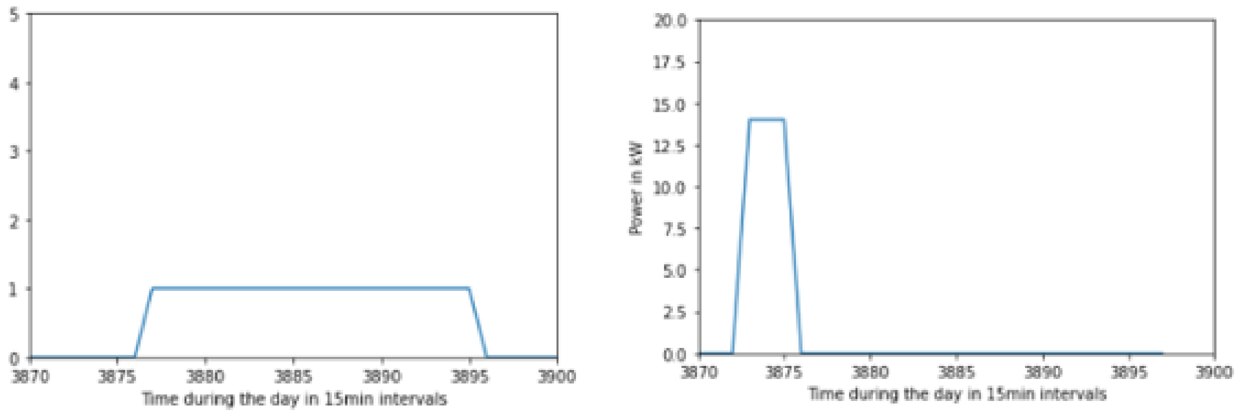

Figure 8 DSO reservation (left) and TSO activation (right) for the same time frame

For the FCR market, a random function was set up that simulates the FCR service being activated at a certain probability. In Figure 9 you can see the weekly FCR activation profile if we assume 10% of our bids get activated. The bidding strategy follows an always available approach, where the first priority is to always deliver the *contracted amount and don’t risk any fines.*

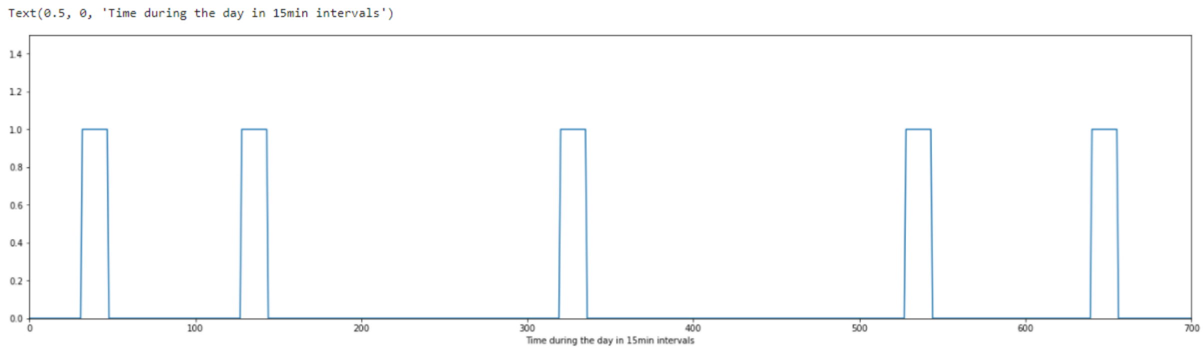

Figure 9 Scenario 3 - FCR activation profile for 10% activation rate

When a bid on the FCR market gets activated, the storage gets charged and discharged based on the measured frequency on the grid:

> *"An installation must be able to continuously supply the* full quantity of FCR awarded/contracted for a period of not less than 15 minutes in the event of a deviation of 200 mHz or more, or to supply partial delivery for a proportionately *longer period in the event of frequency deviations lower than 200 mHz."* [57]

However, simulating different dispatch behavior based on the actual network frequency is beyond the scope of this research. As one can see in Figure 10, when a bid gets activated for a block of 4 hours, the program simulates a stagnating SOC. Even though this does not comply with the physical reality, it is a reasonable assumption since FCR is a symmetrical product that on average dispatches equally in both directions. This should result on average in the same SOC at the beginning and the end of a contracted period. Important is, that during this phase no implicit service in form of self-consumption will be used.

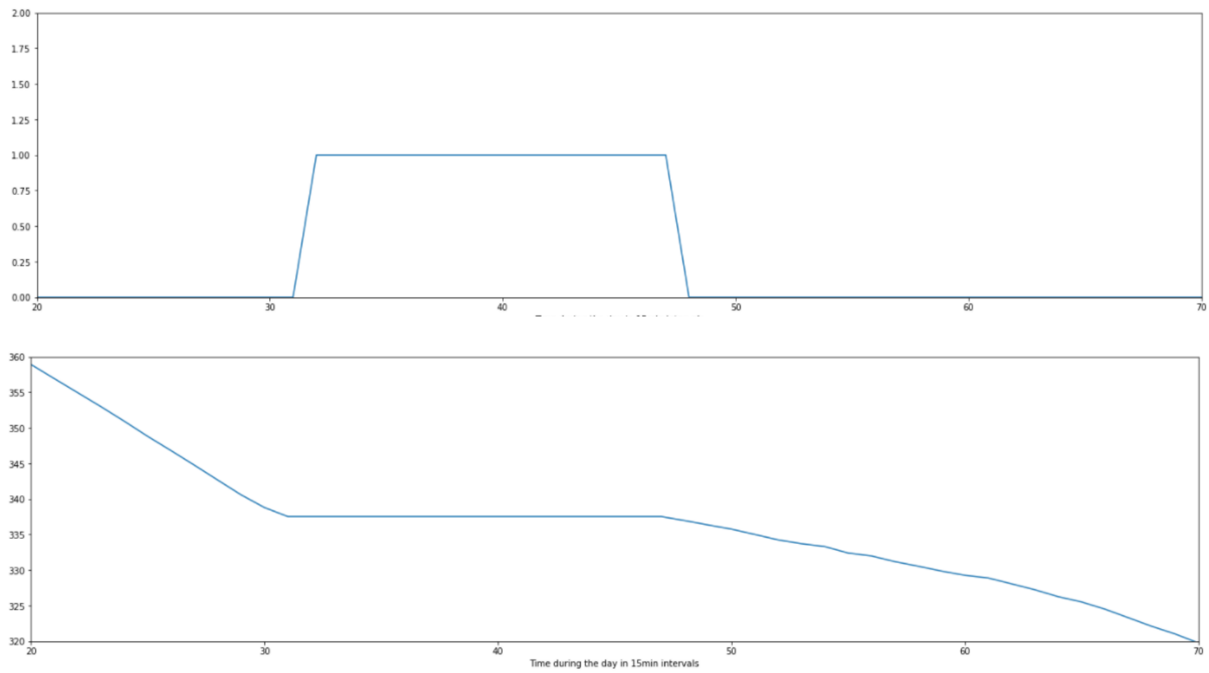

Figure 10 Scenario 3 - FCR simulation – Activation of FCR service (top) and state of charge in kWh (bottom) for the same time frame

If the elevator demand is covered, there is no congestion on the DSO grid and no bid gets activated on the FCR market, the Nijestee corporation uses the storage for self-consumption. The following financial data is used for these calculations.

The financial analysis is based on the data below and will follow the same structure for all scenarios.

Table 2 Financial data for the base case and all three scenarios

	Base Case	Scenario 1	Scenario 2	Scenario 3	Source
CAPEX & OPEX					
CAPEX 15kWp BIPV[4]	40,000 €				NIJ[5]
OPEX BIPV	*750 € Maintenance* *100 € insurance*				NIJ[5]
Electricity price bought	*0.16 €/kWh*				[58]
Installation extra grid connection	1,638€[6]	-			[59]
Costs for grid connection per year	428€ [6]	-			[59]
CAPEX storage[4]	-	*750 €/kW*			[29]
OPEX storage	-	*10 €/kW*			[29]
CAPEX Charging stations[4]	-	-	11,440 €		NIJ[5]
OPEX Charging stations	-	-	*400 € Maintenance* *151 € Insurance*		[60, 61]
Revenue streams					
Electricity price sold	*0.16 €/kWh* [7]				[58]
EV charging fee	-	*0.4€ per kWh charged*			[59, 62]
DSO congestion reserve[8]	-	-	-	*15,000 €*	Assumption
DSO congestion remuneration per MWh	-	-	-	250 €[9]	[63]
FCR renumeration per MW reserve	-	-	-	*138 €/MW*[10]	[64]
Financial result					
NPV	$NPV = \sum_{i=1}^{n} \frac{Cash\ Flow_i}{(1+r)^i} - Initial\ Investment$				

This data was mostly derived from literature or partners in the project. For the DSO congestion reserve, a random assumption was made. Since the goal of this research is to develop a business model that is beneficial for all stakeholders, it will be analyzed whether an extra

[4] Including installation costs
[5] NIJ: This is information based on information from the Nijestee corporation based on their discussions with suppliers
[6] Assuming two 3*16A connections are installed
[7] The Net Metering Scheme is currently phasing out which is why the financial model simulates a by 9% *decreasing electricity price from 2022 until 2031. From 2031 the price is at 0.06€/kWh*
[8] Fixed payment per year
[9] The interview partner from Enexis mentioned that such a model is only interesting if it is lower than the ürices for flexibility on GoPacs (*currently around 300€/M*Wh). The used as a benchmark
[10] *Based on €/MW average of 2020*

payment by the DSO of 15,000€ for reserving and blocking the battery is enough to at least break even.

3.1.5. Model Validation

"The users of […] models, the decision-makers using information obtained from the results of these models, and the individuals affected by decisions based on these models are all rightly concerned with whether *a model and its results are 'correct' for its use."* Sargent [43]

To assure that the results of this model are correct, the following validation and verification measures were applied (as defined by Sargent [43]):

- Trace
- Extreme condition test
- Face validity
- Structured walkthrough
- Sensitivity analysis

First, certain values were traced back, which means that for all possible scenarios described in 3.1.2. the output was controlled and analyzed whether the calculations are correct.

Second, for the extreme value test, the parameters that can be found at the beginning of the code (appendix 8.6) were set to 0 or extremely high values. With this technique, it could be verified whether all parameters were functional and included in the calculation of the program.

Face validity and structured walk-through were conducted in interviews with experts from the field. The conceptual model was verified and approved by a project manager of the STORY project[11], a German DSO, a project manager for a local energy storage system at the New Energy Coalition, and three different battery manufacturers. The whole research process was accompanied by the thesis supervisor Marten van der Laan, who worked on the USEF framework and is a professor for system integration at the Hanze University. The model itself was discussed in a structured walkthrough with modeling expert Drs. Ing. Frank Pierie. In this session, the calculations and logic of the model were reviewed and finally approved. Moreover, a model discussion session was organized where Sustainable Energy Systems Management students presented their model and asked critical questions. Even though it was an event of master students, it added certainty to the model since the model was presented in a detailed session where critical questions were asked.

Additionally, a sensitivity analysis was conducted to investigate the factors that have the biggest impact on the results. The outcome of this analysis is presented in the result section in 0.

[11] STORY is a horizon 2020 project, that focussed on integration of storage into the energy system

3.1.6. Boundaries

The BIPV are already in place with a CAPEX of *40.000€. The installation size of 15kWp* is a constant in this model and will not be varied to improve system optimization. Moreover, the model does not account for losses in the grid and connections between different devices in the system. Additionally, the energy supplier is not included in this business model.

An Energy Service Company could improve the business model by improving the energy management of the Nijestee building through control & advice services, but this is out of the scope of this research.

The role of the aggregator is simplified and does not include aspects like different transfer of energy options. Moreover, it is assumed that the battery of this business model is pooled together with other flexibility sources of the aggregator to reach the 1MW requirement for FCR markets. Similar to the aggregator, the DSO and TSO services are also simplified and do not include all technical details. The delivery of services follows the priorities described in 3.1.4 but disregards technical aspects such as the exact frequency situation for FCR services.

Additionally, all storage capacities as mentioned in the following parts assume a 1C rate where kWh=kW. The depth of discharge is held fixed at 20% and the charging efficiency is 95%. Self-discharge was not included.

Moreover, the data received from the partners of the project only included the periods from March until September this year. This data had to be manipulated to obtain a dataset for a whole year. More details on the data can be found in

3.2. Interviews

Even though modeling is the central methodology of this study, interviews were used to improve the model, validate the calculations but also to research the different perspectives and expectations of different stakeholders. This was especially valuable for scenario 3 (Figure 7)where several stakeholders have to align their expectations and collaborate.

But since the expertise of those stakeholders is very different, it was not possible to conduct interviews with exactly aligned questions and a rigid structure. Instead, semi-structured interviews were conducted, where some topics were pre-set, but the interviews had the liberty to expand into an open discussion if adequate [65].

With a project manager from the STORY project, it was discussed which lessons they learned and how these can be implemented in the Making-City case. The DSO gave feedback on the conceptualization of the model and elaborated on the DSO*'s* needs and expectations for such a service. Additionally, an energy cooperative was interviewed to discuss the possibility of a co-investment strategy and the possibility for them to take the aggregator role. Three battery manufacturers gave insights on the different specifications and business cases for Lithium-Ion, Flywheel, and Redox-Flow Batteries.

All these insights were used to improve the conceptual design and also the computerized model. This happened in an iterative process, where the researcher took findings from the interviews, built them in the model, and went with new, more precise questions in the next interviews.

Table 3 Interview partners for semi-structured interviews (except for the structured-walkthrough with Dr. Ing. Pierie for confidentiality reasons anonymized)

Interview Partner	Organization	Expertise
1	Project manager New Energy Coalition	Project Development and Legal Context of Storage Systems
2	Senior Scientist VTT Research	Project Manager in the Horizon 2020 STORY project
3	RUG Ph.D. Researcher	Research on Business Models for Energy Storage
4,5 & 6	Croonwolter&dros B.V.	Aggregator
7	Grunneger Power	Renewable Energy Project Development and Energy Cooperatives
8	Elestor B.V.	Hydrogen Bromine Flow Battery
9	QuinteQ	Flywheel Storage
10	iwell	Li-ion Battery
11	bnNetze GmBH	DSO (Germany)
12	Enexis	DSO
Drs. Ing. Pierie	Hanze Unisiversity of Applied Sciences	Research on Energy Systems Modelling

4. Results

In 3.1.3 framework was developed on a schematic level. These concepts were used in a second step where they were transformed into numerical models in python and Microsoft excel as described in 3.1.4.

In this section, the results from the technical and financial analysis are discussed. As described in 3.1.2, the technical model was implemented in python and the financial model was implemented using Microsoft Excel. Each scenario will be analyzed separately. To answer the research question of how a business model for energy storage could be designed, we need to analyze the profiles, how they are matched, and also how this match or mismatch affects the profitability of the business case. First, the base case scenario will be analyzed. This will give a benchmark for scenarios 1, 2, and 3.

The analysis of the three alternative scenarios (as described in 3.1.3.) is split into two parts. First, the results from the technical model will present the outcome in terms of profile analysis, storage size, self-consumption as well as the amount of electricity sold to and bought from the grid. Afterward, the cost structure, as well as revenue streams and income, will be discussed concluding with a financial analysis using the NPV. This will be done for each scenario respectively. In the final section of this chapter, the results of the different scenarios will be summarized. After this summary, the results of the interviews will be presented and discuss the perspectives of different stakeholders concerning the business model that was designed in this research.

4.1. Base Case Scenario

For the technical analysis, first at the profiles of electricity consumption of the house and the elevator as well as the electricity generation from the BIPV panels.

When comparing the profiles of demand and BIPV, one can see that the building has contradicting patterns. While consumption peaks are in the morning and evening, the BIPV produces most during the noon hours, when the sun is shining. However, there is a big difference between winter days with little sun and summer days with more sun.

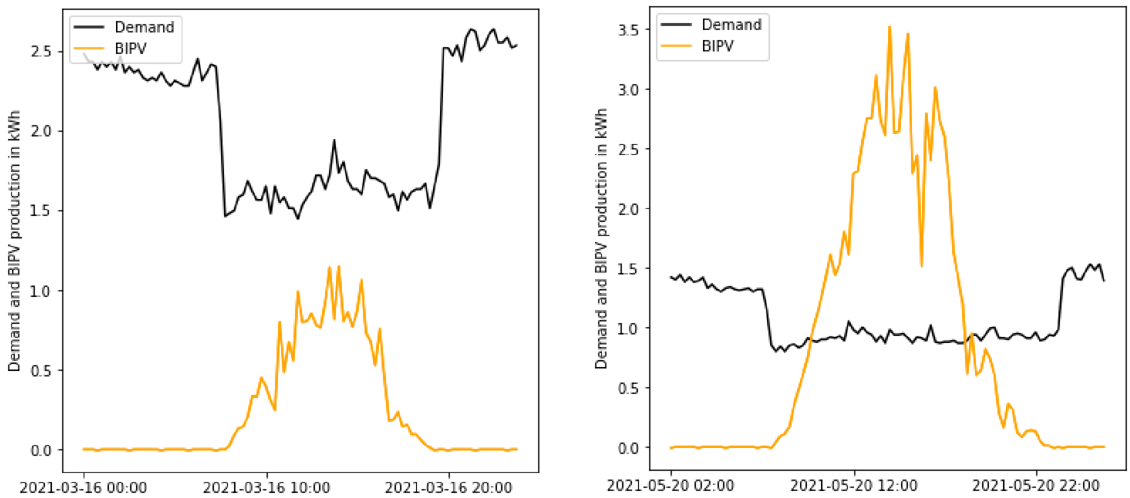

Figure 11 Demand and BIPV generation in kWh for a winter day (left) and a summer day (right)

While in winter the self-generated electricity can be consumed to 100%, we produce surplus electricity in summer (Figure 11).

For the mismatch during the summer month an additional storage system is one proposed solution to increase self-consumption and thus the efficiency of the system [66]. A BESS could be the ideal solution, but in the described scenario (3.1.3) the elevator is the main factor and needs to be covered.

The elevators on a typical day are mostly used during the night and in the evening hours (Figure 11, left). Over the entire year, there are two instances where the combined power demand of the elevators and the common areas in the building is larger than the capacity of the grid connection (Figure 11, right).

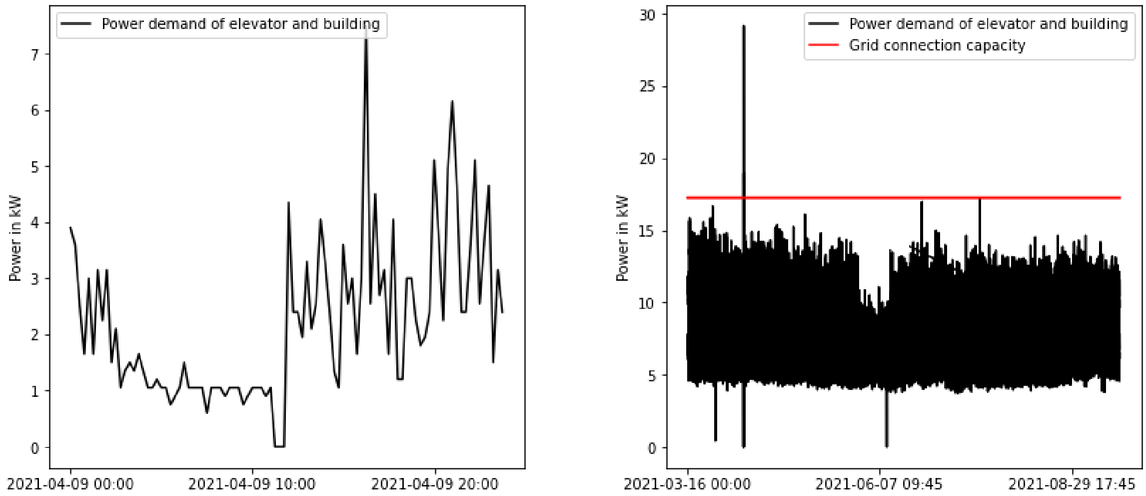

Figure 12 Typical daily profile of both elevators (left) and power demand of elevators and building combined relative to grid connection capacity (right)

Thus, an overload of the grid connection due to the elevator power consumption seems rather rare. Especially the peak that can be seen in February in the yearly profile seems to be an anomaly. This could be due to measurement errors since just the power demand of the building reaches 24.82 kW in this instance which would overload the grid connection even without elevator demand. The quality of the data and its implication for this study will be further discussed in section 5. For the technical and financial analysis, it is assumed that the Nijestee corporation has to upgrade the grid connection for those power peaks.

To compare the results of the different scenarios to a base case, the results for a scenario if the housing corporation would not invest in a battery are analyzed.

Table 4 Base case scenario - summary

Technical data		Period
BIPV generation (kWh)	17012	Annual
Electricity consumption of common areas (kWh, incl. elevators)	69601	Annual
Self-consumption (kWh)	12219	Annual
Electricity sold (kWh)	4792	Annual
Financial data		
CAPEX BIPV (15kWp)	*40.000€*	one-time
OPEX BIPV	*850.00 €*	Annual
Installation extra grid connection	*1,638€*	one-time
Costs for extra grid connection per year	428 €	Annual
Costs from electricity bought	*9,181 €*	Annual
Revenue from electricity sold	*766€*[16]	Annual
Savings through self-consumption	*1955€*	Annual
Financial result		
NPV	-128,847€	Over 15 years

16 Revenue in year 1. The revenue decreases over the whole period due to the phase-out of the Net Metering scheme

The data concerning the costs for the grid connection were derived from [59]. The base case scenario is a negative business case. This is mainly due to the fact that the installation and usage of a larger grid connection have CAPEX and OPEX but do not generate revenue. Additionally, the BIPV panels are also a negative business case. Since they are installed at a 90° angle, their efficiency is lower than conventional PV panels. Moreover, their installation is more complex and the technology is less developed than conventional PV. This results in a CAPEX of 2.67 *€/Wp* which is considerably larger than conventional PV (*0.56€/Wp)* [67] and makes the project unprofitable. However, different energy generation technologies are not the focus of this research. The following chapters focus on the question of whether a storage device can improve the profitability of the business case. The three scenarios described in 3.1.3 could be attractive alternatives compared to the conventional approach where the grid connection is upgraded.

In case a scenario results in a negative NPV, it is analyzed which factors can be changed to reach a NPV of 0, which would indicate that the company is neither making profits nor making losses.

4.2. Scenario 1

4.2.1. Scenario 1 – Technical Analysis

If the Nijestee corporation wants to be able to cover the elevator demand at all times and avoid an upgrade of the grid connection, a 12kWh/12kW storage device is needed. This is due to the peaks when both elevators are used which result in 10.8kW peak power demand. Energy storage with a smaller energy capacity could also be considered since it is mainly the peak power that defines the battery size. During the power peaks of the elevator profile, only 2.7kWh are charged from the battery. However, for this research, a 1C rate was assumed which is why with charging losses of 5% a 12kW power capacity is needed to cover the elevator's power peaks.

It was considered to use the battery to cover the demand of the building and improve the self-consumption of the building. With a 12 kWh storage, 13632.22 kWh of the 17012 kWh BIPV generation is consumed by the building. Thus, self-consumption could be increased to 80%. The residual energy of 3379.78 kWh is sold to the grid for 0.16 *€/kWh*.

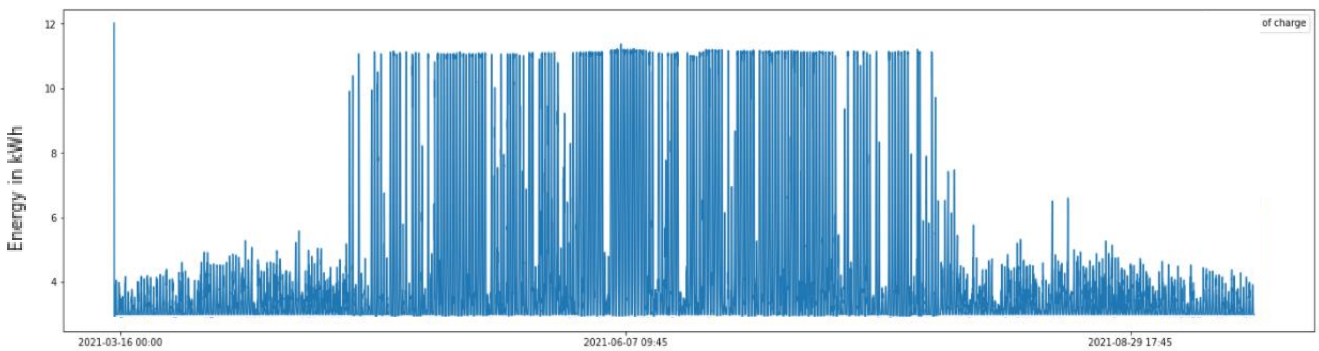

Figure 13 Scenario 1 – 12 kWh storage used elevator peak-shaving and self-consumption improvement

Whether this strategy is a better business case than the base case scenario is discussed in the financial analysis.

4.2.2. Scenario 1 – Financial Analysis

In this business case there are 3 main revenue streams:

- Savings through own consumption
- Savings because no extra elevator connection is needed
- Revenue from electricity sold to the grid

For the minimum sized battery that could cover the peaks of the elevator, the following costs and revenue streams were considered:

Table 5 Scenario 1 - Financial analysis

CAPEX & OPEX		Period
CAPEX BIPV (15kWp)	40,*000€*	one-time
CAPEX battery	9.*000€*	one-time
OPEX BIPV and storage	1.600 €	Annual
Installation extra grid connection	-	one-time
Revenue streams & costs		
Costs for extra grid connection per year	-	Annual
Costs from electricity bought	*8,955€*	Annual
Revenue from electricity sold [16]	540€	Annual
Savings through self-consumption	2,181€	Annual
Financial result		
NPV	-130,812€	Over 15 years

Compared to the conventional solution with a new grid connection, this approach is slightly less profitable. Even though we can save 1,*638€ on the grid* connection and *save 654€ on the electricity bill, this is not enough to cover the high CAPEX* of the storage installation. This is due to the fact, that the BIPV by themselves are a negative business case. They have relatively high CAPEX compared to conventional PV installation while also having a lower efficiency since they are rigidly fixed to a vertical wall and thus do not have the optimal tilt. To analyze the effect of different factors on the business case, a sensitivity analysis was conducted.

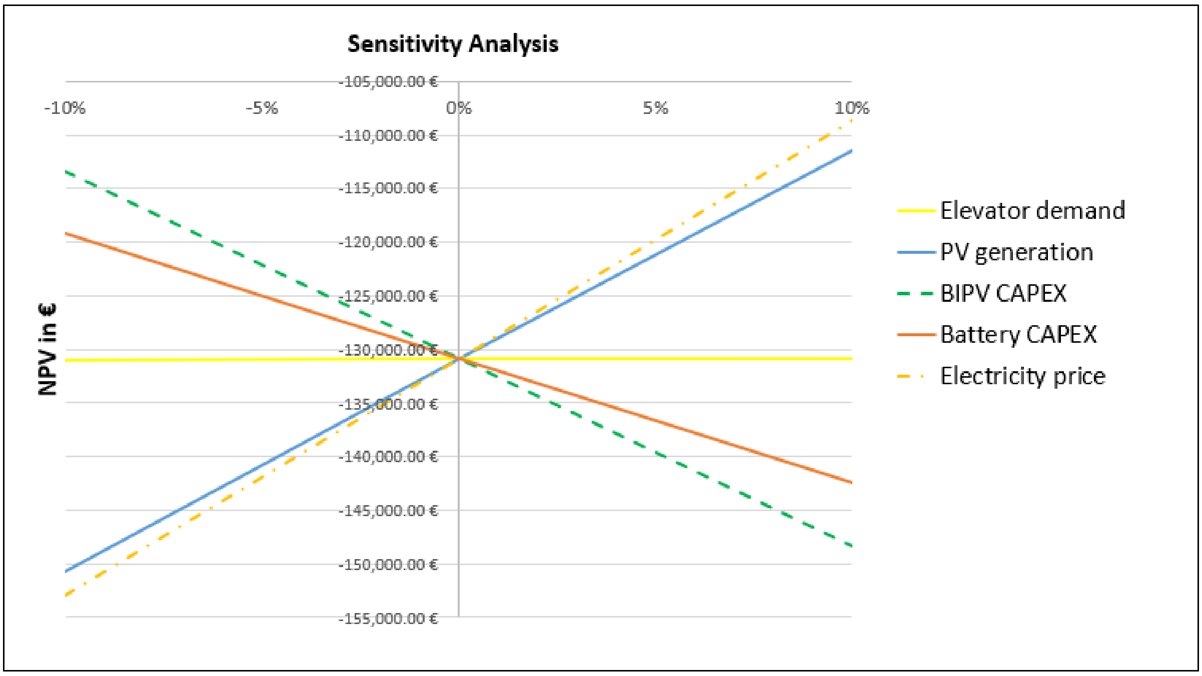

Figure 14 Scenario 1 - Sensitivity Analysis

Especially the CAPEX of the BIPV and the battery have a considerable effect on the business case. The front-up investment is one of the most important factors in this scenario. To reach the same NPV as the base case scenario, either the CAPEX for the battery have to be reduced to 549€*. Similarly,* a cost reduction of 10% of the BIPV *to 1.81€/Wp would be sufficient to be as* (un-)profitable as the base case.

However, production and consumption profiles also have a big impact. If the PV generation increases, this could benefit the case, but only if no additional CAPEX is needed. This indicates the influence improved panel efficiency could have. A building with normal PV with an ideal 30° tilt is likely more profitable than BIPV that have a lower efficiency due to their rigid vertical position.

Most of the factors within the model have a linear relation to the NPV. However, this is not the case for the elevator. This is due to the fact, that with increased elevator demand, the battery needs to be sized up, which increases the CAPEX and thus decreases the profitability of the business case.

An idea to improve the business case would be to not invest in energy storage as an asset but use a leasing/ renting approach (Table 1). The housing company would not be investing themselves but leasing the battery from a manufacturer. Assuming a *battery is leased for 115€ per month which also includes maintenance costs, the NPV* would decrease to -*136,271 €.*

4.3. Scenario 2

4.3.1. Scenario 2 – Technical Analysis

Scenario 2 is very similar to scenario 1 but it includes another consumption profile: Two EV charging stations. The idea behind this scenario is that with this additional demand (especially around the noon hours) the self-consumption of the building can be increased. The two EV charging stations consume combined 4,880 kWh per year which is partially delivered by the storage-BIPV system.

The analysis of daily BIPV generation, electricity demand, and elevator profile is equal to the one for scenario 1. The additional profile of the EV shows the following pattern:

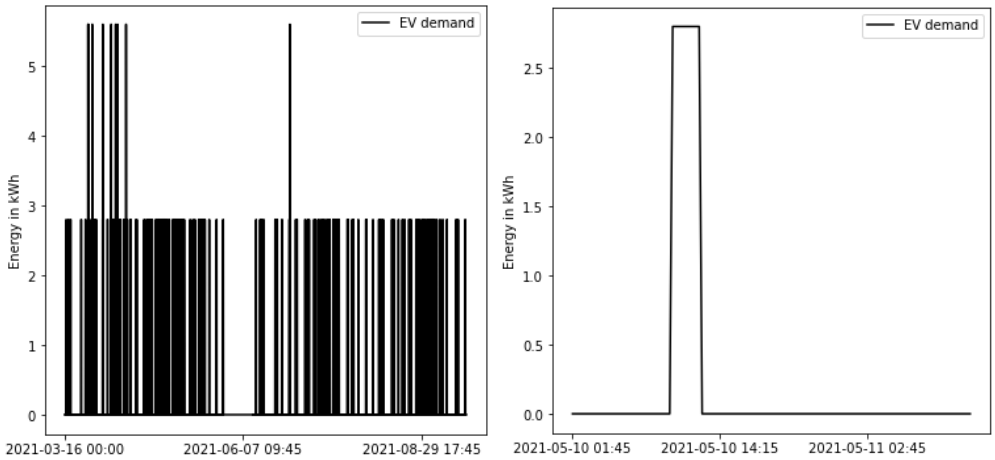

Figure 15 Annual EV demand (left) and example of a daily EV charge pattern (right)

As one can see, there is demand in the noon hours which could counteract the mismatch between demand and supply during the summer days (figure 11) The self-consumption is similar but for scenario 2, it was also considered to increase the storage and thus increase the self-consumption.

However, since the BIPV production is relatively small compared to the consumption of the building (see figure 11), the installation already has a self-consumption of 75% without any storage device. The self-consumption can be improved as shown below.

Table 6 Scenario 2 - Technical Analysis

Capacity (kWh/kW)	**Ss**	**Sc**	**self-consumption**	**Energy to grid**	**EV charged from grid**	**Energy from grid total**
			In kWh			
0	18%	75%	12713	4298	4880	73986
12	20%	81%	13794	3217	3488	58800
14	20%	83%	14035	2976	3474	58544
16	21%	84%	14264	2747	3466	58307
18	21%	85%	14460	2551	3456	58101
20	21%	86%	14610	2401	3444	57940
30	22%	89%	15201	1810	3398	57302
40	23%	92%	15626	1385	3358	56837
50	23%	93%	15905	1106	3338	56538
60	23%	94%	16074	937	3326	56358
70	23%	95%	16157	854	3318	56266

With an increased storage capacity, the system also charges the EVs through the battery more often and uses less energy from the grid for these services. This could improve the viability of the business model since the self-generated electricity is cheaper for the Nijestee corporation and would thus result in a higher margin gained from the EV charging stations. This will be analyzed in the following section.

4.3.2. Scenario 2 – Financial Analysis

Scenario 2 has 4 main revenue streams:

- Money savings through own consumption
- Money savings because no extra elevator connection is needed
- Revenue from electricity sold to the grid
- Revenue from service fee for electric vehicles

The results from Table 6 were implemented in the financial analysis. It resulted that a 12kWh battery is the least expensive scenario.

Table 7 Scenario 2 - Financial Analysis

CAPEX & OPEX		Period
CAPEX BIPV (15kWp, incl. installation)	40,*000€*	one-time
CAPEX battery	9,*000€*	one-time
CAPEX Charging stations [4]	*11,440€*	one time
OPEX BIPV, storage, and charging stations	2,097 €	Annual
Installation extra grid connection	-	-
Costs for extra grid connection per year	-	-
Revenue streams		
Costs for extra grid connection per year	-	Annual
Revenue from electricity sold	514€	Annual
Costs from electricity bought[17]	9,487 €	Annual
Savings through self-consumption	*2,207 €*	Annual
Revenue from EV charging stations	*1,171 €*	Annual
Financial result		
NPV	-131,489€	Over 15 years

Compared to scenario 1, the EV charging stations do not add value to the business case. With the given demand profiles the NPV decreases to *-131,489.54€. Moreover*, did the self-consumption only improve slightly. This is due to the fact that the BIPV production is relatively small compared to the consumption mentioned before and shown in figure 11.

In the sensitivity analysis, similar patterns like in scenario 1 were discovered. However, it results that the EV demand has a larger impact than the margin we can charge.

[17] This also includes demand of EV charging stations which are charged from the grid if the storage is uncharged.

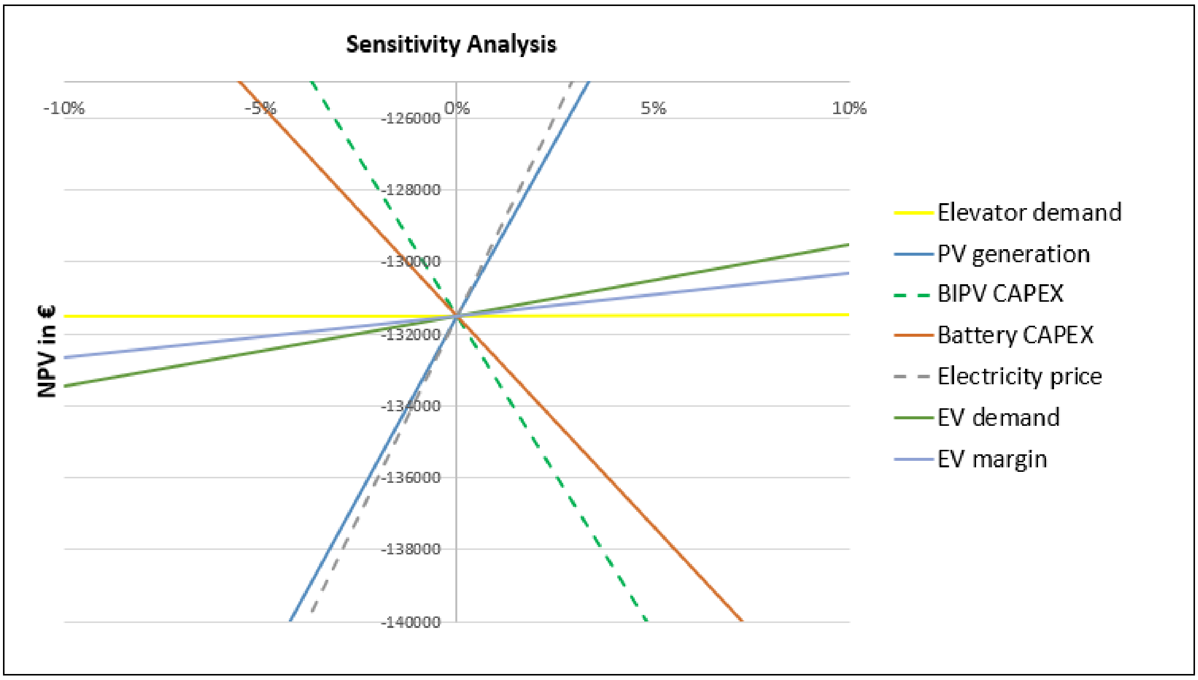

Figure 16 Scenario 2 - Sensitivity Analysis

However, the demand has a considerable effect on the business case, and if the EV profile increases from 4,880kWh to 5,531 kWh per year this results in a business case that is exactly as expensive as the base case scenario. Considering that the measurements of the EV charging stations were made during the corona pandemic, it is reasonable to assume that demand for e-mobility will increase again in the future. If the EV-demand increases by 20% to 5,856 kWh per year, the NPV would be improved to -127,528€ which would be less costly than the base case scenario.

The charging fee from EV customers is also another crucial factor. Overall charging prices for EV vehicles are between 0.2-*0.6€*/kWh [39, 62] and for this case, it was assumed that this total fee is 0.40*€/kWh for the end*-customer. This includes the *electricity price for the Nijestee corporation of 0.16€/kWh* [58] and a service fee of 0.24*€/kWh. The service fee is th*e margin that results in an additional revenue stream of 1,171€ *per year.* If this *margin is increased to 0.44€/kWh* this would lead to an overall charging fee for the customer *of 0.6€/kWh and result in a NPV of* -121,588*€.* However, a minimum price of a *total 0.45 €/kWh (0.29€/kWh margin) is needed to reach a* business case with the same value as the base case scenario.

For scenario 2, it was also analyzed how different battery sizes affect the business case. It results that the larger CAPEX of a larger battery is relatively higher than increased income from improved self-consumption (see figure 17)

Increasing the size of the battery does not improve the business case. However, it does improve the self-consumption rate.

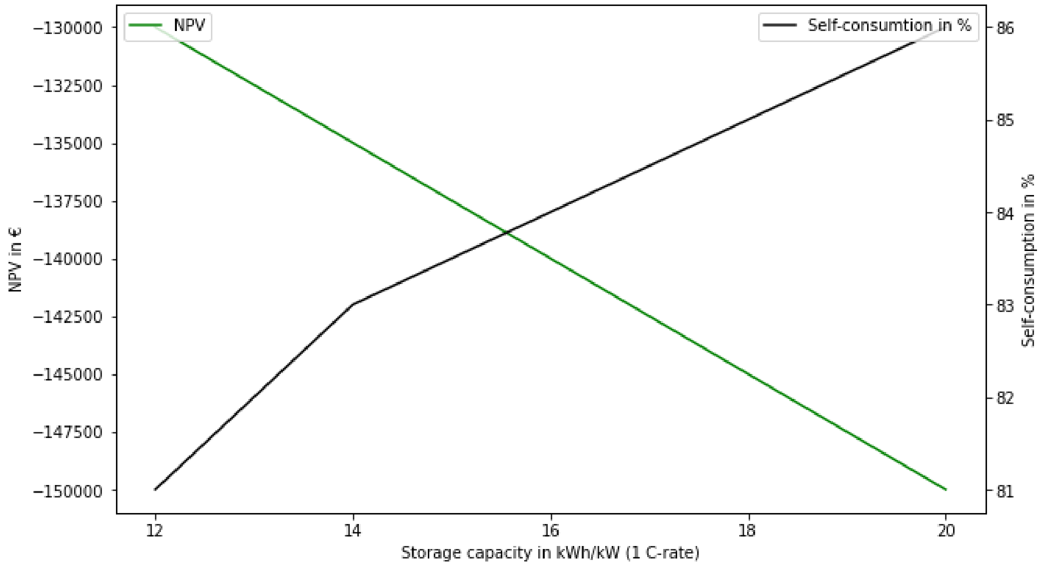

Figure 17 Scenario 2 - Relation between storage capacity, NPV and self-consumption

Improved self-consumption would be of interest for the Making-City project since the more energy is consumed locally, the less energy is lost during its transport which would be beneficial for a potential PED. The Nijestee corporation has a financial interest in this project, so they likely prefer a smaller installation. This might conflict with the goals of the Making-City project. This issue will be discussed in the discussion section of this paper.

As for scenario 1, a lease option for the battery was also considered. If the Nijestee corporation leases a battery for less *for 115€* per year the total fee charged from the EV customer has to be increased to at least *0.56€* to be less expensive than the base case scenario.

4.4. Scenario 3

4.4.1. Scenario 3 – Technical Analysis

The priorities as defined in 3.1.4 were applied to different storage capacities in combination with different congestion scenarios. The main idea is that the storage system reserves capacity for the DSO and if the local grid is congested, the battery is charged to relieve this congestion. For this service, 200k kWh are constantly kept free in the storage. If for instance a 600 kWh battery is installed and it reaches a state of charge of 400 kWh, it will stop charging the battery and sell the excess energy to the grid via the wholesale market. If the DSO makes use of this reserve, the consumption of the Nijestee building will be used to restore the 200 kWh upwards capacity.

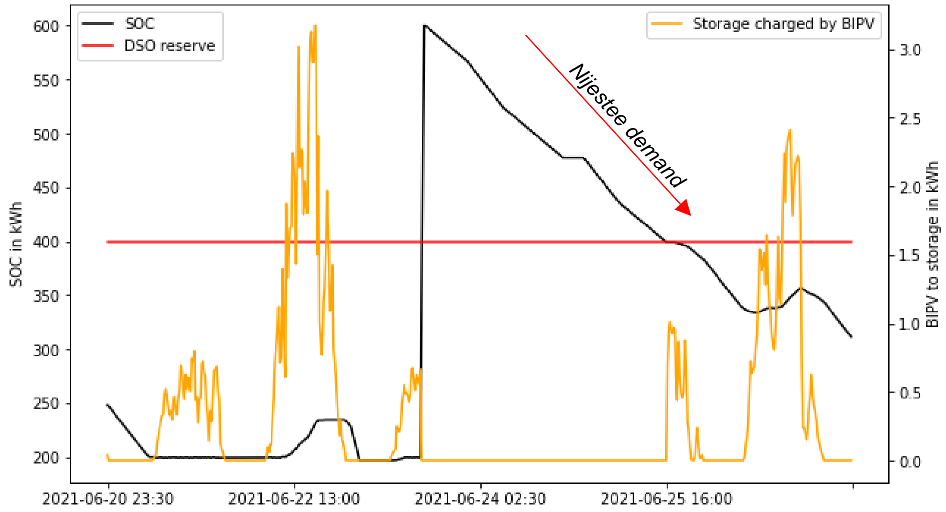

Figure 18 Scenario 3 - DSO congestion reserve activation

The different DSO congestion profiles were simulated based on the data available via GoPacs [63]. For 2020 there were 8 instances where the network of the local grid operator Liander was congested (Figure 19, top left). Additionally, a scenario with weekly congestion as well as congestion every second day was simulated.

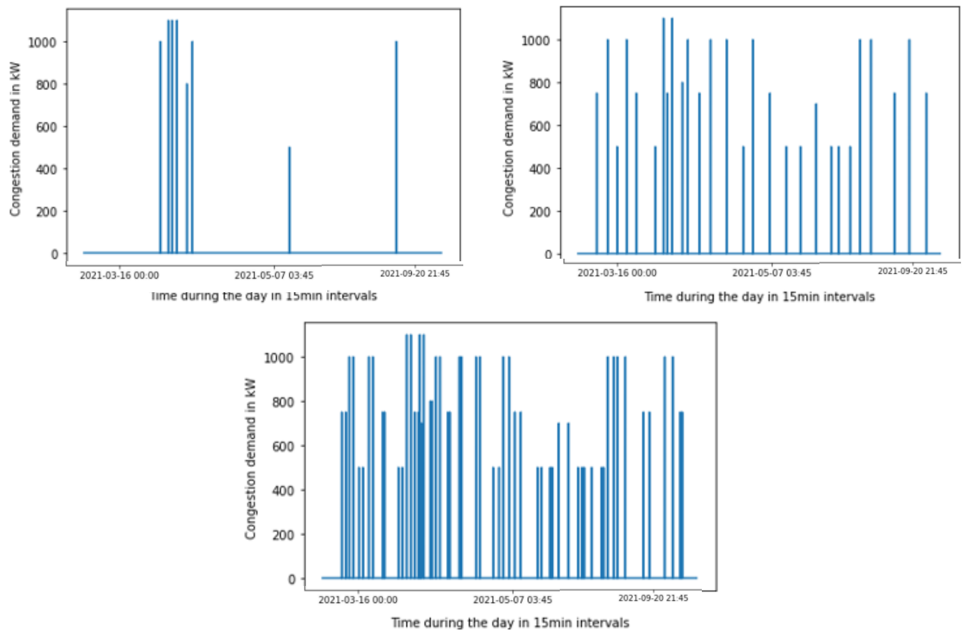

Figure 19 Different congestion scenarios: Original data from GoPacs from 2020 (top-left), simulated weekly congestions (top-right), simulated congestion every second day (bottom)

These congestion scenarios were applied to simulations with 400kWh, 500kWh, and 600kWh storage systems. The FCR activation probability was held constant at 10% which means that without the interference of other services, 10% of our bids on the FCR market will get activated. However, since relieving DSO congestion has higher priority it can be expected that in scenarios with more local grid congestion less FCR services will be delivered. With more congestion, the storage is more often reserved for the DSO and can thus not be used for other flexibility services.

Table 8 Scenario 3 - Flexibility services based on different congestion scenarios and storage capacities

Congestions	**Capacity (kWh/kW)**	**DSO congestion relief (kWh)**	**FCR[18]**
Monthly	400	3352	224
	500	4738	224
	600	5829	224
Weekly	400	13918	214
	500	18902	214
	600	23091	214
Every two days	400	24707	196
	500	30039	196
	600	33249	196

It results that increased demand for the DSO decreasing the possibility to activate services on the FCR market. Whether this increases or decreases the profitability and whether the higher CAPEX of larger storage can be equalized by bigger revenues will be analyzed in the next section.

4.4.2. Scenario 3 – Financial Analysis

The third scenario includes three additional stakeholders: the DSO, the TSO, and an aggregator. Concerning the flexibility services for the grid operators, congestion management was considered on the DSO level and FCR services for the TSO. They were calculated as discussed in 3.1.4.

Scenario 3 applies value stacking and thus has 6 different revenue streams:

- Savings through increased self-consumption
- Savings because no extra elevator connection is needed
- Revenue from electricity sold to the grid
- Revenue from service fee for electric vehicles
- Income from DSO services
- Income from FCR markets

[18] These are the amount of FCR bids activated over a whole year assuming an overall 10% probability that bids get activated

For this scenario, close collaboration between the Nijestee corporation and the aggregator is needed. The interaction of the business partners can be summarized with the following figure:

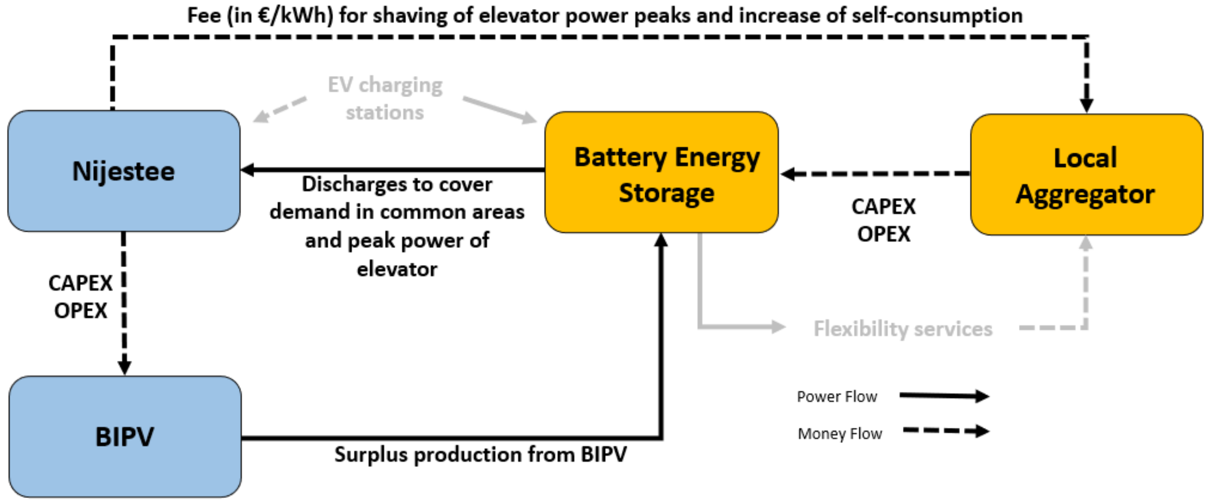

Figure 20 Scenario 3 - Interaction between Nijestee as Active Customer and the Aggregator

Both stakeholders use the BIPV as well as the storage device, but Nijestee owns the BIPV as well as it pays the investment in the EV infrastructure. The aggregator invests in the storage system. Both parties carry the CAPEX and OPEX for their respective part. The Nijestee corporation earns all revenues from the EV charging service, while the profit from the flexibility services goes to the aggregator.

Nijestee has savings due to a lower electricity bill. But since the electricity can be taken from the storage, Nijestee pays the bill to the aggregator instead of its supplier. Thus, the aggregator can be sure that the DSO reserve is quickly restored as described in 4.4.1 and also has an additional revenue stream. In case there is a year where the BIPV of Nijestee charge more to the battery than the building consumes, the process is inversed and the aggregator pays Nijestee the difference since in this case, Nijestee delivered their BIPV electricity without equal compensation.

After several iterations with different capacities in combination with different congestion scenarios, the most promising installation appears to be a 400kWh system where 250kW/kWh symmetrical are reserved for FCR and DSO services. As for the other scenarios, larger storage increases the CAPEX and thus decreases the profitability.

Table 9 NPV for the aggregator depending on congestion demand and storage capacity

Congestions	**Capacity**	**DSO_charge**	**FCR**	**NPV AGR**
	kWh/kW	*kWh*	*Number of FCR activations*	*in €*
	400	*3,352*	*224*	*- 42,345*
Once a month	*500*	*4,738*	*224*	*- 102,524*
	600	*5,829*	*224*	*- 163,509*
	400	*13,919*	*214*	*- 15,195*
Weekly	*500*	*18,902*	*214*	*- 66,118*
	600	*23,092*	*214*	*- 119,211*
	400	*24,707*	*196*	*10,840*
Every two days	*500*	*30,040*	*196*	*- 54,857*
	600	*33,250*	*196*	*- 97,203*

As shown by Table 9, with increased congestion, the business model becomes more profitable since the revenue from congestion services activated increases. However, an increase in service deliveries for the DSO blocks the storage capacity, which can then not be used for bids on the FCR market. But contrary to Alaperä et al. [14], increased congestion improves the business case. This is probably due to the optimistic double revenue stream from the DSO. However, even with the flexibility price based on GoPacs and a yearly reservation fee, the business model is not profitable.

Table 10 Scenario 3 - Financial Analysis

	NIJ	AGR
CAPEX & OPEX		
CAPEX BIPV (15kWp, incl. installation)	40,000 €	-
CAPEX battery	-	300,000 €
CAPEX Charging stations (incl. installation)	11,440 €	
OPEX BIPV and EV charging stations	*1,378€*	-
OPEX storage	-	5,000 €
Installation extra grid connection [19]	-	-
Costs for extra grid connection per year	-	-
Nijestee Electricity bill[17]	8,972€	-
Revenue streams		
EV charging fee	1,*171 €*	-
DSO congestion reserve	-	15,000 €
DSO congestion remuneration per MWh	-	250 €
DSO congestion relieved [20]		3352.19 kWh
DSO congestion relief revenue	-	1,005€
FCR market	-	3352€
Nijestee Electricity payment	-	*8,972€*
Financial result		
NPV	-126,305 €	*-42,345 €*
IRR	-	-3.13%[21]

To reach an NPV of 0 and break-even, one could consider different annual congestion *reservation fees for the DSO. In the low congestion scenario, an annual fee of 19,647€* would reach a NPV of 0. Since increased congestion already improves the business model through the congestion remuneration per MWh, for the weekly-congestion *scenario an annual fee of 16,667€ and for the high congestion scenario 13,810€* is sufficient.

[19] Included in storage installation costs since grid-scale storage needs an extra grid connection.
[20] For congestion scenario 1 (monthly congestion)
[21] For this scenario the IRR is calculated to be able to compare it with [7].

The importance of the annual reservation fee was confirmed by the sensitivity analysis. The sensitivity analysis for the case of the 400kWh storage shows, that especially the annual reservation fee is crucial for this business case and has an even larger effect than the FCR remun*eration in €/MW.*

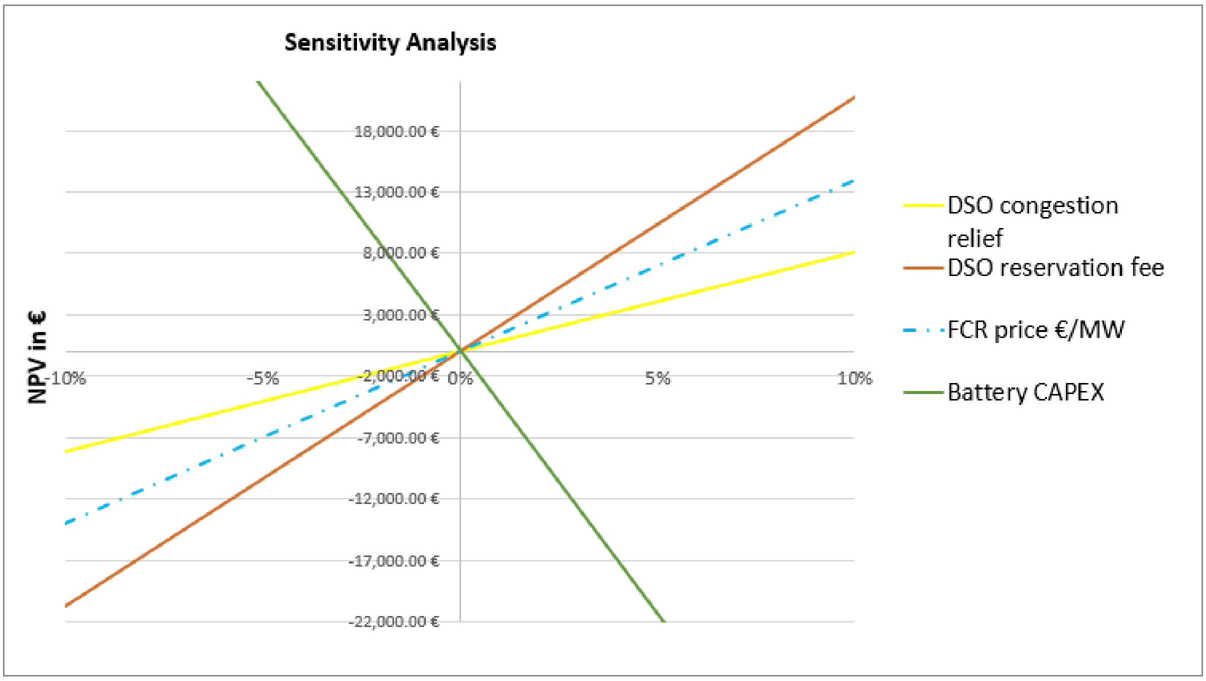

Figure 21 Scenario 3 - Sensitivity Analysis

4.5. Summary

In this section, the results of all scenarios will be summarized. One common theme throughout all scenarios was the issue of the high CAPEX. In each case, the smallest installation was the most economical solution. One can also see that the self-consumption increases from scenario 1 to scenario 3. However, the highest self-consumption and least expensive case for Nijestee is not feasible without an annual congestion fee from the DSO.

Table 11 Summary of base case and all three scenarios

				NIJ	AGR
CAPEX & OPEX	Base	Scenario 1	Scenario 2	Scenario 3	
CAPEX BIPV (15kWp, incl. installation)	*40,000€*	*40.000€*	40,*000€*	40,000 €	-
CAPEX battery	-	*9.000€*	9,*000€*	-	300,000€
CAPEX Charging stations (incl. installation)	-	-	*11,440€*	11,440€	-
OPEX BIPV and EV charging stations	-	-	2,097€	*1,378€*	-
OPEX storage	-	-	-	-	5,000 €
Installation extra grid connection [22]	*1,638€*	-	-	-	-
Costs for extra grid connection per year	428€	-	-	-	-
Nijestee Electricity bill[23]	*9,181€*	*8,955€*	8,929€	8,414€	-
Revenue streams					
Revenue from electricity sold	*766€*	*540€*	514€	-	-
EV charging fee	-	-	*1,171 €*	1,*171 €*	-
DSO congestion reserve	-	-	-	-	15,000 €
DSO congestion remuneration per MWh	-	-	-	-	250 €
DSO congestion relieved kWh [24]	-	-	-		3352
DSO congestion relief revenue	-	-	-	-	1,005€
FCR market	-	-	-	-	4629€
Nijestee Electricity payment	-	-	-	-	8,414€
Self-consumption	71.8%	80%	81%	95%	
Financial result					
NPV *in €*	-128,847.34	-130,812.03	-131,489.54	-126,305	-42,345

[22] Included in storage installation costs since grid-scale storage needs an extra grid connection.
[23] Only electricity to cover demand from the building. Electricity for EV charging stations is separately calculated.
[24] For congestion scenario 1 (monthly congestion)

4.6. Results from Interviews

All interviewees were presented with the conceptual model as developed in 3.1.3. The transcripts can be found in appendix 8.8. Their remarks will be discussed in this section.

The conceptual design was mostly accepted, however, the interview partners from Croonwolter&dros B.V. remarked that for scenario 3 it would likely be more efficient to have to separate systems (8.5.4, 17:03). It would be better to have smaller storage in the basement of the building that covers the elevator and larger installation outside the building for flexibility services. The combination of both in one system adds complexity that has little added value according to them (8.5.4, 19:01).

To get a general impression of these kinds of business cases, interviewee 2 (former project manager in the Horizon 2020 STORY project) shared her experience. She reported issues with permissions from the local government for grid-scale batteries (8.5.2, 2:41) as well as problems with fire safety regulations (8.5.2, 4:12). In their project, it also was an issue that an *"integrator" was missing,* with which she meant companies that manufacture storage systems and also deliver the IT infrastructure for the control software (8.5.2. 4:21). She said that the PED development is picking up speed (8.5.2, 24:38) and that especially storage as a service becomes more attractive (8.5.2, 28:20). However, she also argued that these business models are rather a temporary solution until the grid is upgraded (8.5.2, 25:58).

This was backed by interview 1 who claimed these business models only offer a business case for a short period of five to six years since parallel to flexibility services, the grid operators are also upgrading the grid (8.5.1, 10:22). In the interview conducted with interview partner 1, the legal context of energy storage was discussed. Concerning legal barriers discussed in 2.4.1, he mentioned that the double taxation got abolished, that the Net Metering is currently being phased out, and that the grid code is being updated (8.5.1, 10:20). The phasing out of the Net Metering scheme was modeled as explained in appendix 8.7. The upgrade of the grid code was also discussed with a representative from the Dutch DSO Enexis. Interview partner 1 also said that the success of such a demand depends on the need for flexibility but stressed *that "we are past the phase of experiments in the Netherlands" (*8.5.1, 14:22).

The interview partner from the aggregator commented that the priorities of such business cases are usually reversed and that normally one would prioritize to bid on the imbalance market and after that focus on solving local grid congestions (8.5.4, 43:36). Furthermore, they stated that it would be common to also have banks and insurance companies involved in such a business model (8.5.4, 23:29). They also noted that they already cooperated with energy cooperatives, but that every additional stakeholder adds complexity to such a business model and decreases the chances of success (8.5.4, 23:29).

In the interview with the representative of the local energy cooperative GrunnegerPower, it was discussed whether they would be interested to participate in such a collaborative business model and be part of the financing of the project (8.5.9). Interviewee 7 said that they would indeed be interested but mainly if the storage would be installed in connection with their solar farm projects. Here the storage would be especially used for peak-shaving during noon. Furthermore, he mentioned that they have access to funds like Fonds Goeie Doen which could provide 50% of the investment, which could be an interesting opportunity for the case in Groningen (8.5.9).

The business model design was also discussed with a researcher in the field of energy storage. He verified the model and its conceptualization but stressed that the DSO needs to be convinced as it was also mentioned by interviewee 1 and interviewee 2 (8.5.3, 34:52). According to him, the DSO doubts income, service quality, and the potential benefits of such a project (8.5.3, 36:06).

These aspects were brought into the discussion with two DSOs, one DSO from Germany and one DSO from the Netherlands. The DSO from Germany agreed that such a business model could be interesting for the DSO if the aggregator takes over the role of a coordinator of such service (8.5.8, 23:20). Nevertheless, he stated that currently in his area there are no big congestion issues on a local grid level and that *from a DSO's perspective this* business is not interesting yet. But in five years more loads will be connected to the grid and then congestion could become a problem (8.5.8, 23:20). The Dutch DSO also sees storage systems as part of the future energy system (8.5.10) but he said that in the network of Enexis they do not have real congestion yet. They are currently not connecting new customers to the grid due to capacity constraints, but only few actual congestions occur. According to interviewee 12, this will change once the grid code is upgraded, because then the DSO will be obliged to connect new customers, and then congestion might become an issue (8.5.10). However, he confirmed the statements of interviewee 1 (8.5.1) and interview partner 2 (8.5.2) concerning storage being only a temporal solution. Furthermore, he mentioned that Enexis would not pay more than they would pay via the flexibility exchange *platform GoPacs (currently 300€/MWh).* According to him, Enexis can upgrade certain areas in 2-3 years which is why the DSO would not give guarantees for flexibility demand. He emphasized that storage systems should apply value stacking and should offer services to DSO and TSO to diversify their risk (8.5.10).

5. Discussion

As the results have shown, scenario 1 would more expensive than the base case scenario, and scenarios 2 and 3 would only be under specific conditions less expensive for the Nijestee corporation. For scenario 2 it depends considerably on the demand for EV charging and the price charged from EV-customer. Increasing the price could cause a decrease in demand which would result in lower profits since demand is more important than the margin itself (figure 16). Further research should investigate the ideal pricing for EV charging in Groningen. Flexible tariffs that are lower during noon might attract more customers which would reduce the effect of the BIPV power peaks. Scenario 3 depends heavily on the flexibility demand of the DSO as shown in (figure 21) and also confirmed by the interview partners. However, the exact flexibility demand is not yet clear. In a future scenario with weekly congestion, the business model predicts an NPV of *6,549€ with an IRR of 4,16%* which would not confirm the result of Lombardi and Schwabe [7] who estimated an IRR of 11-40% by 2025. Once the new grid code is developed as described by interview partner 12, the demand for flexibility will increase which makes the business model more attractive for investors. Further research should analyze where in Groningen these congestions will most likely occur and how frequent they will arise. It should be investigated whether these congestion points are in a location where the storage device could be connected to the solar installations of GrunnegerPower, since there seems to be a demand for peak-shaving and interest to collaborate (8.5.5). This could be an ideal case to test the theoretical business model developed in this paper in a practical context.

Even though the results give us some indications of how a business model for energy storage in the Making-City case can be designed, they do have their limitations. The data that was used for the technical analysis was based on 15-minute and one-minute data. However, elevators can have power peaks of only several seconds which are not always captured by such aggregated data. If the data could be measured in 10-ms-intervals, it might result that there are more elevator power peaks than initially expected. This would affect the sizing of the battery and thus the profitability of the business case. Hence, the results can be used as an indication, but to get detailed results for scenarios 1 and 2, measurements should be taken directly at the installation site of the elevator.

Additionally, for scenario 3 the technical model was considerably simplified, and especially the business model that includes stacking several flexibility services for the grid operators suffers from oversimplification. However, it was useful to analyze under which conditions such a business model could become more profitable. The financial and technical results should be used as an indication but not as a real-life prediction. Further research should investigate model designs that can precisely simulate different frequency fluctuations and their effect on the upward/downward dispatch behavior of the energy storage. The activation of FCR services considerably influences the business case, but in this research, a predefined activation rate and dispatch volume limit the validity of the model. Modeling based on historic frequency data would add significant value. Also, the prediction of flexibility demand would be of great importance and further research should analyze the possibility of AI applications in this sector.

Additionally, more stakeholders are in practice involved in such a business model. As emphasized by interview partner 4, insurance companies and banks are also involved in these projects (8.5.4, 23:29). Moreover, the involvement of an Energy Service Company (ESCo) was not considered and could be investigated in future research to analyze whether an ESCo can add value to this collaborative business model.

Furthermore, other costs besides monetary aspects should be considered such as environmental and social costs. We have to ask the question: How sustainable are different energy storage technologies? Li-ion batteries are currently the market leader but are in some cases manufactured under the questionable circumstance and also cause emissions in their production as mentioned by interview partner 2 (8.8.2, 25:58). A Life-Cycle-Analysis of an energy storage business model would add more insights into this question and help to make real sustainable decisions. Concerning the social costs, there could be similar phenomena like the Not-In-My-Backyard issue for wind and solar. Researchers from the social sciences should interview citizens and find out how they perceive large storage systems in their neighborhoods. Large battery containers, for instance, could have a wind-turbine-like horizon-pollution effect in the cityscape, this should be analyzed by qualitative research where citizens are interviewed.

The overall design of this research used a rather broad approach. This allowed many factors to be analyzed, from technical decisions concerning the capacity and different financial aspects up to the different expectations of the stakeholders. But this comes at the cost of superficiality. The different aspects could be analyzed but only in a superficial manner. Further research should look into technical details such as the storage deterioration rate when different flexibility services are delivered, the profitability of other flexibility services such as passive balancing and aFRR/mFRR.

The financial analysis in this research showed that in all three scenarios the CAPEX is one of the main barriers to the success of this business model. The cost of storage has been decreasing considerably over the last year (source) and the fact that demand for flexibility is increasing might intensify this development (source). Further research should investigate how the CAPEX can be decreased and how this might allow new business models like the one described in this research to be implemented.

6. Conclusion

This research tried to answer the question of how a business model for energy storage can be designed and become beneficial for all stakeholders involved. To answer this question, a multi-method approach was used where literature review, technical as well financial modeling, and qualitative research in form of semi-structured interviews were combined. This approach was applied in a practical context for the Making-City case in Groningen.

It resulted that scenario 1, where the storage is only used for self-consumption improvement and elevator-peak shaving was simulated, is more expensive than the base case scenario where the connection was upgraded. This is mainly due to the high CAPEX of storage and BIPV.

In scenario 2 EV charging stations were added to the case. With the given EV demand profile this was even more expensive than scenario 1. However, if the EV demand increases (after the end of the pandemic) this business model could become more beneficial than the base case if the EV demand increases to 5885 kWh per year. Optionally, the owner of the EV charging could also increase the charging price to *0.45€/kWh.* However, it still has to be investigated how an increased charging price would affect the demand.

Scenario 3 simulated a value stacking approach where flexibility is offered to DSO and TSO. Here the coordination between the aggregator and the Nijestee corporation is crucial. But even more does the profitability of this business case depend on the demand for flexibility from the DSO. In a scenario with monthly congestion, a remuneration of 250*€/MWh* congestion relief is needed in combination with a yearly reservation fee of 19,647€ to become attractive for all stakeholders involved.

This answers the first of my research questions. The second was how this collaborative business could be applied in other contexts. For this reason, a more generalized framework was developed.

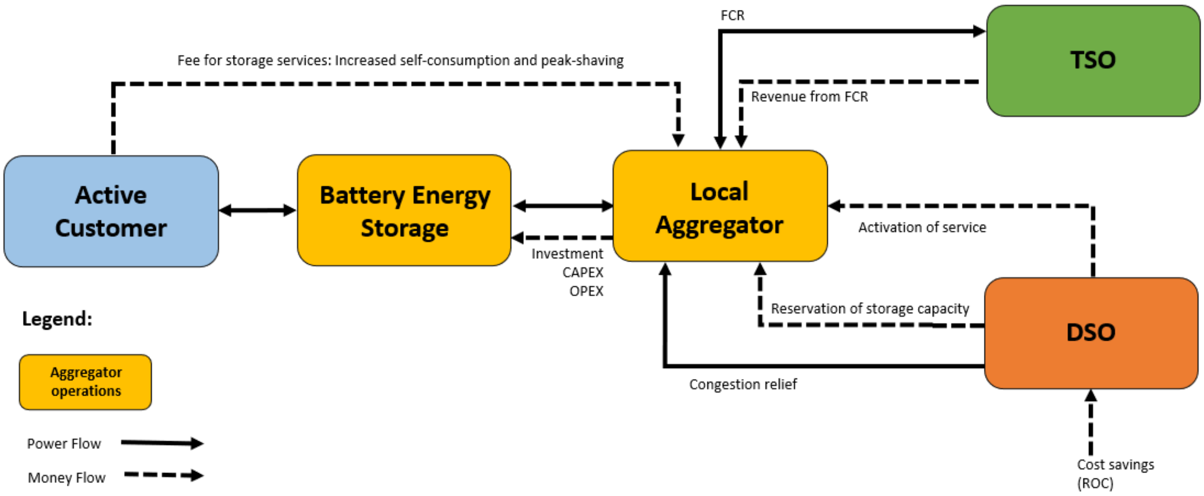

Figure 22 A collaborative business model for energy storage

This framework should be applied and tested in real-life applications. These can be in Groningen like discussed in 4.6 where Grunne*gerPower's* overproduction problem and *Enexis' congestion issues are solved* by a shared energy storage coordinated by an aggregator like Croonwolter&dros B.V. But this framework should also be tested in other countries that are facing congestion issues in the future, like Germany. If such a storage business case can be successfully implemented in the Netherlands, it can afterwards be exported to the world.

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8. Appendix

8.1. Different Flexibility Services

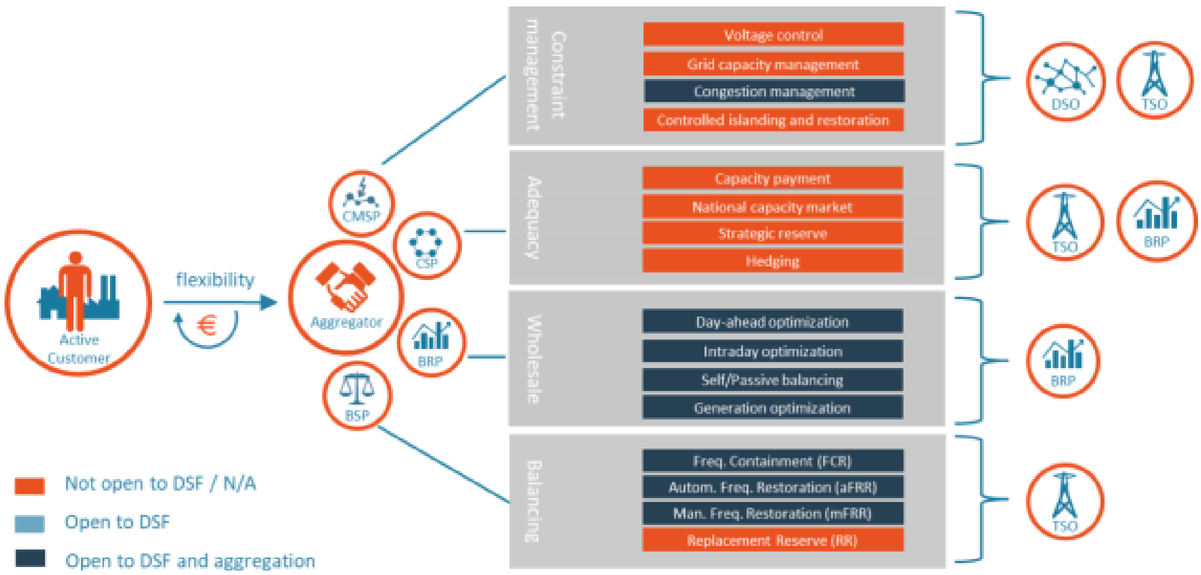
For the case described in 1.2, implicit services will be considered in terms of increased self-consumption of the Nijestee building and peak-shaving for their elevators. The elevator peak-shaving is a form of kWmax control and thus reduces the maximum load of the building withing a predefined period [16, 68].

Since the Nijestee corporation is generating, consuming and storing electricity, they can be considered an active customer [16]. Other important actors in the field of flexibility are the supplier, aggregator, the Balancing responsible parties (BRPs), the distribution system operator (DSO), the transmission system operator (TSO). The following paragraph will shortly describe each actor and their role to get an overview over the flexibility service ecosystem.

The supplier is source of electricity and invoices the energy to consumer. BRPs are contracted by supplier or aggregators and are responsible for its imbalances in the market. The supplier and its BRPs want to reduce costs and want to avoid imbalance fees which can be avoided with flexibility services. The DSO is responsible for the local distribution grid, its maintenance and its connection to other areas. The TSO transports energy in a certain region before it will be taken over by the DSOs local grid. DSO and TSO together assure the long-term reliability of the system and are also concerned with security of supply at all times. The DSO and TSO want to avoid expensive grid upgrades but also want to use flexibility services to assure power quality and adequacy (e.g., voltage and frequency limits) [16].

For this case study the flexibility services available in the Netherlands are of special interest since the system context concerning legal, economic, social and policy aspects are similar. In the Netherlands transmission tariffs are capacity-based charges, peak optimization is an option for active customers to reduce their electricity bills. However, there is a flat charge-based distribution tariff with a fixed price per kWh that applies to all active customers with a connection <3*80A. Thus, time of usage optimisation is not an option in the Netherlands. Only few suppliers from the commercial and industrial segment have dynamic pricing tariffs with their suppliers [68].

Nevertheless, there are several services that are open to demand side flexibility (DSF) and can be included in the business model:



The main focus of this research will be on the services that are open to DSF and aggregation to evaluate different revenue streams of the energy storage business model. Thus, DSO constraint management will be considered as well as balancing services for the TSO.

The goal of congestion management is to avoid overload of the grid during peak loads, which could cause *fallout of the system. It is "currently only available to TSOs in most European countries, but may, in the future, be made available to DSOs"* [16]. For this research we will assume the storage device to be available for DSO congestion management to analyse possible revenue streams from local grid relieve services in a future scenario.

Wholesale services contain day-ahead optimization where loads are shifted to periods with cheaper prices for a day-ahead interval. The intraday market has similar characteristics but is opened once the day-ahead market is closed and focuses on shorter intervals closer to real time. With self- and passive balancing BRPs can either reduce their own portfolio imbalance or purposely deviate from their portfolio to support the TSO to reduce system imbalance [16]. However, especially Frequency Containment Reserves (FCR) is interesting since the margins are considerably higher than prices on the whole sale market [64, 69].

"According to the European Network Code, balancing services aim to restore system frequency to its nominal frequency of 50 Hz." [16] This service is activated in milliseconds and is usually procured ahead [16]. The reimbursement is based on marginal pricing where bids with the lowest price performance are carried out. This means that flexibility services to restore the frequency do not necessarily guarantee income since not every bid will get activated. FCR is a symmetrical product which means that the capacity must be held available for upward and downward dispatch [70].

8.2. Ownership structure

Besides the question of which services should be offered, the decision about ownership of the battery is also crucial [17]. In 2013, first business models for electrical storage where developed by the British Distribution Network Operator (DNO) [71]:

- **DNO merchant**: DNO owns and operates assets. The DNO is responsible to manage the electrical storage in a form that it generates revenue from wholesale markets and ancillary services.
- **DSO model**: DNO owns, operates, maintains as well as develops and constructs electrical storage on a wider scale. DNO would also organise the financing and hold commercial control over the asset.
- **DNO contracted**: DNO owns asset. But a third party will manage dispatch instructions and ancillary services to generate revenue.
- **Contracted service**: DNO runs tender for third parties to build and operate electrical storage. DNO makes fixed annual payment to third party to provide services that stabilise the grid. In situations when the storage is not required for grid security matters, the third party can manage the asset freely.
- **Charging incentives**: DNO incentivises third party through dynamic pricing to build storage capacity. Dynamic in this context means that the storage makes an arbitrage when there is an oversupply and prices are low as well as when there is a shortage and prices are high. This allows a margin for third party when they charge at low prices and discharge at high prices.

The advantage of the DNO merchant and DSO model is that the DNO hold control over the storage and that its purpose to stabilise the grid is the only priority. Additionally might it be beneficial for financing because it is considered a national infrastructure project and would thus be considered a save investment with lower cost of debt [71].
However, the DNO contracted and the contracted service model would have the advantage that the DNO would not have to acquire extra skills to manage the storage. Moreover, this might create synergy effects because the third party already owns other storage assets that could be aggregated together with this particular storage. But the DNO would not control the asset which could cause a conflict of interest since the third party wants to optimise the assets value and grid security is in this context not necessarily the first priority [71].
The business model that is based on the charging incentives has the advantage that the DNO has no commercial risk and through the incentives, storage will be built in the areas where it is most needed. However, there is no guarantee that third parties will respond to these incentives. And if they respond and build the storage, there is no guarantee for the DNO that those parties will participate in stabilising the grid instead of only focus on profit maximisation [71].

First studies analysed different types of ownership in the context of community batteries and focused on four different types of ownership structure [24]:

- **Third party owned community battery**: The battery is owned and operated by a local group (local council, community group, non-profit retailer). The battery focusses to deliver maximum value for customer while ensuring financial viability of the battery.

- **Third party owned for-profit model**: Owner and operator is a retailer or aggregator. The main interest is to increase the *battery's profit instead of* creating value for the customer.
- **DSO owned community battery**: DSO owns and operates the battery with the goal to support the network, increase flexibility and provide customer demand side management.
- **DSO owned for-profit model**: In this model the battery is owned by the DSO but half of it is leased out to a third party. That means that 50% of the capacity was used for grid support purposes and the other 50% were managed by an aggregator or retailer with the aim to optimise the profits.

Here the researchers concluded that the third party owned battery was the most profitable model and that especially the for-profit variant can be financially viable, if a significant proportion was leased for market participation [24]. This could even be demonstrated in a pilot project in Australia where a battery offered frequency stabilisation while also generating profit from energy and balancing markets [72]. Proka *et al.* [9] argued similarly that third parties could own and manage the asset, which would allow to optimize the energy use, avoid curtailment and improve its profitability.

This business model will analyse a value stacking approach where the local grid operator is supported and the battery shall be used for balancing services. Thus, the ownership structure follows a similar approach like the contracted services as defined by UK Power (2013). Since Shaw [24] showed that a third party-owned model was the most profitable, the business model for scenario will include an aggregator that owns and operates the storage device.

8.3. Analysis of storage cases & pilots

This chapter analysis pilot projects that are comparable to the case study in Groningen. This brief summary gives insights on the knowledge gained in this area so far and will help to get a broader picture on the challenges for energy storage in a community setting. This chapter synthetises the aspects that could be learned from the projects and indicate the differences to the Groningen case which will lead to the knowledge gap, that this research tries to fill.

8.3.1. Interflex Eindhoven (Netherlands)

The Interflex project is a Horizon 2020 project that has the goal to keep up the dialogue between regulation, technology and business players and to harmonize the development towards a new energy system. Six industry scale pilot projects were set up in five different EU Member States. One of these projects was a demonstrator in Eindhoven [42].

The scope of the project included the deployment of a stationary battery, PV panels of private households, EV charging stations for flexibility service and an ICT system to develop a local market. The battery had a capacity of 315kWh with 225 kW maximum output and the test area covered 350 households. For this area a local market design was developed. Additionally, the goal was to enable flexibility services, congestion management, voltage support and promote a multi-service for the battery management [13].

To enable all market parties to participate equally on the flexibility and energy markets, the implementation of a flexibility market for DSOs without obligatory participation (an open market) was proposed. Aggregators have the opportunity to offer flexibility to the DSO, through a single-buyer flexibility market. However, aggregators can optimize their offerings, by enabling them to bypass the flexibility market and trade on other markets (e.g. wholesale markets, ancillary service market, portfolio optimization) [13].

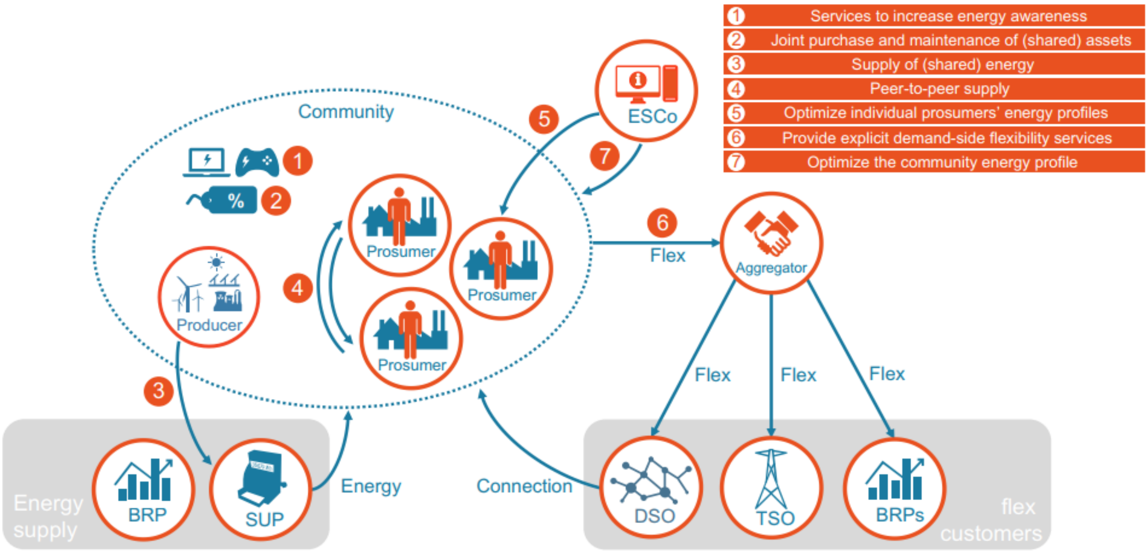
Concerning the investigation of different flexibility services did the researchers underline the fact that EV as source of flexibility can be an option, but that the reliability highly depends on the availability of the EVs.

8.3.2. Neighbourhood battery Rijhousten (Netherlands)

In Rijsenhout was in 2017 the first neighbourhood battery in the Netherlands deployed [73]. It is a shared local battery with a capacity of 128 kWh and covers 35 households [4, 74]. The battery was implemented together with an energy management system from the company Lyv that also came with an application for the residents. First preliminary results show that the self-consumption could be increased by 100% which additionally lowered the impact on the grid and allowed the battery to regulate the voltage control. In a later phase of the project, it is planned that local tenders will be published to trade residual energy on a local market [73].

8.3.3. Gridflex Heeten (Netherlands)

In this case, the battery capacity was split over 24 household with 5kWh each (120 kWh total). This storage was part of a 47-household-community [4]. Here focus was on avoiding peaks on transformer level (figure below).



Value proposition for citizen energy communities [75]

They concluded that a local energy community certainly has a chance to lower peaks *on the grid and can save 1500€/year on grid costs for inhabitants.* [75] But several legal issues where a barrier and a feasible business case still needs to be developed.

The costs are currently not yet proportional to the returns and they identified three key problems within the current system:

1. There is a need for plug & play equipment so that installation costs are manageable.
2. There are too many conversion losses with current battery technologies.
3. Current regulations do not allow the energy tariff to vary in such a way that that it encourages end users to structurally change their energy behaviour
4. The active involvement of all value chain partners is of crucial importance

Within GridFlex Heeten it was only possible to 'play' with the transport costs due to an exemption. Since these constitute only a limited part of the energy price, the incentive that could be given was only too limited to really change the energy behaviour of the end user [76].

8.3.4. Other pilots outside the Netherlands

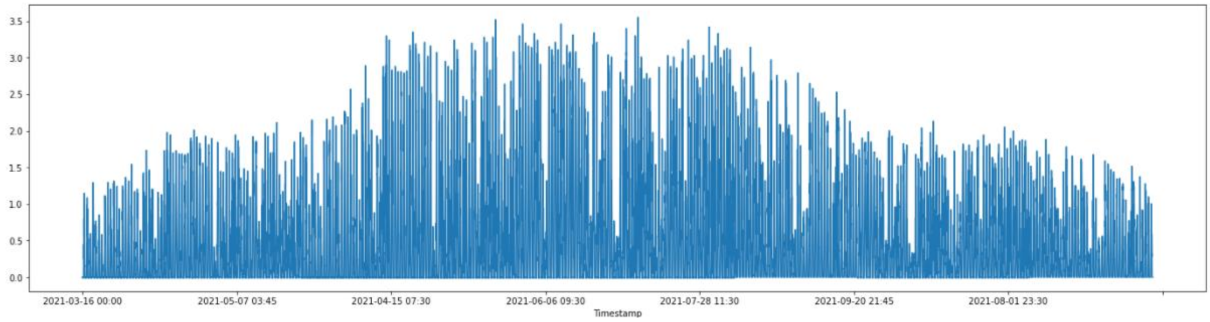
The first presented pilots only focused on demonstration projects in the Netherlands because one can assume a similar system context which makes them more applicable to the case in Groningen. However, there are several projects worldwide that investigated similar community systems with interesting insights for this research.

* no public information available

Location	System	Profitability	BESS operator	Ownership
Carros, France	33 kW 106 kWh	Not profitable	DSO & Aggregator	1. DSO (Enedis) 2. Aggregator (Engie)
Sainte Marguerite, France	2 batteries: 250 kW and 620 kWh 33 kW and 262 kWh	Not profitable	Depending whether islands mode [1] or not [2] 1. DSO 2. Remote-controlled by Aggregator	1. DSO (Enedis) 2. Aggregator (Engie)
Simris, Sweden	Wind turbine 500 kW Solar PV 440 kW 2 Li-ion batteries: 800kW/330kWh 200kW/1050kWh	Not profitable	Assets controlled by E.ON Battery SoC-controlled DSO-steering of customer assets via Demand Response (?)	Distributed, resident owned
Eindhoven, Netherlands	315 kWh/225 kW battery Household PVs EV charging	*	Three parties are involved in the operation: DSO's Grid Management System interacts via aggregator platform with the local infrastructure management system that is operated by a third party.	*
Heeten, Netherlands	22 times 5 kWh sea salt batteries combined to 120 kWh virtual battery; private PV installations	Not profitable	Dr 10 (Battery company) ICT group control incentive Victrum build local intelligence University of Twente	Battery company leased the battery during the pilot Enexis
Leuven, Belgium	46kWh electrical storage 20kW PVt XX l Water reservoir	*	*	*
Suha, Slovenia	Li-Ion battery, 170kW, 450 kWh 7 PV power plants, 210 kW	No, if only DSO services are offered	DSO	DSO
Strombank, Germany	100 kW Li-Ion battery, 116 kWh storage capacity	Not profitable	PV and CHP owners	PV & CHP owner; financed in the context of a research project contracting model, where the battery is provided, installed and run by an external provider
Solar Neighbourhood, Germany	250 kWh Li-Ion storage (expansion to 800kWh) each house: 5KW PV on the roof, air-heating pumps	Not profitable	ENTEGA Energie	*
Rijsenhout, Netherlands	128 kWh battery	Probably not	Liander Tegenstroom is not project management Agregator is involved co-operation with an aggregator offering electricity/balancing power	Liander TegenStroom
Lempäälä, Finland	4 MW solar power gas engine capacity of 8,1 MW 130 kW fuel cell 1.6 MW BESS	Profitable	Fortum	Elenia: to grid protection and islanding Fortum: grid connection and to the battery system

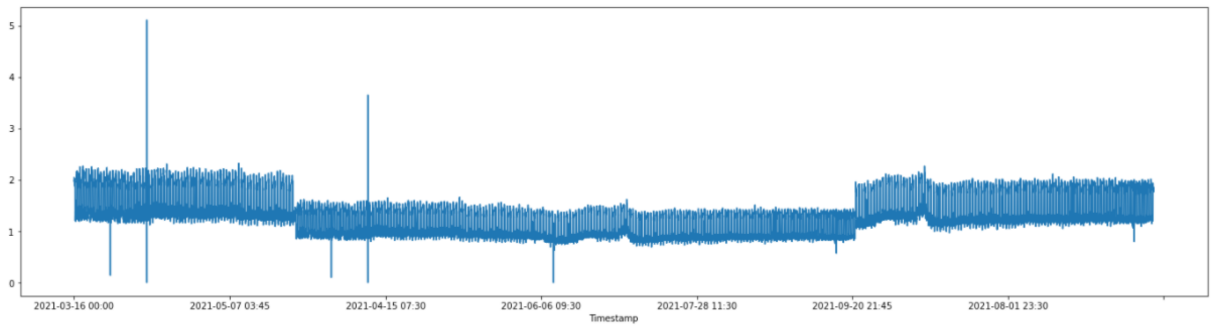
8.4. Data

The data for consumption of the common areas in the building and the elevator as well as the production of the BIPV was supplied by Sustainable Buildings B.V. who support the Nijestee corporation with the gathering of the data. The data was measured in one minute sequences and was aggregated to 15 minute intervals. The original dataframe covered the months from March until September since the company only started the measurements at the beginning of the year. To have a data set for a full year, the dataset was appended to itself and multiplied by a winter factor. For this case it was assumed that the BIPV generation decreases by 40% in winter. This resulted in the profile shown in .



Annual BIPV generation profile after data manipulation

For the demand, the following profile was derived for a full year:

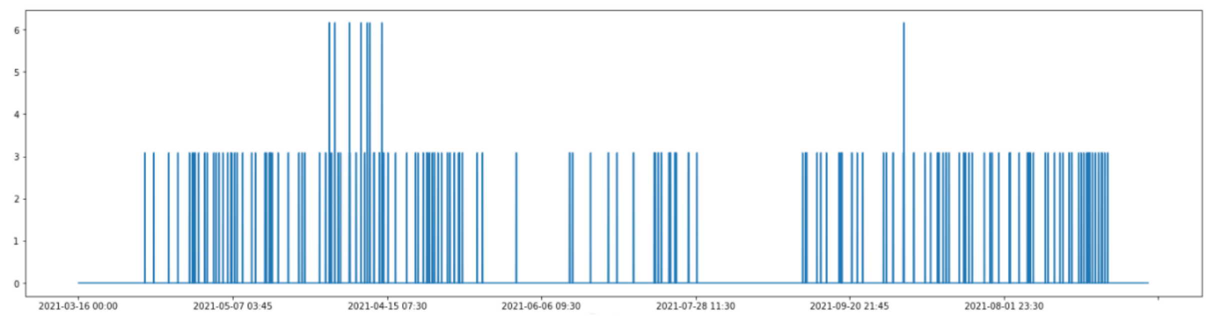


Annual consumption profile after manipulation

The winter factor that was added to the demand profile was based on the yearly consumption which was roughly 50.000kWh[25]. The given data from March until September was multiplied by 0.4 and appended to the dataframe which resulted in a yearly demand of 49352.27 kWh.

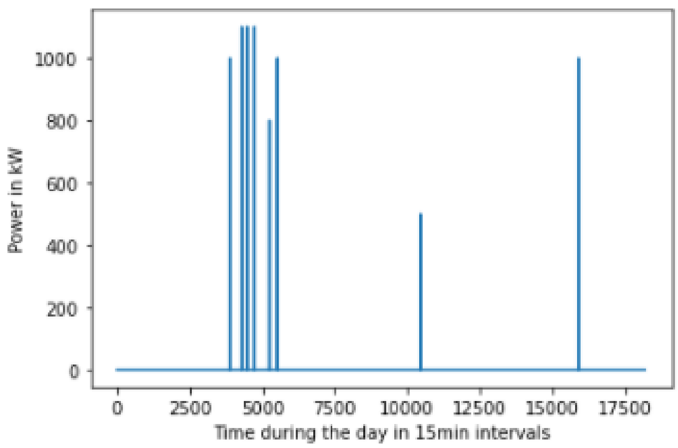
For scenario 2, EV data could be used from another deliverable of the Making-City project, where increased penetration of EVs in Groningen was analysed. In this project 19 EV charging stations where installed in a business area. However, not all of them were used over the whole period of the project. For this research the profile of two charging stations that were activated throughout the whole year were selected (figure 24).

[25] This figure was given by the Nijestee corporation



Annual EV profile

The data for DSO congestion bases on information gathered on the GoPacs platform [77]. The congestions that were reported on GoPacs happened 8 times within the period of the measured data from Nijestee. These congestions were up to 1MW.



Scenario 3 - DSO congestion profile based on data from GoPacs

8.5. Logics of the programme

8.5.1. General operation and priorities

For the whole process, it is assumed that it always first checked whether the elevator has to be covered by the battery. If this is the case, then the battery is discharged. After the battery is discharged the programme includes the PV production. There are instances where the PV installation actually draws current to start its process, this is taken from the grid. When the PV generated electricity, this is charged to the battery to the extent that there is free capacity.

For the 3rd scenario the DSO and TSO are added. After covering the elevator, the relieve of grid congestion has the highest priority. In the parameters (7.3.3.) an DSO reserve can be defined. This means, that a given capacity is always kept free for the DSO. If for instance, we have a 600kWh battery and the DSO reserve is 200kWh, the battery will not be charged with the PVs once it is at SOC of 400 kWh.

8.5.2. Decision programme based on pre-defined factors

For scenario 1 & 2, there are 4 main factors that define how the output is calculated:

1. Elevator demand	2. Battery	3.PV	4. Demand
1. > grid connection 2. < grid connection	1. >0 2. > elevator 3. < elevator	1. <=0 2. >0, PV > free capacity 3. >0, PV < free capacity	1. > free capacity - elevator buffer 2. < free capacity - elevator buffer

Scenario 1 & 2 - Decision factors

The amount of electricity charged to the battery, sent to the grid and consumed from the grid is based on these 4 factors (figure above) . For instance, when the elevator demand is larger than the capacity of the grid connection (situation 1.1.), and the available capacity is larger than the elevator demand (situation 2.2.), then the battery will be discharged to cover the elevator. If we then also have PV production, but this PV production is larger than the free capacity (situation 3.2.), we charge the amount of free capacity onto the battery and the rest of the PV generated electricity will be sold to the grid.

The main difference between scenario 1 and 2 is that for scenario 2, the consumption of the EV is included into the demand and we want to cover this demand by discharging the battery. To assure that this does not hamper the operation of the elevator an *"elevator buffer" is introduced.* This is battery capacity that is reserved for the demand of the elevator. If the state of charge of the battery is equal or below this threshold, the battery will not be discharged to cover the demand of the building. For scenario 1 we could calculate that 36kWh capacity are needed, so this capacity is the elevator buffer. And this specific reserve will then be included in scenario 2 (and also scenario 3), where the programme then takes the additional decision to self-consume or not. If for instance the free capacity of the battery minus what is saved for the elevator is larger than the demand (situation 4.2.), then the whole demand can be covered by the battery.

These decisions result in the following outcome:

self_consumption	self_sufficiency	battery_size	energy_from_grid	energy_to_grid	min_elevator_check	own_consumption	times_elevator_not_covered
0.082497	0.066502	20.0	61169.80876	51211.78163	-10.45122	4604.71837	354.0
0.089210	0.071913	25.0	61169.80876	50837.09974	-10.45122	4979.40026	316.0
0.113696	0.091651	30.0	61169.80876	49470.39560	-10.45122	6346.10440	169.0
0.122871	0.099047	35.0	61169.80876	48958.28582	-10.45122	6858.21418	120.0
0.145355	0.117171	40.0	61169.80876	47703.31735	4.32793	8113.18265	0.0

Example result for scenario 1

The programme calculates self-consumption, self-sufficiency as well as how much electricity is sent to and received from the grid. Those values are automatically exported from python to the financial model in excel and can be used there for the financial analysis.

Additionally, for every single point in the data set, the programme calculates whether the elevator has to be covered by the battery and whether the battery has enough capacity. The variab*le "elevator_check" calculates the state of charge of the battery* minus the demand of the elevator and if this is negative, the programme concludes that the elevator cannot be covered neither by the battery (lack of capacity) nor by the grid (grid connection constraints). If there is at least one time where the elevator is not covered, the programme increases the capacity by a chosen and restarts the process until the battery is large enough that the elevator is 100% covered.

For scenario 3 we have two additional levels:

1. Elevator demand	2. Battery	3.PV	4. Demand	5. DSO	6. TSO
1. > grid connection 2. < grid connection	1. >0 2. > elevator 3. < elevator	1. <=0 2. >0, PV > free capacity 3. >0, PV < free capacity	1. > free capacity - elevator buffer 2. < free capacity - elevator buffer	1. Congestion 2. No congestion	1. bid gets activated *2. bid doesn't get* activated

Scenario 3 - Decision factors

If the grid on DSO level is congested, the battery will charge from the grid. The amount is defined by the size of the congestion, the battery capacity available for congestion service and the charging rate of the battery. For the DSO service, a reservation system was programmed. If the programme detects DSO congestion need, it will block the battery 2 hours before and 2 hours after this congestion incident. This simulates storage as a service where the DSO can use his congestion forecast and use this prediction to reserve extra capacity. However, the DSO does not know to the minute precise when the congestion will occur. So in this model, the DSO reserves capacity 2 hours before and 2 hours after the congestion is predicted. This can be adapted based on the DSOs needs, but for this study an overall four-hour reservation time is used as default.

If the battery is neither blocked by the elevator nor by the DSO, its capacity (minus elevator buffer and DSO buffer) can be used to play on the imbalance or FCR market. However, bids are not always activated. If a bid is activated, the battery is charged or discharged accordingly. This results in the following output:

self_consumption	self_sufficiency	battery_size	DSO_charge	TSO_FCR_delivered	TSO_imbalance_profit	energy_from_grid	energy_to_grid
0.669346	0.416952	400.0	360.0	975.0	0.0	5668.119439	38621.983857
0.707138	0.440494	500.0	360.0	1115.0	0.0	2169.220519	38111.646392
0.718519	0.447583	600.0	360.0	1168.0	0.0	1152.139313	37920.331405

Example result for scenario 3

In this case the service on TSO level that we focussed on is FCR, which can be changed using the parameters to services on the capacity imbalance markets. For the TSO services, the profit is calculated within the python programme since the activation corre*lates to the €/MW clearing price in that time slot. If a bid g*ets activated, we multiply the amount that is charged or discharged from the battery with the price from that auction.

8.6. Parameters

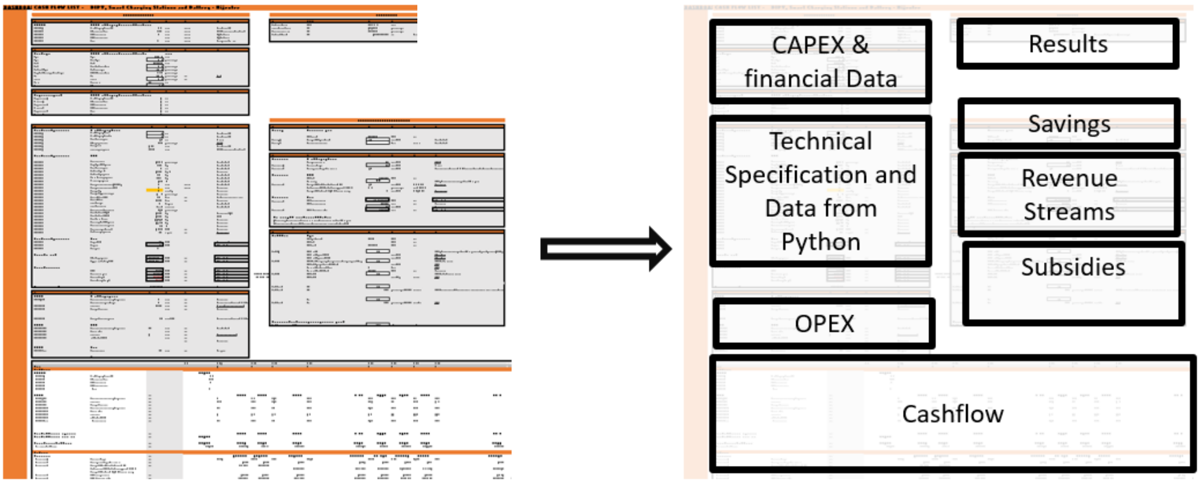
Parameters

```
# Scenario
scenario = 1                        # 1 = Elevator, BIPV, Battery
                                    # 2 = Elevator, BIPV, Battery, EV
                                    # 3 = Elevator, BIPV, Battery, EV, Flexibility Services

# Battery specifics
battery = 4                         # 1 = Li-ion
                                    # 2 = flywheel
                                    # 3 = flow
                                    # 4 = customised
efficiency = 1                      # charging efficiency of battery
rate = 10                           # kW charge rate
capacity = 0                        # kWh minimum capacity
max_capacity = 50                   # maximal capacity that will be tested; for scenario 2 & 3
self_discharge = 0                  # self discharge per h
dod = 0                             # Maximum depth of discharge; 0 = can be discharged to 0 %

# Optimization settings
capacity_interval = 10              # kWh to caluclate different battery sizes
connection_limit = 8                # maximum kW that can be delivered through grid connection
demand_factor = 1                   # factor to simulate different demand scenarios; x=1.5 means 50% more consumeption
pv_factor = 5                       # factor to simulate different pv scenarios; x=1.5 means 50% more generation
elevator_factor = 1                 # factor to simulate different elevator profile scenarios; x=1.5 means 50% more demand from the elevator
EV_factor = 1                       # factor to simulate different EV profile scenarios; x=1.5 means 50% more demand from EV charging stations
elevator_buffer = 36                # kWh that are reserved for elevator demand
DSO_buffer = 200                    # kWh free battery capacity that is reserved for DSO congestion services
TSO_service = 2                     # 1 = Imbalance market
                                    # 2 = FCR market
bids_activated = 0.01               # x% (1=100%) of bids will be activated
demand_on = 1                       # 0 = demand will not be included for in self-consumption
                                    # 1 = demand will be included in self-consumption

data = 1                            # 1 = Data given from Nijeste (March-Sept.)
                                    # 2 = Simulated dataset including winter
export_to_excel = 0                 # 0 = results from technical model are not exported to excel
                                    # 1 = results from technical model are exported to excel
```

Parameters within the python programme

8.7. Explanation sheet for economic model

To present the logics behind the economic model, this explanation sheet will use the main structure (figure below) to explain each section.



Main structure of economic model

CAPEX & Financial Data: Capital expenditure; add investment values of your installation, split costs for physical system and installation service if possible. The financial data includes details about the equity structure, WACC, tax as inflation as well as the depreciation/ amortization period.

Technological Specifics: Very case dependent; for this example-project the model was used for a combination of BIPV and Smart Charging Stations. Accordingly, in section data was added about demand for EVs, BIPV efficiencies, electricity consumption of the building etc. This has to be adapted depending on the context.

OPEX: Operational expenditure; also very case dependent but generally includes electricity prices, insurance and maintenance.

Savings & Revenue: This is the section where a project generates its profitability, either through money saved (on electricity for instance) or revenue from electricity sold, *services. etc. This section also includes a part for "Cost of goods sold".*

Subsidies: Subsidies can be turned on and off and depend on certain condition (e.g. stand-alone project or part of a company). In this model the SDE++, SCE, ISDE, MIA and Vamil subsidy are included.

Financial Result: Are derived from the cashflow. Include Net Present Value (NPV), Internal Rate of Return (IRR), Return on Investment (ROI) and Payback Time (PP).

Cashflow: The cashflow section is split into Cash-Inflow, Cash-Outflow, Cashflow Overall (Inflow-Outflow) and Income Statement. The Income Statement includes tax, interest, depreciation and amortization in its calculation. The bottom row with the Net Cashflow over 15 years is used for the NPV and IRR calculations.

Main Variables

This part of the Tutorial goes through the main variables that can be changed to influence the profitability of a certain business model. The variables are always indicated in red.

In CAPEX & Financial Data (figure below) the main variables are the concerning the equity structure. Depending on the cost of capital, this can considerably influence the business case. Inflation and depreciation/ amortization period usually stay the same but can be adjusted if needed.

Group	Name	Factor	Unit	Frequency	Source
CAPEX	**BIPV, Smart Charging Stations and Battery – Nijestee**				
CAPEX 1	Smart Charging Stations (SC)	I 2,090	euros	once	New Motion B.V.
CAPEX 2	SC Installation (labour)	I 9,350	euros	once	BAM Bouwen en Techniek
CAPEX 3	BIPV (incl. Installation)	I 40,000	euros	once	A 12 at Nijestee
CAPEX 4	BIPV Installation (excl. tax)	I -	euros	once	A 12 at Nijestee
CAPEX 5	Battery	I 300,000	euros	once	European Commission

Group	Name	Factor	Unit	Frequency	Source
Cost of Capital	**BIPV, Smart Charging Stations and Battery – N**	**I 351,440**	**euros**		
Equity	Equity	I 123,004	euros	-	
Equity	Cost of Equity	4.00%	percentage	-	
Debt	Debt	I 228,436	euros	-	
Debt	Cost of Debt/Interest Rate	1.00%	percentage	-	
Debt and Equity	Debt leverage	65.00%	percentage	-	
Weighted Average Cost of Capital	WACC/Discount Rate	2.05%	percentage	-	
Tax	Tax	25.00%	percentage	yearly	KvK
Inflation	Inflation	2.00%	percentage	yearly	
Lifetime	Project lifetime	15	years	-	
Agregator investment	Share of investment	50%	percentage		

Group	Name	Factor	Unit	Frequency	Source
Depreciation period	**BIPV, Smart Charging Stations and Battery – Nijestee**				
Depreciation 1	Smart Charging Stations (SC)	10	years	-	
Amortization 1	SC Installation (labour)	10	years	-	
Deprecitation 2	BIPV (incl. Installation)	10	years	-	
Amortization 2	BIPV Installation (excl. tax)	10	years	-	
Depreciation 3	Battery	10	years	-	
Amortization 3	Battery	10	years	-	

Economic Model - CAPEX and Financial Data

For the Technological Specifications (figure below) the outputs from the technical model in python are automatically exported and will then be used for further economic analysis.

Technical Specifications	**Battery**				
CAPEX 5	Prize per kWh	750	I/kWh		European Commission
CAPEX 5	Capacity	400	kWh		Python Model
CAPEX 5	Total price	300,000	I		
Electricity Demand					
	EV charging staions	12,728.56	kWh	yearly	Python Model
	Appartment building & CS	49,870.62	kWh	yearly	Python Model
Electricity Generation					
	BIPV	47,690	kWh	yearly	Python Model
	Own consumption	466,587	kWh	yearly	Python Model
	Electricity sold to grid	-233,977	kWh	yearly	Python Model
	Electricity bought from grid	-63,015	kWh	yearly	Python Model
Total electricity surplus/ shortage	yearly	416,716.55	yearly	yearly	Calculation

Economic Model - Technical Specifications

As explained above, OPEX (figure below) mainly considers maintenance, insurance and electricity price for the business model. The electricity price does affect the profitability of the case if the self-generated electricity does not cover the own demand then the charging stations have to fed with electricity from the grid.

Group	Name	Factor	Unit	Frequency	Source
OPEX	**Smart Charging station**				
OPEX 1 SC	Maintenance (cleaning & inspection)	400.00	euros	yearly	Calculation
	Maintenance per charger	200.00	euros	yearly	https://www.rvo.nl/sites/default/f
OPEX 2 SC	Insurance	878.60	euros	yearly	Estimation: Zonnepanelengids
OPEX 3 SC	Price paid for electricity	-	euros	yearly	Calculation
OPEX 3 SC	Price paid for electricity per unit	0.22	euro/kWh		https://www.rvo.nl/sites/default/f
OPEX	**BIPV**				
OPEX 4 BIPV	Maintenance (cleaning & inspection)	750	euros	yearly	Han Folkerts (NIJ)
OPEX 5 BIPV	Consumables	-	euros	yearly	
OPEX 6 BIPV	Insurance	100	euros	yearly	Zonnepanelengids
OPEX 7 BIPV	*(add other OPEX)*		euros	yearly	
				yearly	Calculation
OPEX	**Battery**				
OPEX 8 Battery	Maintenance	750	euros	yearly	Assumption
	Total	**2,878.60**			

Economic Model - OPEX

In Savings (figure below) one can play with the electricity price to calculate different revenues for different price scenarios. In this sections the costs for the extra elevator connection can be included and will be taken into consideration for the final revenue.

Group	Name	Factor	Unit	Frequency	Source
Savings	**Own consumption**				
	kWh saved	466,587	kWh	yearly	
Savings 1	Price per kWh purchased	0.150	euros/kWh	-	Han Folkerts (NIJ)
Savings 2	Elevator connection		Euros	one time	Han Folkerts (NIJ)

Economic Model - Savings

The Revenue (figure below) mainly depends on the fee that is charged to EV customers and the electricity price. The electricity price changes considerably depending on whether it is a private household or commercial building.

Group	Name	Factor	Unit	Frequency	Source
Revenue	**Smart Charging Stations**				
	Total price for customer	0.41	euros/kWh	-	ANWB
Revenue 1	Service charge	0.29	euros/kWh	-	Estimation
Revenue 2	Electricity price charged from customer	0.12	euro/kWh	-	https://www.rvo.nl/sites/default/files/2020/12/een-startgids-voor-bed
Revenue	**BIPV**				
	kWh sold	-233,977	kWh	yearly	
	Net metering*	ON	-	-	"YES" if grid connection is not larger than 3*80 amperes
Revenue 3	Price per kWh sold (Feed-in Tarrif until 2022)	0.150	euros/kWh	2020-2022	Nieuwestroom
	Reduction sold kWh for Net Metering price 2023-2030	9.00%	percentage	yearly (2023-2030)	
	Price per kWh sold after 2031-2035 (excl. net metering)	0.060	euros/kWh	2031-2035	Milieucentraal
Revenue	**Battery**				
Revenue 4	DSO congestion relief	1103.947283	kWh	yearly	Python Model
	DSO congestion relief	165.591	euros	yearly	Calculation
		0.15	euros/kWh		Assumption
Revenue 5	TSO imbalance market	82857.1	euros	yearly	Python Model

***Net metering (L30) can be turned "ON" when:**
1. the electricity grid connection has a total maximum forward value of no more than 3*80 amperes
2. the total electricity production (E51) is less/equil to the electricity consumption of a building (E56).
3. the electricity is sold to the grid (E54)

Economic Model - Revenue

For BIPV the revenue depends in big parts on the net metering situation and the tariffs. These tariffs will decrease from 2023-2030 which is included in the cashflow calculations.

Subsidies (figure below) can be simply turned on and of depending on whether the conditions (in red) are fulfilled. Important is especially the question about the characteristic of the project at the bottom: If the project is part of an organisation, tax reduction through subsidies can be applied to the overall EBT and thus make the project more profitable.

Group	Name	Factor	Unit	Frequency	Source
Subsidy & fiscal	**Equity**				
	kWh produced	47,690	kWh	yearly	
	kWh sold	0	kWh	yearly	
	kWh used	466,587	kWh	yearly	
Subsidy 1	SDE++ subsidy	NO	-	-	"YES" if grid connection is larger than 3*80 amperes and peak power
	SDE++ subsidy (per sold kWh)	I -	euros/kWh	-	Ekwadraat
	SDE++ subsidy (per used kWh)	I -	euros/kWh	-	Ekwadraat
Subsidy 2	SCE (Subsidieregeling Coöperatieve Energieopwekking)	NO	-	-	"YES" if VvE is system owner
	SCE subsidy (per produced kWh sold)	I -	euros/kWh	-	RVO
	Maximum subsidized full load hours	900	hours		RVO
	Maximum subsidized kWh sold	14,112	kWh	yearly	Calculation
Subsidy 3	ISDE subsidy	NO	-	-	"YES" if VvE or Nijestee is system owner
	ISDE subsidy	I -	euros/kWp	once	RVO
Subsidy/fiscal 4	MIA	NO			
Subsidy/fiscal 4	MIA	36%	percentage/CAPEX	year one	RVO : https://www.rvo.nl/subsidies-regelingen/milieulijst-en-energie
	Vamil	NO			
Subsidy/fiscal 5	Vamil	75%	percentage/CAPEX	variable	RVO
Business case: Stand-alone project or part of a company?					
Subsidies apply to overall EBT of a company (yes-no)		YES	= Project is part of a company with several income streams		

Economic Model - Subsidies

Finally, the outcome can be analysed in the result section.

Name	Abbreviation	Factor	Unit	
Net Present Value	NPV	133,520.72	euros	
Internal Rate of Return	IRR	3.42%	percentage	
Return on Investment	ROI	33.75%	percentage	
Payback Period	PP	7.36	years	Calculated with profit from year 1 as average

8.8. Interview Transcripts and Confirmations

For objective written verbalisation of the interviews the programme OtterAI was used. However, some parts of the transcription might not be fully complete due to the poor audio quality of the recordings. The transcriptions were manually corrected as good as possible and only clear and understandable sections were used for the result sections. Arguments that were used are marked in bold.

8.8.1. Interviewpartner 1 – Manager of Energy Storage Projects

SUMMARY KEYWORDS

battery, connection, net metering, system, legal, case, flexibility, barrier, problem, congestion management, market, law, business, electricity, services, double taxation, offer, scenario, solar panels, battery storage

00:00

So yeah, since this is for my, for my thesis and interview, first of all, what thanks for taking the time. Of course, let me know if it's a consent to record you. That's fine. Easy, yes or no question.

00:12
It's fine.

00:13
Okay, great. And then maybe just to start with, explain briefly, what is your job here at the New Energy Coalition, what is your background to give a little bit of

00:24
to provide generated through the recording existence? Now, my name is [..] and I work at the new coalition as a project manager, which is a very generic title for doing whatever. For the record, by the way, that I have a background as a lawyer, **I studied law started the Public Law later on is specialized in international and European law.** And after that, first specialize into international law. So I get Europe later on also within the Netherlands, looking at system integration in the regulatory frameworks, so it's basically web technology and societal aspects come together now and one framework. And of course, we had a very crystal clear framework, which is based on a Christian Gas, gas for heating, electricity and free industry, and also electricity production. And of course, efficiency will cause some secondary energy stores. Now, of course, with the energy transition in some, some advocacy is becoming more of a sort of primary source because you get the electricity and then what, and of course, the **intermittency is getting a problem congestion.** So that's basically what I did research into when I started working at University of Colorado for a couple of years. For a couple of years research within the university, I made a switch to more project development, but also some of the consulting, which I also do with a new Energy Coalition. So basically, what I do now is develop projects, I manage projects, I do lecturing, I'm also involved in getting courses. I also do some legal advice, silting studies, that's more because I do. And I also do sort of a bit of relation management, because I mean, when you when you study a law, it's basically the laws always about something. Yeah, to always look at the system behind the framework. So it's really gives you a very broad perspective. Yeah.

02:34
And then the problems that you mentioned so far that you came across neighborhood batteries or battery system, you say like transformation of the system. So what what is your expertise in the area of battery systems energy storage,

02:47
basically, I I think it's out right now, still doing research into that, I think **I was out for almost seven years working on the integration of flexibility**, which is, that's the service which can also be provided by, for example, a neighborhood battery, all sorts of different organizational settings in which this flexibility or this battery could be utilized. Stopped this year, I did a studies with hospital, which is a Dutch consultancy company for rvot, which is the rightful name at the Dutch enterprise organization on

the regulatory and financial barriers for the integration of smart energy solutions, which of course, is also the household battery was also one of the cases which was presented by the market parties in the consultations we help,

03:40

okay. And since your legal expert, I want to really use this discussion to dig a bit deeper into the legal barriers to these kind of business models. Because what I've read too far that it's technically possible, I've seen pilots where it's, you know, the even profitable, but then it's always the legal barriers, at least to some degree. It's not the single barrier, but it's one of them. And so far, I found four major issues, I might just, you know, name them up, and you tell me, like, where am I missing anything? Just to make sure for the business model, I got got the legal content, right. Yeah. So the first one would be the net metering scheme, because you know, you don't really have an incentive with us to get a battery. Second one is the double taxation. We're getting taxed when it's charging and discharging, which makes it less less attractive as a business case. Yeah. Lack of subsidies, which, from what I read comes from the fact that it's not defined well in the legal text yet because it's not a production unit. It's not a consumption unit is both at the same time. And then, the last one that I had is the limitation of the D O T. So to actually own storage assets because if they store electricity, they would have to sell it and they are legally not not really allowed to do that so far, from what I've read. So far. Once on this, and like, Am I missing anything? that specific question?

05:02

Yeah, well, personally, I'm a bit troubled by the definition of, let's say a legal barrier. Yeah. Because basically, I don't really think the **law is maybe the barrier in this sense, but the business case is a barrier.** Because I think if you, for example, look at these for like, the first is we say the the double double taxation, was it

05:30

the first one? The first one was net metering,

05:32

net metering? Well, we will be sort of integrated with the studies that we set, well, **net metering is going to be abolished**? Well, net metering is only relevant for small household connections. So if you have a large battery? Well, **it depends on the capacity, whether net metering is relevant enough.** So that that's, that's one, you can only net meter up to a certain extent. So I think this is mostly irrelevant for households connections. And if so, then the question is also well, if you don't have net metering, we don't necessarily prevent the better business case for, for for for battery storage, because if you don't have net metering, that might also imply that people start buying solar panels, because they are getting more and more expensive. The battery doesn't get cheaper, because net metering disappears. So that basically means now instead of just having to buy solar panels, you need to buy solar panels, and a battery, which will probably cause and that's also what a lot of parties and I started with Discover, and that will probably cause people must buy solar panels anyway. So it's not really solving the problem. It's just making the business case for for selling solar panels may be even more complex. And also, if you look at all the additional administration, allocation, reconciliation, it's not necessarily making things better. So I'm not saying it's not a solution, but I'm not sure I'm not convinced this is a really hard legal barrier. And also, **I wouldn't call net metering real legal barrier. Because I mean, the law doesn't prohibit or prevent net metering from being sort of scaled down.** I mean, we have the law on taxes for on some environmental grounds, which just allows lowering the percentage, which is currently at that at that sort of 100%. refund for net metering. But I mean, that could be scaled down quite easily. It just takes the government to take a decision there. So is that a legal barrier? Well, I would say it's more of a policy thing than a legal thing.

07:57
Okay. Okay. Well, I'm not a legal expert. That's why I'm talking to you. Like for me, Paul, policymakers make the law. So this way it made what makes my understanding a legal issue.

08:06
The policy makers don't beg the law to just decide on the law. Yeah. Okay. Okay. I mean, so So I think this is more of the **I would call this a policy issue**. And it's not like I mean, in the end, it's policy being framed into the law. Yeah. But it's just that the government is reluctant on scaling down the percentage of net metering. And that's really the issue. Then the other thing you mentioned, what's the double taxation? Well, it really that's for large battery storage. That's, that's, that's going to be fixed. Now. Last **Tuesday, the government announced this will be abolished, double taxation.** Although personally, from a legal perspective, I'm not too happy with this development, because it sort of messes with the system. Because we have a system in which you have a connection, and you're being sort of three that's on this condition that you have connection and following, of course, you're being billed for the actions you sort of perform with this connection. So it's a bit complex, but in the end, I think there were other ways of fixing this. Because in the end, I think it also depends on what you would like to use this battery for. Yeah, I mean, that really depends and most useful cases. FCR, congestion management, or balancing services, and maybe very small margin, let's say wholesale trading or whatever.

09:53
And it's interesting that you mentioned congestion management because it was definitely one of the one of the servers I'm looking into, you know this for this business case, and I read the USEF Framework. And Marten is an experts, my supervisor, and he said that there's no real agreement yet how to handle how to handle this service like why why is it why is it not going ahead? And where are we at the porobblems?

10:20
this currently being developed a new network codes, or at least an amendment to the existing network code, which is proposing a new system for congestion management. **This system is being worked on for I think, now over two years, I think almost even close to three or more**. And if you include, let's say, the informal debates that have been going on with this, this system, I think you can easily count to seven. It's proved to be a very difficult process. Because while there is no market for

flexibility, so basically, what you need to solve is a chicken and egg problem. **If the network operator doesn't ask for flexibility, there's no incentive for aggregators investing and flexibility**, for example, by providing this battery, so you cannot earn any money, you can't offer flexibility, and you can't buy flexibility, which doesn't exist. So it's really hypothetical. Also, possession matters where there's just short term solution for expanding the grid. So it only offers a business case, I mean, if you would purely look into this, **congestion management will only offer a business case for a short period** of time, let's say five years, six years, maybe maybe slightly longer, but it's not really realistic to expect. So it's, and that's not enough for sort of creating a business case for a battery storage on a specific location. So in a bit more work. So that's one of the one of the issues. So now **they're really struggling to find a say the proper conditions for providing congestion**. And I think this also relates to your fourth barrier, which I think isn't the barrier, because the network operator doesn't have to sell electricity to use a battery, in my opinion. And it's and **also European law doesn't prohibits the network operator to operate a battery if it's being used as as part of the network, or to provide flexibility**. And, of course, they might be influencing the market for production supply of electricity, but there's no prohibition on influencing it's just a prohibition on actual production and trade. And also, I mean, I mean, what they could also do, and this is, I think, no problem at all, it said, **you could just start a tender saying, well, we want to have a battery here, because we think this would be beneficial for the network**. And if no, of the London market party's response, they have a right in the European law to say, well, then build has better yourselves. And they can even attend to the exploitation of the battery or part of it, or the free capacity of its which which could be used for credit or whatever. So there are definitely constructions which can be applied. The problem is that these construction require investment risks and decisions and policies from the system operators, which they currently don't have. **So I don't call this [DSO owneership] legal barrier, but I call it a problem within the existing system for network operations,** and also regulatory supervision, because also the Dutch regulatory authority is just now starting to look at how this whole market could work and looking at the current proposals being made. I think it's good as been worked on. But I think there are still a lot of things that need to be defined and tested and worked out in practice.

14:06

And you mentioned so far the DSO, it's so just so to make sure anything that could make a tender, and if normally exit could build themselves, but then you say there's an investment risk. And what were the other factor that you mentioned the technology? Well,

14:22

I think the there's no problem with that. But still, you need to make sure that you have let's say a proposition also for for, let's say, an exploitation agreement. So if I have a battery, you know, I would offer the battery capacity to you and say, Well, this is what I mean, and everything apart from that are everything including this is part of the services you should provide. So I can close that agreement for you. But **that requires sort of an idea about how this agreement should look like**. And one of the biggest challenges for system operators is that there has to be **non discriminatory.** So if I As a system operator who make a specific offer to you implies that anyone that's the same circumstances as you are as a system user should be able to receive the same offer. Yeah. So if I provide this neighborhood battery, unless it's an experiment, or whatever is clear experiment otherwise isn't allowed. I mean, it's allowed, but **then it should be part of regular system race to any comparable situation, that system user should be able to receive the same offer**, which I just made to you. So then, I mean, it's not just sort of testing something, unless it's, like I said, a clever experiment. But I think **we're quite sort of past that phase of experimenting in the Netherlands**, you just need to make working propositions. Yeah, that's, that's a challenge.

15:49
So yeah, especially you mentioned the, like, an agreement so that it's clear. And then let me just think it's 10 to also want to give you some room that you don't have to jump right from one meeting to the other. But um, concerning the double taxation, you said, for big batteries, it's been changing, you know, the size of the battery, or like the capacity.

16:11
I should have a look. And very easy to find. Yeah,

16:14
then I'll just look it up. Okay.

16:15
I mean, take a look at the website of storage now, which is the Dutch association for storage companies, companies working on storage services. Yeah. It's very easy to find.

16:26
Yeah. But they are changing this, like, so they're changing this now that they'll say it's very interesting, this might improve my business case. And then I might. Just to conclude, I could show you what I've been drafting so far. Yes. Just to give an idea, it's still it's still a work in progress. So the idea is, basically this house has a solar panel. And so they're thinking, Okay, should we install a battery? This is the first scenario which I'm calculating the technical technicalities, then the second scenario is the same thing. But with Evie charging stations. So we maybe can increase self consumption. And the third scenario is in the flexibility service, we get a big battery, that is also neighborhood bedroom, and it also could allow flexibility services. And the way I have designed for now, I just have conceptualized so you might have a look on this one. Yeah. And then just consumers. I can slide around. So I can explain a little bit in case there any questions?

17:25
Yeah. Let's see. It's usually very different from how I picture it. Because usually, when I picture this from, let's say, the legal perspective, which is basically you have an installation. Yeah, the connection. Yeah. And you have a system?

17:41
Yeah. Yeah, those are the way that that I pictured it. So my focus is the Nijestee corperation, they have this building. So I made it from their perspective, basically. And they have so this is for Scenario One. And two, they also have been in the third center, the recharging station and the PV generation. And then they have the battery, which they obviously use for the EB charging stations and the PV, but it's a huge battery. So they this cooperation for small building for an apartment in running the word won't invest 500,000 euros. So that's why I thought they could partner up with a Logan aggregator local aggregator, and I saw business cases where the local aggregator manage to actually support the DSO and the TSO. Yeah, with flexibility in on the imbalance

18:22
market. In fact, federal cases around 500 kilowatts,

18:26
so yeah. So in the greater green from the making city at 600 600 kilowatt hours. In the in the case that I saw when I could do this, it was one megawatt hour. So you know, that was already quite quite a big, quite a big battery, but they're

18:40
in the **market for one megawatt and also more markets to open up with**, for example, the fcr, etc.

18:48
Yeah, that's also an option that I'm looking into, you know, so they have the idea of 600 kilowatt hours. But if I see, okay, if we have a megawatt hour, and then we have access to markets, that actually makes a big positive business case, but that's what I'm, you know, just showing this, I showed this to Marten and now I'm showing this to you is to look at in like from a legal perspective where you could think,

19:06
have you ever also looked into the connection agreement? So the connection and transport agreement with a system upgrade? Because you have a lot? What will you know, what a connection sizes?

19:17
I think it's like a small household. So three times ATMs?

19:22
Yeah, it's Max. Everything below three times ATMs, that's small. But if you have nice status, that's a problem building or Yeah, so but some apartment buildings have a joint connection. So that means then you have a much larger connection of the three times ATMs Yeah. Which also means that the tariffs for this connection are different if you have let's say, low voltage connection. So everything below 400 volts, yeah, that means you have a capacity agreement. So you have a capacity use based on your connection size. If you have, let's say, medium voltage, a connection, that means that

you have to pay for the transport of the amount of energy and a contract at peak and realized peak per month. So that means if you have this, this this larger connection, it might be worthwhile also looking at how to **minimize the peak to get a lower connection cost** that might also improve your business case. Yeah.

20:29
Yeah, one part, it's actually good point looking in the connection for the battery that I need, because they also have an elevator where they actually try to avoid an extra grid connection because they need so that's the OCD, we install a battery in polar elevated with the battery to avoid this connection. But I want to close into into the connections in the savings that we can make. Yeah, yeah. Yeah. Okay. Yeah, this was actually what I wanted to show you more or less. Yeah, so this was already pretty helpful. Some got some new ideas, some new things I have to research.

21:05
Yeah, if you have something on writing, or you want to have an evaluation or a second opinion, I'm happy to look at it. Yeah, definitely.

21:11
This is like just really the concepts on your billing, like the technical model. And I will run into like, probably several,

21:17
I would also, I would recommend you also to sort of draft an **organizational chain,** let's say from from the installation. So basically, what you're proposing here is part of the installation part of the markets. But I also would also sort of make an organizational model in which you drop the installation connection. So that **defines the interaction with the system operator, and also the associated costs**. And let's say the system to which also the other system user connected, I think it then translated into that said, to use that model, I think there's also **helps you to understand a bit better from a legal point of view**. How these allegedly barriers work, because mainly they're they're part of this organizational change, which is, if something's within the installation, you can do whatever, yeah, law doesn't give a go. But if as soon as you sort of need to go through the connection with the system operator, through the system, and then back to other system operators, so you start interaction using the system that provides a very different scenario. So that's, that's a huge difference. And it also has a very different framework, which I think is really irrelevant. Also, for the **business case, as soon as you sort of can avoid making use of the system that avoids a lot of taxes, system costs, and other let's say requirements**, like having, like if you want to do supply services to other system users, having having a requirement of a supply license, etc, etc. Yeah, yeah, definitely, definitely look into this. Yeah, I think I can I can reflect that. And I would, I would also recommend you to maybe look at the report we did for our Rvo which is available. I can also if you can send me a reminder by email I can I can show you the report as

23:11
well. Okay. Yeah, perfect. Thanks a lot. That was some great some great input. Good.

23:15
I hope it was useful. Definitely.

8.8.2. Interviewpartner 2 – Senior Scientists Renewable Energy in Energy Efficient Buildings and Communities

SUMMARY KEYWORDS
project, business model, dso, battery, case, storage, question, building, point, deliverable, technology, grid, battery storage, services, tso, instance, systems, operates, find, energy

00:00
I'll start the recording. And yeah, to start with maybe so I introduced you a little bit to the project to start maybe would be interesting to hear a bit about you, your background and what you're currently working on and your experience.

00:16
So I've worked **at VTT, for 20 odd years**, I started actually, with innovated a building technology unit at that time, but I studied solar thermal connection for district heating systems. And my background is I've been working on **energy efficient buildings**, and how to provide that energy with renewables mostly, and more and **more on the district scale**. And more and more worked on international projects. So Nordic projects, and also, eu projects have coordinated two projects, and a technical **coordinator for the Xs project**, which is about energy positive buildings. Yeah, that's short, I started to I wanted to be an engineer, because I wanted to promote renewables, and especially solar energy. So the batteries, the energy storage is very much related to my passion, because you need stock to store the solar energy somehow.

01:44
Yeah, yeah. And then coming to the to the story project. What I read the literature is also that, you know, these projects, they have a lot of stakeholders involved, and she could see my little concept, you know, you don't you have the apartment building, you have the battery manufacturer, but you also have an aggregator the DSO, the TSO. And in literature, I found that they said that a lot of times, like different expectations actually, can be a problem, because you know, everyone wants to have their share of the cake and want to make the most profit and save the most money. From your experience in the in the story of project. I know, this is a very broad and big question, but what are the main success factors for a business model? Like, like I showed you where you have so many stakeholders involved in a local storage device?

02:35
Where would I start?

02:38

I guess? That's a good question.

02:41
I think one of the important point is that they all **need to understand what what, what the system is**, because in many in the story project**, it was difficult for some stakeholders to understand what is the storage, how the storage works**, and what technology because there are also some safety issues in the in different depending on what kind of storage you have their technology. And in storage project, for instance, **it was a bit challenging to get building permission for the neighborhood storage**, because they didn't understand what it is and how it works.

03:28
And if you say it's a neighbor, so people that live there or the municipality,

03:33
it's the it's the public servants. So who are those people giving the building permit?

03:40
Okay, so from the municipality, I guess, our local government, okay.

03:45
Yeah. Even that, and then it's for also for the if it's depending on where it's located, in your case, would it be located inside the building or somewhere?

04:02
So for the scenario one, and two will be probably inside the building for the scenario two or three, it would probably be the big installation, and then in front of the building, or, yeah,

04:12
we also discovered if it's **in the building, then there might be some challenges for the fire for the fire department**, for instance. The know if there is a button that we're in storage, or if it's what kind of storage is it? Is it a fire challenge or risk or something like that? Yeah. And of course, also in Yeah, that's that's the first thing I made some notes actually.

04:53
Yeah, I read on your website that you mentioned these these these fire safety issues, and I was actually surprised I was I thought there will be standards. Is that still the case? They did they have changed it, or

05:06
our partner have worked on that in Belgium? And I'm not sure it's now clear in other countries, also. Okay. So that's, that was. Yeah, it's, of course, that that is the challenge when they're all these different partners have different wishes. And that is actually one thing that made might be beneficial for the business model is that there, **there was a lack of integrators. So an actor who could integrate both the storage and the**

control system, and all that kind of their, their activities. So that that would solve part of the challenges, because it was it's, it was we found that these systems do not exist as hole. There are no, there weren't at that time when we were running the project. There were no holistic systems available. So you find the batteries, you could find the storage for that container for that. But there was a big **lack of systems, that would be what contained both the batteries and the control system**, for instance. Okay. Yeah.

06:45

And you mentioned already the, the case of the case study in Belgium. And I went through the cases a little bit, and especially the one in Belgium, Sana very interesting, because on the website, it said that they cooperated with the local distribution network operator to like, find out various business models. I didn't have time to get like read through all the deliverables. But I was just wondering, in general, how did you find the cooperation with the DSOs? And especially in this case, what what business models? Could you come up with? Together with the TSO ideas? Oh, sorry.

07:27

In that case, I don't I'm not sure if we've really found a business model. But at least the communication with DSO had started already during the preparation phase. We were asking actually them to join the project at some point, but for some reason, that they they didn't join, but and we we had quite a good discussion. And the communication with them or discussion. Point, yeah. Yeah, the this that that was proceeding towards like a local energy community, which would then provide maybe some services to the DSO. And mainly concentrating on on because in that case, there were some problems with the power quality and the energy quality, because it was a distant or end of the line. area. And that was the main main point in that demonstration to get a good quality hour to the to the neighborhood. But it as there were some additional excess energy available from the site, then it could be sold to the DSO or so.

09:16

Yeah, especially the role of the DSO, something I really want to discuss the reach I get, get in touch with the DSO here in Groningen, but it's you know, they're very busy and have a lot of things to do at the moment. So that's, that's very hard. But it's interesting what you say. And also, like I read something similar on the webpage, where you said that the clear contracts with suppliers are very important, because they're one of the problems and that the roles and responsibilities have to be clear in such kind of models. And if I just quickly show again, little the concept I drew from my master thesis. So this is basically the model that I I would propose and that I'm trying to like Molyneux and verify. Do you think the issue With the clear roles and responsibility could is solved in my case, the way I describe it here or is is, what else? What additionally has to be clarified to to have the direction of a successful project?

10:23

It depends on the **regulations**. That's one point, because, for instance, there might be different regulations on who can use storage is, for instance, and and who is who is allowed to make business out of it. **Who can sell this aggregation? Services?** So, so that these kind of things? Actually, there is one, one deliverable that I would suggest you to read? Yeah, I'm not sure if it's available on the on the story at site. Yeah. But send it to you. Yeah, that will be very nice. Yeah, it's it's the main main deliverable on the on the business models. But in that, that looks like a collection of the material that was made about the business models. But in that document, there is some some points of view on the aggregation business business model. Was that was written by one of our partners who has who was working on on that idea. So it wasn't realized in our project. But they were studying that what what would be needed? For instance? It's probably not enough that there is one building? Yeah, is there some limit that they calculated that should be to make the aggregation business possible and viable, that you should have enough aggregation potential? For instance, this kind of findings, and there's a lot of material there so hard to run 96 pages in. But it's, it's handling a lot of points of view on the business models. But there are two points in that deliverable. There's a variance analysis of the aggregation business model. That's about I think, 220 pages or something. And then there are these two boxes, ideas of the, from this particular partner about the aggregation base. And I would read those, especially, because they are like, very feet on the ground. So they have really looked into this seriously, so that they are thinking if they would be stuck in that kind of bits. Okay. Yeah. So flexibility called this company,

13:33
if you could send me this report, that would be great, because I was already looking at the deliverables, but it's sometimes you know, just so much information. It's can be so much. It can be it can be a bit confusing, which deliverable contains which information but that sounds like exactly what I'm, you know, I'm phenomenally I already developed something, as you can see, but I'm still trying to look at other projects, what have been done so far. And I'm trying to, you know, make this little summary table of projects and what they've done and what they found out. And one, one question I also had about the story projects, I don't know whether you can tell it for every single one. But do you know about subsidies are legal exemptions that they had sometimes because I know for instance, from project where they had didn't have to pay taxes, or they weren't connected to the commercial markets, and that's what the DSO could actually own the battery or that other legal exemptions where they didn't have to follow the rules to just try out the case. I was just wondering, do you know more about this or can you tell me where I can find more information about you know, the legal exemptions in the for each case?

14:39
Kind of sandboxes that this thing? Call it? Yeah. That rings some bell maybes through the breach cooperation, we could find something. It's cooperation of the European projects. Why sense,

15:02
said, on the website where it says bridge, is that what you mean?

15:10

Yeah, probably. Okay. I have in the new project that I'm now working on this access project, the coordinator is still in the breach cooperation. So I could ask him if he happens to remember something. Yeah, he was the work package file leader of the demo board, but it's later it in this project.

15:45
One, one thing that was, I already mentioned the regulations. And and that was one of the biggest barriers that we fought. And that is also leading to the development of the business model is to, for the partners in that or the provider, or the owner of the business model should take, like, make very thorough risk assessment. Because maybe if to see if there's some something, if it's still a viable business model, after the change of regulations, or if there are some, like problems in the maintenance or something like that

16:39
risk assessment yet, definitely are on the list. Because I'm also interviewing very federal manufacturers. So that's a good follow up question. I can ask them, like, how do I how to assess risk? And definitely also for the question, what is the success for that risk, risk management support, and

17:02
they were, like, other relevant business model that we developed in story was was this related to the compressed air energy storage, because they, they developed this kind of stacked business models that they had several points that where they could they were offering, they were thinking of our services to the TSO and the DSO. And also residential area, although that never was realized. But they made the business model. There wasn't Ireland, right? Yes, in Ireland,

17:42
and why did it not work out?

17:47
Because the technology wasn't available.

17:53
Yet the compressed air storage?

17:55
Yeah. In that. In that volume, it was was either you should buy a very big one or then a smaller one. **And on that scale, it wasn't available even at three offers. During the preparation phase. Then all said sorry, we don't have it**

18:18
is and what other technologies Did you looked into? I saw in Spain, it was a lithium ion battery, for instance. But what other technologies were did you choose? So you had compressed air storage lithium ion other technology? And you know, also like, why

why did you pick those ones? It's also interesting decision for me, because I also have to pick a technology for for my case.

18:48
We also looked **at lead acid batteries**. And then one of the one demo we had also **thermal storage,** actually to the demos we had also thermal storage is that is maybe maybe not so relevant for your case.

19:12
Okay, and which, which, which storage technology from your perspective, in your experience was the most promising? I mean, from what from the projects that you had

19:25
it depends on your needs. **I'm not putting my my faith in in any particular technology, it always depends on on your needs.** Yeah. Like

19:40
okay. And let me just see what other questions I have. I still have so many questions but I you only have six minutes left, right. So I better better still, because one question also had is obvious Before you try to save for every single case, but the question about ownership financing and operating the battery is also very crucial. So who operates it? And who owns it. So who actually pays the money for the battery? And in your cases, I couldn't, couldn't find that much information on the website and maybe still have to read the deliverables? Maybe it's in the delivery that you're going to send to me afterwards. But so so who owned the battery? Or like, who bought it? Was it the DSO? Or was it a third company? Was there was there any advantage that you could see between different systems?

20:43
It didn't, there were different solutions for that also. So in the Spanish case, it was the the company who used it, who owned also the battery, the battery company? No, no, no, not the battery, but

21:08
it was a company that was pretty much it was preparing some producing some some equipment for for cold storage is for for for refrigerators and so on.

21:31
But it was like it was an industrial company, who owned the storage also.

21:36
Okay. Do you happen to have the name of the company? Yeah.

21:51
Yes,

21:54

if not, I'm sure I can. If not, I'm sure I can find in the deliveries, I don't expect you it. I think it's impossible to know all the detailed information for every single project. I mean, just you know, I'm just you know, so you maybe know, like, I'm get a bit more context, I'm trying to, like, make a little table of the projects that were done so far. And then analyze whether profitable, who owned the battery, operated the battery, you know, which services? And so that's why you know, this, this question about, like, who owns it and who operates it? is, for me, very interesting. And yeah, so in Spain, it was a industrial company, UK.

22:32
Yeah. For, for the Soho case, for the Slovenian case, it was the DSO, who was owning and operating it. And that they are, so was the was the partner in the project. And maybe that is someone who you could contact because they probably would have a lot of ideas and a lot of inputs to just to give you.

23:02
Yeah, yeah, if you could send me the contact or get us in touch. That would be great. Because especially, I still have to talk to the DSL, and you know, to to also find out Okay, does my mother make sense for you or not? Or in which case, it doesn't make sense. So that will be very interesting.

23:22
Yeah. And they are very prone to development. So so they are very interested in answering questions and participating in discussions and that kind of thing.

23:32
Oh, yeah, that would be great. I mean, even though it's not the duchies Oh, like any DS Oh, just to get the DSO perspective. That would be interesting. Yeah. And maybe a concluding question. I also looked into the ideas report that you sent me also very interesting project very similar to what we are working on and making city. But one question I had is, so you worked on the ideas project, then the story. So I was just wondering, what changed since then, you know, since from in this area, from ideas to story, and what do you think is changing in the future? So from from now onwards, so that like, these two questions, what what, what were the big changes in last six years? And what are going to be the big changes in next six years?

24:24
Actually, it's the discussion on the energy positive neighborhoods is or Now they call it positive energy districts.

24:33
Yeah. Yeah, that sounds familiar. Yeah. Different names.

24:38
It's actually taking taking speed, okay. Right now. So this is the discussion is now starting on the energy positive neighborhoods. So we were a bit in before of our time in the project and in The story project, we were not looking at positive energy, we were

just looking at ways to waste balance, the grid are important to support the grid, actually.

25:15
And in your experience, because obviously, for my business model, it's crucial that the that the DSO needs this flexibility, otherwise, I'm not going to make any money. But I talk to people that are in contact with the local, these are here. And they said that some people in from the DSO, they say, We don't need flexibility services, we just upgrade the grid. And then my basic, my business model is basically dead. Because from that point on, it doesn't make any sense. Did you? Did you encountered similar similar problems or that the these are instead of getting flexibility, just focused on upgrading the grid and, you know, kind of ignores the whole storage subject

25:58
and **slow upgrade rate. In the meantime, I think this kind of business models are needed.** And also be because the renewables are increasing in the grid. But one, one finding that we made in story was that **we're not so sure if it's when it is environmentally beneficial to have this storage** is because in many cases, the like, **the demand response** and things like that, that they can which with which, with a can control, the stability of the grid is quite enough. You have to have a really big amount of renewables in the grid before it's environmentally beneficial to have storage is better in storage,

27:11
you mean, economically or environmentally? Environment environmentally, because then we can consume more local. And then yeah. Okay. Interesting.

27:23
Yeah. Because is the project production of this? battery energy storage is uses a lot of energy. And you have the losses there. So so the, the round efficiency is not very good. True. Yeah. If you get, by other means, balance the grid. It's better. Yeah. Yeah. Yeah.

27:55
Yeah, that might be for my conclusion, something for further for further research, that there should also be, like a lifecycle analysis that includes the production of the of the battery, or at least that's a good point that you mentioned this. So I, when I define my boundaries, for my research, I declare that I don't include the production of the battery storage. But that's, that's a very interesting point. And one,

28:20
I would like to add, when I was talking about the the integrator, we were also finding out that it's quite difficult for or the owners, the building owners, for instance, to operate this kind of batteries, they would need to understand a lot about the the function or the batteries or the grid and this kind of things. So in that sense, that's why we wrote the paper about the **battery energy storage as as service. That could be a solution.** So even if so if the aggregator is giving the services to the grid, maybe it's the one that

should be the integrator and providing the service also for the for the building owners. Such

29:17
so that that basically the aggregator, so **it's not the building owner that buys a battery, but it's the aggregator that puts a battery there, it operates, it controls it monitors it, and it makes the operating decision.** And it's the building owners just sitting there and you know, enjoying his lower electricity bills. Yeah, okay. Yeah. Yeah, that's about it.

29:39
How many building owners actually know anything about the stories technologies or energy technologies or anything? Yeah. Put the plug in the wall and take up to get some energy out of it.

29:54
Yeah. Yeah, definitely. That's actually a good point. I definitely will do some more research in in the direction of Battery battery storage as a service? Because I don't think as you said that building on us will. We'll be very keen to having to learn all these things about battery storage. But yeah, to be honest, I think those were, those are most of my questions. Do you have anything to add anything that comes to mind after all this discussion or anything? Question about my project or my master or anything that's still unclear?

30:38
That's a very interesting project. item that you have for your master's thesis, and I see it, see the result. But actually, I'm just offering you more and more to read. Sorry about that.

30:59
It's more information, though, all we need. So it's all good. Yeah.

31:02
So in this, this deliverable that I mentioned, you can find this information about the about the business models. But there's also another thing that I would offer you to read is our like replication deliverable, the report that we send for replication, because that also includes some of the barriers and challenges that are basing the business models. So before you get to the business model, you have also this different technical and also about the stakeholders, there was also something about the stakeholders. So that that report, that is about the challenges of storage is okay. Yeah,

31:57
great. Yeah. If you could send us on that would be great. Yeah.

32:01

There's also a lot of other things, but I think you can just find, find, according to the sub chapter names of the titles, yeah. Which, which are most interesting for you. Yeah, the public, public deliverables, so I can send them to you. With no problem at all.

32:24
Perfect. Yeah. Thanks a lot for the help and for taking the time even though you're busy because everyone's coming back from holiday.

32:43
it's a bit it's a bit late already. So I still have a bit to go. A few late at least one more. Yeah. Then. Yeah, thanks. Thanks a lot for all the help information from for the interesting discussion. I will make sure to include all everything you said my report and send it on to you. So you can have a look as well. And

33:05
I hope you'll say may have gone longer than sideways. But

33:10
yeah, that's okay. I feel like I have more questions than answers and before but I think that's always in research the way it is. When you find new stuff. You just always find new things, and then you get more curious about it. So yeah, thanks a lot for the inspiration. And then good luck with all the project currently and then maybe at some point on an energy fair or something we will meet in person, you never know.

33:33
Yes. Thank you. Have a nice day and see you soon. Goodbye.

8.8.3. Interviewpartner 3 – PhD Researcher on Energy Storage Systems

SUMMARY KEYWORDS
fcr, market, congestion, model, business models, storage, battery, services, calculate, scenario, dso, reserve, capacity, idea, housing corporation, elevator, questions, electricity, grid, charging

01:53
Well, I am bizarre. Meanwhile, Maddy I am last year **PhD student at University of Groningen and and as you said, I am working on exploring business models for energy storage in the Netherlands**. And to do so, I investigated the potential business models and I developed a map of single application business models for electricity storage, and specifically i i only focus on power to power electricity storage in my thesis, and then I used a modeling approach agent based modeling to fix to analyze the electricity market and the performance of electricity storage in such a market.

02:40

Okay. So your background is technical. So the electrical engineer from house or

02:46
No, I, I am I studied **Industrial and Systems Engineering** in my bachelor and then in Delphi, the master in systems engineering, policy analysis and management. Okay, so my bachelor was a combination between technical aspects and economic and my best, my master was a combination between, again Systems Engineering and economic samples.

03:12
Okay, perfect. Then I might just start explaining a little bit what I'm working on. Just see, do you have the right to share the screen?

03:24
Yes, I gave you the permission to share looks

03:28
good. And I'm just sharing my screen. So you should be on the making city slide now. Yeah. Let me just get full screen.

03:37
I say the whole PowerPoint. Presentation Mode.

03:42
Yeah, I'm just trying to get it. There you go. That's that should be better. So they're making silly project. The goal is basically to to analyze the possibility of positive energy districts and groaning so that the district in Groningen is producing more energy than it consumes. And here, I'm looking into a case for battery that has three scenarios. So the first scenario it is well, first of all, it's about an apartment building. And we're now just looking to different scenarios for battery for this apartment building. Because the issue that this part apartment building has is that it has an elevator, and there are like extreme peak consumption of this elevator the peak power and for these peak power, there is an extra elevator connection needed. So the idea would be to install a battery that covers the peaks. So makes this extra grid connection obsolete and thus could be a positive business case. So in a schematic way, these are just the power and money flows. So it's very simplified for now. We have building integrated PV in the building, they charge the battery and then the battery covers the elevator. So in this case, the bed the battery is only there to cover the elevator, which would Then save connection costs for the whole corporation. And before we go to the next one, because they increase in complexity, these business cases, I was just wondering Sure. Is this clear? Do you have questions for this for this case?

05:13
Yeah, this one is clear only the BI PV P is building PVS photovoltaic, what is either

05:22

building integrated PV saw the building integrated. So the story behind this is or the idea behind this is that because we want to increase PV production, but the rooftops are sort of limited. So the idea is building integrated for the vertical at the wall, which decreases their efficiency, but it is additional solar power. So that's the idea behind behind SBI PV. And then for the second case, for this is just a battery that is only used for the elevator. And then in the second case, we are including Evie charging stations, and also use the battery for self consumption. So the battery will not be only sized to cover the peaks of the elevator. But it will also be used to improve self consumption so that the company can save money on its electricity bill, and also be connected to the charging station. So we have more consumption and more consumption, more self consumption. And in combination with the business case of the charging stations, I want to look whether this can be beneficial. And this case, a question that I get a lot is, then how are these Evie charging system connected to the grid. So since I'm not an electrical engineer, I simplified it here. So the connection for the Eevee charging stations, they have an extra connection to the grid, which is and these costs are included in the Eevee charging stations business case. So we would still try to save the extra connection for the elevator with the battery, but increase our self consumption and also support the Evie charging stations with this battery. If that makes sense. If not, if you have any questions, just let me know.

07:04
Yeah, so far clear. Oh, by the way. You know the difference between this scenario and the previous scenario is just the income from Evie charging stations. Yes,

07:18
yeah. And that we because we have more consumption, because we have this extra consumption from the EV charging stations, we increase our self consumption rate. So basically, normally, if you only have the EV charging stations, you would charge them from the grid, and then you have a margin because you charge the customer the margin between the charging fee minus what you pay for the electricity. And if we combine these two business cases, the idea is at least that we can use our own generated electricity, which is cheaper than the electricity from the grid. So the margin of the Evie charging stations case would be bigger. And that's at least a hypothesis. That's the idea of this business. Yeah. And then in the third scenario, this is when we're kind of assuming a large scale battery, where then also like more stakeholders involved, and we have value staking and also flexibility services. For these aren t sound this is a bit more complicated. So basically, we have the same business case like before, so if any charging stations PV generation, and housing cooperation, in this case, we do have an extra grid connection because the battery would be assumed to have in smaller, they're 400 to 600 kilowatt hours, maybe even bigger. But he obviously we need an extra connection for the battery. So this would then not be the basically savings for the Housing Corporation. But the idea would be that we have a business case of a community scaled battery, where we can supply DSO and TSO with services, which is you know, through an aggregate, we pull the resources. So we have the MN Mega Mart requirement for these for these markets. But at the same time, the Housing Corporation is leasing part of the storage. So we have a huge battery. That is a bit business case itself. And it basically rents out storage capacity to the Housing

Corporation. So the Housing Corporation doesn't invest in that sense, but it would this is wrong on the drawing because I'm adapting this after my analysis. So they would not invest in capex, but they would rather rent part of the storage. So that's then sort of the idea behind this business case. And then the flexibility service, obviously we would need to cooperate with an aggregator to as I said, get this megawatt capacity that you need for flexibility markets. And the idea here because my research focuses on local energy storage would be first priority to focus on the diesel. So if there is good congestion, we want to charge the battery you want to read leaf grid congestion, this is our first priority. And then our second priority is if the diesel doesn't need any services, we have the tiers Oh, well, we have the tiers or level or we don't we try to play on different imbalance market like fcr and passive balancing and these kinds of markets. So the idea is basically that you have Housing Corporation, which saves on an elevator connection, and has the sort of like the leasing parts of the battery, and the aggregator who then analyzes Okay, is there a demand from the DSO and then the idea is that the diesel can reserve capacity on a certain time ahead. And if this capacity is reserved, then we're not gonna play on the imbalance markets. But if the DSO doesn't forecast congestion, then we play on the imbalance market. So we're making sure when the battery is not used for the DSL, that it's not just standing there and being unprofitable, we try to be a bit on the like for now mainly looking in the fcr. Mark. And that's, that's for now the idea. One thing I'm looking into is whether it might be better to separate these two business cases. So having just one small storage for the housing, and then a large for this service, because technically, I told you a few experts that, that this could you know, the benefits of combining this might be not worth the effort of actual electrical infrastructure. But for now, this is the basic concept that I have. So cover the elevator for the Housing Corporation, we live good congestion. And in that order that priority, the other two services are not needed. And we would like to play on the imbalance markets with this metric.

11:45

Okay, interesting. I just wanted to ask you to clarify you your question was whether you combined it to a smaller storage with a larger storage or I didn't understand this part of the question.

12:03

So, the idea is that we have one large battery that is able to cover the housing, so that we would have we had like certain capacity reserved. So, in the first scenario, I calculate how large the battery has to be for the elevator profile. Yeah, this is what I calculated my technical model, and then we know this capacity. So then in this business case, which is obviously more complex, we can say that the Housing Corporation would lease part of the battery of this large battery, so that they don't install it themselves and have the high capex and high OPEX but that they basically book or rent, which is you you also made mentioned rental models in your in your paper that they rent part of the storage, which was calculated in the scenario before so then we know okay, we need 15 kilowatts and kilowatt hour capacity to cover the elevator. So these 15 kilowatt hours will be reserved in this in this larger bedroom

13:14

well to I think to make decision whether this is a good or to combine it or not, we need to calculate a number of things, but I'm also thinking that if you want to combine the applications and services, one of the complexities that either we want to have something you know, some you know a number of 50 kilowatt hours, capacities next to each other, we want to divide divided the capacity into smaller capacities and reserved each of them for an application or **no we want to consider the whole capacity and assign the applications to ease with the idea that one application is not very important at a certain moment and other is important, for example, the nice we can charge EVs and the and in the mornings we can supply the house.** So I think these are the two approaches and I didn't consider it in my models, but it is widely recognized as a good opportunity that we utilize the as up maximize the utilization of the whole storage capacity by scheduling these applications not by dividing it to you know certain capacities and assign each capacity to a certain application, okay.

15:01
So you would then also recommend that we shouldn't. The problem is when the like, it is hard to predict the consumption of the elevator obviously, sometimes where it's used more or less. But it is hard to predict when people come and leave. And when they two people leave at the same time, obviously, there will be a higher peak. So this is why I was afraid if I don't have this, what I call, they call it like an elevator reserved in my model, that then the elevator reserve interferes with other services. So there might be the idea might be to have two separate systems, a smaller battery just focuses on the elevator, and then a larger battery, which has all these values, taking characteristics of, you know, stacking different flexibility services, but then I wouldn't make it to different business models and where you say, then it is better to **have scheduled times for each services that we deliver to the TSO and the DSO, instead of saying we reserved this capacity for you in this capacity for another stakeholder**. Is that Is that what you would you mind?

16:14
Yes, that is one way of doing it. I don't, I'm not saying that it is a better way of doing it. But that is a sort of a smarter way of doing it. And it needs in better participation from of course, and consumers. And also they need a good, maybe **artificial intelligence** things to do that. I didn't cover that part in my models, yet. But that is the story of this intelligent things. One idea is that there are some reports, they classify the storage, energy storage applications, and they determine which applications has synergy with each other and which, which are which do not have synergy. If we select applications which has synergy with each other, maybe we can have a better benefit the stacking.

17:21
Yeah, I think I think I know what you would study, would you say that you're talking about? My focus here was mainly that will my research question or in my literature review, I elaborate a bit more on grid congestion and how it's becoming more and more of a problem. And that in the Netherlands we have earlier Margaret congestions, because the grid is not as good as in other countries. Because Netherlands I used to use a lot of gas. And that's how I kind of argue that okay, grid congestion is our first

focus. And then SGR markets. And maybe to show you how I calculated it. Because, well, I'm not an engineer, but I tried to simplify it to get just get an estimation of how different flexibility service could interfere each other. So if you if you're interested, I could show you my my program, what what what it's calculating, to see where this makes sense for to avoid while you're sticking,

18:19

by the way, before you show the model, I should say that the the conceptualization you provided for this scenario is totally okay. But I just wanted to know, we can think about it differently. But for now it is okay. Maybe it could be a future research for you. Yeah, yeah. But

18:35

this is exactly where I'm conducting these interviews to get opinions from experts. And you know, to show different designs for such for such a model. Because only calculating, I feel like, you can calculate so many different details, but I'm just trying to get like a bigger picture of what this would look like. And yeah, so I'm very grateful for your for your input. And if I just quickly jump into my model. So the idea is basically that I have technical model programming in Python, that basically iterates different illiterates different capacities, and then looks, how high is the self consumption? How high is the generation and what flexibility service do we deliver. So this is in the third scenario. So we have this flexibility service we use Well, let's have a look at capacities 406 100. Those are specifications for the battery that I can change, but I don't want to play around with this too much. What I would like to look into and this is basically the elevator bathroom that I included. So this is basically the capacity that is not used. Because it's still kind of the idea to cover the elevator. And then I have different congestion scenarios. So the first one is just from gold pack. So the data from 2020 I think They there were only eight congestions over the whole period. But they were quite large. So in that case, we basically basement I looked into, so there was once a month there was a congestion. And then the second scenario simulated weekly congestion. And then in the third scenario simulated, like congestion every day. And the idea is that basically What my program does, it always reserves half of the capacity. So with a capacity of 400, reserves 200 for the DSO and 200. Well, if these are not used, then for the for the fcr market. And I tried to include because it's very on the SER market, I couldn't find historical data on the frequency changes, and whether we up or like dispatch upwards or downwards. So what I did is that I basically said, I sent a random function. And then basically said, okay, at a certain probability we dispatch, and then it's a certain probability upwards or downwards. And if you dispatch upwards, we basically deplete the whole reserve. And we just use that downwards, we charge up to the max capacity just to simulate, okay, in a worst case scenario, the bid gets activated on the SCR market. And afterwards, we don't have any reserve left. So that's a little bit the idea. I know, it's over simplified. But I tried to look into whether you know, the DSO and the fcr services actually sort of impede each other. And so what it does now, is it looks for for kilowatt hours. And it does all these calculations concerning whether the elevators connect the elevators, covered depths, stead of discharge, depending on the PV production. And then calculate different activation rates and revenues. Is that is that idea clear?

21:56
So far? Yeah. Yeah, more or less?

21:59
Because I really struggled to model fcr markets because of this fluctuating characteristics. I don't, you know, I don't have experience with playing on the SER market, but I assume that basically dispatch up and downwards quite a lot in the in the blocks where you are reserved. So here, I just assume, okay, our bedroom is used for four hours for the entire block in one direction. Yeah. And. Wait, um, maybe let me just ran it again. I'm sorry. We have to wait.

22:51
But while we wait here that the program runs, I actually have a question. Concerning other because I looked into fcr. But there are also other flexibility services. That might be interesting. So fcr is obviously one of the most interesting because you just have the highest, the highest price, if you look at it. But then I was wondering whether you also know about business models that look into MF AR, M F R da. Because here, we also can see that they like if you look at the prices, they're quite heavily increasing.

23:33
I am personally not aware of that at the moment about the business models. Okay. I just consider them as sort of, you know, participation in balancing market.

23:47
Yeah. Yeah. Because yeah, to be honest, I had different courses on flexibility service and balancing markets on two different universities. And sometimes they the terminology also changes a little bit, which makes it confusing for these are all service for frequency but then on tenant, I also found data, I don't know whether you use this portal or just the tenant website where you can export data and they have imbalance and imbalance prices. And do you know, are these and capacities This is not fcr? There's no frequency is capacities that I showed on a on a national transmission grade level, or am I understanding this incorrectly?

24:37
Well, to be perfectly honest, I'm also still many things are still vague for me as well. Because of the differences in terminologies. Yeah. Sometimes when it talks about reserve capacity, for example, or imbalance, they are talking about things that they have tendered Before Yeah, and for example, an energy company won the tender and they reserve a capacity and when they produce and when they activate the capacity they get they get money back based according to the beat they made before okay. But there is also the sort of energy markets and that is sometimes like intraday market sometimes not, and the inter, and that is not just for the parties who won the tender before the parties who won the tender before are there but other parties can also participate. And for the parties who won the tender the pricing would be ASB, but for the other parties, the pricing is marginal pricing. So, they, their market price is determined and they received the market price, not the amount they bid before. Okay.

So I because of this ambiguity, I decided at this phase of my research, I don't model this market imbalance market that I have in my model is just sort of energy and it is it looks like also intraday market.

26:27
Okay, do you work with USEF framework?

26:33
Not necessarily no use of framework, but I didn't look at I didn't made a strong link between the use of framework and and my thesis. Yeah, but I totally agree with you that there are many differences in terminologies. Yeah. And the recent thing I buy recently, I mean, in the past maybe six years, some even in Europe, some of the terminology has changed. So they have different MFA are AFM in sort of terms. Yeah.

27:14
Yeah. Well, then it's at least reassuring to you that and I'm not the only one who's struggling with this. But yeah, so, these are like different datas are looked into. And so, because it is so ambiguous, I decided to only focus in on on fcr. And now I can show you how this all worked. And what I can show you now is that, so for the first congestion scenario, we have a certain discharge amount and a certain FCR rate activated. And the idea is that our look for my thesis into okay, if we have more congestion, we have less fcr activation, but more deals or discharge, and then see what is more profitable. But the way I simplified it is that are basically so this is the congestion over a year that we have. Now, just and the these are basically reserved capacity. So here in this case, you don't, this is not what is dispatched, this is only when the diesel Okay, from let's say 12 o'clock to four o'clock, we we want to reserve the battery, and then the actual dispatch could happen in a different different time timeframe. And then in that timeframe. Well, now the activation is it's just a 10% so that we can be looking at a model where only 10% of our fcr bids get activated. Then in this case, in this scenario, my model basically says okay, fcr activation is not possible. So the priority is on the DSL who says okay, we needed from, from a certain a certain timeframe, even though the dispatch might be very in this in this period. But during this time, we are not playing on the fcr market. But unless unless we if we don't have a reservation on the diesel we play on the fcr market. And that's a little bit that's a little bit the idea if that makes sense.

29:18
Can you say that again? Because I your time step is now 15 minutes

29:26
Yeah. So, this is this is sorry, this is 15 minute interval I didn't transfer today time What am I do I just show you the same interval. So, this simply for the same time interval. This is the the congestion profile that I got from gold packs. So here we can see the half a megawatt. So power power demand to decongest to grid relieve the grid congestion. But this is this is for only four hours was for two hours sorry, this is for two hours. And the actual reservation of the resort is longer than that. So we assume that these are cannot perfectly predict when the congestion will be activated, because they reserve it not just today before, but maybe a bit longer ahead, because these are

horses congestion planning, see, next week or in two weeks, we might have congestion around that time. And then they basically reserve the battery. So this is not in kilowatt hours, when this this being at one just means the battery is reserved for the DSO. And then this is the actual dispatch. But the important thing is that I tried to avoid the you know, the interference of different services so that we have these all congested, but at the same time, our bids get activated on the imbalance market, but you know, and then you have to download the specs for one servers and upwards especial another. So the idea is that the news or reserves, and in this timeframe, there is no fcr bidding at the moment. So then on the fcr market, you can see we're not we're not bidding at all. If that makes sense.

31:22

It makes sense. But yeah, because I haven't Yeah, because it is fcr market. I didn't look into it carefully. I'm maybe I'm not the right person to validate this part of the model. What story you are providing is making sense of

31:49

Yeah, yeah. But it helps me already just having to explain my ideas and justify them a little bit. And you know, other services and business models, because then this will be transferred into economical model where we then use basically the fcr and these old prices and analyze Okay, how much money do we need from the DSR to make this profitable? That's that's a little bit the idea, but this is very, very simplified for the fcr services.

32:18

But I think for this phase it is acceptable at least the story is acceptable, but okay. You know, the technical things, maybe an electrical engineer needs to

32:34

probably probably electrical engineers will go crazy if I tell him I simplified this, but yeah, so, this is basically the calculations and then to go back to the to the concept, this is then basically one of my conclusions where I say okay, this could be a possible design for Groningen and maybe to end this section or like, I would just like ask you a general idea from your experience working with business models. What in general do you think is like a main success factors of such a you know, business model that involves several stakeholders

33:15

Well, at least for the grid scale it electricity storage that I consider more in my thesis having **reducing the cost the capital cost for energy needs of a storage is the key**

33:35

for success. And for as you said BI for the you know, residential side, I would say the ability of storage for scaling up by stacking the storage units that is also a great factor to success. The smartness of capacity, the storage capacity management could be a success factor for success because it can improve the utilization of the storage and well, let me think thinking about other things.

34:48
I mean, this is already very helpful. So

34:52
yes. Okay, what about this more complex business models? I think Our ability **to convince DSOs to participate is also a key factor for success**, because now they **are facing some barriers, and they can't invest in us or in storage themselves,** and providing some certainty for them for participating their story would be a key. And I think this sort of models and insights from others can help them to take some risk and participate in the storage of story.

35:36
Okay, yeah, these are the actors is also definitely one of my conclusions. I, unfortunately, I didn't had an interview with the Enexis, they didn't have the time, but they at least sent me an email that they think that storage is a future of the part of the future energy system, but they see more markets as owners so that it's not the DSO owning the battery. But it's rather an aggregator or private companies or ESCOs.

36:06
Yeah, I interviewed I think the name was Marcus POIs, or something like that, in ACM. And he was very strict at that time, **that DSOs according to regulations cannot buy and sell electricity and owning storage means buying and selling.** But he was saying at that time that if a storage has been a fit, why he then this Oh, make a tender for it, and for this service, and ask other companies to be it and make investments because they can do that, but they cannot own the storage itself. And the answer I found was that the **DSO could not see sufficient certainty in the incomes or in the quality of the service**. Yeah. So this should become more clear. I think both from the university academic side and from the storage developers. Yeah**. potential benefits should become more clear and tangible**, so that the Esso can really participate.

37:30
Okay. And

37:32
what I also interviewed your is Kenny fair. He was former employee of NX OS, I think. At the time I interviewed him, he was not an employee of enexis anymore. I don't know what he's doing at the moment. But maybe he can also help you. I, I, I cannot refer you to him at the moment. Because it is long time before I talked with him. But maybe by searching his name, your scanning fan he was doing? He was a specialist in storage, actually. So

38:08
okay, yes, you could maybe show me his name later, and email so I can can search him? I'm still bad at spelling Dutch names, unfortunately. Yeah. But yeah, actually, it's interesting that you mentioned that the the aspect of, you know, clear revenue streams, because I showed you my technical model, I might quickly show you my at least what

I'm hoping to get as an outcome from the economical model, because I analyze the economic model in Excel, because it's just easier to follow revenue streams and see different, you know, different factors. And the idea is that I end up with a dashboard like this. Where we basically have a system we basically have the first scenario, and then obviously, different NPV calculation, all this kind of stuff, this is still artificial. So this is still not the real data, but just to get an idea. And then here we have the recharging stations, where we can see this a little bit more profitable, but still not really, probably, I don't know, I'm still working on the data to be honest. And then in the last case, I would like to have sort of a, an overview of different benefits for each of the stakeholders. So we have, we have nice day that save like, you know, grid connection cost, we have an aggregator hopefully makes more money than this with the flexibility services, and for the DSO and T so I'm just calculating the cost. So how how much would it use Oh, we have to pay for reservation. So that that this business, that this business model under the circumstances that I calculated is, is profitable, and then we have here basically Summary of with which we could go, well, obviously, it's technically simplified. So this needs to be worked on. But if the technical model is more elaborate and includes historic data from frequencies and all these kinds of things, that then you could go to a DSO and say, Okay, this is the money that we need you to pay us. So we can build storage, and then the diesel can make a decision. Okay, this is more expensive than our upgrading the grid, or is it like less expensive than upgrading? And this is basically what I'm what I'm trying to find out.

40:35
Oh, by the way, in the scenario three, did you calculate the NPV for ESCO as well? Or

40:42
for the energy service company? No. So I'm not including energy service company, I'm saying I'm assuming that I work with an aggregator. So they are doing that? Yeah. So for for the aggregate, I'm only using calculating the profits because I don't have any data on any data on their financial data. So you know, capital structure, cost of capital, cost of equity, and how they how they want to depreciate the asset. So for the aggregator, we just calculate the profit. And, and then they can use this as a revenue stream, and then use their own calculations for financial analysis. A Well, if the thing is I have to end in, in, in, in one and a half weeks, my fetus. So I don't know what I have time for this. Obviously, it would be ideal to have another sheet where we calculate the NPV for the aggregator. But I don't know yet, when I'll have time for this.

41:44
It is already sufficient. You made the good comparisons and you came up with interesting results. If you want to make if you want to improve, even though you don't have sufficient data on the ESCO side, maybe you can make extreme assumptions about what would be the highest value, for example, for the score, the minimum value and then passing those assumptions. Maybe you can see what would be the other results look like that could result in interesting insights, at least the sensitivity of the business model. Yeah, so think factors, but if you have to hand in the report in one and a half peek, maybe you can do it later on as a future research.

42:35
Yeah, yeah, definitely. This will probably be included in my conclusion. But uh, yeah, so that's, that's the idea. This is the broad outcome. And yeah, I don't know whether you have any further questions, any further remarks? I don't know, whether we go back to the but this is basically everything I looked at so far.

42:57
I should say that you really interesting job. And I really liked it. For scenarios you made, I think they are realistic, maybe not implemented yet in Netherlands effectively, but they are **realistic at at least from the scientific point of view and the approach** you adopted for calculating, calculating NPV that is also interesting and you enrich interesting results, there's still some you know, some work could be done to improve the validity if you want to attract investors, yeah. As you adopted the sort of consolidated modeling approach is different from mine, that is **exploratory modeling approach**. So, with this work, if you want to attract investors, you have to address more details later on for now, I think should be sufficient,

44:01
okay. What is the difference between in column consolidated model and an explorer model? If I can ask the question?

44:08
Well, I wrote a conceptual article on it, that is the second paper of my dissertation, I can send it to you. The difference is that in consolidative modeling, you try to make a model which could be a surrogate or near real world example and throw them the other model you want to produce estimates the outputs are estimates which should be near the close to real world values. Yeah. And if you have something then you can do a lot of excellent analysis about your investment decisions and other decisions. And it could be very interesting for investors but in the in that paper, I Explain that. My analytical framework is about energy storage in 20 years, for example. And we have market complexities, and we have many uncertainties and deep uncertainties in several factors there for whatever perfect our model could be, it wouldn't mean that we, we will have a good and real close to real world estimates. For instead of focusing on that part, I try to make a model which produce the main trends in the electricity market. And then for the external factors and the parameters of the model, I tried to test wide range of values. So I did a lot of tests. Instead of doing one test, for one scenario, I did a lot of tests. In addition to all the random variables I had in the model, and then with use of data mining, I tried to find some patterns in the in the produce data sets. And then those insights could be interesting for investors and decision makers to have some clue about potential, you know, factors which could be beneficial or not beneficial. But they are not good for making a concrete investment.

46:33
Yeah, I think I'm also more looking into like an explorative model. So seeing which factors affect the business model in which direction, but then you you said, you work more on the intraday markets and working with arbitrage of electricity prices than the revenue stream that you can generate with your storage.

46:53
I worked on, you know, I modeled, they had market and balancing market in terms and that is similar to intraday markets. And in the last paper of my thesis, I compared only to a storage of two business models. One was the wholesale arbitrage in which you can buy electricity, for example, at one o'clock in the midnight and then sell it at one in the afternoon. So both selling and buying and selling are in the wholesale, they had markets. And other business model is about reserve capacity in which you can buy electricity in their head market. And you can sell it in the balancing markets. Although you can also buy it in the balancing and sell it in the balancing. But I made this sort of simplifying assumption. And I compare these two scenarios or business models. For now, of course, there are several other business models that you saw in my first paper. And I also haven't analyzed the benefit of staking yet. That is something I can do in the next phase of my research. But currently I worked on I focused on single application business models, and only two of them.

48:46
I I personally think that it's needed separate effort by a good long term project, like a PhD project, instead of no simplifying, it's in a master project.

49:02
Yeah, yeah, my idea is that I can at least, if somebody's indication, so that at least I can say, Okay, if, for instance, there's higher congestion, then we might be actually less profitable because we have less revenue from the fcr market. Or we might have more because the DSO is with increased congestion has higher willingness to pay. So this is basically in this large scenario, what I'm looking into. But yeah, actually, we're almost at the end of the hour. And I have a lot of food for thought for the next week. So thanks a lot for this. On end, yeah, I don't know whether you have any final remarks or questions.

49:46
No, not any further remarks. If you have any further questions, you can send me an email or send me a WhatsApp message. I will be at your service as much as I can. The free these days but

50:02
yeah, yeah, then well, in general, thanks a lot for taking the time. There was really helpful was very interesting to talk to an expert who actually like this in depth research in that field. I am aware that you can't be expert in all the services. It's just too too complex. But yeah, thanks a lot for taking the time. Good luck with your

50:24
welcome. And thank you for this call. And good luck with delivering the reports then.

50:33
Yeah, it's it's a Lastly, these things. I mean, I think he can, you know, that is better than I do, especially at the end, they get very intense but it's also very interesting face

because I start getting results now. So I'm just very like every morning I'm curious about what memo will spit out this thing. So yeah, thanks a lot for taking the time and good luck with your thesis project as well in your research, and then hopefully see you see you back soon. Physically, the energy can. Yeah. Okay. Thank you. Goodbye.

8.8.4. Interviewpartner 4, 5 & 6 – Aggregator Croonwolter&dros B.V.

SUMMARY KEYWORDS

battery, elevator, connection, grid, reserve, case, capacity, scenario, congestion, business, dsl, assume, play, costs, market, idea, kilowatt, kilowatt hour battery, dso, deliver

00:02
Learn for the next time.

00:04
Thanks a lot for the flexibility. So yeah. So now, I introduce a little bit to the case, I'm gonna share my screen again. And yeah, really looking forward to any feedback that you have any ideas, problems, remarks on this on this business case? This concept or questions do you have as well?

00:28
Okay. So starting from simple to big.

00:31
Yeah. Do you comment on the on the scenario one and two as well? That will you mean? Yeah. Okay.

00:42
We can also do that.

00:46
Yeah, so this is the first case, basically, we have a battery and want to cover the elevator. That's basically so

00:52
what what will you do when you don't have your battery loaded? And that's, for instance, during winter times, yeah. Or connection is not big enough.

01:13
Yeah, this is an error or something goes wrong. I just

01:17
used. Yeah. So the battery, there's also my model, there's an option that I can charge from the grid. But in general, in my, in my model that I that I wrote in Python, it basically

has the profile to be IPvs has the demand, also from the building, and then it, it basically uses a battery size and starts at zero, basically. So we don't have a battery now goes to 10. And every time it sees, okay, the elevators not covered, it increases the battery by a certain amount of certain interval that I can choose in my program, and then it basically adds up, see, okay, is this big enough to cover the elevator over the whole year, and if not, then it's above. And then at some point, we reach the point where we can see okay, so with this elevator, where will this battery we can cover the elevator, and then also, we have the option to charge from the grid. So then the battery if the tip is not enough, we can charge it from the

02:11
Yeah, but for instance, there are a lot of people using the battery at a certain time period, and your battery is empty.

02:23
So the battery is only on the for the elevator. So there is a mechanism that only when the elevator has sort of standby consumption when it's not used. And this can be covered by the current grid connection. But as soon as the current grid connection is not enough, that's when the battery get activated. So we don't use a battery here in this case for self consumption, it is only focused on covering so once the the power, like the power that can be put through the line through the grid collection is not enough, that's when the battery is activated. So it's not in this case, it's not used for self consumption. And in the second case, if we move on then here I basically saw the first case I find out how big the battery has to be. And here in the second case, I have what I called an elevator reserve or an elevator buffer so this is you know, we have a larger battery. But if we know for instance, we have a 70 kilowatt hour battery and we need at least like always, like the 30 kilowatt hours that result from the first scenario that we need for the elevator then when discharge is to that point of 30 kilowatt hours and then it's not going to touch the battery for self consumption then it's going to only again there's a mechanism with okay we only discharged when the elevator needs a battery. So then there's then there's a sort of like this additional capacity for improvement self consumption.

03:45
So when we at least when we look at the first one from a technical point of view, we do see the risk what I think also Stefan mentioned if there's something wrong with the battery whatever Yeah, you cannot use your elevator that's that's a disadvantage basically.

04:00
But the second one was the stairs

04:02
Yeah, the second one I don't really you have to use the stairs the second one I don't really get that you still with the same so in the second one if you move to one to the next one. We introduced the EV charging stations but if the connection was already totally full that you cannot handle the elevator picks are you going to put in all this extra

EV charging stations don't you have to increase them anyway the connection to the building and in that case you lose from the battery the one of the business cases it might still make sense to load the battery from solar and play it in the EV the elevator would in this case not need the battery anymore I guess that's it I'm just checking this increase anyway for all EV charging you will do

04:51
this is this is a discussion that I had also with a building owners and I asked them how far like to which point A this EV charging So idea is already was already discussed with a local DSO with a local grid operator. And they it's just an idea for now. So for my, for my thesis, I basically have the assumption that the EV has an extra grid connection, because it's anyway in front of the meter. I don't know what this is the correct terminology, but basically, in this case, we assume that the battery can cover the charging stations, but they do have an extra connection. But this this is not a this is an not grid connection. That is there is connected to the house and the elevator, this is only connected to the charging stations. But this is later included in my economical model.

05:44
Yes, like the systems otherwise, how do you get your energy from the battery to the Evie charging if you do not, yeah.

05:51
And that's something like I have. So I have a technical model in Python, where it calculates what I just told you before the profiles and it looks, the battery capacity needs. And then an XLR has like a second model where I then calculate the cost and there in the costs. I have then included that in this scenario. We don't have the savings of the grid connections anymore. So we kind of then have to see how much does the grid connection on all this connecting, like connecting the system of the charging stations, and the battery system costs. So there's an like international and additional installation cost. So that's how I tried to include it. It's good that you point this out.

06:30
Because we made this dotted line down. So this cost savings on the elevator connections. You don't have in this scenario, necessarily anymore, so you have to enter exagrid connection anyway. So yes, sir. But just for me the scenario seems not to make so it gets to make economical sense to put the battery load cheap solar energy your battery and loaded in your cars at a cheaper you know that so you don't have to buy the energy basically, but supply it yourself. Yeah. Yes. Don't think you can add to business cases. And this particular one, I'm just thinking out loud.

07:06
Yeah. Okay. But that's perfect. That's exactly the feedback that I need because the the idea that I had said that we basically so we save the good connection of the elevator but then obviously as you said you have this extra insulation costs for the connection of the Evie charging stations. So my idea was we don't have a grid connection that we have for the elevator. But then we have this connection cost between the charging

stations and the battery system but we have in our the in our project making city we have an extra business case on this EV charging stations, where all these costs for installation installing it are already included. So that's why I just here it's it is definitely limitations with that you pointed out some more stresses then in my feed is that this is definitely a limitation. But basically for the EV charging station this is basically a business case that I add to the scenario one where the cost for connecting the charging stations is already included.

08:05
Yeah. So what I basically mean to say is I just share my screen Yeah, go ahead just shortly so you have a certain settings. So the point is you have scenario one you you save the connection and you install the battery for the lifter that's basically the business case Yeah. And in Scenario two not I just type it you basically plays it. So you were you add to this that you you place Evie chargers you and you can basically load them with with stored solar energy from the battery

09:13
but as of this prayer of the EV chargers will always be this extra grid connection. And because it will have this extra grid connection, you will lose this business case in this case because you do not save from the connection you still have it anyway. Yeah, and it will be electrically connected otherwise you cannot load your battery in the other one and are not isolated systems it will give you larger grid connection. So I just want that's what I just want to say in case you lose. Basically the business sense of scenario one because you have this connection. Anyway, that's kind of the juice whether even otherwise you you count yourself to rich, because then you've count first on I saved from this connection isn't this. Then in the second place you add the connection Shouldn't you do all kinds of goofy stuff and you get some other value, but you should not add them? That's okay. As I think.

10:08
Yeah, yeah. So for now, I assume that the connection costs are included in the business case that we calculated before for the EV, but I'll double check this how, how the combination with the battery? Will,

10:20
you can have a look at it like we have it already. Then if he is being installed in phase two. In phase one, we already had this installed. So we have this working, and then can we get some additional revenue out of it? In that case? It would work. But I do think,

10:37
yeah, okay. Okay. Additional question to the to Rob's question about connecting to the grid. And it brings back to the design. In the scenario one, I think you mentioned that you are also your battery storage is also accounting for the, for the search of elevator. Am I right?

11:00

For the

11:01
What do you mean, what the elevator you mentioned? I guess? Yeah. So

11:04
in the first scenario, it's basically only for the peak of the elevator, only for the

11:08
peak, only saw the peak. And for the base, you use the grid. Electricity.

11:14
Yeah. So there, they have a, I think the three times ATM connection, but they have actually in the building, they have two elevators. And combined with consumption of the common areas where they have electricity. For the light for the heating and all these kinds of things. With the peaks of the elevator, it reaches the limit, it shoots over the power limits from the grid connection. And that's what we want to avoid with a bedroom.

11:41
I see. Yeah. So you connecting to the grid is inevitable. In this case. You need to have some grid support.

11:53
Yeah, so without the battery, you can upgrade the grid connection to deliver these peaks, or we have the current connection. And then when there is a peak, then we discharge the battery. that's those are the two solutions. I'm trying to compare. I see. Okay, any any other question defeat beggar, by the way, sorry, very, very good. Just you know, having to justify the concept helps me already a lot.

12:21
So now, if you can spell it again, on the screen, because we lost it. Yeah.

12:27
Yeah. So this is in Scenario One, and two. And these were kind of given to me, this is something that I'm doing for my company, basically, where I'm where I'm looking into, you know, is this profitable or not compared to just increasing the grid connection. And then the third scenario, and the main reason why I wanted to talk to you today is then the third scenario, which is basically a hypothesis then of my thesis, which is obviously much more complex, involves much more stakeholders, and much more revenue streams and all these kinds of things. So yeah, just just to refresh, so we have the business case before but we have a larger battery that pulled with sources of an aggregator delivers services in form of grid congestion management to do so, which is the first priority. And then secondly, on fcr markets or other imbalanced markets. And I'm sure you have a lot of questions.

13:28

So we do build these kind of systems in general and arrange them. So a lot of it is say I would say, technical and appointed. This gives some technical control questions as you cannot, you know, you have some prioritization on who uses the battery and to what extent otherwise, your elevator will, will break down because you're still controlling also the elevator with the battery, I think. Using it for the pigs.

13:56
Yeah, yeah. So that's still the idea.

13:59
And then,

14:01
yeah, then the first question is, how to the local aggregator know, when he can use the battery and when not. So when will the beaks be used within the building? And then can we use the battery for trading? So, there should be some kind **of communication with the battery energy management system**. And basically, the **aggregator will need to know it 24 hours in front, what flexibility there is within the battery.** So what what trading capacity do you supply? Yeah.

14:54
So how is this that you check this lift behavior? How do these lifts work? In the company at night, it will physically don't work, I guess. Is there some rush hour? Or is it like luxury in the morning? Or?

15:06
Yes, so so so they sent me they sent me the profiles. But the way I approached it for now is not that I'm predicting the consumption of the elevator. And then try to say, Okay, tomorrow, we have this in that capacity. But rather than I say, Well, I assume is technical design, where we have it split modular, I talked to two or three, three battery manufacturers, and they told me that it would be possible technically, to basically reserve have a module reserved for the elevator. So the capacity that I could calculate in scenario one, which is, let's say, 15 kilowatt hours, with 15 kilowatts, maximum output is enough to cover the elevated amount. And then this is kind of reserved for the housing

15:53
to make it in the drawing. So so half of the battery is just reserved always for the elevator, you can just as aggregative play with the other however much you like.

16:03
Yeah, so then the idea would be that the advantage for the housing cooperation is then that they basically have synergies because, well, there's there's a business case with an element with these large batteries and flexibility services. And they can use parts of this battery, which is then already installed. So they don't, you know, they I'm also looking into whether they can lease this capacity. So they're basically rent capacity on this battery. But this is this is reserved for the Housing Corporation. So in the first

scenario, I calculate how much does the elevator need. And then this capacity is sort of rented, rented out, like storage as a service itself is like a buzzword, apparently, in academic literature, that, that then, is only used for the elevator, and then the local aggregator knows, okay, all the rest, I can use it for, for flexibility services. That makes sense.

17:03
But in that case, these **cases are relatively separate** I think, in the sense that you say it's, in my opinion, the use of times perhaps during the weekend, that elevator is most likely not used at all? I don't I assume it's the office building, for example, or something. So let's say business wise, it's also the most easy way to calculate assets. But it's, I would say the least intelligent approach, since you business wise, you can basically **always calculate the blue separate from the orange** in the only advantage you have in this case is that instead of two small batteries, you can buy one larger one. And this is the gain of, of merging these two business models. But I don't think they're so

18:09
when you want to combine both business cases you Yeah, which which one has got priority above the other one,

18:25
combined that you split? Stefan. So they say this, like a battery 50% is always used for elevating. And it's controlled research with this with its logics of loading and unloading. And the other 50 is for the aggregator who can basically do, obviously, in some software, you have to assume the stuff. Yeah,

18:44
but that that's a good point, because that's also something I'm like, because this is a design, like the concept that I came up in the beginning of the more calculated, I feel like it makes more sense to install a small battery in the basement of the housing and then have a separate large battery in front of the building.

19:01
Given the complexity of adding it up, would most likely negate the advantage of buying one battery just for my good feeling so especially since so if you could use it more intelligently so you have this battery anyway you can use because we have a battery for the elevator, but we don't use it during the weekends. We don't use it at night and during day we mostly use it whatever lunchtime and yada, you you could get some benefits out of it. But I also think this one battery for this one elevators relatively small. No, it will already have the problem that integrating these systems goes also at the cost that the cost would the business case would be really difficult to. So by adding this into one battery**, I think you add more costing in control and complexity than it would just to split it up and put the two batteries especially if you You don't have the advantage of having one battery that it's dynamic, how much you can use nothing**. It's just basically you split the capacity. And, yeah, you already made it into college. Really, really practical, it's I think both, both business cases make sense separately. So a battery for energy. Say, flexibility obviously is a business case, which

makes sense. The battery for this elevator you can calculate might also make sense. But combining them in this scenario with this is not logic, we now are not using the spare battery you have anyways, for something else, we just increase the battery size so another can use it. But get the **complexity of integrating these systems**. On which you then have to build all kinds of fail safes that nothing goes wrong with not the aggregated pools and your battery and your elevator doesn't work or whatever. So it, it makes it relatively complex for a really small battery. Okay, I just cannot imagine. And then as as as to building it most likely as a big basement and plays in place of plenty. You could place this orange battery, just split them up with one small one for the elevator in the elevator control room or whatever. And put some in the basement some other battery for this energy control. Both **both business cases are plausible, but adding them together does not**. I don't see it brings the value in this position myself, for sure.

21:38
Yeah, but that's exactly well, this is very interesting that you say this, because I already discussed this with my supervisors whether this would be an option. And this kind of confirms an idea that I have for now. So I would then basically have a small battery in the basement and then a larger battery on the that then like covers local grid congestion, and these kind of these large battery

22:00
should be really, so the small battery should be close to the whatever the mechanics of the elevator, and the loads to be as close to the connection point to the grid basically connected.

22:15
How big is your PV generation, then? Does it cover?

22:22
That 15 kilowatt peak?

22:30
But one, yeah, sorry. Go ahead with a question. Terribly, please. Good. Yeah. My question was in general, because, well, as I said, I don't have a technical background. And it is like a techno economical analysis, and also including some, well, you know, some more factors I'm having to do with energy cooperatives, for instance. So you know, also see, like, how can we include the citizens. So it's a very, like broad research and kind of touches everything superficially.

22:59
So it's, but but but

23:01
one idea, for instance, that I had is that this local aggregator could also cooperate with an energy cooperative, so that, you know, the people they you know, energy cooperatives for now, they invest in wind power and solar panels. And it's like the local

citizens that invest? Do you have any experience with this? And do you think this could be an option to cooperate with an energy cooperative to maybe that CO invest in this battery with the aggregator and then split split the revenue? Have you any experience with this? Or

23:29

Yes, so the basic, so basically, for you, in general, **the more stakeholders you add to a project to more complex it becomes, the more bigger the chance of failing**, put it like this. So, for example, if you put this all behind the meter in one building, it's already much more complex, much easier than if you put one thing behind another meter and another metric. The point is, so with, if you can pay place a windmill, on the area of this building somewhere, say I have no idea what we're talking about, if this is some building in danger, and you have you can put some generation on a general area, so behind the scene, even to finance it, if you so then the finance revenue system, basically just the cooperation would be the source of finance, which get the revenue out of it. Yeah. Basically, when you have the revenue in itself, so it's it can already be financed by debt and can also play along in this game. That's not necessarily a problem. It but do not forget the amount of stakeholder if it's already it will be in the general area but not at the same of the building. So it will be at the end of the street. Then it will have its own grid connection. And it gets already much more more complex as the amount of stakeholders included Also other parties and not not so much in your diagram in your mind, **banks usually have to finance it,** there are **insurance companies** who will also put in demands. And before you know, you get a lot of stakeholders, each having an opinion and you can make it, you can make it really complex really fast without. So, but in general, if we check, so any windmills, it will say, so this was the one you said?

25:29

No, no, no, the idea the idea was more to because I talked to interview them, energy corporative called huning energy. And they actually said they are interested in investing in a battery with the capital that they have from the citizen. And so this could like in like, have another like investment potential this and then maybe we could increase the battery or lower the CapEx for the aggregator, or, you know, because that's that, that's more theory. It's not about installing,

25:57

in this case, this orange battery as it's a big battery, most likely. The question is, if you install a big battery, and you want to do this trading route, and you then need to increase your grid connection anyway, and defeat again, the purpose of the blue?

26:16

Yeah, so in this large case, again, the grid connection is not well, then the grid connection is included in the battery costs. So you know, in this case,

26:29

the whole blue system, I would guess, in general, my my guess, so if you installed the orange and the blue battery, you might need to increase

26:38
that lately. You only need and orange battery,

26:42
you're only doing this because the lift is already covered by the bigger connection from the grid.

26:49
Yeah, to maximize the returns, I would like to trade more and more into the gates and have less self consumption. Yeah, the focus would be again, as I like to be on that thing on the orange.

27:03
Yeah, the idea here was that we have a larger, like connection. But this is, you know, this is included in the installation cost of the battery anyway, but it

27:13
still would defeat the whole purpose of having the blue system.

27:19
Well, the

27:22
business point of view, yeah,

27:24
you have to make a good connection anyway. So buying this mobile, that was a good connection you don't need.

27:29
But if I understand correctly, then well, you need a larger connection for the battery. And then we still have the power peaks from the elevator, which would be additional to what? So there would still be power capacity needed extra for the elements. efficient. But then Yeah, true. But then there's only the one time the grid operator has to come and dig a hole basically. Yeah. So that's, that's yeah. Okay, I get this idea. Yeah, but that's that's definitely a good point. But in this case, this business case, the goal would not be to save the elevator, good connections, like we have, we have savings here on the elevator costs. But this is more because we anyway, have to install larger grid connection. So there will be less costs, you know, embarked on the on the excerpt

28:13
to share this between both correct. Then, yeah, see a battery, much like any other assets, like PV or a windmill, or if he charges or anything, it's an asset which somebody has to buy in on. And this can be a corporation, or some whatever, that the in the entity for the business case, this is also a relatively I would almost say irrelevant, if you get the money from a corporation or from a bank or from your and all of them would, I

would assume on some, unless it's a subsidy, you don't have to pay something back in or in all other cases, most likely, whoever puts the money in one some return on them investments eventually. Okay. Okay. And in this case. So yeah, the cost of buying the battery can go to some cooperation. Okay.

29:16
But yeah, that's a good point. I also, well, obviously had to be mandatory. And they also said that the more stakeholder you include, the more expectations you have. And it becomes more complicated. So but this is definitely a good point that you confirm this. So I can discuss this in like the conclusion.

29:29
Correct? Yeah. So it's, it's also, it's also really common that see this, this so a lot of time you have a developer when an area wants to install some stuff, this developer doesn't have the money to do it does have the plan, find some investors, and a mix of banks, green energy, local cooperation, and then it's, it's really it's because it's our adoos ama. So because of all these renewable projects, you can basically you see a lot that people are obviously happy to invest in something socially good. And then, yeah, so this is really common, I would say,

30:08
Okay, interesting.

30:10
And I have a question about the corporation's perspective into this, what is their priority is their priority to like, ensure that the the peaks of elevators met so that they have lower build or their priority is to perhaps explore the Explore the trading opportunities, or something else? Or maybe have more resilience system so that maybe in that case, two batteries make more sense. So what are they expecting out of this project?

30:41
So their main goal is to save the elevator costs basically. And other than that, so in the second scenario is I look into whether improved like increasing self consumption with the battery will be profitable for the company. But the main reason is the elevator, we want, we don't want an extra good connection. That's, that's our main focus or like, we don't want a larger grid connection, which also over the year, we'll have larger costs. So the elevator connections, really their their main purpose,

31:12
but the cost of these exagrid connection,

31:15
this is what we're still trying to figure out. So they don't have any exact information on this. But I found from a Enexis

31:23
a, on the website of the Enexis.

31:26
So what I found, let me see what I can quickly show you around on

31:30
my car, sometimes you think is this cost, whatever. 1300 euros.

31:36
So this is a my daughter's I'm still learning. But so this is what I think they have four different grid connection costs. And I'm assuming for now that this is the current connection they have, or they still have to get back to me on this. Exactly. But then I assume that we would have to upgrade to the next larger category, which would then be 400 euros more per year, plus, obviously, the installation costs. So this is the this is the data that I'm working with currently. But it's a good point. But yeah, I'm still waiting for the Housing Corporation to come back to me with with the actual data.

32:16
Yes, because that's a really important one. Because understand if it's actually fun to do to you, you might be just easier. Yeah,

32:25
yeah, the idea GRE for now, it's also in the economic analysts, because because they, they are no technicians, and they don't know that I can tell them, Okay, if you can save this amount of money per year, then it will be profitable if it's less than. So that basically, if they say, I feel like in these kind of products, getting the data is always a problem. So like, if they don't get the data to me in time, I will, my conclusion will be around, okay, how much do we need to save on the connection, so it becomes profitable. But I actually have one more thing that I would like to discuss with you because this fcr markets. So I'm looking for now into fcr, markets are pretty complicated. And especially because it is depending on the frequency in the grid, it's very hard to predict whether you know, you can if you were dispatching upwards or downwards, and then concerning the grid congestion is also you know, I have to make sure that these don't interfere. And I would like to, if you still have the time to show you my model, how I'm modeling it, and to just see what your ideas because I'm simplifying it. And whether this is just a simplification that is still you know, can you mentioned the limits of the research, or whether it's just incorrect? If you would still be interested in that. I would like to discuss that if you had it. Yeah. And I'll just quickly jump into my model. This is basically the interface I'll just have to run the program for a second and then

34:11
and then what it basically does, so these are here I have the three scenarios, the battery specifications, i i Not off that important for now, but I just are here I assume that the power like the power capacity is similar to the kilowatt capacity. And what it does then it iterates or it looks for 400 kilowatt hour battery 500 to 600 kilowatt hour battery, and then I have a congested scenario. So this is a congested that I found online. I'll show you the profile later. Once Once the program runs from go packs, which was congestion announced by Leanna and then in the battery. So let's say I have a 600

kilowatt hour battery. I have a reserve for the DSO where we say okay, 300 kilowatt, was are reserved for you. And if the DSL, he has first priority, if he says we don't need it, then we use this to play on the fcr market. And on the SER market because I had problems to, to find data on the frequency and whether we actually dispatch upwards or downwards, I basically simplified it in that way that I just say, okay, bits get activated. Yes or no, and upwards or downwards, it's I just use a random function. So here we can say, estimate. Okay, so this means 100% of our bits get activated. And what this looks like, for just show you quickly program is that then obviously, we have this for our blocks, and we always upwards and downwards dispatch, which is very unrealistic. But this is a fact I want to recommend later look, okay, if we, if our service gets activated, 10% of the time, 20% of the time, this our different revenues and the the way it discharges the battery, because I have this problem of you know, I don't have the frequency data, I know exactly how much they're going to dispatch Apple downwards, because it's a symmetrical product. So they have to be able to dispatch in both directions. I just assumed that is totally depleted for that amount in one of the directions. So either it is like fully charged up or fully up. So you keep it half an hour, you unload fully recharged food. Exactly. So up to up to this limit, right. So I'm not going to zero because you know, we will always want to keep that reserved for the DSO and, and then well, he obviously good to see that the elevators covered with a foreigner kilowatt hour battery. But once this is

36:39
done, but don't yeah, you say you want to keep a reserve for the DSO but go packs is the system used by DSOs? So this is already user market. Yeah. Yeah, the way

36:57
that I thought of it for now, it said, I used I used to go pick Stata. And I saw Well, I just went on the website and basically manually edit this profile when they so this is from the last year when they had congestions. So this is in kilowatt, and I assume that then with together with an aggregator we can pull resources and relieve this congestion. So every time we have we have a congestion here are battery charges. Yeah. And the way this looks is that so here we have this is a congested area. I think it was about four hours. We're not going to deliver.

37:36
I'm not discussing that. But you say you it was like go I understood as the way you said it did go back and do is over different scenarios. But I just mean that go packs, is the platform by diesels.

37:49
Oh, no, no, no, no. Like I got this data from go packs to get an idea on estimation on these are congestion. Yeah. So yeah. And the way I did it, is that a program that is said, so here, we have to do congestion. So here we are, we're not going to deliver one megawatt, but we're going to deliver you know what we can? And then because it is oh, I assume that they don't know on the minute precisely when they actually need this capacity. I then assume that they basically reserve this time. So here this is not kilowatt hour or anything this when there's one, this only means that in this time, we're

not going to use the battery for fcr markets other than balancing services because the day before or like the time frame that we have to agree and I think for the SMR market you have to place your bids the day before so before that the DSR has to say we reserving the battery and here I'm assuming for a capacity of four hours this is what we actually congest

38:50
Stefan funds today no D is

38:55
currently **24 hours in advanced we get a profile basically for curtailment** but that is the Go backs market. You have got also other markets where you can play on

39:12
a blow from lawyer from and then word internet

39:17
and how much So also, it's **not only the time period, but also the capacity** I think what's important what they want to pre reserve what we get currently is for a certain time period, maybe they only need half of the battery and the other half you can trade on a other market. So

39:45
you can basically assume that the foot DSO flexibility you will know the in advance. Okay, what 15 minutes intervals and how much of the battery capacity

39:58
okay, that That's good, you know, so that's why I also like So here, I'm basically assuming that they reserve it for four hours the day before and then they they have this. So, this is then something that needs to be agreed on for the So, this is then what we can deliver this is the capacity as you said,

40:15
the capacity next capacity. So what I would say does not total, they really deserve it. They do not do a reservation or an asset, **they just do what they want.** Exactly.

40:27
Okay, and they know exactly the same. So it would not be reserved here. It would it would be then just just for the month, okay.

40:35
Really bet on the exact 15 minutes the extract.

40:38
Okay, okay. Okay, um,

40:41

is basically how the mechanism works is, we get, for instance, today at 10 o'clock, we get from the DSO for tomorrow at a certain time period, how much capacity they want to curtail. So it can be tomorrow between 11 and 12 o'clock in the morning, they want to curtail 300 or 100 kilowatts, and then we must respond from can we deliver that flexibility or not? Okay, and when we can not deliver it, how much capacity do we have?

41:23
Okay, and what do they pay? per? I don't know whether it's confidential, but uh, whether like, what that is all

41:32
the BS.

41:36
What do we get paid was a lot compared to alternatives. But now the better now he does get less than the if you do so the MG, but that's

41:44
Yeah, but that is part of the market. So that is the whole market market. Basically a bidding going on? It's, it's the same as stocks on the NASDAQ or whatever.

41:59
Okay. Okay. Yeah, my idea here was that I, I read that value stacking is often a problem, because sometimes these different services can, you know, interfere with each other. So my idea behind this reservation is that maybe it's not the day ahead, but maybe a month ahead where the design doesn't have as precise data. They can reserve like for a longer period than they actually might need it. Just to make sure. Because when we then look at the this is our SDR gets activated.

42:27
FCR is paying also for availability. So that's different, but go pacs is not.

42:34
Okay, okay.

42:37
The it are two completely different markets. Yeah. So basically fcr is they just reserve capacity. And the Go backs is they need the capacity.

42:56
Yeah. But my idea said that, well, while this service is sort of like the batteries sort of block for the DSO, we are not even we're not available as a reserve for the FCR market, or for for the this four hour block

43:12

of No, it's the other way around. If you've looked for the FCR market, we're not available for the user, but the user will not look it if they don't need it. You don't have to have it available.

43:24
Yeah, but I mean, we cannot we cannot agree with the DSL the day before. Okay, we deliver this and that and then still play on the fcr market. No, no, no, that

43:36
goes first. Because it it will claim real capacity. **And whatever is left, you can play with our market with other markets.** But these other markets you can combine so you can play with the DSO on the go Plex. But also just play on the internet or intraday

44:01
or? Yeah,

44:03
the issue is that for my master thesis, my topic is called local energy storage for groaning. So the idea is, well, what you

44:15
see stored in the guest fields.

44:17
That's why they want to get rid of it, you know, they have to change the system. So that in Groningen, and then export the business model to other places. But that's basically the idea of my master thesis. But the idea is that here in this business case, a DSO has higher priority, because, you know, that's the idea of local energy storage in my master. And only if the DSO doesn't need it, then we play on the I get the idea that in the FDR markets, we are only you know, we reserved capacity. So we kind of if I understood correctly, we don't necessarily activate the battery and then can think see, okay, we can deliver other services.

44:53
In maybe, maybe you must combine that with **other markets** and leave out fcr marketing

45:10
That's what I thought Yeah. And that's why that's why these priorities are maybe bit different from what you say. But we first want to make sure that we deliver to the that we can deliver to the DSO, local good. Resolving work, congestion is more important to us. But then if the DSL doesn't resolve the battery, then he can see that. So this is upward dispatch, this is downward dispatch. And then here in this time area, this is when we basically reserved the battery for the DSL. And then we get a reservation capacity, reservation payment, like a reservation fee. And also, then later, the activation itself. So we have two times I had this in a business model that I looked into my literature review, if I just quickly show this, as was the case in Finland, where they

were an energy service company basically had this reservation mechanism. But then at the same time, they had a payment for extra extra delivery. And, and then if this was not needed, then they played on the SCR market. So that's why I've kind of like tried and tried to copy copy this.

46:20
We need to go to another meeting at 10.

46:22
Oh, I'm sorry. No.

46:24
So what what's, how do you see the next steps? For my series? Yeah.

46:38
So what I'm looking into now is different activation rates, and see how it affects the business case. And also I'm looking, I have different diesel profiles. So this is just eight times per year. But I have different these profiles with weekly congestion and congestion every second day. And then I want to see how it affects profitability. Because the more we deliver to the diesel, the less we can play on the imbalance market. And that's what I'm looking into. But I can send you a summary of my report. And then I don't want to keep you away from your meeting. I'm sure it's

47:10
it with a Enexis

47:12
Enexis concerning what we are talking about here. Okay.

47:19
And also for my thesis, so thank you. Yeah,

47:22
yeah, I was just having to go through this concepts and ideas was very, very helpful. Thanks a lot for taking the time. Good luck with everything and discussion with the Nexus.

47:35
Okay, thank you.

47:37
Mo. Keep up the good work. And we stay in touch

8.8.5. Interviewpartner 7 – Grunneger Power

Due to technical issues, the recording could not be transcribed. Main points that were raised were confirmed via an analogue confirmation.

Hanze
University of Applied Scienc
Groningen

Confirmation of Interview and Content of Discussion

With this document I, Joep Broekhuis, confirm that I have been part of an interview in the context of the master thesis of Timo Dettmering.

The following aspects were discussed:

- The Making-City project and the conceptualisation of the three scenarios
- How do you decide in which projects to invest?
  Who makes the decisions? Do members have a say on that?
  Answer: Members have a say on the plan, but the project must be convincing, currently battery business model has not been developed yet.
- Do you invest in neighbourhood batteries?
  If not, why not? What are the barriers?
  Answers: Support is needed otherwise it is too expensive. Since it is risky, debt is expensive. Grunneger Power would be interested to invest and has contacts to banks, but debt is expensive. Storage projects would mainly be interesting in combination with solar parks of Grunneger power. Grunneger Power can use money from funds like Fonds Goeie Doen, which can provide 50% of the investment.
- What would be the most important success factor of such a business model from the perspective of an energy cooperative?
  Answers: It needs to be profitable. Close to own solar parks such as the Meerdorpen project. Social sub-groups must work together:
  https://www.paddepoelenergiek.nl/ ; https://cooperatievewijkraad050.nl/ ; https://www.energiek-groningen.nl/ ; Cocreatie ; Energiewerkplats Paddepoeal.
  The downside of having this many different social sub-groups within one area is that they have to cooperate with each other, which is not always the case. They have different opinions or stakes amongst each other regarding different projects.

With this document I confirm that now major flaws were found and that the model has valid logics and operations.

[redacted]

Date, place, signature

8.8.6. Interviewpartner 8 – Elestor Energy Storage

SUMMARY KEYWORDS

battery, company, price, megawatt hour, kilowatt hour, question, flow, case, model, storage, reserve, technology, application, bromine, elevator, economic, system, year, fcr, energy

00:02

Good afternoon, you know, this is Tim Redmayne from the New Energy Coalition. Hi. I'm sorry. Yeah, no, I don't know technology. Sometimes it's just not on our side. I'm sorry that this, this didn't work.

00:16

We can also do it by phone if you like.

00:18

Yeah, that would be great. If that doesn't doesn't bother you at all. Perfect. Thanks a lot. Yeah. First of all, thanks a lot that you make make the time. I'm very, very looking forward. We're excited about this discussion. Before I start with interviewer the questions that I have, um, do you have any, any any questions or any things that are not clear to you yet that you maybe want to ask for it up?

00:41

No, I don't, I don't think so. The only thing is that I have a visitor for 50 minutes left for you. Okay,

00:51

perfect. I try to keep a choice. So maybe, to give you a brief introduction, about the project, it's called Making city. So the idea is that we have two districts here in Groningen, this is where I'm located at the moment that we try to get energy positive. And in this project, I'm working on a building that has an elevator, you need charging stations and PV panels, and they're thinking about installing a battery. So I'm working on the business case, because for them, it's interesting to install a battery because I can avoid extra connection costs. For I understand what you mean. Yeah, exactly. So that's what I'm, that's, that's more or less a scenario. That's what I'm working working on. So I'm working for the New Energy Coalition, the Business Development Department, but I'm also writing my master thesis about this topic and this questions. So before we get into the question, I was just wondering whether I could record this interview for my matches, then. Great. And then worst case, and I just stopped the recording, and then I, yeah, I would send you the master thesis. So you can have a look, in case there's something you don't want to have published. But that would be okay. Thank you. So then coming to my questions. First of all, for, for my research method interviews, it would be interesting to just have a little short introduction about yourself. So what is your background? And also the maybe a brief introduction to the illustre technology that you just explain what it is about, and why is it better than other technologies?

02:28

I wouldn't say it's better. **There's no silver bullet in this world. So highly depends on where you want to use the battery for.** So my name is [..]. I'm a **physicist from origin**. I joined to the elestor in 2015, when I met the founder of the company who is currently the CTO. I'm also one of the first actually the first investment company before I work in the optical disk world, that something completely different, where I brought the company from four people in a prototype to global market leader. So now I want to do this again with this company, that now also as an investment. So that is a bit of my background. He Lester is now 26 FTE, we build batteries based on the flow country principle. Our mission, I always say our obsession is **to reduce the storage cost per megawatt hour**. So that's not necessarily only the capex, if you calculate that figure, it's referred to as levelized cost of storage. **You include also efficiency, lifetime depth of discharge**, all these kinds of figures and he put them together in a put together in the formula, and then you get the figure that tells you what it really costs for a megawatt hour to stay overnight in the battery. And that is an important thing for us because these batteries are installed **in combination with solar parks and wind parks.** Were times of overcapacity, the electricity price is really low. So in such situations, the owner of the winter sun Park would recharge the battery and then feed in the battery when there's a shortage and then he gets a much better price. So our customers make **money with the battery, because of course the difference between high and low price**, but in addition, they have to pay for the mastering for the mastering for the story. So the story costs per megawatt hour are decisive for the viability of the business. So, this is what our focus is always flow batteries are most economic in long duration storage with long duration, I mean, breaching longer periods of time. So**, from an hour onwards or five hours, maybe onwards, flow batteries become much more economic**. And that is because with flow batteries, you can make any combination of our internal megawatts of megawatt hours where these are coupled in one conventional batteries. But if you would look for a storage system to reach one hour, then I will not sell you with low batteries go to lithium, because then that technology becomes more economic. But from five hours and more, our system definitely becomes more economic. So, it is a bit of a positioning we are Yeah, this year has been a big year, year a big change, a lot of things come together, we signed the first large commercial deals for a system up to 250 megawatt hour. We like to build very large because the larger the system, the more economic that becomes for our customer. So, yeah, this is the year where we restart our where we have our commercial sales. That's, of course, a big turning point. After investing in this company for six years. We started to recover something here.

06:59

Sounds very sounds very exciting. Yeah. So I mean, as I mentioned the case before, this, you know, the building on us if think about li covering the elevator demand with a battery to avoid electricity connection, like an extra connection. But if I understand you, right, and also, from what I've researched the flow better, we probably will not suitable for that case, because then you would need, you know, just for a few hours, if it's quick, correct, okay. But then

07:26
that means if I mean the flow, but we could do it technically, our flow well, for us really fast and fast enough to do these kinds of applications. But **it would only be economic, if you combine the application of this flow battery with the elevator application.** So if there's more applications that you can serve with one battery, then you could still think about it. If it's a battery dedicated for for elevator spikes, removal, then this is not the right solution. In such case I would look at there is a company that builds these type of systems actually for actually for elevators. Because these elevators Well, I don't have to explain to you they create power demand. Exactly. And that's single peak determines what you pay the whole year for the connection. So if you can cut off that or at least make it smaller, you can can make some money. Yes. Trying to remember what the company

08:35
they think you're talking about. I will, I

08:39
will Yeah, I love it. But it depends on how these picture look. But the Fly wheel will could, for instance, also be that as a nice company in the Netherlands, called QinTech, they build small flywheels installed them for instance, with crates that serve very similar application.

09:04
Our needs and these are absorbed by the by the flywheel system.

09:12
So flow batteries purely for this application would not be a good solution. Yeah. Technically, yes. economically.

09:21
Yeah. Well, that's that's also from from what I've read from your website. And also what I've researched about flow bed is was kind of what I was guessing already. But the idea the building owners and the New Energy Coalition gave me actually a lot of like room to play. So for my for the business case for the model, I don't know also just you know, only cover the elevator, but there's also a second scenario where they might install EV charging stations. And a third scenario where they increase battery capacity and build some sort of a some sort of a community energy battery with which is then maybe megawatt scale. Just sending Because I can't unfortunately, I can't show you what I've been modeling so far on my screen shared by a team. So I just sent you an email with a quick PowerPoint. It's just one or two slides, we can quickly a second, where you can see the the concept that we that we built so far. It is, explains a little bit like the three scenarios, and I'm looking well, I'm also contracting, I will, but I just thought LSD is just such an interesting technology. And if we have a bigger case, we're in the third scenario on the PowerPoint, you will see we also include flexibility service.

That's where thought flow batteries, like the one from illustre could become interesting, because then we talk about I think they wanted to install 600 kilowatt hour, batteries or even larger. And that's what I'm trying to figure out at the moment whether this would make sense maybe with the floor bedroom.

10:51
Yeah, I feel PowerPoint now actually three scenarios. Exactly. So 60 to 70 kilowatt hour. But, you know, if you buy a lithium battery, you just level you need that many kilowatt hours. But in our case, you need to tell me how many kilowatt hours and how many kilowatts you need. To get complicated,

11:15
but then the the interesting part would be the would be the third case of what you can see on slide number five, where we have a local aggregator would then also be in the picture to the tenant and a Nexus and in this case, from the make making city what they had in mind is a 600 kilowatt hour and a 600 kilowatt battery. So power energy ratio from one.

11:41
And that would still be more than lithium battery.

11:46
Okay. From what scale? Would you say? Would it make sense to start thinking about

11:52
the ratio or energy power should be five to one or more? Okay. Okay, just based on the economics. Technically, we could do this, but you will not be happy.

12:05
Yeah, that's exactly where we like to, you know, talk to different battery manufacturers, because as I said, they give me a lot of prayer room. So the battery can be different sized in different different design, maybe with the structure

12:16
for an hour, maybe just a few feet on, the energy of the battery is too cheap. So even if he would just double the MLC Park, additional price might be like 10 or 50%. More interesting. And with lithium batteries, you would have to buy a second battery. Then you also get second power, amount of power. So in our system, you can see, well, this is the power that I need. kilowatt hours determine how many hours you can break, that battery must at least be five hours. That is what our calculation does have. So we are actually that's why I reacted. So when you said the best battery. I don't think there was a bad battery in the area where were our playground this? I think we are much better than the lithium ion. Really short term storage applications. Yeah.

13:23
Yeah. But that's why I'm also looking into different business models with a bigger battery in different energy to to power ratio to then, like use my financial model and the

data that I get from the building company and from the local distribution, to see whether a battery flow battery would actually make sense. But then

13:43
they think in terms of lithium batteries, talk to me, like we need a section of kilowatt hour. But once you realize that you are free to define, so you have an **unconditional freedom of choice**. Yeah, you might you might find an optimal solution.

14:06
Yeah, that's basically so I'm still working on refining the model. And interviews like this basically gives me an idea of maybe how to manipulate certain algorithms and optimize the model. And then 111 important aspect would be for me the charge and discharge rate. So if we talk for instance, about well, let's say 600 kilowatt hour battery, what will be typical discharge rate of an LST battery, or even a bigger battery? If we talk about mega

14:34
watt hours? Yeah, I think you'll you'll refer to see right. Yeah, this

14:37
theory would be interesting. Yeah. Well,

14:39
you know, that is actually what you can choose, you know, a battery. Lithium battery, see, rate of one is one megawatt one megawatt hour. **But in our battery, you can choose any combination of megawatts and megawatt hours.** So That means that the C rates I mean one megawatt per megawatt hour is that our system can deliver one megawatt for 10 hours or half a megawatt for 20 hours

15:11
okay. But then But then you said What a find interesting? Well, especially the scaling part that you can scale independently power and energy, but then you said that, like so the power the power output is more expensive part of the battery if I recall it Do you have I couldn't find it on the website, but like a spec sheet with specifications of euro per kilowatt hour or euro per kilowatt, depending on the different size, I saw some graphs where that's that was the picked it. But it would be for my model, interesting to have some some concrete numbers, your fixture

15:50
figures on the vertical axis. I didn't do that intentionally. The point is that, yeah, we are just entering the market and the systems are now quite expensive. But with larger quantities, the prices will go down fast. So that is why I mean, it's still not a catalog product where you just look up all the surprises what I tried to say is that the projects that we do now are based on the project calculation, so there's no price list Yeah,

16:32

and in in the project that you seem to be working on at the moment, you measured wind parks and solar parks, which then can have you see profit from you know, different margins on the electricity prices. But have you also thought about what you can see in the in the third model, I'm using the flow battery to deliver flexibility services to TSO or D zones such as fcr or congestion management these kinds of services

16:59
fcr services are typically lithium battery applications. Technically, you could do that with our system but also their unique battery with short duration. I mean, this is excellent and FCR markets as well as in Germany, in the Netherlands is really quite small market saturated market it wouldn't be our focus but but again, it could be our **focus if it is combined with other applications** of the same battery that we can do ser FL to buy a battery for fer od without batteries.

17:51
And then which which kind of servers were you thinking about them for instance would that be like for instance, the EV charging stations where you could be charged like like in the second case or something similar or

18:01
charging stations, but yeah, especially those applications you know, more from a broader point of view, we are closing down hopefully, fossil power plants at the same time become more dependent on solar wind. And then we need to bridge longer periods of time. And this is **where our flow batteries are by far the most economical days like today, I think it's quite windy today, but you know, you can have like three four days in a row where there is hardly any generation**

18:38
and this is where I flow, but this is where you want to use. When I say want to use this is the most economic

18:50
solution. Yeah, so also for fcr technically, it couldn't be done. It would not be something for us, but you will see you see that in some countries you get new mechanisms on the electricity market, you get **remunerations for having spare capacity storage**, whether it's bad to just by keeping it available, Belgium you have what is called the CRM capacity remuneration mechanism and maybe have found it and that is based on having spare capacity start without even delivering so you **get you get paid for keeping reserves** and I think that is where the market will go to. Once we are more depending on ceramic

19:47
well, well this is this is also this what I meant that I have quite a bit playground in my thesis and in my in my research that it could also be an option to have sort of like a reserve battery and then then that will be an application. Let's say we have megawatt scale battery that is reserved for the team on the diesel. And that's when you say,

additional to this FCL could still be possible. So like having a reserve and then fcr. Could make sense if I could.

20:13
Technically that's called revenue stacking. Yeah, yeah. While you're sticking Yeah. benefits from different revenue streams? Yeah, yeah.

20:23
That's from the from the USEF framework, I think I have it laying here in front of me so. So that's definitely also something I'm looking into. But then something that is interesting for me. So if we have a case where the value stack, so we have, let's say, the battery is part of a reserve and also delivers fcr, in short term,

20:43
serve an elevator, also an

20:45
application? Exactly, exactly. How would this affect the deterioration rate of the battery, because these services can be quite power intensive, and also worked on the life life cycles of a bedroom,

21:01
maybe it's for the team, but for flowback, which it's not, yeah, you can you can, you can overpower this battery charging and discharging without damaging what you also use, **the efficiency will drop quite fast.** To don't damage the battery from that.

21:23
So just in the charging cycle itself, the efficiency drops, not long term,

21:28
efficiency itself, the lifetime will be short. **The other big difference with lithium is that we can, there's no relationship between lifetime and depth of discharge.** In other words, we can use the full capacity. While if you would do that with lithium, you will experience this much short term lifetime. So that is also one of the reasons why our LCLS like two times lower.

22:01
And that's exactly the combination that I'm looking into. So that would definitely be something that is interesting to me. And well, at least you know, I want to compare different technologies. And then and then try to build this this into my model. What I'm also looking into, in my thesis, if I just quickly have a look at my questions. That batteries and business models for batteries often have barriers, especially in the regulatory area, where you have double taxation, net metering, which is a disincentivizing measure, do well do you experience this right now you say you go go going commercial now, which is very exciting, obviously. But hold on, you see, like the organization has

22:45
been abolished since a couple of weeks. In the Netherlands, at least, the news was sent out by maybe, you know, this platform, energy storage, and that's a Dutch branch organization for storage technologies. They've published on their website, that there's double taxation. Stop, maybe not immediately, but now the decision has been taken, that the law will be adjusted so that we don't have to double taxation.

23:23
But I mean, any any other regulatory barriers, because I'm also, you know, notice, a neighbor of

23:29
neighborhood batteries is difficult. It's not our immediate target, because of this, because you know, the, you know, the companies who the **DSOs they are not entitled to exploit the battery** in this world. And so you have a, we have an energy supplier, and we have the company that puts the cables in the ground. They have also a separate role. That if you connect a number of houses together that's in front of the meter, then you are in the regime of the network company. That party is not allowed to exploit a battery. And that is a legal hurdle. So if you look at if you look at neighborhood batteries, there has been an investigation done by DNV. GL, maybe three, four years ago and download that on the internet. I will send you a link to that if you like yeah, definitely something that gives an assessment based on lithium. And this is in many cases but in the Netherlands, we only have like five or six real neighborhood batteries. because they are installed desktop environments regime. **So they don't have to comply with the most exceptional case.** But other than that there are no flow but no neighborhood battery. So that will be legal hurdle

25:23
of the battery of the these are not being able to on the on the battery. Exactly. That's also that's also what I'm looking into because in my master it's called energy systems management. So we try to get the system perspective. And that's what also trying my master thesis so not just the economics, the business technology, but also the legal part. To me, in many cases after many technologies seems to be a bigger hurdle than many people would like. So that's definitely some some interesting aspects. You mentioned there.

25:51
I will send you the link to distortion now, shall we? I

25:56
consider

25:58
them already.

25:59

No, I didn't know them. I heard that the double taxation got abolished, but of the page that itself. I haven't looked at it. So that will be very interesting.

26:09
Storage, I will just send you the link and then you can afraid to listen Dutch.

26:15
That's good expression. vicinia LON even a lira. Oh, okay, then you will

26:19
find it. If you find news. I think there will be news from us. Because we have quite a procedure to work in the level of innovation of Arkham. We are.

26:40
Yeah, that's that's also a I just That's why I was so so excited about this discussion, because it just, I was just very curious about the technology.

26:50
This is a big topic addition, now I see this announcement on the website. So I'll send you this one. In the meantime, I will talk I do that.

27:03
Yeah, I'm actually I think I've asked almost all my question, I just have one or two left. So well, if you look at the scenario, like the more complicated scenario, neighborhood scale will be includes every service, maybe, you know, reserve capacity, I would just be interested, I also read many studies that in many cases, you know, different expectations of these business models are a problem. So because you have so many different stakeholders, the battery company that leaves o t, so the building owners, you know, there may be an energy service company and aggregator I also try to find out what you know, each party is expecting or what could be, you know, a problem for each party. So that's also something you as a battery manufacturer and developer, what will be the most important success factor for you know, such a project or business model to develop? And what would be the most, like important for you in this kind of business model? In terms of collaboration with others and communication or any other aspect that you see critical?

28:13
not such an easy question, you hear a question?

28:19
So take your time. No,

28:21
that's not a problem. Yeah, I mean, for our customers, I have learned that **our customers will immediately make a return on investment** calculation is negative. They don't buy. Maybe you can refresh your

28:44

question again. Yeah, maybe so something. When you have these kind of projects, it will not just be your technical installation, it will also be probably an ICT company or energy service company, which then works with the ICT company or an aggregator that aggregates from different barriers. So when you have so many stakeholders, what do you think is a successful factor in these kind of, well, complicated business models where you have so many also even sometimes different expectations?

29:16

Yeah. Yeah, that's a well, that's a difficult question, I guess. I think everybody wants wants to have some positive revenues or something out of this. But, I mean, it must be it must be economical, viable for each of them. But that's that's a no brainer,

29:40

of course. Yeah. But I mean, that's also also something I mean, if that's, that's it for now. Then I just take a note and discusses with the next interview.

29:49

Yeah. I'm not sure I can really answer that question. Just think about it. Yeah.

29:58

No, that's absolutely that's absolutely And then I just look at the clock. It's 40 minutes. But I only have one last question. And that's just about the source material like the electrolyte material, you were use hydrogen and bromine. And there was just curious how you source it because it is obviously more sustainable than vanadium. But where how do you sources and from where because another another sustainable

30:29

but also not so rare. The general expectation in this industry, I mean, it's not just wishful thinking, for me, this is really what most people think is that selenium will not survive this race to the bottom of the electric, battery prices for radium is per kilowatt hour, 20 times more expensive, how it is improving. So there LCLS is, like a factor of five higher also than we have. With debt LCLS, you're out the money because no business case. I mean, I used to be a business case, when batteries prices were still you know, 2000 euro per kilowatt hour 10 years ago, but now you you buy a battery for maybe less than 400 euro per kilowatt hour battery, so. So we are you know, during this the price decrease, they have they acid, the bottom of, of the price for vanadium. That's a pity, because it's the system is much less complex than we have really established technology, it's proven. But the economics Don't say that. If you just look at the reserves of palladium, these are very limited actually. Bromine is found in seawater, we get this delivered by a company called HCl. It's really a company. That's not a coincidence, because they sourced this mainly in the density because the concentration of bromine salts is much higher than anywhere else. So this is a big company, the other supplier, this availa, also a huge company. They have been distracting extracting data from from seawater for the last 80 years or so. **The good thing is that the supply cannot be dominated by limited number of countries like you have with the team and actually also vanadium. vanadium comes for 85%**

from from the three countries that is dominated by four countries. And I sometimes make a joke. Are we going from OPEC to back? If you know what I mean? Yeah, so there is no price competition. It's a it's a, it's a game that is played in in the squeezing the su pply. That raises the price. This is how it works. If we would put all our eggs in one basket in the Lydian basket, I'm pretty sure we'll have this as an example at school former school board that this will also be before when you're only fully globally. And that's what Hoback. So scarcity of materials is absolute no brainer. For us. We want to calculate if you would build every single battery worldwide with our technology, just as an experiment to think about, you would need less than 1,000th of a percent of the blood probe in reserve

34:01
1,000th of a percent. Well, we

34:08
want to build all these batteries with an ATM, you can do 1% With all the reserves. Yeah. So that gives you a bit of how these qualities are. I think it's really something in bromine in the world was really astonishing. I mean, for us, it's important to to be comfortable that the price of bromine will never raise. Yeah. There's no There's no mechanism that pushes this price up.

34:42
Yeah, very interesting. i The more the more I read about the flow battery, the more I got kind of excited about the technology. But but then yeah, I mean, as you said various times now in the interview, it always depends on the use case. So I will definitely have a look and what we do Casting you know, maybe, like having it as a reserved capacity that also partially maybe then covers the elevator because you know, has capacity left over? And we'll look at this Do you know is it possible to get like a spreadsheet with some specs once I talk to the because I'm still talking to the corporation of like when I know okay,

35:21
sure we have we have a brochure and on the backside there is an example of a system that gives you the specifications as well if you have a minute, I think show that to you

35:41
because obviously, to do my model Yeah, because for my model, I would just be interested in some concrete numbers but

35:51
numbers efficiency weight size

36:03
I was also looking on your website but I couldn't find the brochure there.

36:10
We need to know where

36:13
are we like really reluctance in your mailbox? I read like the Thomas Edison.

36:19
Backside there's a page giving you technical specifications. Perfect.

36:24
Yeah, thanks a lot. Yeah, and then and then that was basically I want to give you a break before you're before me don't worry about Yeah, thanks. Thanks a lot for for the information it was very interesting that he gave me some some new ideas for the business model. And yeah, very, very complicated, but also very exciting and interesting. So I'll let you I'll let you know once my thesis is finished, and you can have a read through if you want no gonna be published any information or something like this. But yeah, so first, Thanks all for taking taking the time. Really appreciate it.

37:04
My pleasure. I wish you all the success with your seizures.

37:08
Yeah, thanks a lot success to you. And good luck with everything. Thank you

8.8.7. Interviewpartner 9 – QuinteQ Flywheel Storage

SUMMARY KEYWORDS
flywheel, working, case, elevator, battery, technology, question, round trip efficiency, charging, bit, congestion, applications, shaving, energy, grid, cycles, system, company, business, prototypes

00:00
They studied **innovation management**, they ain't over. Worked with KLM at first for a couple of years until Corona crisis, and then got into contact going in contact with, with krytac. I got to know Paul. Yeah, yeah, family party. And I heard about what he was doing and figured, hey, this is this is something very interesting. And he's doing very cool stuff, I want to see if I can learn from him. And I stick I found a way to stick to the company, which was through unpaid internship at the time. And I just figured, okay, this is a sector that's new for me, because I don't have a background in I don't have a background in any technical study. And I don't have a background in energy. But I found the sector. Very interesting. So for me, this was a way to get into get into this into the sector, and also with a very interesting company. And for working there since the part time for a while and since two, and I'm working officially for full time for a start. The company is founded in 2016. It has roots in the United States. And the technology was developed by by Boeing Company. And Boeing's worked on it for about 15 years, designing this flywheel that we're currently using right now. And Paul, which is our co founder, made a deal with Boeing to commercialize the technology and bring it to the

markets in the Netherlands. So that's a bit of the star observer company. And then the company won the Empulse award in the Netherlands for most promising energy technology for energy transition. And that was sort of the start, really at the start of the company here in the Netherlands. From then on, they worked on a breathalyzer before, right? We worked on this collaboration with the invented Dallas for a subsidiary program to develop and build two prototypes for military use case and civilian use case. That's that's the phase where we're in right now. Me personally, I've started working in June for my own boss, and a company I'm doing a piece of new business development, looking for a better market fit. My scope was on industrial electrification. I got that through. I don't know if this is the detail level you need for your research, but I'll tell you in can skip it later on if you don't need it. I get that through another opportunity with FMA which is a branch organization. Field leavener certification, they have a program where we can do a have to dig a bit for the correct English word for this article, application study. Yes, application study where you do you do some research to see where in a certain sector, your your technology can add value to this is a path that I took with sleep, and it's currently working on right now which scope is under certification, seed industry is moving to more and more electrified processes putting more and more stress on the system. Obviously, their audit process is also being electrified. So there is some some some demand for flexibility services, like you see already was your case, right for a civilian case. So same is happening also in industry. And we're looking into the industry right now. I'm looking specifically looking at the industry we're now seeing where are opportunities for us to add value. And that's where I'm currently working on right now.

04:20
Okay. By the way, we scheduled the meeting until 1030. Do you have to leave at 1030 sharp for meeting

04:27
I got nothing afterwards. So okay, good,

04:30
then I Oh, no, no, I don't, I was just trying to make sure that because otherwise, I would have had like push through the question a bit. But then because this is like, you know, this is you know, not expensive, especially my question but like it gives me a lot of like, sort of like a bigger picture. This is very, very useful information. And then like to stay a little bit on my question, you know, so you mentioned a few applications already. So what are like typical applications where you where you think you can use your technology where it might be better than likely fume ion batteries or flow batteries?

05:04
Yeah. So the lot about the flywheel that we're developing. I haven't told you that certain that that makes it better in the picture as to what we're what's our unique selling point. So the flower that we're developing is the is the only flower that's **fully magnetically levitated**. Innovative chamber and as the best we stabilized because we're using superconductive crystals, high temperature crystals to keep it in place. And you've I think you've you've mentioned you knew a bit about how to fly works, right? So you

have you have something spinning and it's it keeps spinning industrial life storing energy. So it's kinetic energy, yeah, what we call them. Mechanical battery,

05:53
what I what I got the pretty like, positively surprised though, like in class, we said like that flywheels normally have a discharge rate of like 20% per hour, sometimes a, you massively decrease this, basically raising all the disadvantages of a flywheel.

06:08
Yeah, because the rotor that we have, it's, first of all, **we choose to go for our light, strong and light rotor made of carbon.** And because it's fully like magnetically levitated, and that's the only way the only system that has that you don't have any friction points. So you don't have it's also an effective chamber. So you're just **no friction** from air, because it's an FAQ, but also it's not on a on a bearing pin. So usually it's stabilized on the bearing pin, it's you do have some magnetic pull to reduce the reduce the pressure and reduce friction. But for us, it's really liberating in nothingness. There's nothing stopping almost nothing stopping flywheel. And that's what what enables us to create these super low discharge rates. And with that, you also have because you don't have any dare aware, I mean, sorry, wrong word. **You also have a immense amount of cycles. And you have the ability to respond super fast.** So that's that's to sum up. What's What's the unique thing about flywheel you have huge amount of cycles, you have incredibly fast response time. And you don't have any, you can discharge all you want, you could go all the way from **1% to 0%**. A million Yeah, well, close to a million times we **get 350,000 cycles** that we can make.

07:38
You said there is no Tr, tr. We are sorry. It's not very, no friction.

07:46
Yeah, no friction. And whereas that so that's the big advantage of lithium is lithium is less cycles to make. And after a while, they start to decrease in efficiency. And also lithium is more sensitive to temperature changes. Yeah. So that's, that's the strong points of the flywheel. So applications looking at applications with looking pitch shaving frequency regulation, energy trading is something that you can do. And we would be shaking, we can we can already. See that. That's functionality you do. And in cases we're looking at, for example, crystallization for Metro and trams. For voltage drops, for regenerating brake energy. For looking right now at its we feel it's very promising his feet shaving for EV charging. Because it's also putting a lot of pressure on the grid. We're looking applications of avoiding costly and timely grid upgrades. Yeah. Because you allow progressive your peak shaving you allow for operation to continue still or expand without expensive, great expansion? Yeah.

09:05
Do you also then look into so this is all he's talking about? **Peak shaving, destressing the grid is sort of like congestion management as well.** Yeah. Okay. Yeah. congestion management,

09:13
you can you can call that. And today yeah, that's, that's a bit of the differences. And I don't know if this this is sufficient for an answer for you. Yeah. That's,

09:25
that's, that's interesting. Because, you know, for the, for the case, I'm trying to compare different technologies and I have a technical model where then like, plug in the depth of discharge and all this kind of data and then see, okay, how does it fit? Yeah. Because, well, for the elevated actually, it doesn't have too much demand. I can't because it's private that I can give you the exact data but for instance, one question I had when I looked at your specs, you had a like 100 kilowatt and then 10 kilowatt hour with a series of 10. You can see right, but is there also like, do you Think about like smaller installations where it's just, you know, let's say, I don't know, 20 kilowatts and five kilowatt hours or something like this, or is this the minimum?

10:10
Well, **we are in development or still so that the prototype** that we're currently developing is in this in this range. You'd have to make a redesign on the on the on the product, but I, again, I'm not I'm not the one who's designing it. So as far as my, my answer is valid, we can **we can change the aspects of the flywheel a bit to change** that. Yeah. Okay. But you're, I believe if you go for an elevator, you need more more kilowatts, than kilowatt hours.

10:52
Yeah, that's correct. Right. Yeah. So that's, that's a little bit the idea that, you know, you there's basically no consumption or like the consumption, you can take it from the grid, because it's lower than the grid connection. Yeah. But then there are peaks where you just for this peak, you need an extra connection. So that you know, that's when that's when you know, you need to shave these peaks. That's why we will will also like sauna to me very interesting technology, because it kind of is exactly build build for that. Yeah, basically.

11:19
I think it's interesting thing to combine it and what you said when in combination with EV charging, that's where you need more higher amounts of kilowatts. **Yeah, because it depends on what kind of charging you do. If you do opportunity charging, it's a high kilowatts. But if it's more overnight, charging, flywheels not so that's not necessarily for overnight charging,**

11:45
opportunity charging, you mean like charge when the prices are low in the discharge. When prices

11:50
started, I went away with that this you you quickly charges for a little proof for extra energy to live to last longer. But I'm thinking if you charge darts from residential area,

it's my probably always overnight charging. Yeah, so you just blow anyway, you come back from work, and then the next day you take off again,

12:12

yeah, okay. But yeah, that's also the interesting part about this. Battery sector, energy storage sectors, like you like, you really need to find the right technology that doesn't fit like everything for everyone. So it's, yeah, exactly. For instance, one thing I also question like, because the idea is that I also, you know, for instance, if you remember the bigger case, I'll just share my screen quickly, made a bit more make it a bit more understandable, but more graphic. In the bigger case, we have. So we would work with an aggregator that then cooperates with the DSO and the TSO, whereas the priorities are clear. So we have to cover the elevator, if the elevators covered, then we can relieve congestion from the grid, if there is any congestion. And if there is no congestion, we try to like play on the imbalance market. Have you looked into the imbalance market already with with with your technology and you know, making these kind of multiple revenue streams, including the imbalance market?

13:13

Yeah, yeah. So we're also **looking into that we see it as a major opportunity** for us because of our ability to make so many cycles, and we can we can earn a lot of money on that market, if we use that flyer for that vacation.

13:29

Yeah. And then one question I had is like a little bit technical, because, for instance, I'll do my best. Let's say for instance, there is grid congestion. And then obviously, we're not charging in 15 minutes, we're charging over two hours, but then the elevator is needed in exactly these two hours. And then obviously, like the batteries kind of blocked with a diesel service, so it can be used for the elevator, which is the main purpose. So I think like from what I've read from your, like, specification sheet is that you have like this modular approach, so you can stack it up. And like there are several several flywheels in one container, right. Yeah. And so would it be technically possible to have like, one fly will covering the elevator? And then if there is a DS? Oh, you know, we have two or three flavors reserved for the DS. Oh, but that worst case, we could dispatch for the DS Oh, and the elevator at the same time? Would that you think technically be possible?

14:31

I believe so. But I'm not sure if it's economically desirable. Okay. How we're usually utilizing our business cases, or we were filling it in is so let's say we we have a flywheel with fly off system in place and the capacity of the flywheel system can fall at four 50% It covers the needs of the elevator. It can sometimes if we have some some occasional peaks for for EV charging that that's maybe another, another 30 or 40 50%. But that's only uncertain times. And that means that a lot of time hours during the day, we still have like 50%. capacity left for trading. Yeah, usually we're not on the we're on this balance market that's using slots of 15 minutes. Some one hour to two hour slots, we don't really we don't have an application for and then we use the same we can use the same fly wheel or or yeah, if **we have to fly wheels or three fliers or five fly**

wheels, and you say, Okay, you go for that one. And you go for that one. Yeah, you can make it

16:02
customized?

16:04
Yeah, you can make it customized. And they can work on different different applications at the same time and just let it spin a bit faster, because the system is asking for more. So you just let it spin faster.

16:13
Yeah. And then it's just about the the connection that has to be done. split it

16:16
up. Yeah, exactly. Okay.

16:18
But why did you say why wouldn't it be economical?

16:22
Well, because the price, so if you would have only a flywheel for one flywheel system only for trading, you could do that force, but then it's trading machine and you have full time for trading. But you're looking for the combination. So you prefer really I think you would want to have like, **one system for for both the peak shaving for the elevator and trading**, which otherwise, if you if you would separate it, you would, then yeah, if you want to make it a positive business case out of it, you wouldn't have to limit yourself to the amount of flywheels. Okay, now, that makes sense.

17:04
Yeah. So what you're saying is like, if we split it up, then we also have like, more probably like more installation costs, because we have to like this all like the software like separate for each flywheel. Whereas used to, like proposed it, you know, you just take one flywheel for both servers, but you can deliver it you can deliver both servers at the same time just by spinning the wheel quicker. The question is, can

17:26
you stack the business case still, because we're looking at stacking business cases with multiple applications? And then yet only one one business case on the system? Okay, so there's separated, that's what I'm and that's what I mean.

17:38
Okay, so when stacking value, it's better to like stack value on one.

17:43
One system, one system. Yeah. Okay. I just have a different system for a different application.

17:48
Okay. Yeah, I didn't, I didn't that was basically my question, because I wasn't sure whether you can, you know, just have two applications being powered by the same system. I thought it's kind of you know, like, oh, yeah, if the elevator is going, then I can't put given electricity to the DSO because, you know, the batteries used for the elevator.

18:05
But yeah, I'm trying to see what you're saying. Yes. Sorry. Repeat it one more time.

18:18
So obviously, I have different priorities. My priority one is covered the elevator priority two is really disagreed congestion. And priority three is, you know, play on the imbalance market if none of the two services are needed. Yeah. And what I trying to understand still, from a technical point of view is when we have a flywheel storage, and the battery like the flywheel is used for the elevator, can we still relieve grid congestion?

18:47
For instance, ours I believe, yes, we can.

18:49
Okay, okay. Because that's, that's an important so we can discharge for to cover the elevator, and then relieve the grid congestion at the same time. Yeah,

18:59
yeah. Can you progress to congestion I don't know if you need to have a certain amount of capacity reserved. Always. Yeah. If you need to reserve it, then you can't use it. Yeah. Because that's not allowed by by law, I think. Yeah. But if it's responsive okay. Yeah, sorry. I have to ask the fish lies a bit so quickly this is don't I'm not having really strong program

19:46
is it helpful for liberal if I leave a drawing on the screen or should I take it down?

19:51
No, that's okay. And if you can, this readable,

19:57
right, I just have to go back to a I'm sorry. To go to Microsoft Teams. Yeah. Maybe Shogun? Yeah, yeah. Okay.

20:16
Actually, I just have one system two applications, right. So what you're asking is, is this possible? Yes. Basically, this balance, you need to have something reserved, you say, Okay, from, let's say I offer I offer this balance services from from eight to 10. And

before I drop it into a pitch right, then I'm there for you if you need me. Yeah, you can optimize that. You can optimize that to combined with the elevator.

20:43
Yeah. Because it's, yeah, that's, that's, that's what I'm looking into. Also, because then, also then depends, you know, depending on technology, I can offer different services to the DSO. So we can say, **Okay, we reserve capacity, or you pay us per kilowatt hour that we released the grid. And that, obviously, depends on the on the technology, but just the fact that this is possible.** That's, it's a very, very interesting. And then one question I had, it's maybe a little bit more general. But when you see these kind of business cases, where you have multiple stakeholders, like us, or TSO and apartment building an elevator, and then you as a battery company that maybe cooperates and also with an aggregator energy service company, it gets quite complicated. But for us a new battery manufacturer, what would be the main success factor of such? Or such a business case? I know it's a tricky question,

21:45
to reframe it a little bit. So what is it? What is when do we find a collaboration like that successful was your Oscar Yeah. Because

21:51
like, obviously, I did manage to review and addict into like, what cases were there before and some studies say that a main problems also just the stakeholders. So all these different tables I just showed you, and describe have different expectations from this business case. So the DSO has an interest. The TSO has an interest, the nice the building has an interest and aggregate as interest. And then, you know, that's why I'm also talking to like, every single one of them and be like, Okay, what's, what's your expectations for the business case? What, what is the most important thing? You know, for you, if you want to have these collaborative business case?

22:25
Yes. So for us, we really see ourselves as supplier in the knee. So we, the other partners are describing they have, they have an operation to feed it, that's important for them. For us, we're just trying to make it possible for them. If we c**an, if we can deliver something that benefits their, their operations, were already happy.** That's for a success. If we can do it in a competitive way. We offer some of these and that's all we need.

22:53
Okay, yeah. Well, that's, that's, that's already, you know, sometimes you think you would, everyone would have the same expectations. But that actually actually differs. I just talked yesterday to an energy cooperative. And they told me that they they're like, four or five different energy, like social groups that have different interests in the area. And that makes it all complicated. Sometimes, you know, you bump,

23:13

but they have different responsibilities. For us. We release, we are just a part, we're only a small part in a total patient, like we already saw the schematic image, we only stare for one part of the total patient. So we can't, we never are able to do to offer the full value by ourselves. We're never able to do that, because we only offer one part in the in the total formula. Yeah. So for us is to be to be the best part in that formula. 44 To serve the total, the total picture? Yeah, yeah, that's probably the success.

23:46
And then you talked about competitiveness. You said, I think in the email, you said something about 180,000 For now, but the costs are going to decrease in future? And how like, how large is it cost decrease going, like expected to be? Do you have any estimations already?

24:07
That's very hard, because we have plans, **we have some plans to make it make it cheaper.** We haven't executed them. So we don't really know yet. And that's mainly also it's not because it's also hard for me because it's not my current job. So I can't really give you a price and never know where we are discussing. We're discussing a change of mass change of production methods that could Yeah, that could cut I think. Yeah, I'm not being very careful with with with promises in this but yeah, maybe we would, **we could go to 110 or 100.**

25:00
Okay. Okay. But

25:03
it's it's very, as rough as Yeah,

25:08
I know. Like, I mean, it's it's still it's still research development. So you might have a breakthrough next week or in five years or never.

25:16
Yeah, it's currently currently fog. And this is this is not my job. We have different guides. Our CTO is working on it. Yeah. And he's also responsible for supply chain and for production process. Yeah. And he has some some ideas to make it cheaper. But we don't we really haven't calculated that method, because refers developing the current prototypes that will be installed to just 22. Yeah, and once those are successful, we're already thinking about how to make that as to to cut the price. Yeah, we have, we have only limited capacity to work on things. So first, build those prototypes down when we have space enhanced, we're going to work on the next generation, which which might have that new production process, which is going to cost the price. The price. Okay. At a price. Okay. Yeah. So that's both estimation. Yeah, I

26:06
know that these these things are probably hard to estimate. You. I'm just checking in the spec sheet. He said that. You use normally the life lifecycle. levelized cost of

storage? Yeah. And there you under underneath 10 cents, right? That's what I what I saw on the specs.

26:30
Yeah. Yeah. **So three cents**. Yeah.

26:34
And what do you because I saw, like, different formulas for the levelized cost of storage, because you include, like, several factors, like, not just life cycles, but also, you know, operation costs or capex? You know, the different winter interesting for me, maybe not now, but if you can, like, send me later, the exact formula that you use, because I know, I know that sometimes battery companies use different LCLS calculations. And then just to like, so I have it, like in my analysis, I have a unified that would be very interesting. And

27:10
I'll send you the formula. Perfect. And, and and the data we use, yeah,

27:16
great. And then other than that, oh, I just had a question concerning the OPEX. So what does it cost and like, you know, if the battery is running, like to operated like maintenance insurance, and these kind of these kind of things,

27:31
insurance, we don't have a picture on yet. Maintenance has to be estimated also, as well, we will learn that from the demos, that from predictions and models, you have very low maintenance. **Because you don't have any wear of the system, the only the only thing that's going to be needing replacement is electrical system**. And that might need to happen after 1515 20 years, something like that. Okay. OPEX costs overhead. Now, let me see, I have a few if you need an I think you need a number, right?

28:05
Yeah, just an estimation for my financial model. Like for now, I think it was most times that in battery technology, something like 2% of CapEx or something like this. But it's still you know, it differs between different technologies.

28:21
See if I can find I don't know if you like to see that now. Otherwise, I need to find

28:26
you can also send it later when you when you have more time. That was just the one I just checking my notes. And it's just one question I had the the old pegs and the the round round trip efficiency.

28:40
Yeah. That's an expected right. Yeah,

28:44
I think there must be somewhere there. You have to stand by losses. You mentioned the standby losses. But then I couldn't find round trip efficiency. I'm sure.

28:59
I think I sent you that brochure, right. Yeah, maybe

29:03
you just call the different. I'll have a look again. Maybe you just called it differently and it didn't sell. And then if I can't find it all I'll let you

29:09
Oh, no, you're right. It's not in there. That's that's an error box. Okay, translate more seconds. That was for your two minutes.

29:32
Say, but uh, yeah, also, like you can have a look afterwards. It was just two things that I was curious about the topics in the round trip efficiency

29:47
now, okay, I'll send it to you. I think it was at this**. Or 9495**, something like that.

29:55
Yeah. Okay. And, yeah, to be honest, those were those Questions pretty much do you have anything on your mind or like things that pop up after discussing all this concerning the case or the project?

30:10
Well the case are very interesting cases very interesting. Especially because yeah, like you see you're able to stake your business case on looking to create shave shaving elevators combined with EV charging combined with trading. That's that's not all, at all companies are geared towards that opportunity. I mean, for you, I guess you'd make sense because you're studying so you're, you know more about a topic and the most companies. Yeah. Service case very interesting. And something that we would like to if possible, we'd like to see the results of your study as well.

30:46
Yeah, I definitely send over over it's also just a short report. It's not a 60 page math lessons. So it's, it's

30:53
Yeah, so and this is this is one part of your your thesis versus the total, the total thesis that's,

30:58

that's the whole thing. So the Hunza University is University of Applied Science.

8.8.8. Interviewpartner 10 – Iwell

For confidentiality reasons this interview could not be recorded. However, the interviewpartner confirmed that they are working on similar projects and that they also offer leasing options for lithium-ion storage system: https://iwell.nl/producten/lease-cube/

8.8.9. Interviewpartner 11 – bnNetze GmbH

00:00:02
So ähm, ich glaube, wir können das Ganze trotzdem auf Deutsch halten. Also das würde ich dann transkribieren und auf Englisch auf Englisch übersetzen. Für die Aufzeichnung erst noch mal vielen Dank, dass Sie sich die Zeit nehmen. Ich weiß, wie ein beschäftigter Mann würde ich mich freuen, wenn Sie vielleicht einmal noch mal kurz vorstellen, vielleicht auch Ihren Hintergrund A und B, vielleicht auch noch mal benennen und vielleicht auch noch mal kurz beschreiben und Ihre Position dort genau.

00:00:29
Ja, also mein Name ist Malte Thoma. Ich bin Ingenieur für Elektrotechnik und Energietechnik und arbeite bei der Bahn Hannover im Bereich Business Development, bin dort Teamleiter bei der Nova, ist ein regionaler Energieversorger in der südwestlichen Ecke von Deutschland und hier speziell bei der Tochtergesellschaft BNetzA. Das ist der Netzbetreiber der Nova. Aufgrund gesetzlicher Vorgaben ist das entflochten. Also wir haben eine separate Netzgesellschaft, aber oben drüber ist die Holding und die heißt eben Bahnen oder AG.

00:01:05
Und dann bin ich ja über sie in Kontakt gekommen. Also über das Projekt haben sie dort auch beteiligt. Da können Sie das vielleicht auch noch ein bisschen beschreiben, worum es darum ging und vielleicht auch kurz etwas, was du die Erkenntnisse waren.

00:01:22
Also beim Projekt waren wir als bei der Nova auch beteiligt, ich persönlich war da Projektleiter und wir hatten die Aufgabe eine eigene Testreihe aufzubauen mit real existierenden POS. Dafür konnten wir 10 von unseren Kunden gewinnen, die der steuerbar gemacht haben, die dann auch durch die Plattform gesteuert wurden. Und gleichzeitig haben wir in dem Projekt eine einen größeren Batteriespeicher installiert, der bei uns auch heute noch in Betrieb ist und der letztendlich funktioniert.

00:01:53
Und bei dem Batteriespeicher auf der Website des Projekts heißt es, dass es hauptsächlich dort auch um Fotos, also den Photovoltaikanlagen, ging, die dort eingespeist werden. Wenn ich es richtig verstanden habe, wurde dort auch überlegt, diese Flexibilität Dienstleistungen für Netzwerk Betreiber zu nutzen oder dass die Batterien auch genutzt wird, um das Netzwerk zu stabilisieren. Leistungs Qualität oder andere andere Services? Wurden die auch bedacht oder ging es da erst einmal nur um PV Speicherung?

00:02:23

Also Sie. Die Batterie arbeitet eigentlich ausschließlich dienlich, sie dient der der Spannungs Haltung. Sie läuft auch im automatischen Betrieb jetzt aktuell. Also sie kriegt keine extra am Steuer Signale und trägt damit zur Stabilisierung bei. Indirekt speichert sie auch den PV-Strom, aber sie steht nicht auf dem Gelände des Landwirts, wo die Anlage sich befindet. Die Batterie steht außerhalb, sie ist auch direkt an unser Netz angeschlossen, nicht an seiner Haus Installation. Und was die Batterie quasi macht ist, dass sie permanent den Spannungs Level auf der Leitung überwacht. Und wenn der Spannungs Level zu hoch wird, dann zieht sie quasi Energie aus der Leitung ab. Damit sinkt die Spannung wieder und speichert diese Energie zwischen und dann nachts, wenn auch der auf der Leitung nicht viel los ist. Da ist die nur schwach belastet. Dann gibt sie die zwischen gespeicherte Energie wieder in verträglichen Dosen wieder ab und das trägt so zur Spannung Erhaltung bei, dass ist die Funktionsweise von der Batterie

00:03:27

und die Batterie war, dass die Investition dann vom Netzwerk betreiben. Ja okay, gab es da und da kommen wir jetzt in die diesem legalen oder regulatorischen Bereich, was eben schon mal ein bisschen erwähnt haben, weil hier in den Niederlanden von dem, was ich bis jetzt recherchiert habe, ist es oftmals schwierig das Netzwerk Betreiber eine Batterie besitzen kann, weil dann technisch gesehen verkauft und kauft er was ist, was nicht legal ist. Wie war die Situation da bei ihm in dem Projekt?

00:04:00

Ja, also das geht auf eine EU-Richtlinie zurück, die jetzt mittlerweile auch in Kraft getreten ist, die es eigentlich verbietet, dass der Netzbetreiber Batteriespeicher besitzen. Wir haben es aber noch bevor diese Richtlinie in Kraft getreten ist, gemacht. Deswegen war es damals auch noch zulässig. Heute wäre es in der Form wahrscheinlich nicht mehr möglich, da müssten einen anderen Weg finden.

00:04:21

Und für Sie als Netzwerk Betreiber sehen Sie Batterien in dem Sinne so, wie Sie es dort genutzt haben, also als einen integralen Bestandteil des zukünftigen Energiesystems, so dass das nur Übergangslösung, bis dann das Netzwerk quasi aufgestockt ist.

00:04:40

Also es gibt immer mehrere Wege zum Ziel. Also das Ziel ist natürlich, das Netzwerk stabil zu halten, Spannungs Qualität einzuhalten, keine Versorgungs und Abbrüche zu haben und man kann das über verschiedene Wege erreichen. Also man kann es über Netzausbau erreichen. Man legt überall stärkere, dickere Kabel in die Straße. Man kann es auch über Batteriespeicher erreichen, die quasi autonom sich regeln. Man kann es über steuerbare Ortsnetz Transformatoren erreichen, man kann es über aktive Spannungsregler erreichen. Also es gibt in der Regel mehrere Wege, mehrere technische Wege zum gleichen Ziel. Und das hängt dann erstens von den regulatorischen Rahmenbedingungen ab, was man machen kann und machen darf. Und es hängt auch von den Kosten im Einzelfall ab, welche Variante die günstigste ist.

00:05:27

Und wenn wir mal hypothetisch, die diese Vorschrift, das Netzwerk Betreiber keine Batterien selbst besitzen darf, würde nicht existieren oder die wird wieder zurückgedreht. Würden Sie sich das dann überlegen oder wäre das dann eine Option, dass dort auch mehr investiert wird? Absolut ja,

00:05:45
absolut. Also wenn das wenn das zurückgedreht würde und es wäre wieder erlaubt und wir könnten die Kosten anrechnen, dann würden wir eigentlich bei jeder Baumaßnahme erst mal prüfen, was ist billiger Netzausbau oder Batteriespeicher oder eine dritte oder vierte Technologie. Aber im Moment ist der Regulierungsfragen sehr stark. Netzausbau kann immer angerechnet werden, Batterie kann gar nicht angerechnet werden und dann ist die Entscheidung sehr schnell gefällt mit einrechnen.

00:06:11
Was genau meinen Sie dann damit?

00:06:13
Also als Netzbetreiber ist man ja ein Monopol im Monopol und das funktioniert dann so, dass es eine Preis auf Aufsicht gibt, also eine Regulierungsbehörde. Man meldet jedes Jahr die Kosten, die entstanden sind, die Regulierungsbehörde prüft das und dann kann man diese Kosten auf die Nutzung Nutzungs Entgelte umlegen. Das heißt, die angeschlossenen Netz Kunden bezahlen das dann. Regierungsbehörde entscheidet. Aber was ist anrechenbar und was es nicht den Kosten, die nicht anrechenbar sind? Da bleibt man drauf sitzen.

00:06:40
Das ergibt, das ergibt Sinn, dass es dann wenig interessant wird, wenn Sie dann sagen wir mal okay, wir bleiben jetzt mal in diesem hypothetischen Fall, nur dass das der Netzbetreiber auch Batterien besitzt und steuern kann. In was für oder was für Batterietechnologie schauen Sie sich dann? Sieht das alles meistens Lithium-Ionen-Batterien oder schauen Sie sich dort auch andere alternative Energie an.. Ich hatte es eben schon mal erwähnt Plug hat Speicher, Flow Batterie. Jetzt habe ich letztens auch von einem Unternehmen gehört, die quasi die Iron Batterie quasi Metall rostet und rostet wird. Was halten Sie von solchen Technologien für ein zukünftiges Energiesystem?

00:07:24
Also die Batterie, die wir gebaut haben, ist eine Batterie und daher kenne ich die Technik jetzt mittlerweile ganz gut. Ja, muss man aber sagen, ist dies noch in einem frühen Stadium unserer Batterie, funktioniert ja, das tut sie. Aber der Wirkungsgrad ist definitiv noch verbesserungswürdig und es gibt auch nicht viele Hersteller, die überhaupt Batterien liefern. Am weitesten ist schlichtweg Lithium Ionen, weil die Zellen, die dort verwendet werden, die kommen aus dem Automobilbau. Das sind exakt dieselben Zellen, auch von den selben Lieferanten. Die werden nur in die 6 reingeschoben und anders miteinander verdrahtet. Aber die Welle ist quasi Automobilbau und deswegen habe ich hier auch eine sehr hohe Dynamik, auch sehr schnell stattfindenden Preisverfall bei den Lithium Ionen Zellen, so dass eigentlich fast wieder auf die Ionen geht. Und alles andere was es sonst noch gibt, befindet sich in der Regel noch in der Forschung Stadium. Also das ist nicht lieferbar, in dem sind alles Ordnung.

00:08:26
Dann würde ich jetzt vielleicht noch mal in diese dieses Schemas gehen, in die Ideen, in diese drei Szenarios, die wir eben schon mal kurz besprochen haben. Dann.

Springen wir einfach noch mal zum Ersten. Ich würde vielleicht, um vielleicht ein bisschen Zeit zu sparen, noch einmal kurz einfach von dem, was ich mich erinnere, noch mal zusammenfassen, bis sie gesagt haben, Sie können dann vielleicht noch mal ergänzen, falls ich es vergessen habe. Also hier definitiv von Ihrem Gefühl her. Es ist sehr unwahrscheinlich, dass die Kostbarem durch die Tendenz extra durch Großpackung dadurch, dass man die extra Netzwerkverbindung vermeidet, wirklich größer sind. Die schaue ich mir noch mal genauer an. Hier und da die Idee Wir brauchen ein bisschen mehr von unserem eigenen Solarstrom hängt dann aber auch noch mal von den von der Leistung der Stations ab. Und dann der dritte Teil, wo ich gerne mehr im Detail darüber sprechen möchte, ist dann diese Sonne und die Sonne, so eine Art Community Batterie, dass die halt eben auch schon wesentlich größere Skala haben. 400 bis 600 Kilowattstunden, vielleicht aber auch bis zu Megawatt, wo man dann auch mit einem lokalen Aggregate zusammenarbeitet, der dann wiederum am. Netzwerk stabilisiert mit verschiedenen Dienstleistungen für den lokalen Netzwerk Betreiber und den nationalen Netzwerk Betreiber. Die Idee ist hier, dass ich bin momentan dabei, den Algorithmus zu programmieren, dass quasi der die erste Priorität ist. Okay, wir wollen mit der Batterie den den Aufzug versorgen. Das war der Gedanke. Dann wollen wir natürlich unseren eigenen Solarstrom speichern. Und wenn dann noch Kapazitäten über sind und Bedarf besteht zum Beispiel sagen wir, dass das das Netzwerk ist überlastet, dass wir dann eben das Netzwerk entlasten können mit der Batterie oder auf den Immobilienmärkten. Eben dann, dass für nationale Betreiber wie Tennet zum Beispiel dann dort unsere Kapazitäten anbieten. Das ist die Idee, die verwende ich gerade. Von daher will ich da vielleicht einfach erst mal die ganz allgemeine Frage stellen Was halten Sie davon? Ergibt das Sinn? Ist das utopisch oder kann das funktionieren? Mit diesen diversen Dienstleistungen eben den Fahrstuhl Einladung und dann, wenn Bedarf besteht, eben auch das lokale und nationale Netzwerk zu stabilisieren.

00:11:10

Also vielleicht mal das Vorbemerkung Es gibt vor allem über den deutschen Markt, weil in jedem Land sind die Regulierungs Vorschriften ein Stück weit anders. Man kann die Ergebnisse oder die ist jetzt gerade über Deutschland dann gleich sagen, werde nicht ohne Weiteres übertragen auf andere europäische Länder. In Deutschland ist es so, dass eigentlich alle großen Batterien am Regelenergie Markt teilnehmen, weil das der attraktivste Markt ist für Batteriespeicher. Also von daher ist mal die Idee grundsätzlich nicht verkehrt. Und diese Regelenergie Märkte werden vom Übertragungsnetzbetreiber betrieben. In dem Fall jetzt hier. Für die Niederlande wäre das eben Tennet. In Deutschland sind es die, die die anderen auch wieder Tennet, 50 Hertz Amprion und Transnet BW Allerdings, und jetzt komme ich hier auf den speziellen Fall. Wenn man am Energiemarkt teilnehmen will Es gibt nicht nur einen, es gibt drei prima Regelungen. Sekundäre Regelungen und Herzliya Regelungen sind also drei unterschiedliche Märkte. Und der attraktivste für Batteriespeicher ist derzeit primär Regelungen, weil dort werden die höchsten Preise bezahlt. Es gibt aber, wenn man an dem Markt teilnehmen will, eine Grundvoraussetzung, die man erfüllen will, nämlich das kleinstmögliche Angebot ist ein MW für eine Stunde. Das muss man also bringen können. Wenn man einem WE mal eine Stunde nimmt, ist es eine Megawatt Stunde. Damit wäre die Batterie, so wie sie hier steht, mit 400 bis 600 Kilowattstunden schlichtweg zu klein. Wurde gar nicht zugelassen zur Teilnahme am Energiemarkt.

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Genau da hatte ich nämlich eine Frage, und zwar inwieweit es möglich wäre. Hier in Holland ist es ähnlich, dass man es gibt eben diese Grenze mit einem Megawatt Stunde, die man in der Lage sein muss zu liefern. Inwieweit ist es möglich, diese Leistungen zusammenzulegen? Also dass man, wenn man jetzt sagt, man hat hier einen Aggregator, der eben nicht nur diese Batterie nimmt, sondern eben auch wenn, sagen wir mal, sind jetzt noch andere Making City Projekte in der Region in Groningen, dass das Gebiet zusammengelegt werden kann, um dann eben diese, diese, diese, diese Voraussetzung zu erfüllen. Inwieweit, inwieweit ist das möglich oder wird das schon gemacht?

00:13:35

Also es ist möglich, ja. Und ja, es wird auch schon gemacht. Es gibt Dienstleister dafür in Deutschland die größere Aggregate Polen, wo jedes einzelne für sich zu klein wäre, um am Energiemarkt teilzunehmen. Aber zusammengenommen hat man dann aber doch genug Leistung und dann gehts. Also das geht ja. Allerdings ist es so, dass die Dienstleister, die unterwegs sind, also in der Regel sagen Also mindestens ein halbes Megawatt Leistung muss das Aggregat schon bringen. Drunter machen sie es nicht, weil der Aufwand schlichtweg zu groß ist. Und der Aufwand entsteht eigentlich über zwei Kanäle. Das eine ist, bevor man mit so einem Aggregat am Regelenergie Markt teilnehmen kann, muss man durch ein sogenanntes Qualifikations Verfahren hindurch. Das heißt, der Übertragungsnetzbetreiber prüft, ob das Aggregat also reagiert, ob es die gewünschte Leistung zur Verfügung stellen kann. Wie zuverlässig die Datenverbindung ist, weil man bei dem Regelenergie mag, ist es so, also gerade beim primär Regelenergie Markt. Da kommen keine keine Steuer Signale vom von der Netze Leitstelle, sondern das Aggregat muss quasi autonom vor Ort regeln und der Übertragungsnetzbetreiber muss sich darauf verlassen können, dass das auch funktioniert. Deswegen gibt es da am Anfang dieses Qualifikations Verfahren. Das ist wie eine Zertifizierung, wo die Anlage auf Herz und Nieren geprüft wird, wo die Messungen gemacht werden, dass die das auch tatsächlich bringt, aber dass die tatsächlich bringt, was sie verspricht. Und dann gilt dieses Zertifikat schon ein paar Jahre und dann muss auch das nachgeprüft machen. Ich glaube 5 Jahre ist die Laufzeit, dann wird zertifiziert. Ob das noch so funktioniert, wie es damals gesprochen wurde. Und dieses Projekt Qualifikations Verfahren ist sehr aufwendig und deswegen lohnt es sich für kleinere Aggregate nicht. Es ist der gleiche Aufwand, ob sie mit einem 100kg Aggregate reingehen oder mit einem 500 KW oder mit einem Einw. Aggregat. Aufwand ist immer dasselbe. Entsprechend sind halt die relativen Kosten bei einem großen Aggregat niedriger. Und sagen die diese Aggregatoren, die es schon gibt, also ein halbes Megawatt soll sie schon haben. Drunter lohnt sich für Sie eigentlich nicht. Machen Sie mit?

00:15:47

Ja, und was halten Sie denn? Wie sehen Sie die Möglichkeiten von dem, was man im Englischen als sogenanntes Weiches bezeichnet wird? Also dass man hier zum Beispiel sagt, habe ich schon gesagt, erste Priorität. Wir wollen natürlich das Haus versorgen bzw. den Fahrstuhl da. Die zweite Priorität ist der lokale Netzwerk Betreiber. Und wenn der es nicht braucht, dann können wir eben auf diesen diesen Regulierungs Märkten unsere, unsere Angebote, unsere Angebote abgeben. Funktioniert es in der Praxis schon mit dieser Priorisierung? Das Okay, wir versuchen erst lokale

Überbelastung auf den Netzwerken zu lösen und falls das nicht der Fall ist, gehen wir auf die nationalen Netzwerke und versuchen dort dann natürlich unseren und unsere Margen für die Batterien einzufahren. Funktioniert das schon? Gibt es da schon Automatisierung und Programme, Unternehmen, die so etwas in der Zeit betreiben, nicht so tun?

00:16:43
Also jetzt müssen wir ein bisschen unterscheiden, also diese Regelenergie Märkte gibt es nur auf nationaler Ebene. Auf EU-Ebene gibt es das ja noch gar nicht. Das heißt, Karsten, der hier eingezeichnet ist, das ist ja der lokale Netzbetreiber. Der bietet sondern so ein Markt überhaupt noch gar nicht an. Und warum bietet er's nicht an. Er bietet es nicht an, weil das nicht muss. Also ich denke, dass es in Holland noch genauso wie in Deutschland. Die Übertragungsnetzbetreiber müssen einen Energiemarkt anbieten. Die Parteien Netzbetreiber nicht, deswegen diese nicht. Das heißt, dieser Pfad da unten vom lokalen Navigator in Access, der existiert in der Realität noch gar nicht. Das müsste man mit dem irgendwie bilaterales Abkommen abschließen. Das der Netzbetreiber da irgendwas bereit ist zu zahlen, wäre Verhandlungssache. Also da kann auch nein sagen, wenn er sagt, es interessiert ihn nicht, dann passiert da unten überhaupt nichts.

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Ja, ja, das ist der Pfad.

00:17:42
Der Pfad, der immer funktioniert, ist der oben rum über die Regelenergie Märkte. Und da muss ich schon ein Stück weit entscheiden, was hat jetzt Prio 1? Also wenn man am Energiemarkt ein Gebot abgibt und kriegt den Zuschlag, dann ist diese Leistung geblockt, egal ob sie abgerufen wird oder nicht. Die kann man da nicht mit irgendwas anderes verwenden, weil es könnte ja zu jedem Zeitpunkt in Abruf kommen. Ja, je nachdem, in welchem Regelenergie man tätig ist. Im Energiemarkt muss es sowieso automatisch funktionieren. Also wenn ich da ein Megawatt verkaufe, dann muss in den Anlagen, die da hinten aggregiert werden, auch wirklich ein Megawatt vorgehalten werden und zwar positiv wie negativ. Und dann kann ich auch nichts anderes mit machen für den Zeitraum, wo ich verkauft habe, also minimal eine Stunde. Ich kann aber auch Tages Angebote abgeben, Wochen, Angebote, Monats und Gebote. Diese Leistung ist geblockt. Das heißt, dieser dieser Bereich, der dann noch übrig bleibt, dieser blaue Bereich, der wird dann entsprechend kleiner.

00:18:39
Ja zu dem Link zu dem Punkt von dem verteilen Netzbetreiber, was sie erwähnt haben. Also das ist auch so ein bisschen die Idee meiner Masterarbeit, dass ich hier herausfinde. Okay, wir nehmen mal an, die wären interessiert an der Zusammenarbeit und wir würden sagen Okay, unsere Priorität Nummer eins oder unsere höhere Priorität ist, sagen wir jetzt mit dem Verteilen jetzt Treiber bei Überbelastung auf dem lokalen Netz zu helfen. Wie wie viel oder wie teuer wäre das für den lokalen Netzbetreiber und Stimmverteilung Netzbetreiber jetzt eben sozusagen Storage as a Service, dass man dann eben diese Batterie Leistung bucht, quasi. Das ist so ein bisschen das, was ich mir angucke, weil weil wie gesagt, ein Markt gibt es da eben noch nicht. Und dann eine andere Sache, wo ich ich habe leider leider kein technisches Narayen. Ich bin kein Elektroingenieur, aber was mich noch interessieren würde, ob

es Systeme gibt oder Batterie Systeme, ob sie von oder von dem Wissen wo wir haben so eine Situation, wo wir etwas dagegen haben mit verschiedenen Dienstleistungen, die wir, die wir anbieten wollen und dass man aber eben eine Batterie hat, die bestimmte Kapazitäten für den Verteil Netzbetreiber und bestimmte Kapazitäten für den für die Regulierungs Märkte dann eben reserviert, dass eben wenn was für die Regulierungs merkte man hat. Man hat dann dort die Kapazitäten blockiert, dass man immer quasi sagen wir mal bestimmte Kilowatt Anzahl von jetzt den 600 Kilowatt 200 Kilowatt für den Netzbetreiber reserviert, die man quasi offen lässt. Ist das ist das Humbug oder könnte das Sinn ergeben?

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Also ich kann. Ich kenne jetzt ehrlich gesagt im Bereich der Batteriespeicher keinen Hersteller, der das irgendwie serienmäßig als als Produkt anbietet, das dieses Sharing der Kapazität. Jetzt muss man aber ein bisschen unterscheiden. Beim Batteriespeicher gibt es ja Produkte von der Stange. Das sind vor allem die kleinen Batteriespeicher für den Heimgebrauch und auch die gewerblichen Batteriespeicher. Die gehen ebenso bis in die Größenklasse. Ich sag mal hundert Kilowattstunden, manche auch ein bisschen drüber hinaus. Das sind fertige Produkte, mehr oder weniger von der Stange. Aber so wie ich den deutschen Markt kenne, ist da kein Hersteller dabei, der schon so eine Option anbietet. Die werden in der Regel wirklich dann ausschließlich für die Eigenverbrauch Optimierung auf dem Gelände eingesetzt und für PKW, aber nicht noch für irgendwelche dienlichen Services, weil es eben dafür noch keinen Markt gibt, weil man da für immer mit dem lokalen Netzbetreiber reden muss und der im Zweifelsfall da auch gar nicht interessiert ist, weil an der Stelle, wo der Netzanschluss ist, gar kein Problem hat. Okay, das muss man auch immer im Blick behalten. Ein Netzbetreiber, wenn er Probleme hat, hat an lokale Probleme nicht überall im Netz die Spannung zu hoch, sondern nur an einem ganz bestimmten Punkt. Es ist nicht überall im Netz eine Überlast, sondern es ist nur an einer ganz bestimmten Stelle. Und wenn er dann mit so einem Batteriespeicher da was tun will, dann muss der Batteriespeicher auch genau an dieser Stelle stehen. Und das ist ja mehr oder weniger Zufall. Also wenn er Glück hat, ist es so. Aber in den meisten Fällen ist es eben genau nicht so. Dann steht der Batteriespeicher irgendwo anders. Weil er ja auch von einem Werbekunden bezahlt wird. Da hat erst mal sein Gelände seinen Verbrauch zu optimieren, der stellte natürlich bei sich auf dem Werksgelände auf. Und wenn an dieser Stelle im Netz kein Problem ist, dann hat der Partei Netzbetreiber auch keine Notwendigkeit irgendwelche Leistungen einzukaufen.

00:22:17

Wo ich eben mal kurz auf die Zeit. Wir haben noch eine Minute. Sie haben ja schon unglaublich viel Information geben. Bin ich, bin ich sehr, sehr dankbar für vielleicht eine abschließende Frage, wenn Sie sich dieses Geschäftsmodell angucken. In der Literatur wurde dann auch oftmals diskutiert, dass ein Problem ist, dass wenn man hier so viele Stakeholder hat, die an so einem Modell mitbeteiligt sind, sind die Erwartungen oftmals sehr unterschiedlich von dem Verteilen Netzbetreiber und den Märkten der Aggregator, Betriebe und so weiter und so fort. Von daher will mich jetzt abschließend noch mal interessieren Was wäre aus Ihrer Perspektive der wichtigste Erfolgsfaktor Erfolgsfaktor für so ein Geschäftsmodell? Aus der durchaus aus Ihrer Sicht. Und was wäre für Sie am wichtigsten?

00:23:07
Also für mich als als verteil Netzbetreiber im Grunde

00:23:10
genommen genau als Vorteil Netzbetreiber.

00:23:20
Also ich schaue mal ein bisschen in die Zukunft, also aktuell, wenn ich jetzt meine Kollegen frage Haben wir Probleme im Netz? Kriege ich immer nur die Antwort Nein, wir haben keine Probleme. Also Stand heute würde ich sagen, das Geschäftsmodell ist aus Sicht eines Netzbetreibers noch nicht attraktiv. Aber schaue ich mal fünf Jahre in die Zukunft auch in Deutschland kommt wirklich ganz massiv neue Ladeinfrastruktur ins Netz. Das ist eigentlich die größte Herausforderung im Moment.

*[Translation: "*So I'm looking a bit into the future, so currently, when I ask my colleagues Do we have problems on the network? I always get the answer no, we don't have any problems. So as things stand today, I would say that the business model is not yet attractive from a network operator's point of view. But if I look five years into the future, in Germany, too, there really is a massive amount of new charging infrastructure coming onto the grid. That is actually the biggest challenge at the moment.*"]*

Es werden unglaublich viele Ladepunkte installiert. Das führt zu einem enormen Leistungs Zuwachs und je nachdem was für Ladepunkte das sind, wenn sie zum Beispiel in Privathäusern sind oder in Apartment Häusern, hat man immer noch den Effekt, dass die dann relativ zeitgleich alle laden werden. Nämlich wenn sie tagsüber mit den Autos unterwegs sind, kommen sie abends zurück. Etwa zwischen 17 und 18 Uhr stecken alle zeitgleich das Ladekabel rein. Das heißt, wie ich sehe, hier in den nächsten Jahren einen ganz großen Bedarf nach gesteuert zum Laden. Und das ist jetzt nicht direkt indirekt ja auch ein Batteriespeicher im Auto drin, den man dann nutzt, aber jetzt nicht wieder bidirektionale Laden. Dass man also quasi Energie in einem an der Autobatterie Zwischenlager hat, sondern es geht wirklich eher zum Ersten Mal darum, diese dieses Laden ein Stück weit zu entzerren. **Also dass die nicht alle um 18 Uhr dann mit voller Leistung ihre Autobatterien, Rollladen und alle auch um 20 Uhr dann damit fertig sind, sondern dass man das mehr über die ganze Nacht streckt, sodass dann am Morgen auch alle voll sind und alle wieder fahren können. Aber das die Belastung sind. Und da könnte tatsächlich ein ein Lokal Aggregator eine interessante Rolle einnehmen, der quasi dieser diese Koordinations Funktion übernimmt, dass der Netzbetreiber nur dem lokalen Koordinator für bestimmte Areale so was wie den Leistungs Korridor vorgibt.**

[Translation: *„So that they are not all at 6 p.m. then with full power their car batteries,* shutters and all also at 8 p.m. then finished with it, but that one stretches it more over the whole night, so that then in the morning also all are full and all can drive again. But that the load are. And a local aggregator could actually play an interesting role here, taking over this coordination function, so to speak, so that the network operator only gives the local coordinator something like the power corridor for certain areas.*"*]

Und der lokale Aggregator sorgt dann dafür, dass die dahinter liegenden Ladepunkte auch genau so angesteuert werden. Das könnte durchaus interessant sein für die Zukunft der nahen Zukunft.

00:25:22
Ja, also dass dann der der Hauptwerks von diesem ganzen Geschäftsmodell eine zentrale, eine zentrale Rolle ist, die das Ganze koordiniert, mit Laden und Entladen und den Kapazitäten. Das wäre dann für Sie als Vorteil Netzbetreiber, dass man einfach ein. Also das ist dann quasi der, dass man das Outsourcen sozusagen genau

00:25:40
so, dass man selber aufbaut und selber alles selber ansteuert. Mit eigener Technik hat man zwischendurch den Dienstleister. Man gibt ihm nur einen Leistungs Korridor vor, meinetwegen morgen. Für Gebiet A hast du fünf Megawatt zur Verfügung vernetzt, Gebiet B hast du 10 Megawatt und dann noch die Zeitfenster dazu und der steuert dann da hintendran die ganzen Ladepunkte, so dass das exakt aufgeht. Das wäre nicht wert.

00:26:04
Und der, wenn das der Netzbetreiber selbst diese diese Rolle übernimmt, das wäre dann zu viel Aufwand intern.

00:26:11
Also was wäre die Alternative, dass er es selber macht und dann stellt sich wieder die Frage Da muss natürlich dann Personal eingestellt werden. Geht die Regulierungsbehörde damit und den Künsten aber andauernd, dass die Politik Gesetze macht, wo eigentlich von den Parteien Netzbetreibern viel erwartet wird? Neue Aufgaben kommen dazu, neue Rollen. Der Netzausbau soll vorangetrieben werden, aber die Regulierungsbehörde steht ständig auf der auf der Kostenbremse und sagt Keine neuen Stellen, keine neuen Stellen. Und deswegen gibt es auch oft nicht auf. Und deswegen geht es auch auf zu langsam, weil die Netzbetreiber gerne das machen würden, aber halt nicht so ohne Weiteres Personal dafür einstellen dürfen.

00:26:47
Und dann wie gesagt, wir haben hier das Problem, dass man ja auch eigentlich den die Batterie oder die Speichertechnologie dann nicht benutzen möchte. Aber ja, super, vielen Dank. Ich will sie jetzt auch gar nicht. Wir sind schon über das Ende der Zeit hinausgeschossen. Vielen, vielen Dank.

00:27:05
Danke!

00:27:07
Das war ein sehr, sehr interessantes Gespräch. Sehr inspirierend. Viele neue Informationen. Haben Sie jetzt noch irgendwelche abschließenden Fragen oder Kommentare?

00:27:17
Aus meiner Sicht alles, alles gut. Ich hoffe, Sie können was anfangen mit dem Input und ich bin natürlich gespannt, wen Sie dann was Sie noch für Kommentare aus den anderen Ländern kriegen, wie es da aussieht.

00:27:28
Ja, ja, also ich. Ich bin gerade momentan über eins von diesen Projekten in Kontakt mit einem Netzbetreiber in Slowenien und versuche hier natürlich auch mit dem

Maeckes zu sprechen. Und dann schaue ich mal, inwieweit inwieweit da die ähnliche Sachen Sachen von sich geben, wie sie mir jetzt gerade berichtet haben, dann ja, vielen Dank. Ich wünsche viel Erfolg.

8.8.10. Interviewpartner 12 – Enexis

Due to technical issues, the recording could not be transcribed. Main points that were raised were confirmed via email.

Van: Timo Dettmering <t.dettmering@newenergycoalition.org>
Verzonden: donderdag 25 november 2021 16:32
Aan: [redacted]@enexis.nl>
Onderwerp: Confirmation of discussion

Hello Marcel,

Thank you a lot for the discussion. It was very interesting to hear the perspective of a DSO on the business model idea.

Unfortunately, there seemed to be an issue with the recording and the audio quality is not usable for my thesis. However, I would still like to use the information you gave me, so would it be possible for you to confirm the following aspects that were discussed:

Value of Batteries:

- Batteries will be part of future energy system

Congestion in the Enexis network:

- Currently there are not as many congestion issues on the Enexis network like for Alliander. We have no real congestion on our network yet because we are not connecting customers that can cause congestion. We have red area's because we can not connect customers to this due to insufficient network capacity.
- Main problem in the north are solar parks that oversupply during the summer months. Also here the remark off the previous bullet
- Currently Enexis is not connecting new customers to the grid
- A new network code is in progress that will force Enexis to connect new customers. Then more congestion is expected. Skip more the new network code forces us to connect customers even when the network capacity is not enough. We have to manage this by doing congestion management.

Renumeration of congestion services:

- Contracted services that include reservation of congestion services are preferred compared to current mechanism where customers have to be connected/disconnected to keep the system balance (market system)
- Prices of such a business model have to be lower than current prices on GoPacs (market system)
- Could you confirm the expected price increase of congestion payments on GoPacs that you mentioned in the interview?. Prices for flexibility on Gopacs are now around € 300,- per MWh.
- Guarantees for such a business model are not realistic. Enexis can upgrade the grid within 2-3 years. For specific areas. Not the complete grid at ones.
- Storage should have multi-service approach and deliver services to DSO and TSO (value stacking)
- GoPacs as a key role for service delivery and communication between aggregators and DSO and TSO for flexibility
- GoPacs will be used as means of communicating contracts for storage and congestion demand (future development)

Market:

- The market is currently waiting for the new network code which includes the requirement to connect new consumer to the grid as described above

Feel free to add information or correct any of the given aspects above.
Again, thank you for your time and the interesting conversation!

Met vriendelijke groet / mit freundlichen Grüßen,
Timo

8.8.11. Interviewpartner 13 - Research on Energy Systems Modelling

Hanze
University of Applied Sciences
Groningen

Confirmation of Structured Walkthrough

With document I, Dr. Ing. Frank Pierie, confirm that I have been part of the structured walkthrough in the context of the master thesis of Timo Dettmering.

The following aspects were discussed:

- The Making-City project and the conceptualisation of the three scenarios
- Research Question and purpose of the model
- The outcome of the model
- Main variables
- The formula and computational logic
- Structure of the model
- The outcome of the extreme value test
- Different decision options within the technical model
- Variables and output within the economic model

With this document I confirm that now major flaws were found and that the model has valid logics and operations.

[redacted]

Date, place, signature