LOOPING IN THE HOUSEHOLD

DESIGNING FOR SMARTER ENERGY BEHAVIOUR AT HOME: A USER-CENTRED APPROACH TO HOME BATTERY USE

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August, 2025

Master thesis
Strategic Product Design, Technical University of Delft

Colophon

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August 2025
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Preface

This report presents the final project of my Master's degree in Strategic Product Design at the Faculty of Industrial Design Engineering at Delft University of Technology. My graduation project was conducted in collaboration with Vattenfall, starting in March 2025 and concluding in July 2025.

Over the past five months, I have explored how the energy transition intersects with everyday family life, zooming in on the role of the home battery in supporting smarter energy behaviour. My research focused on the user side of the equation: what makes energy management feel complicated, and how can design help translate technical potential into everyday relevance?

I am grateful to have carried out this project at Vattenfall, where I was given the space to dive deep, challenge assumptions, and contribute to a topic of real societal relevance. Energy is not just a technical domain; it's a daily reality for every household, and I strongly believe design has an important role to play in bridging that gap.

I would like to express my gratitude to my academic supervisors, Sonja and Matthijs, for their support and sharp, constructive feedback throughout the process. To my chair, Sonja, your calm and grounded presence helped me stay focused throughout the process and and reminded me to trust the process when things felt uncertain. To my mentor, Matthijs, your input helped me sharpen my thinking and push the concept further with each iteration.

I also want to thank my company mentor, Hylke, for your trust, openness, and the many thoughtful conversations. Thank you for making me feel at home at Vattenfall and for always being willing to spar ideas. I'm also grateful to the entire UX- and research team at Vattenfall, and especially to the families who generously participated in the testing.

I'm especially thankful to the people around me. To my friends and family, thank you for your support throughout this journey. Whether it was thinking along, offering a fresh perspective, or simply listening, your input always helped me move forward.

This thesis marks the conclusion of my time at TU Delft and reflects the kind of design work I hope to keep doing in the future: strategic, relevant, and grounded in the everyday lives of people.

Enjoy reading!

Marije

Executive summary

The Dutch energy system is in transition. As the share of solar energy increases and net metering stops in 2027, households are being called upon to play a more active role in managing their own energy. Yet most current solutions are built around technology, not the people using them.

This thesis explores how design can help bridge that gap by guiding households in using their home battery more intelligently, aligning personal goals with system needs.

Conducted in collaboration with Vattenfall, this graduation project investigated how a behavioural, user-centred approach could transform the home battery from a technical product into an adaptive energy system.

Through extensive research across system, household, and user levels, the main barriers in the home battery journey were identified. The project then zoomed in on the use phase. Four key barriers emerged: the energy system does not speak the user's language, fails to become part of daily routines, offers unactionable information, and treats all users the same. These four barriers shaped the core design challenge.

To address this, the concept is grounded in behavioral design. The Fogg Behavior Model, the Transtheoretical Model of Behavior Change (TTM), and the HOOK model were used to structure a strategic approach to behavior change. Central to this is the behavior loop; a cycle of trigger, action, feedback, and reinforcement, which served as both the lens and backbone for concept development.

Through interviews, behavioural mapping, and system-level analysis, the central opportunity was identified: to create a smart, adaptive digital layer around the battery that supports more conscious energy behavior over time.

The outcome is Loop: a household-centered energy system that learns from the family, adapts to their situation, and motivates smart energy action through personalized feedback and stimulation.

Two core system components were developed in detail:

1. The onboarding and learning system, which helps Loop tailor its guidance to each household
2. The motivation system, which reinforces helpful behavior through feedback and stimulation.

The concept was refined through iterative sessions with Dutch families, internal Vattenfall stakeholders, and behavioral scientist Dr. BJ Fogg. The resulting system balances personalization with clarity and aims to lower the threshold for smart energy assets in the home both now and in the future.

Loop is designed not only as a proposition for today's battery users, but as a scalable logic for smart energy behavior across different user segments, assets, and contract types.

Glossary & Abbreviations

Arranged in alphabetical order.

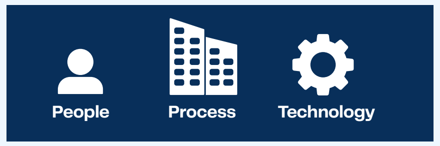
AI	Artificial Intelligence	P2P	Peer-to-Peer
API	Application Programming Interface	PV	Photovoltaic (solar panels)
BRP	Balance Responsible Party	ROI	Return on Investment
EV	Electric Vehicle	TOU	Time of Use (tariff)
FBM	Fogg behaviour Model	TSO	Transmission System Operator
HB	Home Battery	TTM	Transtheoretical Model
HBSS	Home Battery Storage System	TU Delft	Technical University of Delft
HEMS	Home Energy Management System	UI	User interface
JTBD	Jobs to Be Done	UX	User experience
kWh	Kilowatt-hour	VAT	Value Added Tax
ML	Machine Learning		

Reading guide

This report is structured into 6 main parts, following the logic of the Triple Diamond process model (introduced in section 1.3. It moves from discovering the broader system context to defining the design challenge, and ultimately delivering a tailored concept.

At the start of each chapter, a visual indicates where we are in the Triple Diamond, helping you track.

The Discovery phase ends with a series of takeaways per chapter, structured around the People, Process, and Technology (PPT) framework. These synthesise key findings while reflecting my own perspective as a strategic designer.



Appendices marked with a letter (A, B, C, etc.) are general additions to the report. Appendices marked with Roman numerals (I, II, III, etc.) contain confidential information and are excluded from public distribution.

Table of contents

Introduction

This section introduces the graduation project, its broader context, and the approach taken. It outlines the motivation behind the project, Vattenfall's role as industry partner, and the shifting energy landscape that makes this topic both timely and relevant. Finally, it explains how the project was approached.

1.1 Project description

Project introduction

This project takes place within the Home Energy Management (HEM) domain of Vattenfall Netherlands, specifically under the Digital Innovation branch, within the UX Design and Research team. With the introduction of home batteries, Vattenfall is expanding its business model from traditional energy contracts to smart energy solutions that are directly integrated into consumers' home environments.

Vattenfall anticipates that by 2027, due to the phase-out of the netting scheme, customers will start questioning how to manage their solar energy. Vattenfall positions the home battery as a promising solution.

However, the success of this proposition will depend on more than just the technical performance of the battery. It will rely on how well the offering resonates with customer needs, behaviours, and expectations.

This graduation project was initiated to explore how Vattenfall might introduce home batteries to (new) customers in a relevant and meaningful way.

Challenge

This is a new and complex territory for Vattenfall. It is the company's first step beyond the meter into customers' homes. Much is still unknown: the user base is unfamiliar, the full customer journey is undefined, and the market is rapidly evolving with new technologies and competitors entering the space.

The challenge lies in determining what is needed to create a valuable and realistic proposition for Dutch households. How can Vattenfall differentiate itself, define its role, and support customers through an unfamiliar journey?

Project goal

The goal of this project is to design a strategic proposition for Vattenfall's home battery that is clear, honest, and aligned with customer expectations. This includes identifying key barriers and opportunities across the customer journey and defining how Vattenfall can position the home battery in a way that supports household needs and creates value for the company.

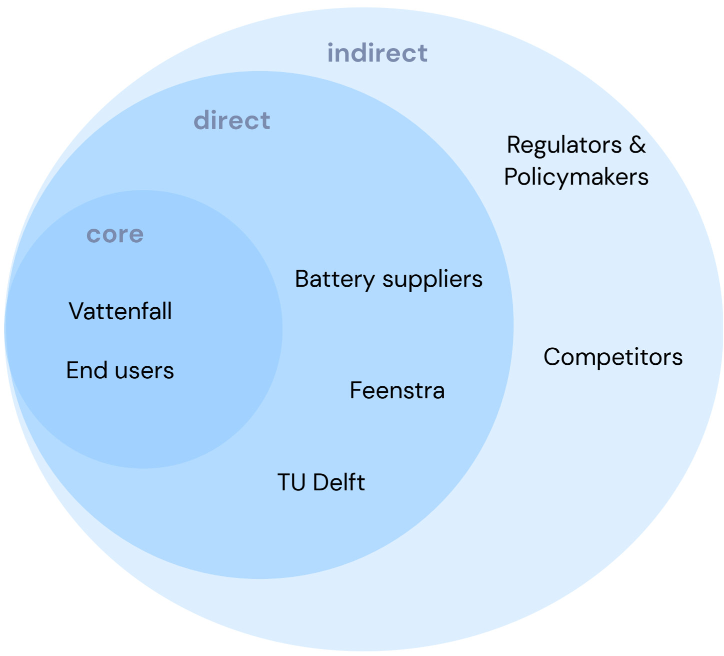
Through research and iterative design, the project aims to uncover relevant opportunity areas and translate them into actionable, user-centered design directions, ultimately strengthening Vattenfall's position in the evolving Dutch energy market.

The original project brief is included in Appendix A. A revised brief, reflecting key research insights, can be found in chapter 12.

Project scope

This project is scoped within the Dutch energy market and focuses on the full customer journey related to residential home batteries. While the initial phase explores this entire journey, the later stages of the project zoom in on one key barrier identified during research.

The scope deliberately excludes the development of exact product capabilities and financial modeling, as these aspects remain underdefined within Vattenfall. Instead, the project takes a user-centric approach, emphasizing behavioural insights, user needs, and potential value propositions to guide future service and product development in the home battery domain.



1.2 Project context

Client info

Vattenfall is a major European energy company active in electricity and heat generation, distribution, and retail. The company operates in Sweden, Germany, the United Kingdom, France, Denmark, Finland, and the Netherlands. In the Netherlands, Vattenfall serves over 1.9 million customers with a primary focus on energy contracts for households and SMEs. The company is 100% owned by the Swedish state.

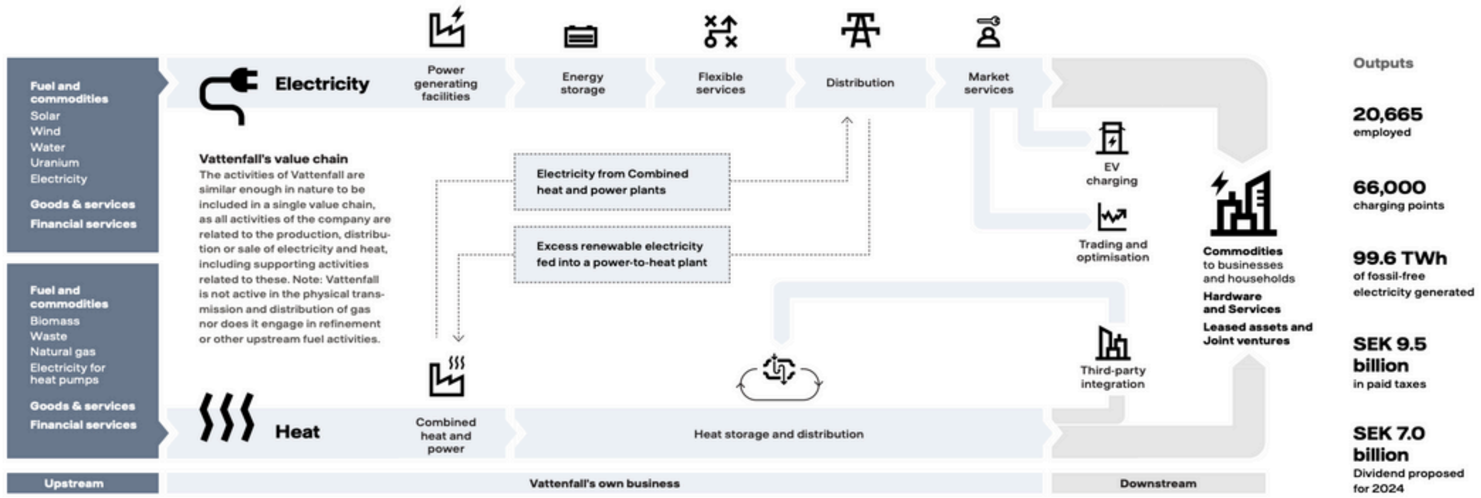
VATTENFALL

Positioning	Values
Trust	Sustainability
Simplicity	Innovation
Stability	Customer centricity

Strategy and vision

Vattenfall is committed to enabling fossil-free living within one generation. This ambition extends beyond its own operations; it collaborates with partners to electrify sectors like transport, heating, and industry. The company sees a growing role for flexibility in energy systems, and positions itself accordingly with new solutions such as home batteries, aligned with its belief that flexibility will increase in value over time (Vattenfall Annual and Sustainabilty Report 2024). Its long-term goal is to achieve a fossil-free energy supply by 2040, in line with the expectations of both its owners and society.

Business model and value chain



(Vattenfall Annual and Sustainabilty Report 2024)

The home battery (HB) would be placed in the "Flexible services" and "Market services" segments of Vattenfall's value chain. It enables households to store and manage electricity usage more intelligently, contributing to flexibility on both household and system level.

Partner

Feenstra

Vattenfall collaborates closely with partner Feenstra, making them a relevant stakeholder within the scope of this project. Feenstra plays a key role in the technical delivery of the home battery proposition.

HEM within Vattenfall

For more information on the home energy management projects within Vattenfall and their maturity levels, see confidential Appendix I.

1.3 Project approach

This project follows the Double Diamond method as a guiding framework, structured around four key phases: Discover, Define, Develop, and Deliver. Due to the broad and complex nature of the initial challenge, a third, smaller diamond was added between the two main diamonds. This intermediate phase helped to narrow the focus after the initial exploration, before zooming in on a specific design direction.

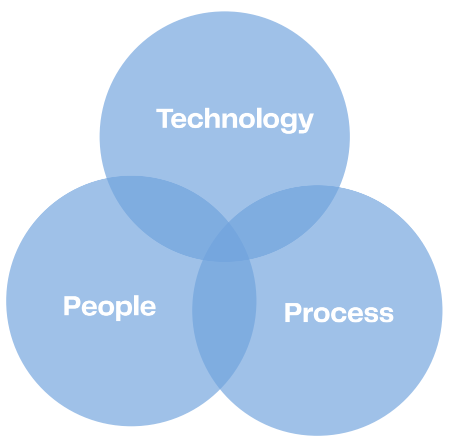
The first diamond focused on understanding the broader energy landscape, user behaviours within Dutch households, and Vattenfall's strategic positioning. This phase resulted in a comprehensive overview of the home battery customer journey, highlighting key barriers that appear before and after purchase. One strategic direction was then selected for further exploration.

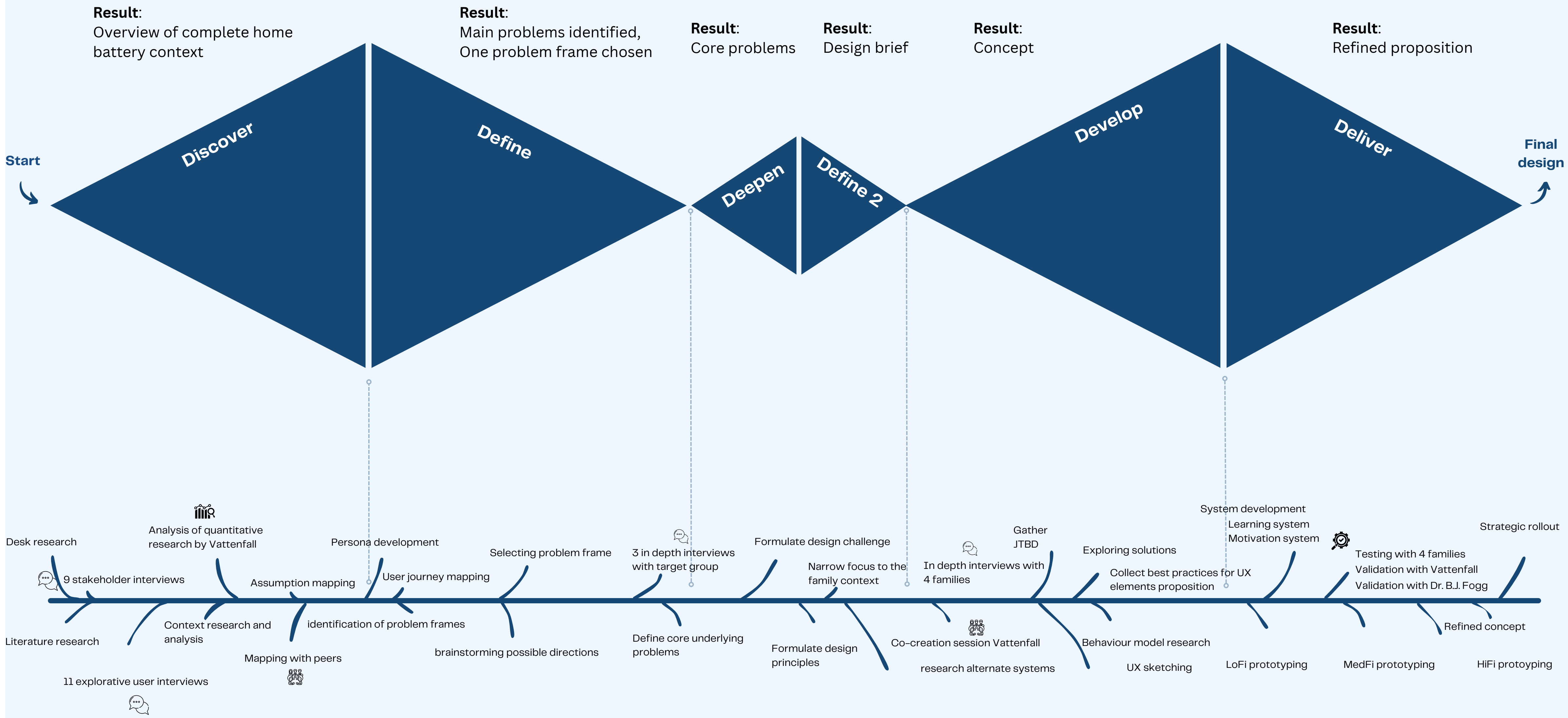
The second, smaller diamond served to deepen this problem framing. Through in-depth interviews, research and synthesis, a clear and actionable design brief was defined to guide the rest of the project.

The final diamond represents the core design process, involving iterative concept development, prototyping, and user validation. This led to the creation of a concrete, user-centred design proposition.

Because of the user-focused nature of this project, research with end users was conducted throughout all phases. The process diagram on the right provides a detailed overview of the activities, outcomes, and decision points, with icons indicating the type of research or method used.

Throughout the process, insights were consistently analysed through three perspectives: technology, business, and customer. These align with the core innovation principles of feasibility, viability, and desirability, ensuring that the final outcome is both relevant to users and strategically grounded for Vattenfall.





Process Visual

Discover

This Discovery section maps the full context in which the smart storage proposition must land, zooming in from system-level dynamics to individual user needs. It synthesises a wide range of research across seven chapters to understand not just what needs to be designed, but why, for whom, and under what conditions.

Insights are captured through the People–Process–Technology (PPT) lens, highlighting patterns, strategic tensions and design opportunities. The chapters move from the Dutch energy system (ch. 2), to household realities (ch. 3), to user behaviour (ch. 4), before bridging (ch. 5) to the home battery proposition (ch. 6) and market landscape (ch. 7).

Finally, Chapter 8 brings it all together through the eyes of the user. By tracing the journey of a typical persona (John) it reveals where frictions arise and what matters most along the way.

2. The Dutch energy system

Electricity is a unique good: it must be produced and consumed simultaneously, cannot easily be stored, and is bound by the physical constraints of transmission infrastructure. These characteristics make the electricity system fundamentally different from conventional markets, and they create complex challenges. Especially as the system undergoes a rapid transition toward decentralization, electrification, and sustainability. Based on desk research, this chapter outlines the key actors in the Dutch electricity system (2.1), the principles of how the system operates (2.2), recent developments and transition dynamics (2.3), and the emerging system needs that shape the context for household and user-level innovation (2.4).

Figure 2.2: Grid operator division (Energievergelijk.nl, 2025)

2.1 Actors in the energy system

The scope of this project focuses on the Dutch energy system. That's why it's important to establish the key actors and how they interact.

The main actors include energy producers, energy suppliers, consumers, the national grid operator, and regional grid operators. Figure 2.1 below outlines these stakeholders, the flow of energy and value between them, and Vattenfall's position within the system.

While consumers are technically part of the energy system, they often have a very limited awareness of how the system operates. Most users do not engage with the broader market or infrastructure behind their energy use. Their only direct touchpoint is typically the energy supplier, from whom they receive a monthly bill or app notification. As a result, energy is often perceived as an abstract and passive utility. Something that "just works" when a switch is flipped. This limited visibility and involvement influence how users think and behave: they may feel little control or ownership over their energy use, and often lack the motivation or knowledge to actively manage it. This disconnect is an important consideration when exploring behavioural change or introducing new technologies like home batteries and will be further discussed in chapter 4.

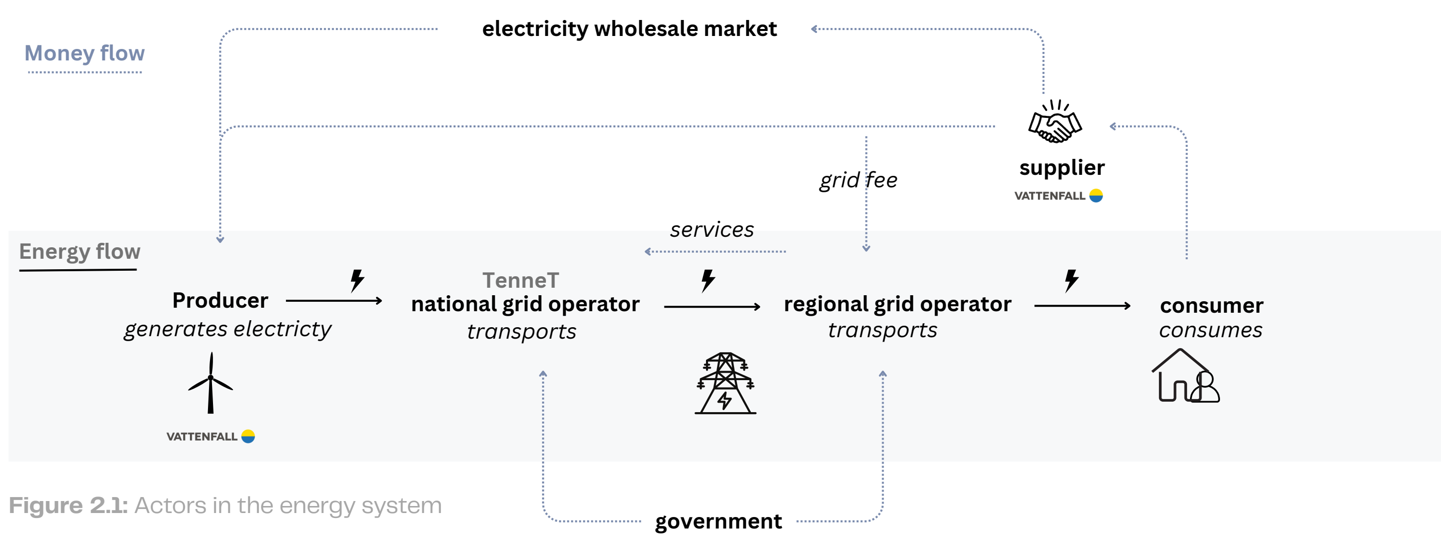


Figure 2.1: Actors in the energy system

It is important to note that Vattenfall operates as both an energy producer and supplier. Energy suppliers, such as Vattenfall, trade electricity between producers and consumers. They can source this energy directly from producers or purchase it through the wholesale electricity market. Grid operators are responsible for transporting electricity. The Netherlands has a single national grid operator, TenneT, which manages the high-voltage transmission network. TenneT distributes electricity to six regional grid operators, each responsible for managing distribution in its own geographic area, as can be seen in Figure 2.2.

2.2 Principles of the energy system

Having established the key actors in the Dutch energy system, this next section explores the fundamental principles that govern how this system operates.

In the Netherlands, the electricity grid operates on a real-time balancing principle, where the amount of electricity produced must always equal the amount consumed. To maintain this equilibrium, the Dutch energy market includes a balancing mechanism with clearly defined roles and responsibilities.

The Transmission System Operator (TSO) responsible for maintaining grid stability in the Netherlands is TenneT. A key actor within this system is the Balancing Responsible Party (BRP), which is financially accountable for ensuring that the electricity consumption or production within its portfolio matches its forecasted values. All electricity suppliers and producers must be associated with a BRP.

To keep their portfolios balanced, BRPs engage in electricity trading with other market participants. These transactions are reported to the regional grid operator, which then forwards the data to TenneT. TenneT compares these reported energy transactions with the actual measured data on electricity consumption and production. Any deviation between the planned and actual traded volumes creates an imbalance, which is financially settled with the BRP with an imbalance price. BRPs that cause imbalances are penalized, while those that help to restore balance, by supplying or absorbing electricity through the imbalance market, are rewarded (Tennet, n.d.).

In this context, the growing availability of flexible energy assets, such as home batteries, plays an increasingly important role. These systems can help reduce grid stress by allowing households to store and use self-generated energy more efficiently. Additionally, under smart control, they can be leveraged by external market actors to support real-time grid balancing—providing both system value and a financial incentive to end users.

2.3 System transition & developments

What is happening

The Dutch energy system is undergoing a transformation, driven by national climate goals, technological advancements, and societal shifts. This transition reflects a move from a centralized, fossil-fuel-based model to a decentralized, renewable, and flexible energy system.

2.3.1 Growth in renewable energy and electrification

The Netherlands aims to achieve a fully sustainable energy system by 2050, with an interim target of sourcing 70% of its electricity from renewable sources by 2030 (Ministerie van Volkshuisvesting, Ruimtelijke Ordening en Milieubeheer, 2025). A key component of this transition is electrification, with increasing adoption of electric vehicles, heat pumps, and electric technologies.

Although national electricity demand has remained relatively stable in recent years, this is expected to change. In 2023, net electricity consumption was 109 terawatt hours (TWh). By 2030, this is projected to rise to between 138 TWh and 159 TWh (PBL, 2023), representing an increase of roughly 27% to 46% compared to 2023 levels (De Boer, n.d.).

This rising demand coincides with a rapid expansion of renewable electricity production, particularly solar energy. The Netherlands is one of the global leaders in solar PV adoption, with continued growth in residential and commercial installations (IEA, 2025).

Together, the rise in electricity demand and the rapid expansion of decentralized renewable generation are putting increasing pressure on the electricity infrastructure. While these developments are essential to achieving sustainability goals, they also expose the limitations of the current grid.

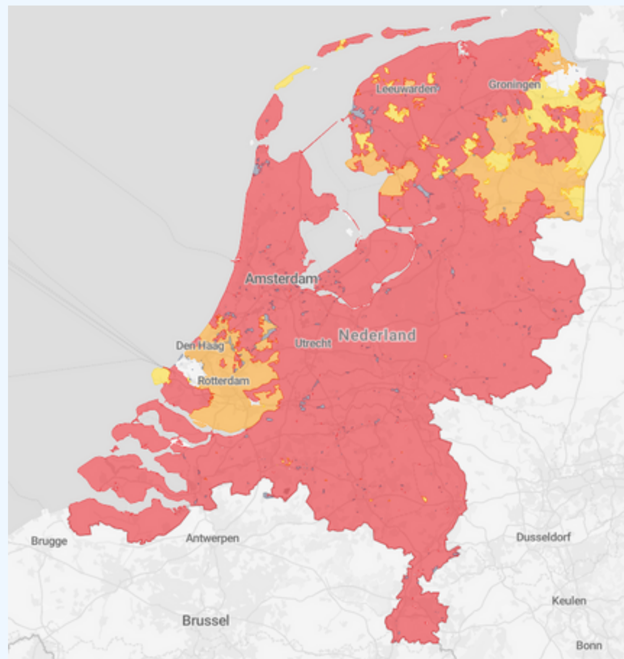


Figure 2.3: Capacity map (DataPortal, n.d.)

2.3.2 Grid congestion and infrastructure challenges

This explosive growth in renewable energy and electrification is placing increasing pressure on the Dutch electricity grid, resulting in widespread grid congestion. Grid congestion occurs when the network's physical capacity is insufficient to handle all electricity transport requests, either from producers wanting to feed in power or from consumers demanding it.

The severity and nature of congestion vary significantly by region (Figure 2.3), depending on both infrastructure limitations and local energy profiles. While TenneT manages the national high-voltage grid, regional operators such as Liander, Stedin, and Enexis oversee the medium- and low-voltage networks. These regional systems differ in their ability to accommodate growing demand. In the northern Netherlands, congestion is often driven by high renewable generation, especially on sunny or windy days. In contrast, in more urbanised regions, congestion is primarily caused by increasing electricity demand, driven by electric vehicles, heat pumps, and electrification of households and businesses (Pató & Regulatory Assistance Project, 2024).

This growing mismatch between the speed of the energy transition and the adaptability of grid infrastructure has become a critical bottleneck for the Dutch energy system (TenneT, 2024).

2.3.3 Political and public tensions

At the same time, frustration is growing among citizens, particularly solar panel owners. The government's sudden decision to end the net metering scheme in 2027 has led to widespread public anger, leading to a mass legal claim supported by over 70,000 people (Van Helvert, 2025). Many feel that policy inconsistency undermines their investments in sustainable technologies.

This frustration is not only directed at the government. Energy companies, Vattenfall included, have introduced feed-in charges for solar owners. This has sparked feelings of distrust and resentment, with some users questioning whether energy companies are acting in their interest (VPRO, 2023).

The resulting policy tension and growing distrust extend beyond solar. Public pressure is mounting on both policymakers and energy providers to offer fair, predictable, and supportive solutions (Van Gastel, 2025). If energy companies are perceived as part of the problem, their ability to introduce new propositions, such as home batteries, may be directly undermined. At the same time, public enthusiasm for renewable energy could decline if no practical answers are provided to address users' economic concerns.

2.3.4 System decentralization and behind the meter technologies

Another defining feature of this transition is the decentralisation of energy systems. As the energy system decentralises, more technologies are emerging that operate 'behind the meter': within the household's own energy environment. Behind-the-meter systems allow users to generate their own energy, store it for later use, and manage consumption more effectively and efficiently (Spendiff-Smith, 2024). (More on these in section 3.3). These technologies operate within the household energy system, beyond the view of the grid operator, and support greater flexibility and self-sufficiency. As a result, the balance of power in the energy system is slowly shifting from centralised operators to prosumers: households that both produce and consume electricity.

2.4 System needs: decentralization, flexibility, self-consumption

What the system now requires to remain stable, affordable, and sustainable

The developments outlined in the previous section show that the Dutch electricity system is not only expanding, but fundamentally transforming. In this new system, the role of the consumer is no longer passive. The system increasingly depends on the everyday decisions and behaviours of households.

To maintain stability and efficiency, three critical system needs have emerged: decentralization, flexibility, and self-consumption. While these are often discussed in technical terms, each has direct implications for what is expected of the consumer.

2.4.1 Decentralization: from grid-centric to user-centric

As discussed in Section 2.3.4, the Dutch energy system is decentralising rapidly. It is shifting from a centrally controlled model to one that relies heavily on distributed energy resources (DERs), such as rooftop solar panels, electric vehicles, and home batteries.

This decentralisation creates both opportunity and complexity. Households become active participants in energy production and balancing, but they are rarely aware of this shift. Most users are not energy experts; they don't interact with the system beyond receiving a bill or viewing a dashboard. Yet the system's stability increasingly depends on whether these users install, use, and manage decentralized technologies in a way that aligns with broader grid needs.

2.4.2 Flexibility: a new form of participation

Flexibility refers to the ability to shift energy consumption or production in time or location. Traditionally, this role was filled by large-scale producers or industrial consumers. Now, households are expected to provide flexibility: by delaying charging, using smart devices, or drawing from stored energy during peak hours.

However, flexibility is unnatural to most users. It requires behavioural change, automation, or third-party coordination, none of which are straightforward. If consumers are to become providers of flexibility, they need clear incentives, user-friendly technologies, and a sense of trust that their participation is worthwhile and beneficial. Without this, the system's reliance on distributed flexibility risks remaining theoretical.

2.4.3 Self-consumption: from export to personal use

As net metering is phased out, the logic of household energy use is also shifting. Previously, solar panel owners could feed excess energy back into the grid for a guaranteed return. With this incentive disappearing, the system now pushes for self-consumption, encouraging users to consume the energy they generate on-site.

This is not just a financial change; it requires a different mindset and level of engagement. Users must become more aware of their energy patterns, possibly adjust their behaviour, or invest in storage solutions like home batteries. Again, this shift is happening faster than many households are prepared for, and without sufficient guidance, adoption may lag behind system needs.

Takeaways

People

Users on the sidelines

The Dutch energy system is predominantly regulated by entities and processes outside the direct influence of individual consumers. For most households, their primary (and often only) interaction with this complex system is through their energy supplier. This limited direct involvement can lead to passive attitudes, confusion, and uncertainty among consumers, especially given the complexity of the energy landscape and frequent policy changes. At the same time, the success of the energy transition increasingly hinges on active consumer participation. Households are being asked to adopt new technologies, shift consumption patterns, and become more self-sufficient in how they generate and use energy. Yet most users remain unaware of this shift in responsibility, let alone equipped to act on it. Without clear incentives, trusted guidance, or understandable messaging, behaviour is unlikely to change at the scale required.

Process

Rethinking the role of the energy provider

The regulatory framework, including the phasing out of the net-metering scheme by 2027, adds urgency for energy companies, including Vattenfall, to redefine their roles from simple energy providers towards active facilitators of flexible, decentralized solutions. In this context, it becomes critical not only to adapt internally, by aligning offerings with emerging system needs, but also to advocate for more proactive, user-centric design of their solutions.

Technology

Smart solutions, tangled system

The existing Dutch grid infrastructure faces significant challenges such as congestion and limited capacity to accommodate the rapid growth of decentralized renewable energy. Home batteries and smart storage solutions emerge as critical technologies that can help alleviate these stresses by balancing supply and demand at the household level. The expansion of behind-the-meter technologies introduces both potential and complexity: while they offer flexibility and self-sufficiency, they also challenge system visibility, making it more challenging for energy providers and grid operators to monitor, coordinate, and manage energy flows.

3. Energy on household level

While the previous chapter examined the electricity system from a macro perspective, this chapter zooms in on the household as a key site of energy use. Households are responsible for a significant share of national energy consumption, and increasingly contribute to energy production through technologies like solar panels. Yet despite their growing systemic relevance, energy remains a difficult topic within the household context.

This disconnect presents a major challenge: to design effective, user-centred energy solutions, we must first understand how energy actually flows through the rhythms of daily life. That is why this chapter introduces John, a fictional but representative Dutch homeowner. While not based on a specific individual, John reflects common patterns in energy use, routines, and household dynamics. By stepping into his home and observing his day, we can gain a more tangible understanding of when, why, and how energy is used and where opportunities lie to intervene, support, or redesign.

Based on desk research, this chapter includes a visual overview of (average) household energy data in the Netherlands, offering a peek into their homes. It outlines how energy is used throughout the day in a typical household (3.1), the financial picture of energy for households now and in 2027 (3.2), and how innovations within the home are reshaping the their role in the energy system (3.3)

3.1. Consumption patterns

Figure 3.1 Energy consumption in the house

Average consumption

Electricity

Average use per day 6,8 kWh.

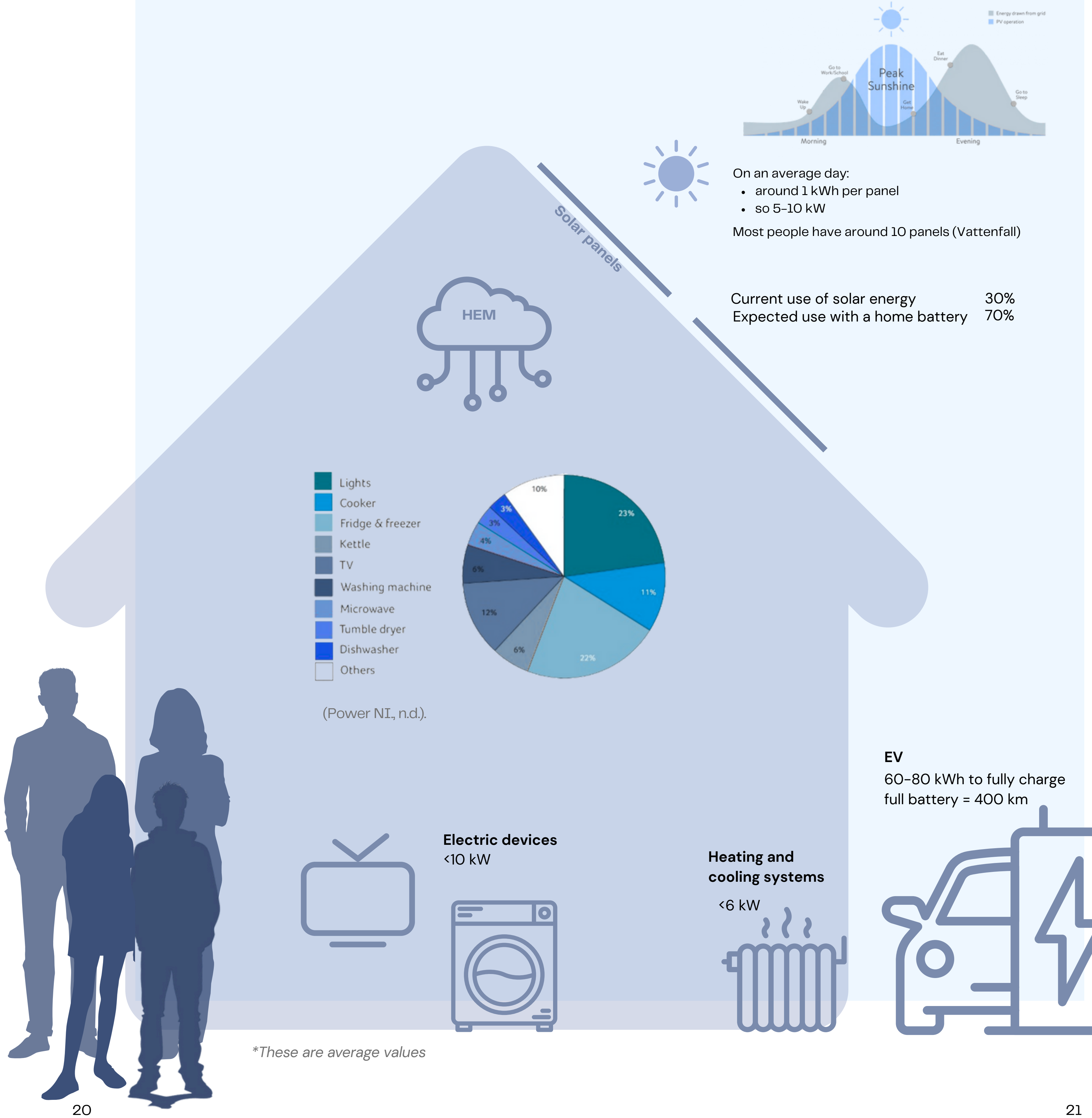
Number of people in household	Average annual consumption in kWh	Cost per month in €*
1	1,640	33.50
2	2,550	56
3	3,080	68.50
4	3,600	81.50
5 or more	3,980	90.50
Average per household	2,500	54.50

Gas

Average use per day of 3,29 m^3

Housing type	Average annual consumption in m^3	Cost per month in €*
Apartment	750	110
Terraced house	990	136
Corner house	1,160	155
Semi-detached house	1,320	172
Detached house	1,740	218
Average all homes	1,000	137

(Nibud, 2025)



3.1.1 Inside John's home

Consumption patterns vary significantly depending on lifestyle, household composition, and personal preferences, shaping both overall energy demand and the potential success of energy-saving solutions.

Typically, household energy use peaks during the morning and evening. Times that align with familiar routines like breakfast, dinner, and family activities. In contrast, solar energy generation reaches its maximum around midday when no one is home (see Figure 3.2).

However, household routines are not static. Since the COVID-19 pandemic, hybrid work has become the norm for a large share of Dutch workers. More than half now regularly work from home two to three days per week (CBS, 2024). This change subtly shifts load patterns in some homes, increasing electricity demand during daytime hours and, in some cases, bringing it closer to solar production peaks.

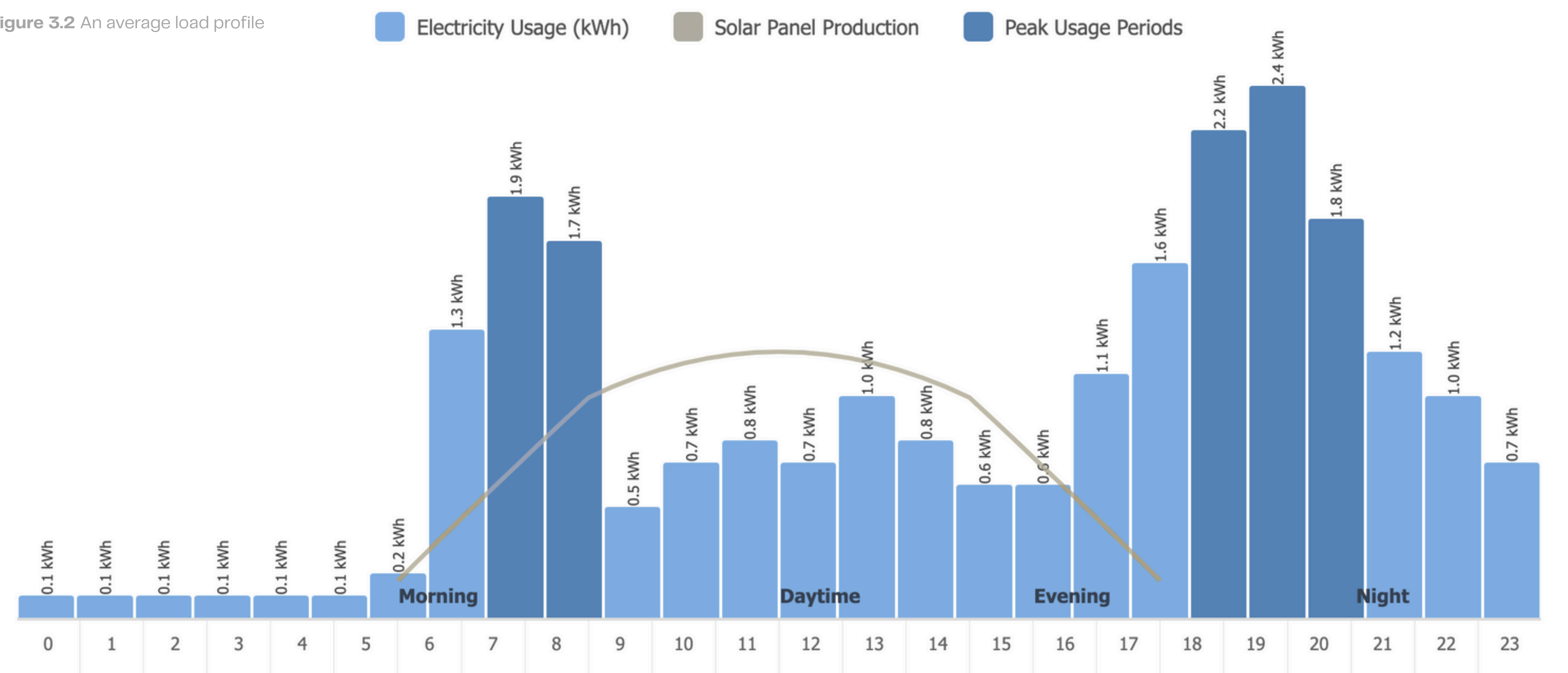
Despite these shifts, a structural misalignment between energy use and generation remains. This highlights the need for solutions that bridge the timing gap. By mapping these daily routines, it becomes possible to identify concrete moments where behaviour could shift or technology could step in.

Let's follow a typical day in the life of John and his family: The energy usage of John's household is visually mapped in Figure 3.2, illustrating how demand fluctuates throughout the day in relation to typical routines and solar production.

H! I'm John, 48 years old, and I work as a primary school teacher. I live in a mid-terrace house just outside Utrecht with my partner Sara and our two kids, who are 11 and 14.

A few years ago, we had 8 solar panels installed on our south-facing roof. Most of our appliances run on electricity now. We don't have a home battery, at least not yet.

Figure 3.2 An average load profile



Morning

John's alarm goes off at 06:30. He switches on the lights in the bedroom, hallway, and bathroom. He turns up the thermostat from 17°C to 21°C, prompting the electric heat pump to kick in. While showering, the electric boiler heats water for the whole family. Emma starts the dishwasher that was loaded the night before. Meanwhile, the kitchen bursts into life: the electric kettle boils water, the toaster and coffee machine are both in use, and the induction stove heats milk for the kids' cereal. The washing machine is started with a 1-hour quick cycle before the family leaves for school and work.

Daytime

At 08:30, the kids are off to school, and John begins his work-from-home day. He powers his laptop, an external monitor, and desk lamp. A smart speaker plays music quietly in the background. Throughout the morning, he occasionally boils water for tea and uses the kitchen appliances for a quick snack. Meanwhile, solar panels on the roof are ramping up energy production.

At 12:30, John makes lunch, using the induction hob and microwave, and briefly opens the windows for ventilation. He then resumes work for the afternoon. The sun is at its peak, and most of the solar energy generated is fed into the grid, since the household demand (though higher than on office days) is still lower than production.

Evening

By 16:00, the kids return home and switch on tablets and the TV. One of them soon heads off to hockey practice. Around 17:30, the family starts preparing dinner. The oven, stove, and extractor fan are all used simultaneously. The dishwasher is reloaded and switched on after dinner.

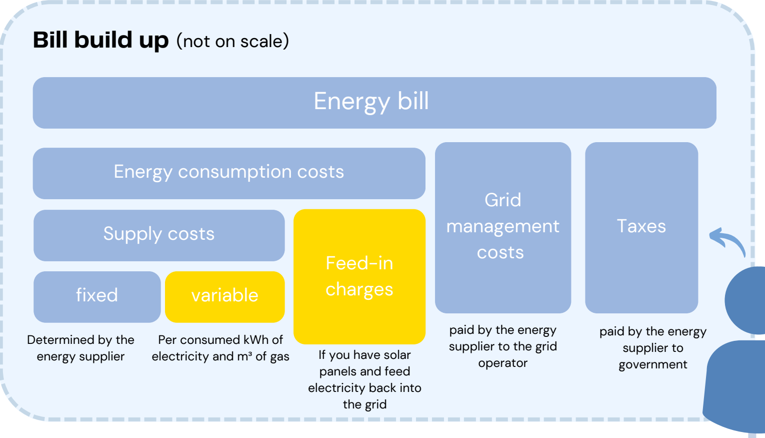
After dinner, the living room lights, television, and gaming console are in use until 20:30. Emma charges her e-bike in the shed, and John plugs in his laptop to prepare lessons. Lights are on throughout the house, the heating system is active, and various devices are charging. The household's energy demand peaks during these evening hours—well after solar production has faded.

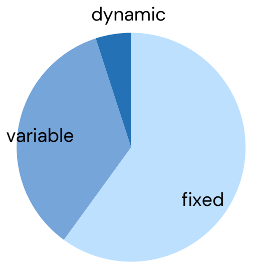
Night

Before bed, one of the kids showers after returning from hockey, triggering another cycle from the electric boiler. Some rooms are still heated as the thermostat maintains 20°C. The phone chargers are plugged in overnight. By midnight, the house returns to standby mode.

3.2 Financial perspective of households

The one thing everyone knows about energy is that it costs money. For most households like John's, the energy bill is what really matters. While sustainability may play a role, financial motivation is almost always the strongest driver, especially when it comes to adopting new technologies like a home battery (Borragán et al., 2024). John installed solar panels a few years ago and has enjoyed the benefits of the net metering scheme, which allowed him to offset his usage and save on his bill. But with the scheme ending in 2027, he's beginning to question: what impact will this have on his monthly costs?





Contract types
Netherlands
(UnitedConsumers, n.d.)

Creates **incentives** for **storage** and **smart energy use**

Self-consumption and shifting energy flows more valuable than feeding back into the grid

Now

Energy returned to the grid is **fully offse**t against energy consumed from the grid.

Example

You consume 2000 kWh from the grid.
You return 2000 kWh from your solar panels.
Result: your net usage = 0 kWh → **€0** electricity cost.

2027

Returned energy is no longer offset, but **sold back to the grid at a (lower) feed-in tariff.**

Example

You use 2000 kWh from the grid → €0.40/kWh → €800 cost
You return 2000 kWh from your solar panels → €0.10/kWh → €200 income
Result: **Even if you return the same amount you use, you still pay €600.**

BILL

€ – costs: Variable energy costs; PV feed in **charges** (...% of bill)

https://www.energievergelijk.nl/energieprijzen

Variable energy costs: +- same (Alice, 2025)

PV feed in charges: lower

€ + earnings – PV feed in **tarrif**

Maximum **earnings** = Number of solar panels × power per panel per year × 0.85* × electricity price per kWh. (Vattenfall, nd)

PV feed in tarrif: much lower

BILL

Variable energy costs
PV feed in **charges**
– € costs

PV feed in **tarrif**
– + € earnings

Differss per type of contract. The -min. 50% guarantee is until 2030

In 2027 ...

What do you earn for exported solar power?

Fixed or variable energy contract	A feed-in tariff from your supplier
Dynamic energy contract	The real-time market price at the moment you export

(Ministerie van Algemene Zaken, 2025)

Vattenfall works with fixed feed-in charges for solar panel owners. These are not per kWh, but calculated in tiers based on the total annual amount of electricity they feed back into the grid. The more they return, the higher the tier and the higher the fixed charge, regardless of when or how often you use electricity.

(Vaste Terugleverkosten Voor Zonnestroom | Vattenfall, n.d.)

Feed-in charges are expected to drop significantly but likely won't disappear. From January 1, 2027, Dutch energy suppliers may only charge consumers for the actual costs of handling returned electricity.

3.3 Energy innovations for the home

As energy systems decentralize and households become more integrated into grid dynamics, a wave of innovations is reshaping how energy is generated, managed, and consumed within the home. This section highlights key technologies that enable smarter, more autonomous, and more sustainable energy behaviour at the household level.

3.3.1 Different assets in the home

The first layer of innovation involves physical technologies that consume or convert energy within the household. A visual overview can be found in Figure 3.4.

Using heat from the environment
One of the most impactful developments is the adoption of electric heat pumps (1), which replace traditional gas boilers. These systems extract heat from the outside air (or ground) and aim to maintain a stable indoor temperature by cycling on and off throughout the day and night. While heat pumps are crucial for decarbonising heating, they significantly increase annual electricity demand, especially in colder months (CBS, 2022). Heat pump water heaters (2) operate on similar principles and are designed specifically to heat water. Both types are far more efficient than electric boilers, often delivering 3 to 4 units of heat for every 1 unit of electricity used (Heat Pump Systems, n.d.)

Using solar power
The solar electricity boiler (3), has also made its entrance into Dutch households. This appliance uses electricity generated by standard photovoltaic (PV) panels to power an electric boiler. Vattenfall now offers this solution as a way to reduce fossil gas use by heating water with self-generated solar energy (Vattenfall, n.d.). Especially for homes with solar panels, it presents a practical step towards increasing self-consumption. In doing so, it offers an alternative to the home battery as a means of maximizing solar energy use and reducing reliance on the grid. This is not to be confused with the solar water heater (4), which uses solar thermal collectors (thermische panelen) to directly heat water. These systems operate independently of electricity and represent a different technological category.

Using electricity instead of gas
Electric boilers (5) are also becoming more common, especially in fully electric homes. Where electric heat pumps work by moving heat (using a relativley small amount of electrcity), electric boilers convert electricty to heat. While some are conFigured to operate during off-peak hours, most still function independently of broader system needs, instead following internal logic to maintain water temperature, often in response to recent usage or heat losses.

In the kitchen, gas stoves are being replaced by induction cooktops (6) and electric ovens (7), which modestly increase electricity demand during usual times of cooking

Charging car at home.
Electric vehicles (EVs) introduce the most substantial shift in household electricity demand. Charging an EV adds substantial load to the household, often during evening hours when solar generation is no longer available. While some households delay charging to benefit from lower nighttime tariffs, unmanaged charging can strain both local infrastructure and household costs. Smart charging systems and coordination with solar generation or battery storage present opportunities for optimization.

Figure 3.4 Different home energy assets

3.3.2 Smart systems and control layers

The second layer of innovation involves the systems that monitor, coordinate, and optimize how energy is used.

Smart meters have become increasingly common in Dutch households. These digital meters track electricity and gas use in real time and can share this data with energy suppliers automatically. Many models include a P1 port, which allows households to connect devices that provide live consumption insights.

Complementing this, smart plugs help monitor and control individual appliances via an app. While not all households use these tools yet, together, they offer an accessible way to start managing their energy consumption more actively.

However, these meters are only the starting point. For more intelligent coordination, Home Energy Management Systems (HEMS) are increasingly being introduced. These platforms connect various appliances and systems, such as thermostats, EV chargers, and boilers, and can automate their operation based on real-time data, user preferences, or external price signals.

Advanced HEMS solutions go beyond simple scheduling. They integrate with weather forecasts, user routines, and tariff structures to determine when to consume, store, or export energy. In doing so, they help households optimize their self-consumption and reduce peak loads. Some systems rely on artificial intelligence to detect patterns over time, offering suggestions or taking automated action to improve energy efficiency.

These developments reflect a broader shift toward smarter, more integrated energy homes, especially when combined with solar panels. How these assets interact with home batteries and contribute to smart storage solutions is explored in more detail in Chapter 6.

Takeaways

People

The gap between system and routine

Households are at the frontline of the energy transition, but their involvement is often shaped by limited understanding and practical concerns. Most consumers, like John, do not think in kilowatt-hours or grid balancing; they think in terms of routines, costs, and convenience. Energy behaviour is highly personal and influenced by family patterns and everyday habits. With the monthly bill as their primary point of contact with the energy system, financial motivations typically outweigh sustainability goals. At the same time, households are being asked to take on more active roles: managing consumption, adopting new technologies, and aligning their behaviour with the broader system. This reveals a clear misalignment between system expectations and the lived experience of users. The story of John shows that meaningful interventions must align with real routines and motivations to succeed.

Process

From supplier to smart living partner

From a business perspective, the energy transition is shifting responsibility downstream: from centralized providers to everyday users. This presents a strategic opening. With decreasing relevance of traditional supply models, there is a growing need to redefine the customer relationship and develop new value propositions.This calls for a shift from transactional to service-oriented thinking: guiding customers through change, bundling energy with tools and insights, and offering personalized journeys. The opportunity lies in becoming not just an energy supplier, but a partner in smarter living.

Technology

Unlocking potential behind the meter

A new generation of household technologies is emerging which holds strong technical potential. Together, these assets are reshaping how energy is used, stored, and understood within the home. It can smooth out the mismatch between solar production and household demand, increase self-consumption, and reduce pressure on the grid. But technology alone isn't enough. As long as the value remains unclear or abstract, households will hesitate. Managing energy can then seem complex and something families like John's will stay away from. To move from potential to adoption, reframing is needed from a technical object to a smart, supportive tool that fits seamlessly into daily life

4. Energy on user level

The transition towards a sustainable energy system in the Netherlands necessitates a deep understanding of energy behaviour at the individual user level. As outlined in Chapter 2, the Dutch energy system is undergoing significant changes, moving towards decentralization and increased reliance on renewable energy sources. This shift, coupled with the household energy dynamics discussed in Chapter 3, creates a foundation to explore how users themselves think, feel, and act in relation to energy. This chapter completes the zoom-in by focusing on the individual user

Based on literature and desk research, this chapter outlines how energy is experienced (4.1), how energy behaviour is shaped and which emerging trends will influence this (4.2), what models explain this behaviour (4.3) and how energy-related decisions are made (4.4).

4.1 Energy experience and perception

How people experience and make sense of energy

4.1.1 The invisibility of energy

Research highlights that most households experience energy as invisible and abstract, which presents a fundamental barrier to behavioural change. Unlike tangible goods, the flow of electricity is not directly observable, making it difficult for users to develop an intuitive understanding of their consumption patterns in real time (Rilling & Herbes, 2022). This lack of tangibility leads to a disconnect between energy-consuming actions and their consequences, which in turn hinders efforts toward efficiency or adoption of new technologies. As Lutzenhiser (1993) noted, "people don't buy energy, they buy services like a hot bath or dinner," underscoring that energy itself remains largely invisible to its users. This invisibility makes it harder to consciously manage energy use, since consumption decisions are typically not guided by immediate feedback or physical cues.

4.1.2 Seeing energy through the bill and missing the rest

Beyond energy's physical invisibility, its financial visibility is also limited. For most Dutch households, the monthly energy bill is the only tangible touchpoint they have with their energy use (Kaufmann et al., 2023). Yet even this touchpoint is often concealed within the broader household budget, bundled with mortgage payments, or automated bank transfers.

As a result, many individuals are only vaguely aware of how much energy costs, let alone how specific behaviours (e.g. long showers, heating patterns, appliance use) translate into financial outcomes. This lack of transparency reduces perceived control over energy use.

4.1.3 Energy as a commodity: taken for granted until crisis hits

Furthermore, in the Netherlands, energy is predominantly perceived as a commodity: a basic utility that is taken for granted until disrupted by a bill or a blackout (Paukstadt & Becker, 2021). This commodified view results in low levels of day-to-day engagement. Most households remain largely unaware of the infrastructure and processes behind generation, distribution, and pricing. As long as energy flows reliably, it tends to fade into the background of everyday life.

However, recent power outages across parts of Europe have triggered a growing awareness of just how dependent daily life is on uninterrupted energy supply (Kassam et al., 2025). Or take the Dutch energy crisis of 2022 for example, where the Dutch government introduced emergency measures such as price caps and energy allowances to protect consumers from unaffordable bills (CBS, 2024). These events exposed the significant influence of external forces on energy affordability and led to more public awareness. In some cases, these disruptions sparked a broader conversation about the need for greater energy independence and resilience.

In short, energy is often ignored as long as it is affordable and available. Only in moments of scarcity or price volatility does it briefly emerge as a visible concern.

4.1.4 Energy complexity: a barrier to engagement

Perceived complexity and inaccessible terminology further complicate the public's relationship with energy. Technical jargon, such as kilowatt-hours, tariffs, and meter readings, can alienate those without technical backgrounds. Surveys of Dutch households reveal low levels of energy literacy: many consumers struggle to understand their bills or the units used (Brounen, Kok, & Quigley, 2013).

Education plays a significant role in this. Individuals with higher education or technical training tend to show greater energy affinity, are more comfortable with topics like smart grids or solar panels, and are more likely to adopt new energy technologies (Alipour et al., 2022). In contrast, less-educated or less-engaged groups often perceive energy systems as overly complex or "not for them," which reinforces the invisibility of energy in daily life.

This issue is becoming more pressing as new technologies, such as heat pumps or EV charging stations, are increasingly integrated into the home. Despite this shift, awareness and understanding of home energy management systems (HEMS) remains low. This gap in comprehension presents a major barrier to behavioural change: individuals cannot effectively manage what they do not fully grasp.

4.1.5 Energy use: managed by one, lived by all

Another important social aspect is that energy use decisions in households are often handled by a single member. Traditionally, one adult (historically, often the male head of household) takes charge of paying energy bills, managing the thermostat, and deciding on energy investments (Van Dam, 2013). Energy initiatives long treated the homeowner as a single decision-maker, overlooking the fact that energy choices take place as a family.

Recent research on family decision-making shows that this dynamic is changing. Decisions are becoming more democratic, with women and even children increasingly involved in discussions about energy use and home improvements (Bartiaux, 2022). Still, in many homes, one person remains the default "energy manager," which can lead to uneven energy awareness. If only one household member actively monitors the energy bill, other members may remain relatively unaware of their consumption patterns. This division of responsibility means variation in energy affinity often aligns with roles: the person tasked with managing energy (regardless of gender) develops higher interest and knowledge, while others treat energy as "out of sight, out of mind." Overall, there is a need to make energy more visible, understandable, and relevant to all consumers in the household.

4.2 Understanding energy behaviour

How people act in relation to energy use

4.2.1 The problem of delayed feedback

A key challenge in changing household energy behaviour is the absence of timely and meaningful feedback (Matsumoto et al., 2022).

As noted in section 4.1.2, the monthly bill is often the only tangible signal consumers receive, but it arrives too late, to meaningfully guide day-to-day decisions. Most people struggle to link routine actions (like taking a long shower or using multiple appliances) with their actual energy impact. Without this connection, energy use remains a passive activity, shaped more by habit than by intention.

While energy apps and online dashboards now provide more immediate access to consumption data, they often function as passive insight tools. Many consumers either do not regularly check them or lack the contextual understanding to interpret what the numbers mean. Without prompts or actionable guidance, this form of feedback tends to remain in the background: available, but not effectively used to inform daily decisions.

In contrast, real-time or immediate feedback significantly improves this connection: when households get instant read-outs or daily updates, they can more easily associate turning off an appliance with a visible drop in consumption (Boomsma et al., 2025).

4.2.2 The role of habits and routines

In the absence of clear feedback or external stimulation, habit becomes the dominant force in energy use. Habits are a powerful, yet often overlooked, determinant of energy behaviour (Webb et al., 2021). Many daily energy-related actions are guided by habit rather than active decision-making. Households develop routines (morning heating schedules, nightly appliance use, how long to shower) that become automatic. These routines often run on autopilot. Once formed, these habits often override conscious intentions, making it difficult to change behaviour even when people are motivated to do so.

Recognizing the automatic nature of much domestic energy use is crucial when designing behavioural strategies: behaviour change remains unlikely unless routines are disrupted, or new behaviours are made easier than the old ones.

4.2.3 Behaviour needed: peak shifting and shaving

Against this behavioural backdrop, new forms of energy engagement like peak shifting and peak shaving are becoming increasingly important (Silva et al., 2020). As the energy system transitions to more decentralised and renewable sources, household energy use needs to become more responsive and flexible, as briefly touched upon in section 2.4.

Peak shifting refers to changing the timing of energy-intensive activities, such as running a washing machine or charging an electric vehicle, from peak hours (typically mornings and evenings) to off-peak periods. Peak shaving, on the other hand, involves reducing overall demand during these peak windows, for example by using less heating or stopping appliance use altogether.

However, these behaviours often conflict with existing routines. Both demand a higher level of awareness, timing, and effort than most households currently apply to energy. In a context where behaviour is shaped by habit and masked by delayed feedback, this presents a challenge: how do we ask people to act more intentionally, when their energy use has long been automated and invisible?

4.2.4 The influence of future energy trends on behaviour

As the energy system evolves, new technological and societal developments are creating conditions that may help unlock behavioural change.

In the Netherlands, public concern for climate change is high, and sustainable behaviours, such as saving energy or reducing waste, are increasingly seen as social norms (NN, 2022). This growing alignment between values and action creates momentum for behavioural change. At the same time, technological innovation is giving households new tools to act. Smart technologies like home energy management systems (HEMS) and AI-driven appliances are becoming more common, allowing consumers to automate and optimise their energy use with minimal effort. As such, they represent a new form of guidance, less reliant on willpower, more embedded in everyday systems.

Research by the AMS Institute shows this potential clearly: combining smart technology with a personal energy coach halved household energy bills. As the study concludes, "a personal energy coach makes all the difference." (Fabrique, n.d.). This underscores that technology works best when it not only automates, but also actively supports and informs users.

Still, automation alone cannot deliver meaningful change. While smart systems can optimise energy use in the background, they cannot replace the active role of the user. The risk lies in treating these technologies as fully automatic solutions, leading to the so-called 'black box effect': where users disengage because they no longer understand or interact with the system (Kosinski, 2025).

The real potential lies in using technology to guide behaviour more intelligently: not by removing the user, but by making energy decisions easier, more timely, and more intuitive. In this way, smart systems can support, not replace, more deliberate, informed energy behaviour. The challenge now is to design systems and interventions that support this shift without disempowering users or letting behaviour disappear behind automation.

4.3 relevant behaviour models

behavioural models were tailored to the selected part of the customer journey and are described in detail in chapter 18

4.4 Decision-Making processes related to energy

To understand how Dutch households make energy-related decisions, researchers have looked closely at solar photovoltaic (PV) adoption as a case study. While various energy technologies are emerging, PV has reached mainstream acceptance in the Netherlands and offers a rich dataset of behavioural patterns, motivators, and barriers.

4.4.1 Financial drivers: the dominant motivation

As explained in 3.2, economic considerations are paramount. Studies in both Germany and the Netherlands found that economic feasibility is one of the major factors determining whether households go solar (or refrain from it) (Borragán et al., 2024 & Agnew et al., 2016). Upfront costs, expected payback time, and subsidies (like the Dutch net metering "salderingsregeling") heavily influence the decision. Most Dutch homeowners are primarily motivated by the potential to reduce their electricity bills.

The framing of PV as a "smart financial choice", with payback periods often under ten years, was central to its uptake. It has shaped consumer expectations around new energy technologies in general. Many now evaluate new energy innovations using similar mental models: What are the costs? What is the return on investment? (Alipour et al., 2022). However, this financial lens may not always align neatly with other emerging technologies like a home battery, which often have more complex benefits or less straightforward payback structures.

4.4.2 Beyond the bill: other motivations

While less dominant, there are also non-financial factors that influence decision-making. Many PV adopters were driven by sustainability values, a desire for energy independence, or the feeling of being "future-proof." These more value-based motivations often complemented the financial rationale (Alipour et al., 2022).

4.4.3 The role of social influence and visibility

Not all energy decisions are driven by financial considerations alone. Social influence and norms also play a significant role. In the case of PV adoption, these effects are particularly strong. Solar panels are highly visible, and their presence on rooftops sends a clear signal to neighbours. Studies have shown that PV adoption tends to cluster locally, with one household's decision often prompting others nearby to follow (Zhang et al., 2023). This effect is partly driven by peer visibility, word-of-mouth, and informal comparison, which together turn solar into a social norm: "everyone is getting panels, we should too."

However, this mechanism may work differently for home batteries. Unlike PV, HB systems are (most of the time) not outwardly visible and do not signal behaviour to others in the same way. As McCarthy and Liu (2024) and Borragán et al. (2024) suggest, this makes HB adoption less influenced by public visibility, status, or environmental signalling. Instead, social influence in the context of HB is likely to operate through interpersonal channels. Adoption may depend more on peer conversations and shared experiences.

4.4.4 Timing and life events

Energy decisions are often triggered by life events or transitions, such as moving house, renovating, or responding to high energy bills. These moments break routine and open space for reconsidering energy choices (Haefner et al., 2024).

In the Dutch context, solar PV adoption has frequently occurred during such transitions (Pieloor, 2022). A new roof or a major home improvement project presents both the technical opportunity and the mental readiness to act. These life events act as natural decision points that lower barriers and increase receptiveness to change.

Takeaways

People

Designing for what people can't see

Households do not experience energy as one coherent topic. It's invisible, abstract, and laced with difficult terminology. You receive an energy bill at the end of the month, pay it, and move on. And why think about it? It's always there, right?

This creates a passive, reactive relationship. Energy use is guided by habits, not choices. People don't associate everyday actions (long showers, running appliances) with real-time consequences. So how can we expect their behaviour to change? Most users do not proactively think about their energy use unless prompted by a bill, blackout, or a life event.

And while everyone contributes to energy use, energy decisions are concentrated in the hands of one individual. This uneven distribution of responsibility creates blind spots: not everyone in the household is involved, but everyone contributes to the outcome. This makes behavioural change even harder, because no one feels fully responsible.

At the same time, the energy system increasingly expects different behaviour from users. Peak shifting and peak shaving are becoming essential. But these actions require intention, timing, and effort; exactly what most households lack in their current relationship with energy. The gap between what's needed and how people actually behave is growing.

Process

After solar – raising the bar for behaviour

If we look from the point of view of Vattenfall, the challenge is clear: the success of smart energy solutions doesn't just depend on technology. It depends on people doing something differently. And that's where things get messy. Most households don't actively manage energy. They follow patterns. Turn on the lights. Heat the house. Run appliances. It's routine. Invisible. Automated.

For Vattenfall, introducing new smart propositions means designing around that behavioural baseline, not against it. And that starts with facing the shadow cast by solar PV. Solar panels changed the game: they were visible, tangible, and made financial sense. People didn't have to do much, just install and save. That set the bar. Now, newer behaviours like peak shifting and peak shaving ask more. More attention, more effort and a less obvious payoff.

The reality is that, if the energy transition relies on smarter behaviour, then that has to be the focus of the proposition. When behaviour is the bottleneck, strategy has to start at the level of routine that shapes everyday energy use, not the level of policy or technology.

Technology

Behavioural design is not an add-on

The chapter reveals a paradox at the heart of energy technology: while innovations like smart meters, home energy management systems (HEMS), and AI-driven appliances promise to simplify energy use, they often risk deepening user disengagement. This is the "black box" effect, where automation limits understanding, and users become passive participants in their own energy systems.

behavioural design sits at the core of this challenge. Several behavioural models can offer design guidance: UTAUT2 and TPB emphasize ease of use and perceived control, while Nudge Theory and the EAST framework highlight the power of subtle, timely cues to steer behaviour.

The opportunity lies in designing for guided autonomy: systems that support users in making better energy decisions without overwhelming them. Moreover, technology must be inclusive. Energy remains a complex, abstract topic for many users, often made harder by technical language and low energy literacy.

Strategic design must bridge this gap by making energy technology not just smart, but human-centered. Because the success of the energy transition depends not just on what technology can do, but on what people are able and willing to do with it.

5. Bridging context and opportunity: the case for residential storage

The Dutch energy system is at a tipping point. The grid is under pressure, strained by rising electricity demand and a surge in decentralised solar generation. Solar panels are everywhere, yet much of the energy they produce is fed back into an already congested grid, often when it's least needed.

So far, households have played a passive role. Energy is invisible, complex, and abstract. Most people only engage with it through their monthly bill. Their behaviour is habitual, financially driven, and rarely aligned with solar production. But that's about to change.

With the end of net metering in 2027, the rules of the game are shifting. Suddenly, the energy bill, the one thing people do care about, is back in focus. For households like John's, storing energy will no longer be optional. It will be essential to keep costs down and make the most of their solar investment.

The question is no longer whether households will adapt, but how.

In light of this shift, this project focuses on residential energy storage, specifically the home battery, as a high-impact opportunity to support smarter household energy use. While not the only possible intervention, the home battery provides a tangible, near-term solution for enhancing self-consumption and household flexibility. It forms the strategic foundation for the design work in this thesis.

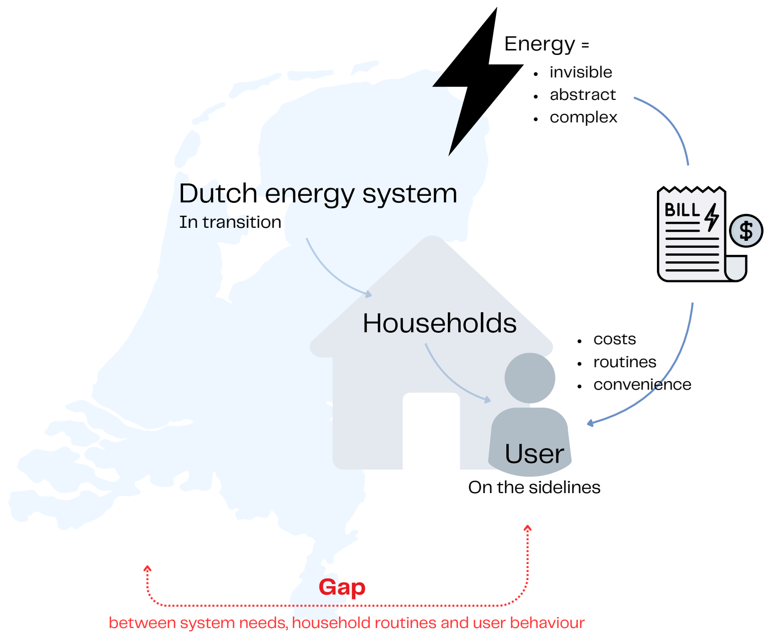


Figure 5.1 The gap between users and the system

Home batteries are no longer a futuristic luxury. They are the missing link between household potential and system stability. They store excess solar power, reduce grid strain, and give users control over when and how they use energy.

But technology alone won't solve the problem. Batteries enable smarter, more flexible living, but they also require a shift in behaviour. The home battery is not just a device, it's a doorway to a new kind of energy relationship. As homes fill with heat pumps, electric vehicles, and smart meters, energy is becoming more complex than ever. What was once a passive utility is now a dynamic system of generation, storage, and optimization. But John doesn't want complexity. That's why the real challenge isn't just building smarter technologies, it's about helping users save money and use energy more wisely, without requiring them to think about it. To move from potential to practice, the home battery must be reframed: not as a technical object, but as a smart, supportive tool that fits seamlessly into daily life.

The opportunity is clear. The timing is right. The challenge now is to make the case compelling and to make the transition easy.

6. The smart storage proposition

Building on Chapter 5, the home battery now takes center stage as the practical link between household behaviour and system needs. That's why it is important to have a good understanding of the smart storage proposition.

As the system changes and net metering phases out, households are increasingly expected to store and manage their own energy. But for most, this shift raises more questions than answers. John has started hearing more about home batteries, but he's not quite sure what they do or whether they're worth it. As the energy landscape around him shifts, he's looking for clarity. What exactly is a smart storage solution? How does it fit with his solar panels? And could it help him save more, or worry less?

This chapter explores the smart storage proposition through a more technical lens. It examines how the home battery works, what value it offers, and how that value depends on the way it's used. In doing so, it explores what it could mean for households like John's.

Drawing from expert interviews, internal conversations, and desk research, this chapter first explains the technical functioning of the battery (6.1), then defines its value proposition (6.2), outlines distinct use cases (6.3), and considers alternative models such as collective storage and electric vehicles (6.4).

6.1 What is a home battery and how does it work?

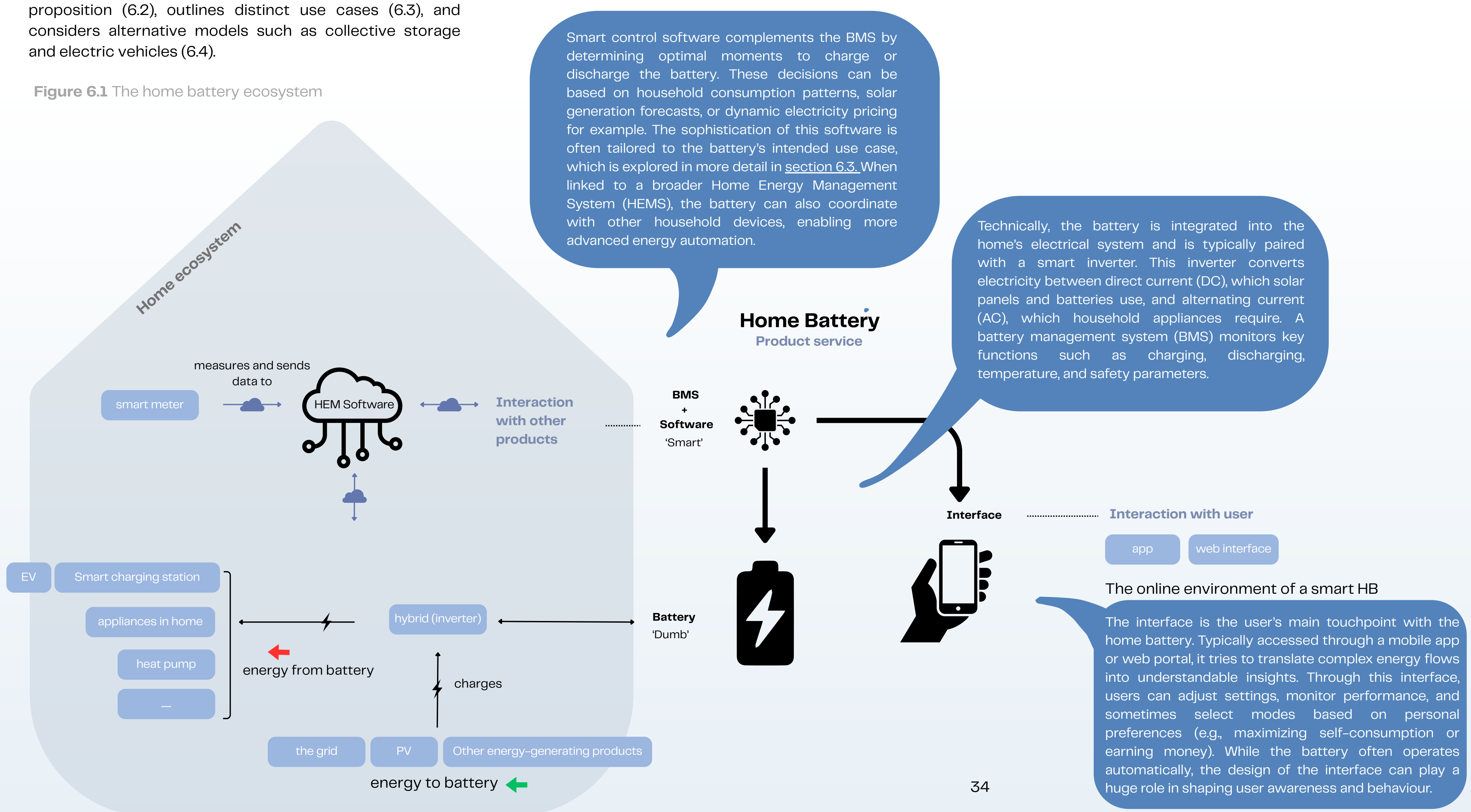
6.1.1 What is it

In short, a home battery allows you to store electricity for later use. This energy can come from your own generation sources, such as solar panels, or be drawn from the electricity grid. Once stored, the energy is temporarily taken out of the grid circulation. It can later be used to power appliances in your home, or fed back into the grid. This form of short cycle energy storage helps households make more efficient and flexible use of electricity.

As illustrated in Figure 6.1, the battery is build up of three key pillars that underpin its functionality: the battery device, its internal control system (Battery Management System and smart software), and the user interface through which households interact with it. These pillars structure the explanation.

6.1.2 How does it work

Figure 6.1 The home battery ecosystem



6.2 Defining the value proposition

Beyond the technical workings of a home battery, it is more relevant in the context of this thesis to explore the value it creates for the end user. After all, adoption depends less on technical specifications and more on whether the solution genuinely fits into daily routines and addresses real-life challenges. To systematically define this value, the Value Proposition Canvas (Osterwalder et al., 2014) is used. By bridging what users care about with what the battery can offer, the canvas provides a structured way to assess product-market fit from the user's point of view.

6.2.1 Key value drivers

The value proposition of a home battery system is composed of various factors that can be categorized into product, system, and service levels.

The factors that I can influence within the scope of this project are marked .

Product level — *average value*

- Product lifetime — *15y+*
- **Product costs** — *2k-10k*
- Warranty — *10y*
- Efficiency — *min. 80% per 10y*
- Installation costs — *x*
- **Payback time** — *?*
- **Size** — *2 moving boxes*
- Capacity — *5-20 kWh*
- Type of battery — *Lithium-ion*
- Safety features — *x*

System level

- Compatibility with other systems
- Software
- Online environment
- Maintenance requirements

Service level

- Pricing Model
- Lead process
- Installation process
- Customer service
- Battery recycling/end-of-life process

- Brand reputation and trust
- experiences from others

6.2.1 Intended value proposition

This section focuses on the intended gain creators and pain relievers of the concept. For the full value proposition canvas, see Appendix E.

Gain creators

- **Optimizes** use of **solar** power throughout the day
- Enables energy use during peak-price hours **without** drawing from the **grid**
- Increases **autonomy** and **resilience** (e.g., backup during outages in some cases)
- Enhances **sustainability profile** of the household
- For **dynamic** contracts: ability to charge during low-price hours and **avoid high-price peaks**.

Pain relievers

- Stores excess solar energy to **avoid low feed-in tariffs**
- Provides visible **insights** into energy flows
- Offers **automation** (in some systems) to reduce need for user action
- In very specific cases, **VAT return** is possible

6.2.3 The proposition in real life

To ground the concept of a home battery in everyday reality, this section illustrates what a it can power and what it can save.

Powering the everyday
To make the workings of a home battery more tangible, visual 6.2 illustrates what 1 kWh of home battery can actually power in daily life. The examples are based on average energy consumption Figures, though the exact duration will always depend on the specific device and household situation.

How much does a battery save you?
To give a rough idea of the financial impact, let's walk through a simplified calculation based on publicly available Figures (partially adapted from Accuselect (Accuselect, n.d.))

Suppose a household installs a GivEnergy single-phase battery with a 9.5 kWh capacity, costing around €5,500 (excl. VAT). The household has solar panels and a fixed energy contract with Vattenfall, paying €0.2919 per kWh for grid electricity (Overstappen.nl, 2025).

Currently, an average household uses about 30% of its solar energy directly and exports the remaining 70% to the grid. With a home battery, self-consumption can increase to around 70%, (van Gastel, 2025).

On sunny days, the battery can be fully charged with self-generated solar energy. But in winter or on cloudy days, solar generation is lower, and the battery is not always fully used. A realistic yearly average is that the battery delivers about 7.4 kWh of usable energy per day. That adds up to roughly 2,700 kWh per year that the household can use directly instead of feeding it into the grid.

Without a battery, they use 30% of that energy directly (810 kWh) and export the remaining 1,890 kWh. With a home battery, self-consumption increases to 70%, meaning the household now uses 1,890 kWh directly and only exports 810 kWh. That's a gain of 1,080 kWh of self-consumed energy per year, enabled by the battery.

- If exported: 1,080 kWh × €0.10 = €108 earned
- If stored and used: 1,080 kWh × €0.2919 = €315 saved

Net gain of storing vs. selling?
≈ **€207 per year**

Figure 6.2 Making battery power tangible

Of course, the real-life value goes beyond savings alone. Households gain more control over their energy use, reduce their dependence on fluctuating grid prices, and take a step toward future flexibility and self-sufficiency.

**Based on a projected post-2027 feed-in tariff of €0.10 per kWh after the stop of net metering. For calculations, see Appendix E*

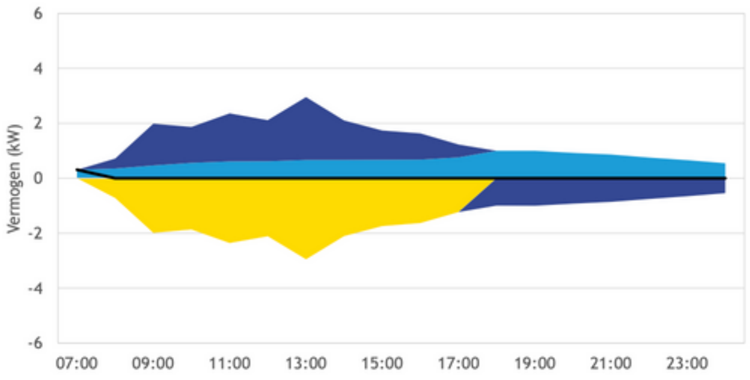
***This calculation assumes ideal conditions: perfect battery efficiency, no energy loss, and no degradation over time. In reality, batteries lose some capacity each year, charging cycles aren't always full, and inverter losses occur. But even with those factors, the long-term financial logic of self-consumption remains strong.*

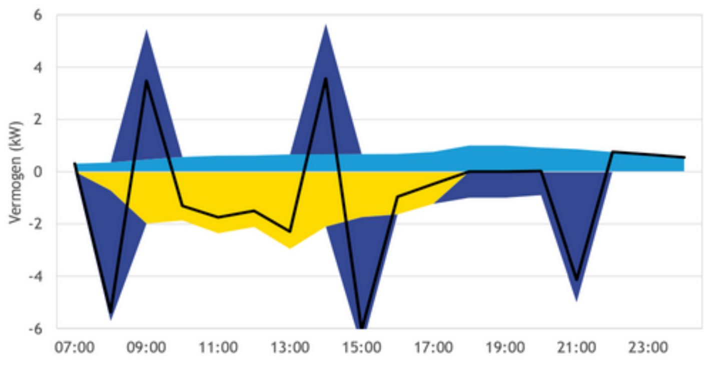
6.3 The different use cases

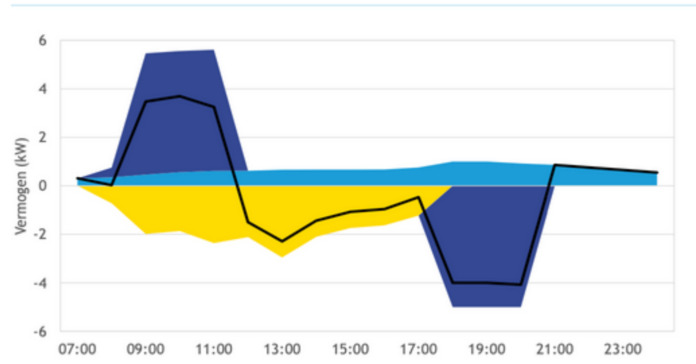
In practice, a home battery can be used in several ways, each unlocking different types of value depending on the household's goals, energy contract, and local grid conditions. They can be broadly divided into two types: self-consumption and energy trading.

Smart battery software can combine multiple use cases (such as self-consumption, trading on the energy market, and participation in the imbalance or congestion market) by automatically prioritising based on price signals and grid conditions. However, peer-to-peer trading and VPP participation often cannot be combined, as they require exclusive control by different platforms or aggregators. Each use case directly influences the financial return of the battery, as it determines when and how stored energy is used or sold, making the business case highly dependent on the chosen application.

The following overview maps out all the possible use cases, along with their technical requirements and associated benefits, each viewed from the perspective of the household user.







Corresponding load profiles

Legend

- = household
- = battery
- = sun
- = usage (+) and feed in (-) from grid

(CE Delft, 2023)

1 - Self-consumption
Storing and using your own generated electricity

How does it work?
You store your self-generated solar energy so it can be used later.

What are the benefits?
- You avoid feeding back 'low-value' electricity
- You become less dependent on the grid

What are the requirements?
- You have solar panels
- This works with a fixed, variable, or dynamic contract

Household level — Saving

2- Trading on the EPEX market
Profiting from fluctuating energy prices

How does it work?
- Your battery charges or discharges based on **energy prices** announced the **day before** on the EPEX market
- You charge when electricity is cheap and discharge (sell/use) when it's expensive

What are the benefits?
- You can lower your energy bill and potentially earn from price differences

What are the requirements?
- Solar panels are not required, but can help you charge for free
- You need a dynamic energy contract

National level - **Individual** energy trading — Actively earning

3- Trading on the imbalance market
Earning by contributing to grid stability

How does it work?
- Your battery charges/discharges based on **real-time** electricity supply
- It is smartly controlled to charge during oversupply and discharge during shortages. This helps keep the grid balanced. You receive a financial reward for this service.

What are the benefits?
- You earn compensation for helping to stabilize the electricity grid

What are the requirements?
- Solar panels are not required, but can support additional storage
- Works with a fixed, variable, or dynamic contract
- Participation via an aggregator or VPP (see usecase 5) is required

*Only a few energy suppliers offer this option.

National level - **Collective** energy trading — Passive earning

4- Trading on the congestion market
Earning by making your battery available to the grid

How does it work?
- In areas where the grid is full, your battery can help by temporarily storing or supplying energy to the grid.
- You receive financial compensation from the grid operator for providing this service.

What are the benefits?
- You earn compensation for helping to reduce local grid congestion

What are the requirements?
- Solar panels are not required, but may help optimize savings
- Works with a fixed, variable, or dynamic contract
- You must **live in a congested area** where grid operators offer these services

Regional level - **Individual** energy trading — Passive earning

5- Participating in a Virtual Power Plant (VPP)
Earning by connecting your battery to a collective system

VPP = a network of home batteries and other energy sources that are collectively managed as if they were one large power plant.

How does it work?
- Your battery becomes part of a Virtual Power Plant (VPP), which trades smartly on the imbalance or congestion market.
- You receive compensation without needing to act yourself.

What are the benefits?
- You receive a fee for participating in the VPP.

What are the requirements?
- Solar panels are not required, but can offer additional benefits
- Works with a fixed, variable, or dynamic contract
- You must be connected to a VPP

Regional/national level - **Collective** energy trading — Passive earning

6- Peer-to-Peer Trading

Selling your solar energy directly to other consumers, without a traditional energy supplier

How does it work?
You sell your surplus solar energy to other consumers via a P2P platform, instead of feeding it back into the grid.

What are the benefits?
- You receive a higher price for your electricity than you would by feeding it into the grid.

What are the requirements?
- You have solar panels
- Works with a fixed, variable, or dynamic contract
- You must be connected to a peer-to-peer platform

Regional/national level - **Direct** energy trading — Actively earning

Usecase

Market outlook

Is the most accessible and stable use case. It reduces household dependence on the grid and protects users from rising electricity prices. Its value will significantly increase once the Dutch net metering scheme is phased out by 2027, making it financially beneficial to consume self-generated energy rather than feed it into the grid.

The scope of this project will be limited to the usecase of self-consumption
For further justification of this choice, See Appendix III

Although the imbalance market currently offers the highest returns, its long-term potential is limited. As the market matures, rewards decrease. CE Delft (2023) predicts saturation at 100,000 connected batteries. An approaching threshold, with over 40,000 already installed (Dutch New Energy Research & Solar365, 2024). As competition grows and margins shrink, this use case may become less appealing for individual users.

Trading on spot prices (e.g. EPEX) offers more dynamic opportunities, allowing users to profit from fluctuations by buying low and using or selling high. However, price differences are hard to predict, influenced by factors like weather variability and changing grid flexibility. While price peaks may rise with more renewables, increased system flexibility could smooth them out. For now, this use case suits early adopters or businesses with advanced energy management and automation tools.

As discussed earlier, grid congestion is already becoming a significant issue in parts off the Netherlands. Grid congestion is expected to worsen in certain areas before grid reinforcements are completed (TenneT TSO B.V., 2025). This will likely increase the value of local flexibility provided by home batteries. Grid operators may implement more specific tariffs or incentives for batteries that can help manage congestion, making this market increasingly attractive for users in relevant locations.

Use cases 5 and 6 represent futuristic and emerging concepts in the Dutch energy market. VPPs are still in their early stages, with limited implementation and uncertain income potential for participants. While VPPs offer the opportunity to contribute to grid stability and potentially generate revenue by trading stored energy, the predictability of earnings remains uncertain as the market evolves.

The Netherlands has been at the forefront of P2P energy trading, implementing supportive policies and pilot projects (source). However, platforms like EnergySwap are still in their pilot phases and not yet available on a large scale.

These developments present promising opportunities for the future, but both VPPs and P2P trading face regulatory hurdles and need to mature before they can fully disrupt the traditional energy market. Therefore they are not the focus of this project

6.4 Alternative smart storage propositions

6.4.1 Collective storage models

A neighbourhood battery is a shared storage system for local households, aimed at balancing local supply and demand. By sharing infrastructure, they could reduce individual investment costs and help communities become more energy independent. While it seems promising due to potential scale advantages, its financial viability is limited.

There is currently no viable business model for storing and resupplying local solar surpluses via a neighbourhood battery. This is due to energy taxes and grid fees incurred when transporting electricity to and from a battery that is not behind the same meter as the generating panels (CE Delft & Witteveen+Bos, 2023).

This makes them highly dependent on regulation, and currently unprofitable under existing tax structures. From a design and implementation perspective, this makes the concept fragile and risky.

6.4.2 Electric vehicles as storage

V2G technology allows electric vehicles to not only charge, but also discharge electricity back to the grid. In theory, this could unlock 14 to 63 GWh of flexible storage capacity by 2030, helping to flatten peak demand, ease grid congestion, and reduce CO_2 emissions (Dutch New Energy Research & Solar365, 2024).

However, its success depends entirely on mass adoption: enough bidirectional EVs, (public) V2G charging points, and favorable regulation. These factors are largely outside the control of individual energy providers. Meanwhile, the home battery market is already taking off. Dutch New Energy Research shows that home battery sales are rising rapidly, despite a still-limited business case. This trend suggests that many households will commit to their own battery first, reducing the likelihood they will later opt into a shared V2G system.

From a design perspective, V2G represents a high-potential but fragile system, one that only works if enough people adopt it at the same time. In contrast, the home battery offers an individual solution that aligns better with current consumer behaviour and market developments.

Takeaways

People

Not here to trade, just to save

For most households, energy storage is still an abstract concept. While the idea of "saving your own energy" appeals to common sense, the mechanics behind it, especially in trading contexts, are often too complex or irrelevant for users. Survey results confirm this (moet nog verwerkt worden ergens). Their primary concern remains personal use and financial return, not active market participation.

Process

Start simple, grow smart

From a business standpoint, the diversity of use cases creates both opportunity and complexity. Each scenario requires different levels of system integration, contract types, and partnerships, particularly when moving beyond self-consumption. For Vattenfall, the key is to focus first on scalable, accessible propositions. Self-consumption offers a clear and immediate value case with fewer dependencies. More advanced trading models may offer higher returns but demand infrastructure, partnerships, and regulatory maturity that are still evolving. Additionally, they are driven purely by price signals, not by sustainability goals. A phased rollout approach, starting simple and expanding as the market matures, offers the best path forward. In this context, the home battery is not just a technical product; it is a bundled proposition that combines hardware, software, and service. From the user's point of view, its value depends not only on how it stores energy, but how it fits into daily life and delivers peace of mind. Companies like Vattenfall have an opportunity to differentiate by offering not just a battery, but a guided energy experience.

Technology

The software is smart, but what about the interface?

Home batteries are technically capable of much more than most users will ever demand. With smart software, they can participate in dynamic energy markets and grid services, maximizing returns through automated decision-making. Yet not all use cases are equally relevant or viable for households. The clearest and most stable value today lies in self-consumption, especially once net metering ends, where control and benefits remain in the hands of the household.

But here lies the issue: the current innovation focus is overfocused on software sophistication and potential earnings, while the everyday experience of the user is overlooked. Optimizing self-consumption sounds promising, but how exactly is the technology supporting the user in doing so? Most users don't want to manage algorithms; they want clarity, confidence, and peace of mind. The real technological challenge is not per se smarter automation, but better translation: intuitive interfaces, meaningful feedback, and actionable insights that guide behaviour. Without this bridge, the system remains technically advanced but practically underused.

7. The smart storage market landscape

As home batteries move from a niche technology toward a potential household standard, understanding the broader market context becomes essential. Using interviews, literature, and desk research, this chapter explores the landscape in which the smart storage proposition must land, approaching it from two angles. The demand side (7.1) examines who is adopting home batteries today, what characterizes this group, and how the profile is expected to shift as the market matures. The supply side (7.2) maps key competitors, their offerings, and the strategic implications for Vattenfall. Special attention is given to communication and positioning strategies (7.2.3), as these shape how batteries are framed and received by consumers. Together, these perspectives provide a grounded view of the challenges and opportunities in scaling smart storage.

7.1 Demand side

The Dutch home battery market is still in an early phase. Market maturity remains low compared to countries like Germany, but growth is accelerating quickly. High solar adoption, increasing energy awareness, and the upcoming end of the net metering scheme are pushing more households to consider energy storage. Still, adoption remains limited, and the gap between early adopters and the mainstream is significant.

7.1.1 Current adoption: quantity and profile

Current demand

As shown in Figure 7.1, current adoption is estimated on 110, 000 (for calculation logic, see Appendix E). Against a backdrop of over 2 million solar-equipped homes (CBS, 2024), this places the market squarely in the early adopter phase, as outlined in Rogers' Diffusion of Innovation Theory (1962): a phase characterized by enthusiasm from tech-savvy, future-oriented users, but not yet widespread public uptake.

Profile of the early adopter

The current early adopters and their profile are far from representative of what companies like Vattenfall are targeting with their proposition for 2027. They form a narrow user group. Existing adopters tend to be tech-savvy individuals, often referred to as energy enthusiasts or energy nerds. These early adopters are highly motivated by cutting-edge technology and the joy of experimentation. They find it exciting to play around with new gadgets, often viewing energy trading as an interesting challenge. For them, the process of adopting a home battery is more about playing with technology and optimising energy usage for fun rather than immediate financial return.

Research shows that they are typically younger, wealthier, and more educated than the average consumer, and even more so than solar-only households (McCarthy & Liu, 2024). They often live in three- to five-person households and possess the financial means and confidence to experiment with new technologies. Within these homes, the battery is often operated by a single person (van Dam, 2013), most commonly male, who takes the lead in managing energy use (Sandjo Tchatchoua et al., 2023).

Figure 7.3 shows a persona that combines characteristics from interviews, literature, and desk research, highlighting the divergence between current adopters and the broader user base targeted for future growth.

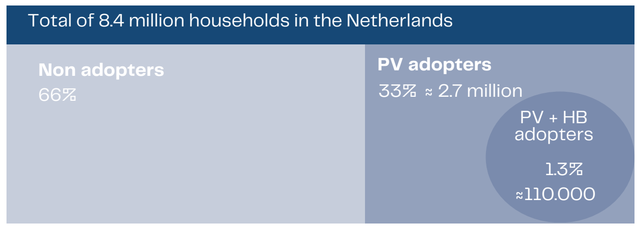


Figure 7.1 Home battery adoption

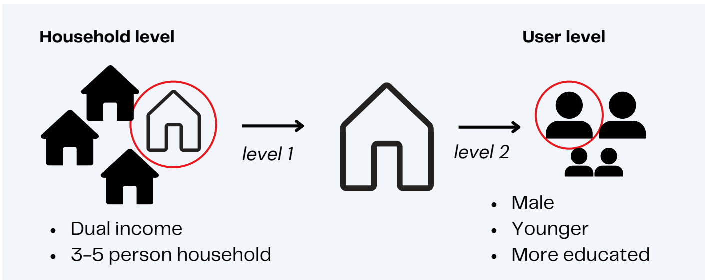


Figure 7.2 Early adopter characteristics

Name: Erik (42), male
Household: Lives with partner and two children in a detached home
Income: Above average (dual income household)
Education: Higher education (HBO/WO)

- Pioneer in sustainable technology
- Already has solar panels, installed ~3 years ago
- Motivated by energy independence and environmental impact
- Has the financial room to invest and values long-term savings
- Follows energy market developments and understands tech basics
- Likely to combine battery with other systems (EV, dynamic contract)

Figure 7.3 Persona early adopter

7.1.2 Future demand: quantity and profile

Future demand

Research from the National Smart Storage Trend Report (Dutch New Energy Research & Solar365, 2024) estimates that the Dutch home battery market will reach a total storage capacity of 10,1 GWh by 2026, a significant increase compared to today. This growth is expected to accelerate further after the phase-out of the net metering scheme in 2027.

A 2024 national survey (Van Gastel, 2024) found that 57% of Dutch consumers intend to purchase a home battery once net metering ends, motivated primarily by the desire to maximize self-consumption of solar energy and gain more control over their electricity bills. This projected demand reflects a broader market shift, from early adopters to a more mainstream audience, marking a key moment for energy companies to act.

For Vattenfall, this presents a substantial business opportunity. The company serves around 2 million energy customers in the Netherlands, which represents roughly 24% of all households. If we estimate 2.7 million Dutch PV adopters, then approximately 648,000 of them are likely to be Vattenfall customers with solar panels. Even if only a fraction of this group adds a home battery, the potential market size is significant.

Profile of the early majority

While early adopters, like Erik, represent a key market segment, the true growth potential lies in the mass market, in families like John's. As we move towards 2027 and beyond, more mainstream consumers will be looking for practical, cost-effective, and easy-to-understand solutions that don't require as much technical knowledge. For Vattenfall, understanding these shifts is critical.

Figure 7.5 shows our persona John, the red thread throughout this report, in more detail. It combines characteristics from interviews, literature, and desk research to represent the mainstream customer segment that companies like Vattenfall aim to reach by 2027

A more elaborate profile of John and his family will be described in chapter 13.

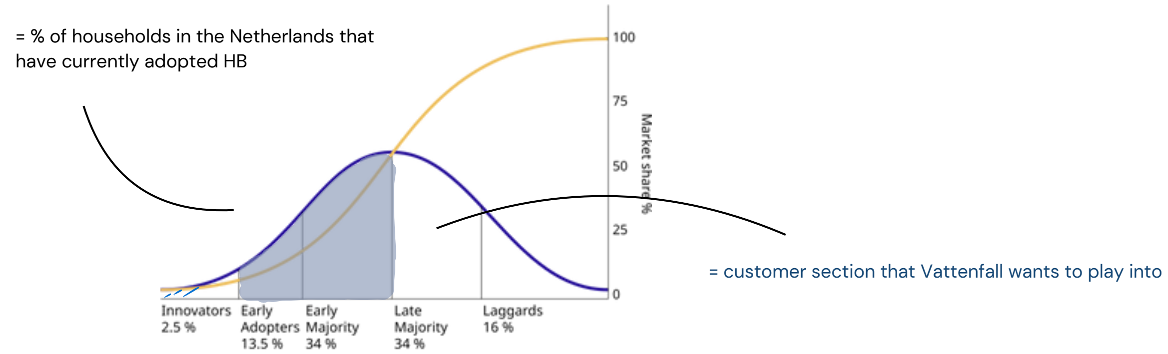


Figure 7.4: Diffusion of Innovation Theory (Rogers et al., 1983)

Name: John (48), male
Household: Lives with partner and two teenage children in a terraced house
Income: Average (dual income household)
Education: HBO degree

- Represents the pragmatic majority: not a trendsetter, but willing to follow when the time is right
- Installed solar panels based on financial incentives and social proof (neighbors, government support)
- Focuses on reliability, ease, and predictable savings over innovation
- Has limited time or interest to explore complex energy solutions
- Needs reassurance: trusted brand, positive reviews, and simple communication
- Waits until products are proven and hassle-free before adopting

Figure 7.5 Persona early majority

7.2 Supply side

While demand for home batteries is rapidly growing, the supply side remains fragmented, with numerous small players, including local installers and emerging platforms, competing alongside established energy companies like Vattenfall and Eneco now entering the space. Understanding this landscape is essential for choosing a clear strategic direction and market positioning.

7.2.2 Competing offerings

An extensive list of competitors relevant for the Dutch home battery market was drafted using desk research. The list was complemented with organizations named in the quantitative research conducted by Vattenfall, as well as those named in user interviews.

Competitors can be organized into different categories. These categories reflect the diversity of players active in or entering the Dutch home battery market, ranging from traditional energy suppliers to tech-driven newcomers. They were chosen to reflect differences in product ownership, market role, and value proposition. They help distinguish between companies that produce their own batteries, offer third-party products, or focus solely on software or energy services.

The visual shows **6 main categories** in the competitive landscape:

Battery producers
Companies that manufacture and sell home batteries. These players are hardware-centric and often tech-heavy. They all sell directly to customers and in addition partner up with (energy) suppliers.

Energy suppliers
This is the category where Vattenfall will be positioned. These companies primarily offer energy contracts and may include batteries as part of their service. The battery is often not central to their overall proposition.

Plug & Play
Brands in this category offer small-scale, modular batteries that do not require professional installation. They are focused on ease of use and self-consumption.

Strategic implications

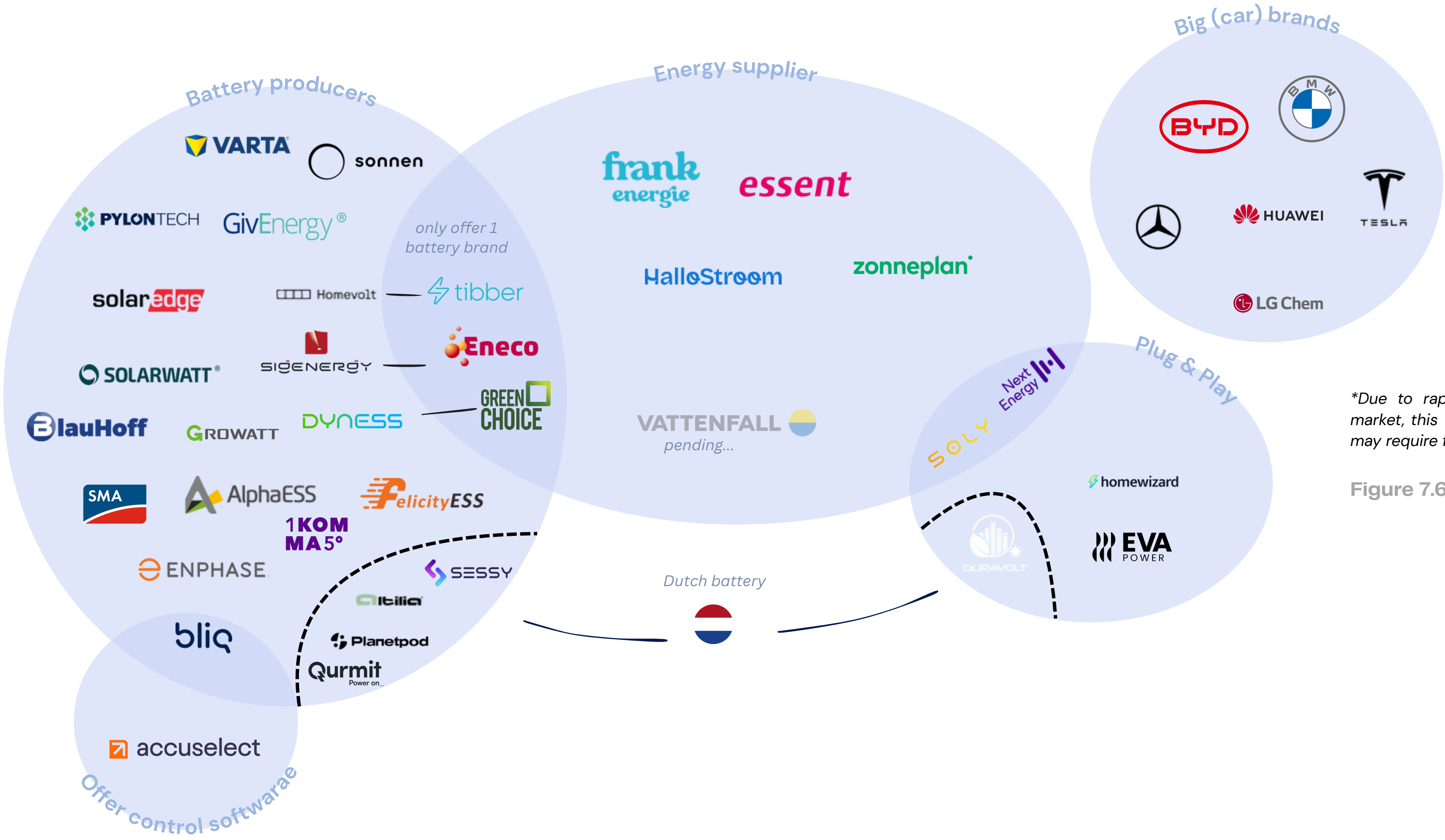
The strategic implications of these categories are outlined in table 7.1. The table highlights the main advantages and disadvantages of each competitor type.

For Vattenfall, the opportunity lies in its direct access to a large customer base, backed by strong brand trust and familiarity. This enables the company to offer integrated energy services that simplify the user experience. However, the added value of buying a battery from an energy supplier is not always clear to consumers. Without technical differentiation, which is difficult to achieve since hardware is not their core business, there is a risk of commoditization. This makes user experience the most important lever for differentiation.

Big (car) brands
Large automotive or tech companies offering batteries as part of a broader product ecosystem.These brands operate in their own brand universe.

Control software providers
Companies that offer standalone energy management software, either without batteries or as a separate layer. Their focus is on optimizing energy flows and enabling smart control.

Dutch batteries
Brands that emphasize local production and development in the Netherlands. These are often smaller companies or startups focused on transparency and independence.



**Due to rapid developments in the home battery market, this visual represents a snapshot in time and may require future updates to remain accurate.*

Figure 7.6 Competitive landscape

Table 7.1 Advantages and disadvantages per competitor type

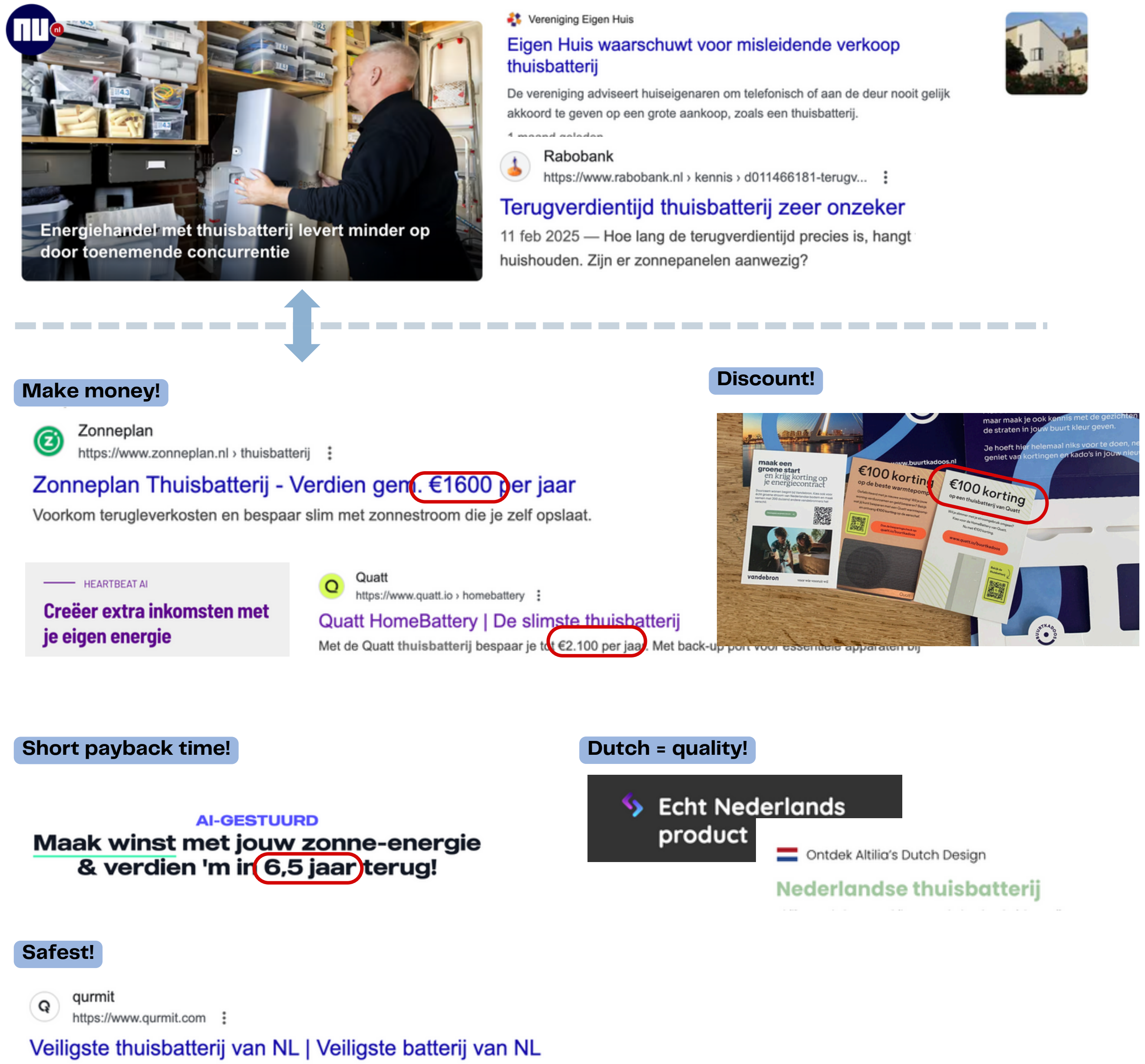
Organisation	Advantages	Disadvantages
Battery producers	• Control over product innovation and performance • Strong technical credibility • Can partner widely across the market	• Struggle to build strong brand differentiation in a crowded market. • Often lack control over the full customer journey (sold via third parties).
Energy suppliers	• Direct access to large customer bases • High trust and familiarity • Ability to offer integrated energy services	• Unclear added value for buying a battery from them. • Often lack technical differentiation • Risk of commoditization without strong UX or added value
Plug & Play suppliers	• Low barrier to adoption • Clear value proposition for self-consumption	• Limited long-term strategic value (not future-proof) • Hard to scale or integrate into grid services • Little brand loyalty or ecosystem potential
Big (car) brand	• Strong, established brand trust • Ecosystem lock-in for customers with EV/solar • High-quality, polished user experience	• Limited adaptability to local market context • Closed systems reduce flexibility and choice • May not prioritize home energy in long term
Control software providers	• Strategic layer in the smart energy stack • Can operate across different hardware brands • Position themselves as future enablers of grid flexibility	• Lack of control over hardware or user onboarding • Added value unclear, as most batteries come with built-in software. • Perceived as difficult to integrate with existing battery systems.
Dutch batteries	• Strong positioning on independence and transparency	• Scaling and reliability still developing

7.2.3 Communication and positioning strategies

Home batteries are a hot topic. They are everywhere: in news articles, sponsored social posts, email campaigns, and even unsolicited phone calls. As public interest grows, so does the intensity of marketing. Early communication strategies focused strongly on financial returns, with bold claims about fast payback times, mirroring the solar strategy.

This emphasis on return on investment is understandable but increasingly problematic. Sales tactics have become aggressive, leading to growing frustration among consumers about vague offers and unclear pricing structures (Radar, 2025). At the same time, critical voices, both in the media and in expert circles, are questioning whether such short payback periods are realistic as they cannot be consistently validated.

This tension has led to a shift. As skepticism grows, a new approach is gaining ground, one that prioritizes honesty, clarity, and trust. Some providers are repositioning themselves with a more grounded story: less about quick profit, more about energy control, independence, and peace of mind.



Takeaways

People

From pioneers to the pragmatic majority

The market is shifting beyond early adopters and while tech-driven pioneers like Erik helped kickstart the market, future growth depends on reaching people like John: solar-owning households who value simplicity, financial clarity, and peace of mind. The transition from early adopters to the pragmatic majority requires a clear, low-effort, trustworthy proposition that aligns with everyday life, not just technology enthusiasm. These mainstream consumers are not actively seeking out home batteries, and when they do, they face a crowded and confusing landscape. Brand loyalty is low and nearly half of the people have no preference at all. Many feel overwhelmed by the fragmented market and frustrated by aggressive, sales-driven messaging that oversells financial returns. To win over the majority, providers must move away from hard-sell tactics and instead offer a clear, honest, and service-driven story. The product must feel low-risk and high-relevance: something that supports, not complicates, daily life.

Process

Winning trust before 2027

The market is fragmented, fast-moving, and filled with strong propositions. Vattenfall's key advantage lies in its established customer base and broad presence across the energy landscape. The company aims to avoid false promises and instead provide customers with clear, realistic expectations.

In a market where almost half of the consumers have no preferred battery provider, this approach is a powerful asset. Rather than competing on specs or focusing on payback time, which is difficult to guarantee due to the newness and complexity of the technology, Vattenfall should offer a clear, realistic, and reassuring story. That means shifting the narrative from financial promises to long-term peace of mind.

The way prospects are approached will make or break adoption. Importantly, timing is everything: people have questions now, the uncertainty around net metering is growing, and home batteries are a hot topic; this is the moment when clear guidance can build trust and capture attention.

Technology

differentiation lies in the experience

The product itself is no longer the differentiator. Home batteries are widely available and increasingly competitive in terms of features and performance. The technical playing field is crowded, and hardware alone won't win. The real challenge now is differentiation. The value lies in how the technology is packaged and delivered, bundled with services, backed by trusted brands, and integrated into a seamless user experience. Vattenfall's advantage isn't the battery, it's the brand, the customer base, and the ability to turn complexity into confidence. UX, customer onboarding, and post-sale support are decisive in turning potential into perceived value.

8.Understanding the user journey of smart storage

Now that a multitude of factors around home batteries have been explored, this chapter brings it all together in one place: John's journey.

This chapter zooms in on the lived experience by following the smart storage proposition through the eyes of the user. John has solar panels, vaguely knows the net metering scheme will end, and occasionally wonders if he should "do something" with that knowledge. But like many others, he's unsure where to start, what to believe, or who to trust. He's not comparing inverters, he's trying to make sense of an increasingly complex energy world.

This chapter unpacks what his journey might look like. From first hearing about the battery, to deciding whether to buy, and ultimately using it in daily life. By tracing this process in detail, the chapter builds on earlier insights and brings the user's lived experience into sharper focus.

8.1 Methodology

To systematically explore how households interact with the home batter over time, this chapter adopts a customer journey mapping approach. A journey map captures the step-by-step experience of a user as they move through the phases of awareness, orientation, decision-making, installation, and use*. This lens reveals not only what users do, but also what they think, feel, and struggle with at each stage.

This method was chosen for two reasons. First, the customer journey framework is particularly suited for complex, unfamiliar propositions like home batteries, where users often need to make sense of new information and navigate unclear decisions. Second, journey mapping helps connect high-level barriers (such as lack of awareness or perceived complexity) to specific pain points in the process. In doing so, it provides a structured base for identifying actionable opportunities for intervention.

The goal of the customer journey map is to synthesize all the (user) insights into one coherent overview that reveals no just what is going wrong, but when, why, and for whom. It helps to identify the most critical barriers that stand in the way of meaningful adoption and use.

Insights were derived from four sources: expert interviews with industry stakeholders, in-depth interviews with (potential) users, a large-scale quantitative survey conducted by Vattenfall and secondary research into consumer behaviour around energy technology adoption. These findings were synthesized into a qualitative map that traces the experience from consideration up to use. The journey map highlights key recurring themes, filtered to reflect only the most relevant user insights for design.

(* certain phases are left out in this journey. The first step of awareness is closely linked to marketing, and as stated before extremely important, but not within the scope of this project. The purchase and implementation phases focus on the sales funnel and technical installation, largely handled by external partners like Feenstra. The advocacy phase is excluded due to its long-term nature and limited relevance to the current proposition stage)

A final note on post-adoption insights: the 'use' phase in this journey contains some insights from current home battery users. While helpful for identifying latent needs and expectations, these perspectives come from early adopters, not the core target group of this project. Therefore, findings in this phase are interpreted with care.

8.2 The journey

See next page.
(Simplified version due to confidentiality)

Legend
- = Qualitative insights
- = Qualitative interview clusters and their painpoints
- = Emotion
- = Important insights.
- = Quotes from participants

8.3 Key barriers identified

While the customer journey reveals a wide range of individual pain points, these should not be viewed in isolation. Many are closely connected, feeding into one another and reinforcing underlying frictions. When clustered and analyzed together, they point to two overarching barrier themes that shape the adoption and experience of home batteries.

Importantly, these barriers occur at different moments in the journey. The first emerges before purchase: 'Drowning before the start'. The second arises after installation: "Doing the job, missing the point'. These themes provide a more strategic lens to interpret user challenges and identify where design can create impact.

8.3.1 'Drowning before the start'

In this phase of the customer journey, there are **too many uncertainties.**

The relatively **new** and **complex** nature of home battery **technology**, combined with a **noisy market** full of **big promises**, **conflicting claims**, and the **need** for **personalized advice**, creates **confusion**. Every household situation is different, making standard solutions insufficient. Where to look, what to believe and who to trust: the landscape **feels like a jungle.**

In response, people are **craving for clarity.** Naturally, they **turn to financial data** for certainty, but this often **falls short**. Promised short payback times are questionable and savings calculators offer shaky predictions. At the same time, there is **poor insight** into what one is actually buying. The battery proposition remains **abstract**, filled with **technical terms,** market mechanisms, and product specs that are **hard to relate to daily life.**

This altogether creates a **mismatch** between the **size of the investment** and the **confidence** people have in making it. Instead of feeling empowered, many feel **lost**. The home battery becomes a **complex and risky decision**, one that's easier to **postpone** than pursue. This leads to many potential customers postpone or **abandon** the idea of adopting a home battery altogether.

8.3.2 'Doing the job, missing the point'

In this phase of the customer journey, The home battery proposition offers **too little support** to **unburden** people in their **energy management**. It's doing its 'job' but the user experience is far from complete.

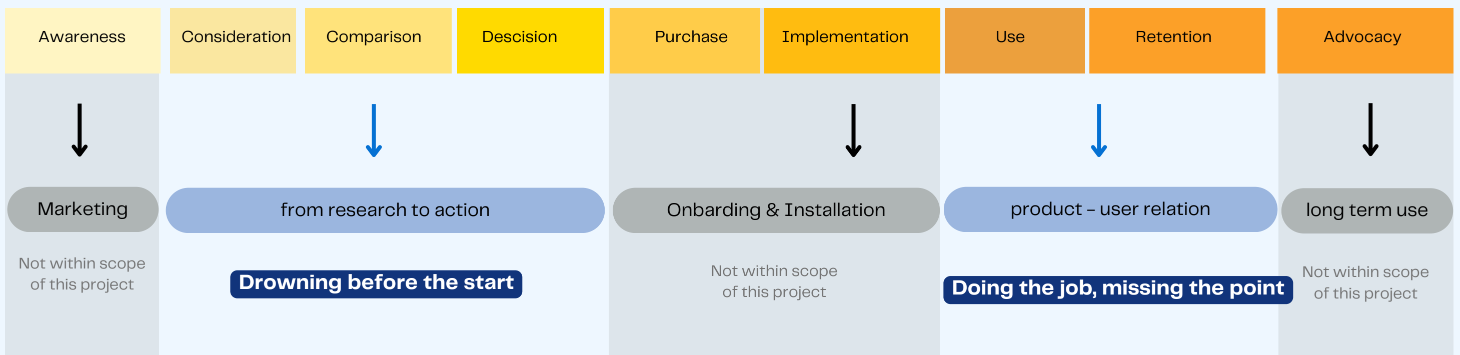
Once installed, the home battery often **fades** into the **background**. It runs quietly in the corner, and while users can check an app to view its status, most don't. **Out of sight** often means **out of mind.**

Those who do open the app, are met with **graphs**, **energy flows**, or kilowatt-hour **statistics**. Useful for some, but **confusing** for the average household. Most people aren't looking to study data, they simply **want to know what they have to** do to maximize their savings.

Their motivation is clear: convenience and cost savings, without added hassle. But if saving money with minimal effort is the **goal, the system must take on more of the thinking.** Instead of presenting passive insights, it should translate data into clear **guidance**, **actionable** suggestions, or quiet **optimizations**, **tailored** to the **user's** habits.

This is where the current **proposition falls short.** The battery becomes a passive tool, quietly doing its job, but **missing** the **opportunity** to truly support the user. Isn't the goal to optimize household energy consumption? To make users feel in control, not confused?

What's needed is a more **proactive system:** one that **thinks along** with the user and **assists where helpful,** without demanding extra attention. It should help households save energy and money in **smarter ways.** The potential is there, but the proposition still falls short.



To protect confidential company information, this report presents a very simplified version of the full customer journey developed during the project. The original version can be found in Appendix III

Pre-adoption

"It all just seems very complex."

consideration → **comparison** → **Decision**

Why are people interested in HB?
Motivations

Main:
- Stop net metering forces them to

Other:
- *Emergency backup power*
- *Sustainability concerns*
- *Overall lower energy bill*

People don't want to earn money, just save it

Lost in the jungle
people don't feel in control
- Information is too technical
- Overwhelmed with options
- Low trust in salespeople or commercial tools
- Complex comparisons
- Conflicting claims

overwhelmded

Online environment is dominant, but does not meet expectations
- Online (via search engine)
- Independent advisor
- People in environment
- Their energy supplier
- Directly from the supplier
- Social media/online forums

Where do they look for information?
Touchpoints

"Everyone is a specialist and I have to leave my email address everywhere."

Not in it for the money, but it costs a lot of money

Financial consideration remains the most important
Investment costs > payback time

What is on their mind?
Considerations

....and **what** is less important
- Safety and noise concerns
- Brand reputation or maturity
- Alternative payment options

Craving for clarity
people want transparency, understandable info, and confidence in what they're buying.
- Poor insight into what you're buying
- No clear numbers
- Lack of personalized advice
- Lack of transparency from suppliers

uncertain

"It will probably be better and more affordable in the future."

Why do people say no?
Deal breakers

Too much uncertainty + **While too big of an investment**

Too much uncertainty:
- Unclear payback time
- Rapid tech development
- Dropping prices
- New technology, waiting for reviews

While too big of an investment:
- Upfront costs
- No subsidy

the waiting game
people are postponing purhcase
- All these factor combined make the risk feel too high

unsatisfied

Majority waits as long as possible, untill they no longer have a choice

Post-adoption

'Checking', 'monitoring' : that's not the goal.
Use is currently framed as control, but it should be about supporting smart action.

"It's not telling me anything, just showing"

Use → **Retention**

What do they expect?
Benefits
- Cost savings
- Preparation for stop netting scheme
- Energy independence, self-sufficiency
- Solar storage
- Emergency backup
- Sustainability, contributing to energy transition
- Future-proofing

Now what?
Unsure whether further action is required or battery handles everything
- No clear next steps
- Unclear performance feedback
- Uncertainty about whether it's working optimally
- Limited guidance / help / advice

Unsure

"...actually, I'm not sure if I'm supposed to do anything"

Installed and running, but the proposition feels unfinished.

Is smart, feels complex
The system may be advanced, but the value underwhelming
- Users don't understand app metrics or visuals
- Belief that it will take effort to manage
- Feeling that energy management is only for the 'tech-savvy'

Reluctant

Out of sight, out of mind
After installation, the battery quietly fades into the background.
- Forgetting it's even part of your home system
- Feeling like the battery "just sits there"

Detached

"I'm assuming it still works, but I don't check it much anymore."

Define

Following an extensive exploration of the home battery context, the next step is to bring together the key findings. This section reflects on the identified barriers and chooses a focus in direction.

9. Design focus

With two key barriers identified in the customer journey, one in the pre-adoption phase and one in the use phase, this chapter outlines the process of selecting a strategic focus. To design something meaningful and go more into depth, a clear direction must be chosen. This section compares both barriers and explains why the use-phase challenge ultimately offers the most potential for impactful design intervention.

9.1 Method

To determine which barrier to focus on, both were evaluated through three lenses: strategic relevance, user impact, and design potential.

Strategic relevance: Where can Vattenfall create the most distinctive value, given its brand, timing, and market position?
User impact: Which barrier reflects the most pressing or underserved user need?
Design potential: Where is there room for meaningful, user-centered design intervention?

This structured approach was complemented by personal considerations and preferences of Vattenfall.

9.2.2 Other perspectives

From a personal perspective, the second barrier also resonates more strongly. It offers the chance to work on a challenge that is less about convincing people to buy, but really helping to connect technology with users while creating business value. Additionally, it also offers more room to explore new design skills, such as behavioural design, systems thinking, and translating data into intuitive user experiences.

The final choice to focus on the use-phase barrier was also discussed with Vattenfall. The use-phase barrier was seen as more strategically aligned with the team's domain and innovation interests.

9.3 Conclusion

The decision is to focus on the use phase of the customer journey. However, the disconnect between Vattenfall's plans and what (potential) customers actually understand, remains an important barrier. This gap was echoed in interviews: users are often unaware of the changes ahead and the role they will need to play, No matter how promising the proposition may be on paper, without bringing users along, through communication, transparency, and intuitive support, it risks never reaching its full potential. This insight has been integrated into the final recommendations.

9.2 Assessment

Pre-purchase

Strategic relevance

High (short term): This barrier presents both a strategic opportunity and a time-sensitive risk for Vattenfall. As a trusted national provider entering a relatively immature market, Vattenfall has an opportunity to cut through noise and build early credibility. It offers a clear moment to step in as a trusted partner and support customers during a period of uncertainty. By acting now, before their home battery proposition is fully market-ready, Vattenfall can build early engagement and strengthen loyalty, before losing customers to more aggressive or faster-moving players. However, this also creates pressure. Vattenfall's internal processes (relatively slow, layered, and risk-averse) may not be able to respond quickly enough. There's a real risk of missing the momentum.

User impact

Medium to high: This barrier blocks adoption entirely. However, for how long? While users currently feel overwhelmed and uncertain, one could question how long they can realistically postpone a decision. With the net metering scheme ending in 2027, the financial logic of solar energy will shift dramatically, making self-consumption, and by extension home storage, increasingly necessary. In that sense, this barrier may resolve itself over time, not because the experience improves, but because the system forces users to act.

Design potential

Medium: While this barrier has more of a strategic angle, the design space is more constrained. Much of the challenge lies in communication, onboarding, and trust-building. Areas that are essential but sit closer to marketing and sales than to product or service design. This makes them harder to influence meaningfully within the scope of this thesis. In addition, the rapidly evolving energy landscape adds complexity. With changing regulations, shifting business models, and ongoing tech developments, any design solution risks becoming outdated before implementation. The opportunity is real, but the window is narrow and the design scope is limited by external dependencies.

Post-purchase

Strategic relevance

High (long term): While less urgent today, this barrier aligns more with Vattenfall's long-term ambition to become a smart energy partner. As adoption grows, experience becomes the differentiator. This is where Vattenfall can build lasting value, through trust, service, and integration. There's also more room for scalability and alignment with other Vattenfall assets and propositions. A well-designed user experience around the battery could connect to broader offerings. However, the risk lies in execution. If the solution isn't grounded in real user needs, it risks becoming something people never asked for. Strategic design here requires careful balance: being forward-thinking, without drifting too far from what people actually value and are ready for.

User impact

Latent, but high: This barrier is more difficult to assess, because the target group doesn't have the home battery yet. Users haven't experienced the system, so they can't yet identify this as a problem. At the same time, I believe it's part of the designer's responsibility to look ahead. The energy management landscape is becoming more complex, while users stay the same. If design doesn't evolve with that complexity, users will be left behind, facing a system that technically works, but doesn't work for them.

Design potential

High: Unlike the first barrier, which centres on trust and early decision-making, this one deals with the everyday reality of living with technology. How it fits into routines, how it communicates, and how it earns a place in people's lives. It is centred around interface and service design. Within this barrier, design can play a key role in turning complex energy flows to actionable guidance. That said, a clear focus within this design space is needed within the timeframe of this project. It will be especially valuable to focus on exploring new forms of energy management and not standard functionalities.

Deepen

This short section deepens the chosen barrier and uncovers the underlying problems.

10. Deepening the problem frame

Now that a clear direction has been chosen, it is possible to zoom in on the underlying dynamics of the selected barrier. Insight suggested that the home battery is currently framed too narrowly: as a product purchase. Yet most users, particularly the mainstream segment, are not primarily looking for hardware. They are looking for outcomes: reassurance, savings, energy independence, and simplicity. The existing narrative fails to meet those expectations, remaining too focused on the technical product rather than the value it should deliver.

The initial framing: "At this stage of the customer journey, the proposition offers too little support to unburden people in their energy management" served as a starting point. However, a deeper understanding is required to uncover the problem behind the problem. Why is there too little support?

10.1 Method

To deepen the problem frame, a series of three in-depth interviews was conducted with members of the target group. As these participants do not yet own a home battery, the research focused partly on latent needs: expectations, concerns, and behaviours that are not yet shaped by direct experience, but can still be explored through comparison and reflection (Sanders & Stappers, 2013).

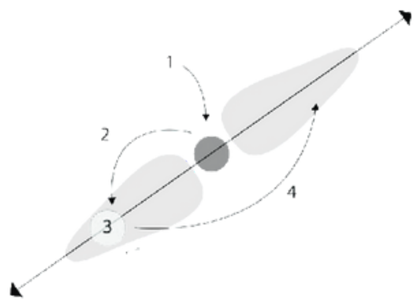


Figure 10.1: Path of expression model

Participants were invited to reflect on similar energy-related experiences such as solar panel apps, energy usage reports, or provider dashboards. These familiar references helped participants reflect on what they find useful, confusing, or lacking in current systems. While not directly about the home battery, these elements can be translated to the context of home battery usage.

In addition, the interviews were structured using the Path of Expression model. Rather than directly asking "What do you expect from a home battery?", it guides participants towards answering that question. Following this model, the conversation moved from current behaviours (present), to previous experiences (past), toward underlying values and routines (depth), and finally to imagined futures (projection). This step-by-step approach was especially valuable in surfacing insights around a technology that participants have not yet interacted with directly. For interview setup see Appendix.

The interview insights were then combined with previous findings and pain points identified in the customer journey (see Chapter 8), to form a more comprehensive picture.

The result is a synthesis of four main insight themes, each linked to a core problem and an underlying value tension. To bring these insights together in a structured way, The overview on the next page visualises how the value tensions connect to the design space and opportunity directions.

10.2 Core problems

Insight

What patterns or behaviours do I see in users?
User level

Right now, the battery is often framed as a product purchase. But users—especially the majority —aren't looking for hardware. They're looking for outcomes: savings, independence, reassurance.

Why?

Many users don't understand how energy flows in their home, how the battery works, or what the actual impact is.

> I see things, but I'm not sure what they mean or what to do with them.

People don't check apps. If the battery isn't visible in their routine, it gets forgotten — even if it's working perfectly. For energy behaviour to matter, it must become part of daily life

> It's in the app somewhere, but I hardly ever use it.

Users value the idea of saving energy and costs, but they don't want to figure out how. Energy use isn't top-of-mind, and the system doesn't actively help them make smarter choices wihtout them having to think about it

> I know the battery could help me save, but I don't really know what to do and I don't want to spend time figuring it out

Users interact with the system from within their own routines, goals, and habits. But the system doesn't seem to notice. It offers the same experience to everyone, making it hard for users to feel seen or personally supported.

> I just have to guess what's smart for me.

Problem

What is the underlying problem?
Product/service level

The current narrative is too product-focused.
At this stage of the customer journey, the proposition offers too little support to unburden people in their energy management.

1
Energy system doesn't speak the user's language

The system communicates in **technical terms** that the majority doesn't understand. As a result, it feels **complex and abstract**, making it difficult to see what's happening or **what to do with the information.**

2
Not embedded in routine/habit

The battery is **easily forgotten** because it never becomes part of the user's routine. Out of sight, out of mind: the system operates quietly in the background, creating a **"black box" effect**. Users don't see what it's doing or why it matters, leading to a **lack of connection with their energy use** and **no sense of ownership.**

3
Information stays passive and unactionable

The system shows data, but **not what to do with it.** The system offers no guidance, no timely prompts. It's a **one-way system** with no dialogue or direction. Users are left unsure whether it's working optimally or if they should act, and **without clear next steps**, everything **feels like extra work**.

4
The system treats every user the same

The system offers a generic experience that **doesn't adjust** to individual **routines, goals, or contexts.** By failing to recognize personal differences, the system is **out of sync with daily life,** making it harder for users to ..[type]

Value tension	Complexity vs. Comprehensibilty	Automation vs. Connection	Optimization vs. Effort	Scale vs. Personalisaion

Opportunity

What design opportunity or direction does this inspire?

Reframing the proposition
From Product to Partnership

How?

	From Confusion to Clarity	**From Invisible to Integrated**	**from Passive to Guided**	**From Generic to Personal**
HMW	How might we give customers clear, relevant feedback on their energy behaviour without overwhelming them?	How might we integrate battery insights into the user's daily flow?	How might we guide customers toward smarter energy use, with minimal effort on their part?	How might we make the system feel more tailored to users' daily routines and preferences?

Define Pt. 2

The second Define section provides a recap of the strategic design choices made throughout the process. It outlines the final design brief and presents a detailed persona profile.

11. Recap of strategic design choices and their rationale

Throughout the design process, a number of key decisions were made to apply strategic focus and ensure feasibility within the project scope. These choices helped define the direction of the concept, but they do not constrain its future potential. The summary below outlines each decision along with the underlying rationale.

Scope of target customer

Who is defined as most relevant for the scope of this project?

Targeting existing Vattenfall clients
Rationale:
In a crowded and fast-evolving energy landscape, Vattenfall's best chance of success lies with its existing client base. Unlike tech-first disruptors, Vattenfall is an energy provider at its core. By focusing on users already within its ecosystem, the company can build on established trust, lower adoption barriers, and create an integrated, service-driven experience that aligns with its capabilities.

Focusing on fixed energy contracts
Rationale:
Most current Vattenfall customers are on fixed-rate energy contracts. Designing for this reality ensures relevance and usability. While dynamic pricing may offer more future flexibility, anchoring the initial proposition in the dominant contract type increases feasibility and user fit, especially among mainstream families who prefer predictability.

Household context: families, including children
Rationale:
Instead of designing for individuals, the system is built around real household dynamics: shared behaviour, differing needs, and collective decision-making. Acknowledging multiple end users opens up opportunities to strengthen the system's alignment with its users

Homeowners with solar panels (5–20) and average to high energy use
Rationale:
These households represent the most realistic and urgent user segment for battery adoption. They have the space and autonomy for installation, gain meaningful returns from optimizing self-consumption, and are less dependent on trading to justify the investment.

Mainstream adoption: average Dutch families, not tech-savvy users
Rationale:
The concept deliberately targets the mainstream: households with limited energy knowledge, average digital skills, and little interest in technical deep dives. This ensures broader market relevance. It also aligns with Vattenfall's customer base and societal goals: enabling the average household to participate in the energy transition without needing to become energy experts

Scope of battery's role

What is defined as the most relevant role of the home battery?

Battery use focused on self-optimisation, not trading
Rationale:
Energy trading was deliberately left out of scope. Research showed limited user interest. Additionally, the financial returns of trading are uncertain and often overstated. Moreover, trading is only possible for users with dynamic contracts, excluding most Vattenfall customers. Prioritizing self-consumption creates a concept that is better aligned with long-term value and ethical considerations.

Shared control of the battery between user and Vattenfall
Rationale:
To strike the right balance between guidance and autonomy, the system gives users influence over preferences while letting Vattenfall handle optimisation in the background. This split reduces effort for the household while preserving transparency and trust.

Integrated home battery systems (not plug-in types)
Rationale: Plug-in batteries offer limited capacity and coordination. Integrated systems allow for full control, better scalability, and future alignment with services. This choice supports long-term strategic and system-level value.

Scope of project direction

What is defined as the most relevant strategic and functional focus for the concept?

Timing: aligned with the net metering phase-out (2027)
Rationale:
The end of the net metering scheme creates both urgency and opportunity. It marks a crucial point where households must rethink their solar setup. The proposition must therefore align with this timing.

Insights from internal stakeholder interviews (see Appendix II helped define the strategic direction of the project. While the exact input remains confidential, it led to the following design decisions:

- Step away from technical specifications
- Design for flexibility and future add-ons

12. Design brief

12.1 Revised problem statement

The current proposition around the home battery is too product-focused. At this stage (use) of the customer journey, it offers too little support to unburden people in their energy management.

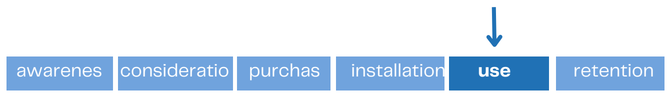
While the home battery is positioned as a smart solution, the way it enters the home does not reflect the reality of household life. The system fails to connect with users in meaningful ways, due to four core problems identified in the research:

1. The energy system doesn't speak the user's language
2. Information remains passive and unactionable
3. The experience is not embedded in routine or habit
4. The system treats every user the same

Together, these issues reveal a deeper misalignment: the technology may be doing its job, but it's missing the point. There's a clear gap between what new home battery systems are technically capable of and what households actually need in daily life. Without bridging that gap, the promise of smart energy risks becoming another overlooked tool.

12.2 Design scope

Phase in the customer journey: 'use' phase



Design medium: interface (app)
The medium of the solution will be a user-facing interface, as behaviour change requires access to the interaction layer, where understanding, feedback, and routines are shaped. To ensure feasibility, the concept will be designed for integration into Vattenfall's existing system and accessed by users through the app.

Family context
Another key design choice is the focus on the family context. While the home is the natural setting for energy use, most solutions still treat users as isolated individuals. This project takes the household as the unit of design, recognizing that energy is managed collectively, shaped by routines, and embedded in shared responsibilities. Without addressing this reality, solutions risk ignoring reality. Consequently, designing for household dynamics offers a strategic advantage. Few competitors actively target this space, making it an opportunity for Vattenfall to stand out by delivering a proposition that reflects how energy is truly lived.

12.3 Design goal

This challenge brings together the core problems and opportunity areas identified in the research, within the context of families managing energy in their home. The aim is to shift from product to partnership:

"Design a household-centred proposition around the home battery that unburdens families in making smart energy decisions, by providing actionable support that fits with daily routines, speaks their language, and requires minimal thinking."

This goal will guide the next phase of the project, shaping ideation, concept development, and the criteria for success.

12.4 Target group

The design is intended for Dutch families who have solar panels and live in owner-occupied homes, typically with two children aged 10–15. These households are financially motivated and environmentally aware, but energy is not top of mind. Their behaviour is shaped by habit, convenience, and shared routines. Most are on fixed energy contracts and have a relatively high electricity demand due to family life.

In this context, the home battery is used to optimize solar energy, save money, and reduce reliance on the grid.

Importantly, energy use is a shared experience. Children in this age group are increasingly tech-literate and individually reachable (94% of Dutch 12-year-olds own a mobile phone, with the average age of first ownership between 9 and 11 (CBS, 2023)), which opens up opportunities for involving the whole family.

An important starting point is that they want to make smart use of their energy, but don't want to think about it. This group expects the battery system to feel low-risk and high-relevance: something that supports, not complicates, daily life.

A representative family, John and his household, is introduced in Chapter 12 to illustrate this group in more detail.

*Important to note: While the design centers around families, the primary focus is on parents and secondary on the children. As parents play a central role in energy decisions, have more influence, and can guide their children's behaviour.

12.5 Design requirements

The insights and decisions made so far have led to a set of design requirements that will guide the upcoming design phase. These requirements ensure the solution supports desired behaviours, fits into family life, and aligns with Vattenfall's broader energy strategy.

User-centric requirements
The solution must.......
- create a sense of partnership, helping families feel the system is working with them, not just running in the background.
- be intuitive and effortless to use, also for users with low energy literacy.
- fit naturally into household routines and timeframes, avoiding disruption or overload.
- use familiar, everyday language that resonates with family life.
- feel personal, not generic, reflecting the family's setup, usage, and needs.

Functional requirements
The solution must......
- guide families in making smart energy decisions in a way that fits their specific needs
- be integrated into Vattenfall's existing digital ecosystem and accessible through the app.
- Differentiate between users within a household, allowing for tailored messaging or interactions.
- Support adaptation and personalisation over time, based on usage behaviour.
- Function across common family devices (e.g. smartphones, tablets) and support shared access.
- Deliver context-aware triggers, surfacing only when relevant

UX requirements
The focus of this project is on the proposition level, defining the role the solution plays in users' lives and the needs it fulfills. While the outcome is inherently tied to an interface, the UX design is considered secondary to the strategic direction. These aspects are considered nice to haves and are addressed if project scope allows.

The design should.....
- Be visually appealing, in line with Vattenfall's brand
- Be intuitive and easy to navigate

13. Persona

In order to get a true feeling of our persona, this profile introduces a representative Dutch family that captures the dynamics, needs, and routines central to the design challenge. They reflect the early majority: practical decision-makers who will become the key target group as the net metering scheme begins to phase out (see section 7.1.2).

13.1 Meet the Millers

13.1.1 Choosing for a home battery

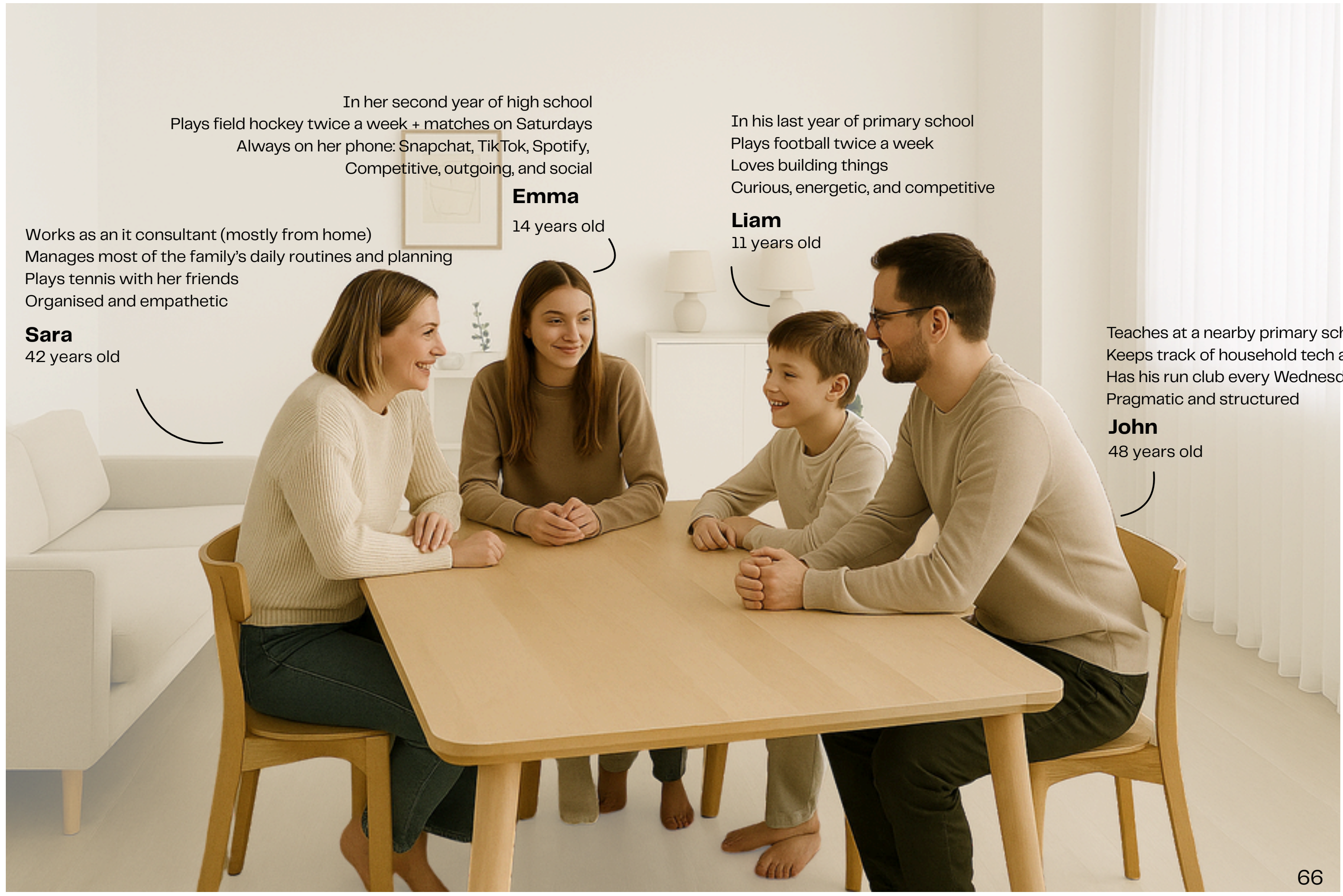
The .. are a Dutch family of four living in Utrecht. They installed solar panels a few years back, mainly driven by financial incentives and social proof; neighbours had them, the government supported it, and it just made sense. Since then, they haven't really paid much attention to their energy setup. But with the upcoming phase-out of net metering, they are incentivised to look at smart energy solutions to protect their investment.

They've decided they want to purchase a home battery, mostly to increase self-consumption, save money and reduce reliance on the grid. However, they have limited time or interest to explore complex energy systems. What they want is a system that understands their situation and takes care of the rest. one that helps them make smart choices, without needing to think about it all the time.

13.1.2 Profile

Location: Nieuwegein, Utrecht
Household: Dual income, owned mid-terraced house
Energy use: Average to high electricity use
Contract: Fixed rate with Vattenfall
Energy setup: 10 solar panels on south-facing roof
Transport: one car, EV
Motivation: Financial and practical
Tech maturity: Moderate, uses digital services, expects low friction

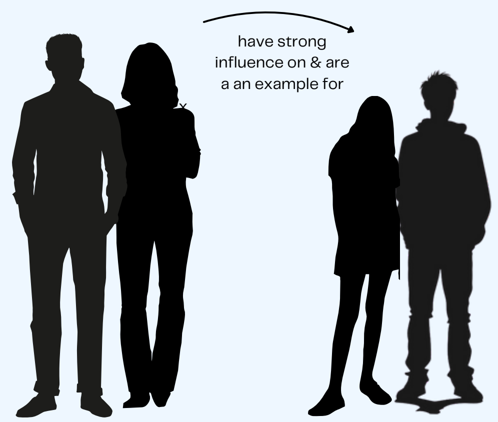
The Millers are a dynamic and typical household, filled with shifting roles, competing routines, and a touch of organized chaos. Their family life runs on predictable rhythms: meals, sports, school, bedtime: a steady flow of activities that shape how and when energy is used in the home.



13.1.3 Dynamics

The family dynamics
the most important insights that influence design

Parents — Primary focus VS **Kids** — Secondary focus



Parents

'Natural' behaviour
More internal motivation
want to make smart energy descisions

Key needs from system
Enabling intentions
Help to get through to kids

Access channel
Where can the solution reach them
Complete app

Kids

'Natural' behaviour
Ignorant (to energy use)
Highly competitive

Key needs from system
Form an understanding
A frame of reference
External motivation

Access channel
Where can the solution reach them
Notification focused

Develop

This section translates insights and opportunities from the Discovery and Define phases into a concrete design response. It grounds the concept's focus in behavioural models and uses behavioural design as the foundation for developing an adaptive home battery system; one that fits real household dynamics. The chapter walks through the development journey, from early sketches to refined system logic.

14. Design approach

With a clear design brief, the Develop phase focused on translating all insights into a concept that supports families in making smarter energy decisions with minimal effort. The process moved from broad opportunity exploration to a focused, tested proposition.

The first step was to understand how the defined opportunity areas could translate into real user needs. Four interviews with families were conducted to explore this in context. Existing home battery interfaces were reviewed, and all input was synthesized into a Jobs to Be Done (JTBD) tree, offering a clear overview of user goals—an established UX method.

An iterative process followed, combining wireframe sketches, best practices from other energy interfaces, a co-creation session with UX designers, inspiration from rapid AI prototyping tools and a review of Vattenfall's current app. Early UX sketches helped explore how the system could behave at a propositional level.

This led to a broad concept direction, which was then refined using behavioural models to focus on the key design elements that drive action.

To refine the focused concept, it was tested with the same four families and further developed through conversations with Vattenfall and their UX designers. Additionally, a meeting with the developer of the behavioural model was arranged.

Figure 14.1 provides an overview of all the steps taken throughout the development phase.

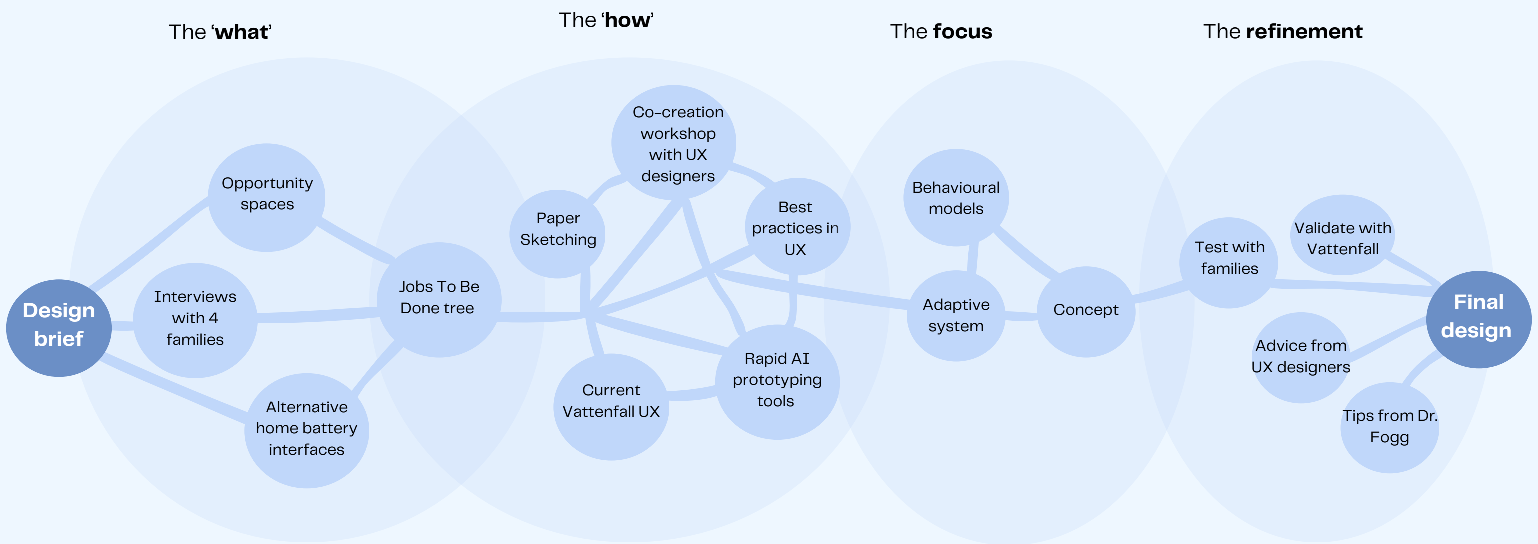


Figure 14.1: From define to deliver

15. The 'what'

15.1 Opportunity spaces

Translating the identified tensions (previously presented in overview FIXME) into opportunity spaces, provides actionable starting points for design. Within the context of use in the home battery proposition for Vattenfall, four opportunity areas have been defined.

The ultimate goal: reframing the proposition from product to partnership. The key elements needed in the solution to enable that shift are visualised in the overview in section 10.2. Each opportunity is accompanied by a guiding 'How Might We' question and initial implications for the design direction.

These four opportunity areas are all equally important and are therefore approached as complementary and interconnected lenses.

15.2 Alternative home battery interfaces

Several current home battery interfaces were reviewed. This helped identify commonly supported functionalities and how competitors approach key Jobs to Be Done.

Rather than serving as a benchmark, this review informed which expectations users might already have—and where there is room to differentiate.

An overview of the findings can be found in Appendix H.

15.2 Interviews with target families

To further shape the solution, a series of in-depth interviews were conducted with families from the target group. These sessions served to ground previously defined opportunity areas in the lived realities of everyday family life. The conversations were guided by the question: how can the system genuinely support families in managing their energy use?

15.2.1 Interview approach

The sessions were informal, open conversations and explored topics such as:

- Family dynamics around energy management
- How (energy) roles differ between parents and children and how these traits can be leveraged in design
- Children's current awareness and involvement in energy use.
- Reactions to different types of potential system support
- Brainstorming the fit of support

A mix of parents and children participated to create a comprehensive view of how energy is used, discussed, and managed at home.

15.2.2 Acquiring participants

The interviews were semi-structured and conducted with four Dutch families matching the target profile described in chapter 13

Families were selected to be as similar as possible on paper to allow for meaningful comparison and follow-up testing. All families lived locally, enabling in-person sessions, which were preferred for this project. See table 15.1 for basic participant information.

Participants were purposely not recruited through Vattenfall, as this might bias the group toward higher energy interest or technical knowledge. Instead, neutral households were chosen to better represent the early majority segment targeted by the final concept.

Table 15.1:
Participant information

Family #	Participant #	Age	Gender	Participated in interview	Participated in testing
1	1	56	M	x	x
	2	48	F		x
	3	15	F	x	x
	4	13	F	x	x
2	5	40	F	x	x
	6	42	M		x
	7	14	M		
	8	10	F	x	x
3	9	44	M	x	x
	10	41	F		x
	11	13	F	x	x
	12	11	F	x	x
4	13	41	M	x	x
	14	40	F	x	
	15	12	M	x	x

15.2.3 Insights and takeaways

The following insights and takeaways emerged from patterns across the four interviews. Interview quotes are used to help illustrate.

P14: "If the app helps without needing too much from me, then we're open to it. But if it nags, I'll probably ignore it."

Insight: There is a willingness to act, but not to manage

Takeaway: The system should take initiative without feeling intrusive

Insight: Children are not involved, but parents express a wish that they were

P9: "My daughter leaves the shower running for ages. I've explained it to her so many times, but she just doesn't really think about energy yet."
P11: "I don't know how much it matters. My parents just pay the bills."

Insight: Energy awareness is limited among kids, this seems to come from not being able to relate.

Takeaway: System needs to find a way to involve the whole family. It should 'speak' to kids in a way that fits their world and motivate them accordingly.

Insight: Gamified feedback and collective reward structures may increase engagement, especially if progress can be tracked together.

P5: "We're competitive in our house. If the kids could 'win' something by doing better, I think they'd be into that."

Takeaway: This aligns with the idea of household-level goals and shared achievements.

P1: "We want help, but not at the cost of our whole evening rhythm."

Insight: Interventions are only welcome when they feel timely and unobtrusive

Takeaway: It is essential for the system to understand and respect daily rhythms, especially shared moments like mealtimes or times of chaos and uses that to define when interventions are welcome.

P13: If I can quickly see how we're doing, and that we're actually saving something, that's what keeps me going
P1: "I'd rather know how we are doing than see how we compare to others."
P5: Honestly, it's not entirely about the money for us. We just don't want to waste energy. It feels wrong."

Insight: Households differ in what motivates them. While some are driven only by financial savings or efficiency, others are also guided by a general sense of responsibility. Social comparisons are not universally motivating. All users prefer to track personal progress over competing with others.

Takeaway: This indicates a reward system focused on team progress and self-reference. The system should allow for customizable motivation framing, offering users a tone and reward strategy that aligns with their values.

P1: "I don't want a daily energy lecture. Just help me do the right thing at the right moment."
Px: "If we get a short forecast at the start of the day, we know what to expect, that would actually help."

Insight: Users want to stay informed, but only on their own terms. Preferences vary in how much guidance is welcome, and when.

Takeaway: The system should support customizable levels of guidance, offering short, low-effort daily insights (e.g., a morning forecast) for those who want to stay in the loop, while keeping interventions sparse and timely for others. Onboarding should be used to identify these preferences early.

Observation across all families: Children in the 10–15 age group use apps almost exclusively for social media, and sometimes have screen time limits.

Takeaway: Kids should not be positioned as direct users. Instead, they can be reached through outside app communcation or shared interactions, as they are unlikely to actively engage with the app themselves.

Observation across all families: All children in the interviewed families played at least one sport regularly.

Takeaway: Might be valuable to use sport as a shared language or frame of reference for kids . A potential lever for relevant metaphors (example), motivational framing ("score points," "team effort"), and contextual personalisation ("good luck at soccer tonight, let's do laundry after").

Insight: When suggestions are addressed to individual family members and linked to their own schedules or activities, they feel more relevant and less like background noise.

P5: : "It would help more if it knew when I was home, not just sent random tips to everyone."

Takeaway: The system should address users personally, based on presence, roles, and routines, not just send general messages to the household. This reinforces shared responsibility while respecting individual contexts.

Conclusion

The interviews revealed that while families are open to smarter energy use, their willingness depends on how well the system fits into their lives.

Parents don't want to manage another system, but do want the system to take the initiave. Children don't really care about energy or apps, but did show other potential ways of involving or interesting.

What stood out was that motivation needs to feel concrete, visible, and emotionally relevant at the family level. Guidance needs varied: some users valued a daily forecast, while others preferred minimal interaction unless necessary. These differences underline the need for customizable support.

Together, these insights directly shape the concept and define the behavioural levers it must address.

16. From 'what' to 'how'

16.1 Jobs To Be Done (JTBD)

16.1.1 The framework

The Jobs to Be Done (JTBD) framework was applied to form the bridge between everything the system should do (the 'what') and how it should do that (the 'how).

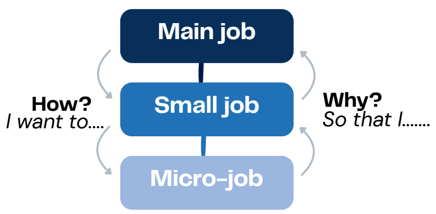
Common in UX design, JTBD helps shift the focus from features or technology to what users are actually trying to achieve, functionally, emotionally, and socially. Instead of building what sounds innovative, it prioritizes solutions that support real-life goals.

This method is particularly relevant in the context of this project. The target group has no experience with managing a home battery system. This means they cannot express their needs in terms of features or technical requirements. However, they can clearly articulate what kind of support would help them in their daily lives. The JTBD approach makes it possible to capture those goals and turn them into actionable design guidance.

A job-to-be-done is typically framed as a goal-driven statement, using the following structure:
"When [situation], I want to [motivation], so that I [expected outcome]."

16.1.2 The structure

To organize and analyze the wide range of needs and expectations uncovered during research, a hierarchical structure was applied:



This hierarchy helps clarify not just what users want, but also why and how they want to achieve it. Reading from top to bottom shows how large goals break down into manageable components (the 'how') . Reading from bottom to top reveals the underlying motivations behind more specific preferences (the 'why')

All jobs were grouped into four overarching themes, which align directly with the four core opportunity areas defined earlier in the research

The final overview of all identified jobs, including their hierarchy and thematic grouping, can be found in Figure 16.1.

16.1.3 The JTBD tree

This map functions as a foundation for system and feature development. It brings together the possible jobs the system can fulfill. This ensures that each component of the eventual interface can be traced back to a real user need. The final concept addresses part of this tree.

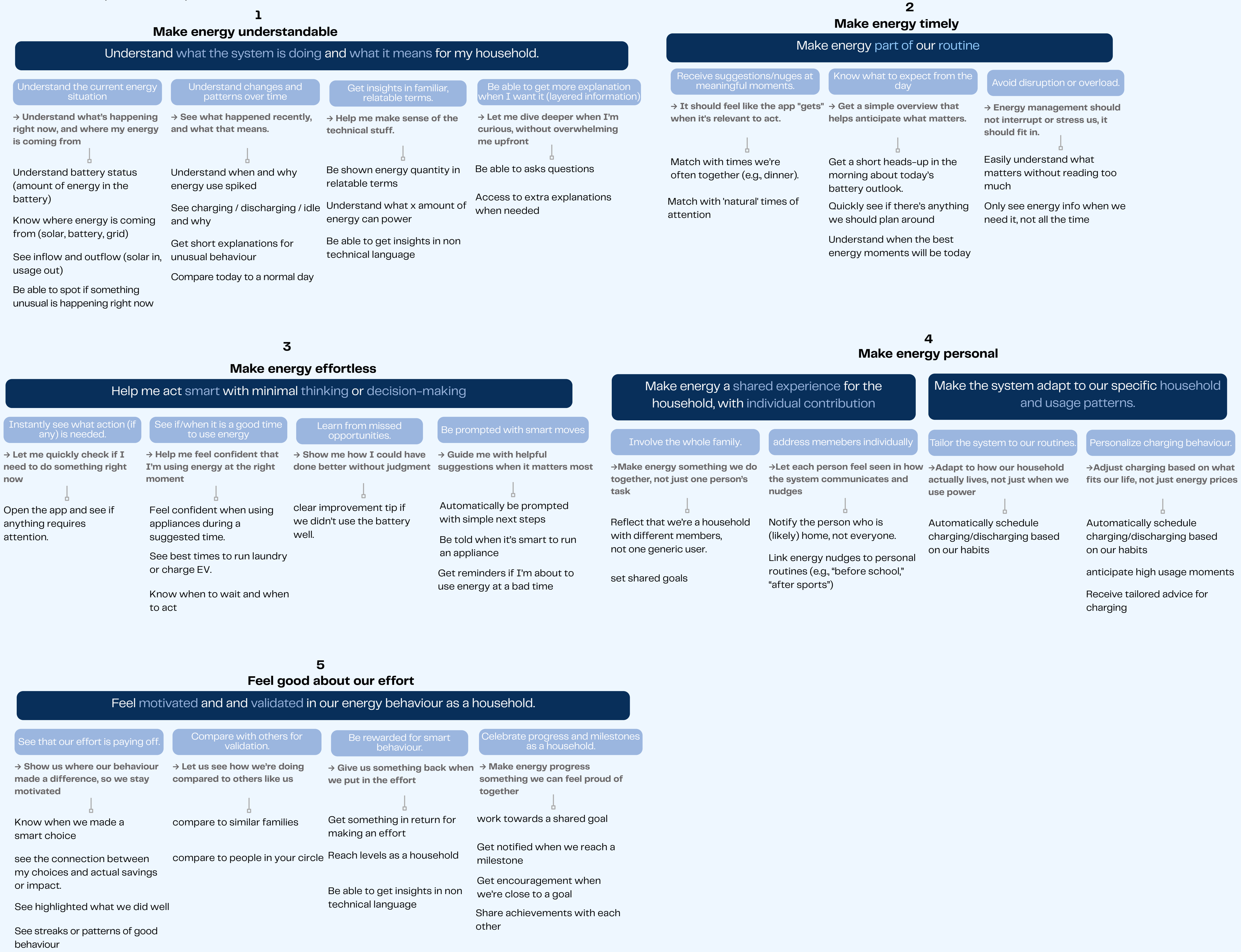
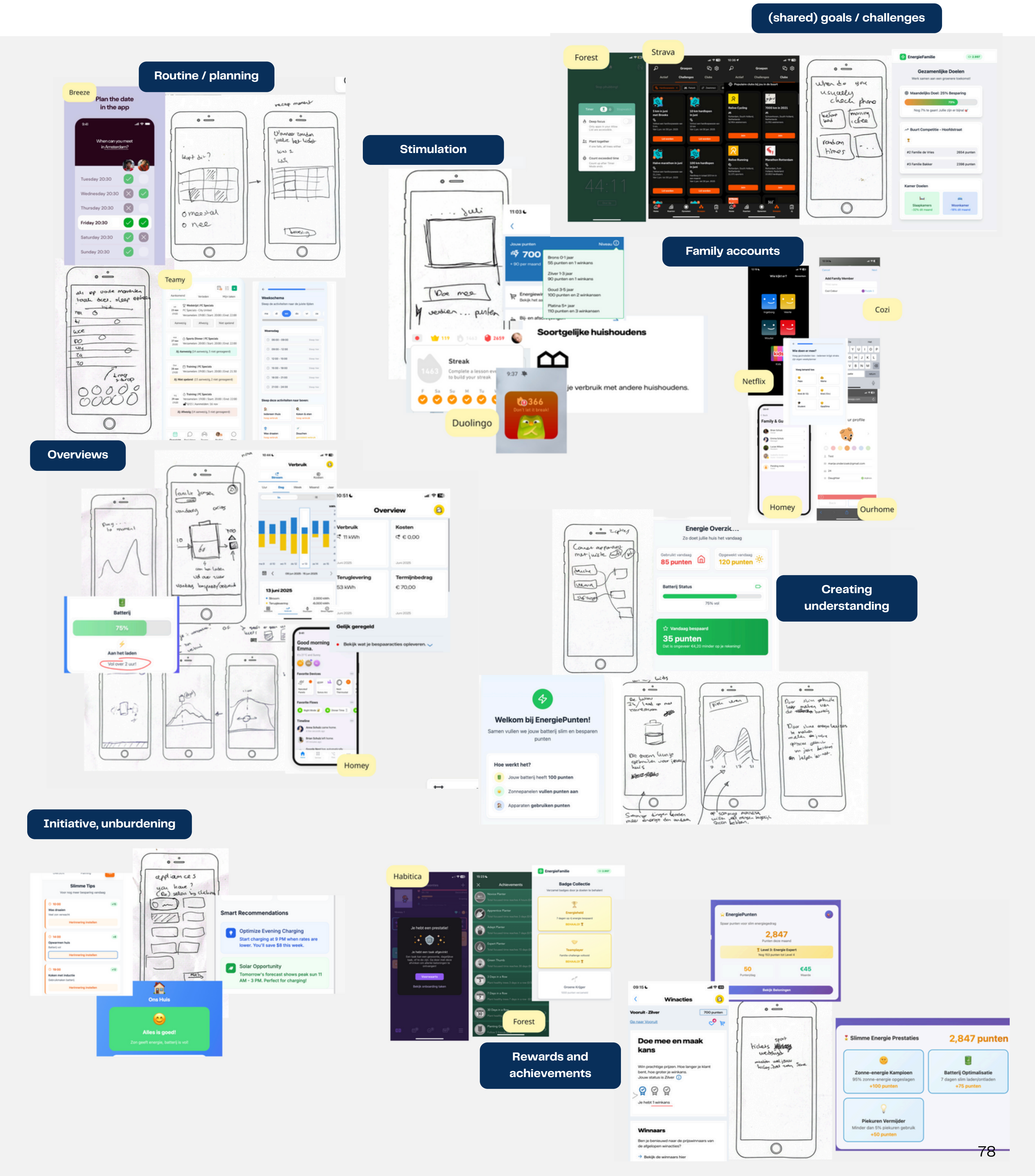


Figure 16.1: JTBD tree

17. The 'How'

17.1 Ideation

In ideation, a mix of between sketching, AI prototyping tools and best practices from other apps, was used. A selection of these explorations is shown in the overview below.



17.2 Co-creation workshop

To ensure that the concept development was grounded in both creative exploration and organisational relevance, a co-creation workshop was conducted with members of Vattenfall's UX design and research team.

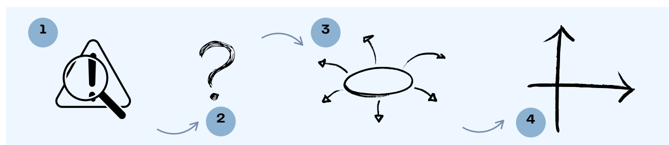
The primary goal of this session was to generate a wide range of potential directions for the concept by collectively ideating around the four core problems identified in earlier research. The workshop served as a divergent phase within the ideation process, opening up space for new perspectives and internally aligned ideas.

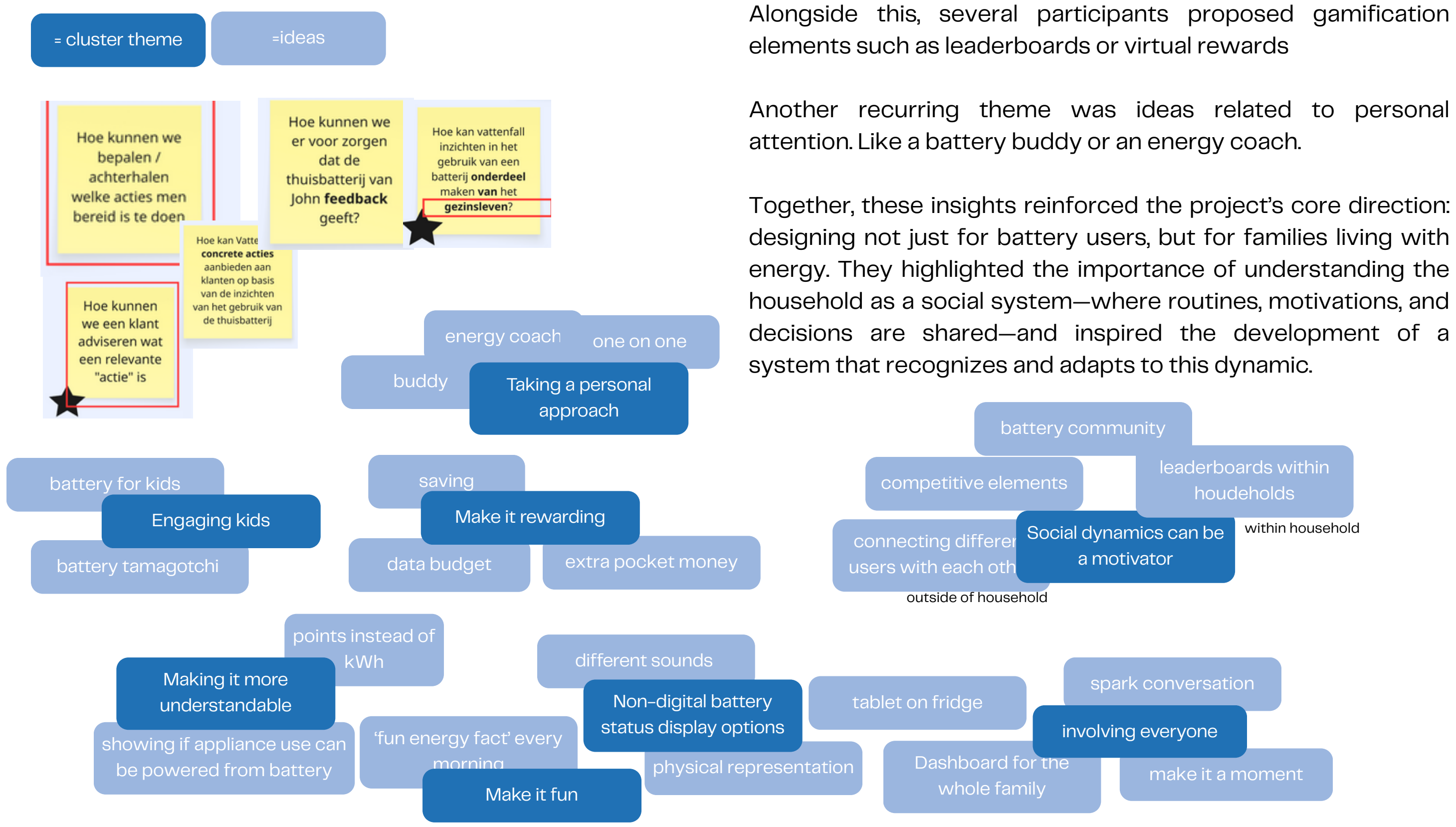
For the full workshop setup, outcomes, and analysis, see Appendix IV

17.2.1 Workshop structure

The session focused on four core problems identified in the earlier stages of the project. These problems were translated into opportunity areas using How Might We (HMW) questions, which acted as prompts to guide creative thinking.

Participants were encouraged to generate as many ideas as possible, using keywords and drawings for low-threshold contributions. After the initial brainstorm, each participant selected the two most promising ideas from another participant's contributions. These selected ideas were then mapped on an impact-feasibility matrix, sparking discussion around which concepts were both desirable and realistic from Vattenfall's perspective.





17.2.2 Workshop outcomes

The outcomes of the workshop were analyzed using the following approach:

- Sorted all input by activity
- Identified recurring themes, popular ideas, surprising angles
- Linked insights to design direction and existing opportunity spaces

Figure 17.1 shows the resulting clusters from the ideation step and interesting HMW's. Ideas were grouped by theme to reveal shared motivations and strategic opportunities.

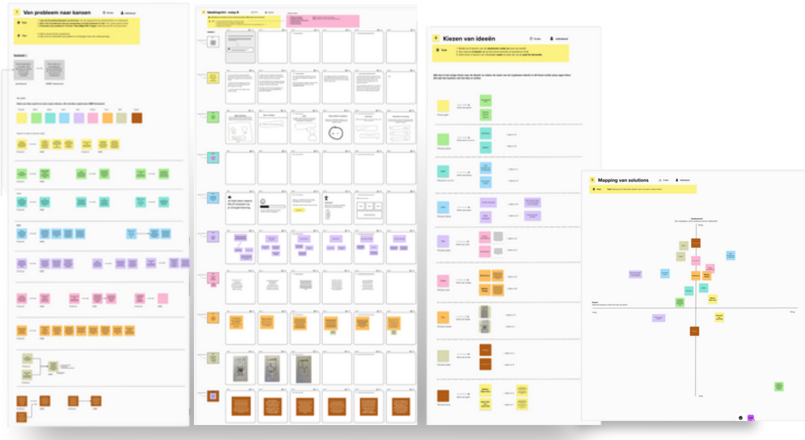


Figure 17.1: Co-creation workshop

Interesting takeaways
What stood out most was the way participants consistently framed energy behaviour as something shared—something that lives in the household, not just in individuals. Many ideas revolved around ways to involve children, suggesting that families are open to playful, age-appropriate ways of building awareness.

Alongside this, several participants proposed gamification elements such as leaderboards or virtual rewards

Another recurring theme was ideas related to personal attention. Like a battery buddy or an energy coach.

Together, these insights reinforced the project's core direction: designing not just for battery users, but for families living with energy. They highlighted the importance of understanding the household as a social system—where routines, motivations, and decisions are shared—and inspired the development of a system that recognizes and adapts to this dynamic.

18. Concept focus: supporting smart energy behaviour through adaptive design

18.1 The core principles

This chapter outlines the core focus of the concept developed in this project. The starting point is a clear problem: the current home battery proposition does not sufficiently support families in their day-to-day energy management. While the system is technically smart, it fails to connect with the household's needs, preferences, and daily life.

Based on the insights gathered, a concept was developed that places behaviour, not technology, at the centre. The goal is to help families manage their energy more intelligently, in a way that feels simple, relevant, and low-effort. But if there's one thing this project made clear, it is that every family is different. Each household has its own routines, preferences, and priorities. This means the system cannot rely on a one-size-fits-all approach. It must adapt.

The concept therefore introduces a system that first learns from the family, then activates targeted behaviours, reinforces those behaviours, and adapts as it learns. This approach forms the basis for a new value proposition: a system that adapts to the people who use it, and in doing so, is able to provide meaningful support for smart energy management (see Figure 18.2).

Instead of designing the full app, the focus is on the part of the system that holds the most potential for adaptation: the onboarding flow, smart system and the motivation mechanism.

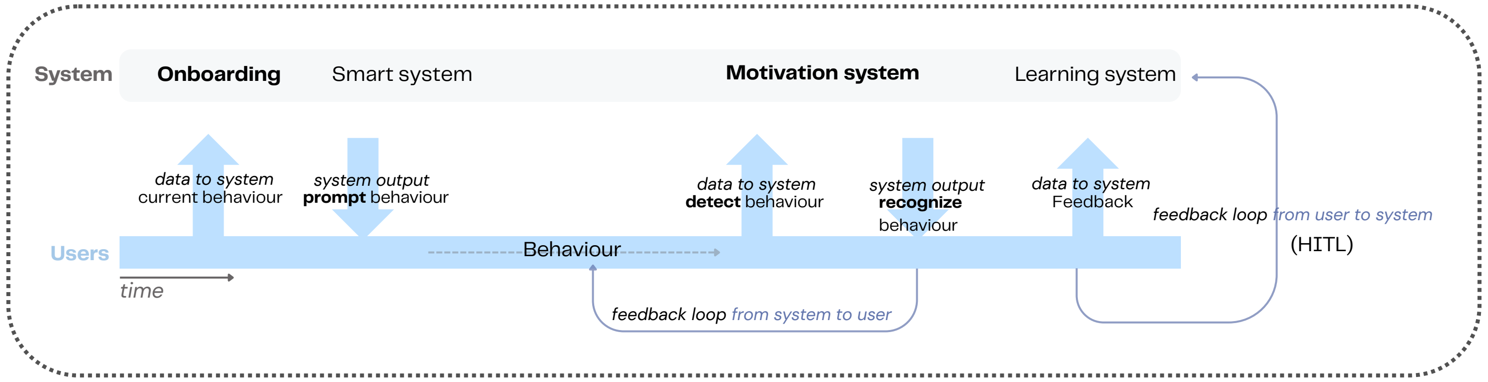


Figure 18.1: Behaviour loop as system focus

> Design behaviour like you would design anything else. Map out the target behaviour, then Figure out what needs to shift in terms of Motivation, ability and prompts to make it happen
>
> **– Dr. BJ Fogg**
> (Fogg et al, n.d.)

18.2 The behaviour loop

To enable this kind of support, the concept is built around a continuous behavioural loop. This loop is illustrated in Figure 18.1.

The blue timeline shows the user journey over time and highlights the dynamic between the system and its users. Each phase in the loop builds on the previous one. Together, they form a self-reinforcing structure that allows the system to adapt to the user and support behaviour change over time.

- Onboarding: The system learns about the household. This input reveals what motivates the family, what it is they want to do and what is realistically achievable in their context.
- Prompting: Based on what it knows, the system activates the right behaviour in the right way
- Behaviour: The user performs the behaviour.
- Feedback: The system detects this behaviour, recognises it, and learns from how the user responds.

This loop creates a learning system that adjusts to the user and supports smarter energy behaviour as part of daily life.

To ground this loop in behavioural science, the concept draws on three complementary models: the Transtheoretical Model (TTM), the Fogg Behaviour Model (FBM), and the Hook Model. These models are explained in the following section.

18.3 behavioural models supporting the concept

The design is grounded in established behavioural models. These models explain how behaviour occurs, how it changes over time, and where design can effectively intervene to stimulate smarter energy use.

Each model contributes from a different angle: in-the-moment behaviour, change over time, and ongoing engagement. Together, they form the behavioural foundation of the concept.

This section introduces the key principles of each model. The final overview (see page 85) shows how they come together to inform the design.

18.3.1 Fogg behaviour Model (FBM)

Behaviour at a specific moment

The most influential model in this project is the Fogg Behaviour Model (FBM), developed by widely recognised behavioural scientist Dr. BJ Fogg. It was further refined through a one-on-one discussion with Dr. BJ Fogg during the development phase. His model forms the backbone of the behaviour loop in the concept.

The FBM explains that behaviour only occurs when three elements align at the same moment: motivation, ability, and a prompt. If one is missing, the behaviour fails.

Fogg's view on motivation is particularly relevant. He warns against trying to artificially increase motivation through design, since it's unsustainable. Instead, he argues that motivation naturally fluctuates in what he calls "motivational waves." High motivation opens a window to perform harder behaviours that pay off later. The key, then, is to recognize those waves and use them to make future behaviour easier.

This insight directly influenced the design strategy:

- Prioritize identifying what users are already motivated to do.
- Use high-motivation windows to establish structure for low-motivation moments.

Fogg summarises this with a central idea: "The best products help people do what they already want to do." This makes the FBM not just a theory of behaviour, but a call for personalized design: first understand the user, then support what they already care about.

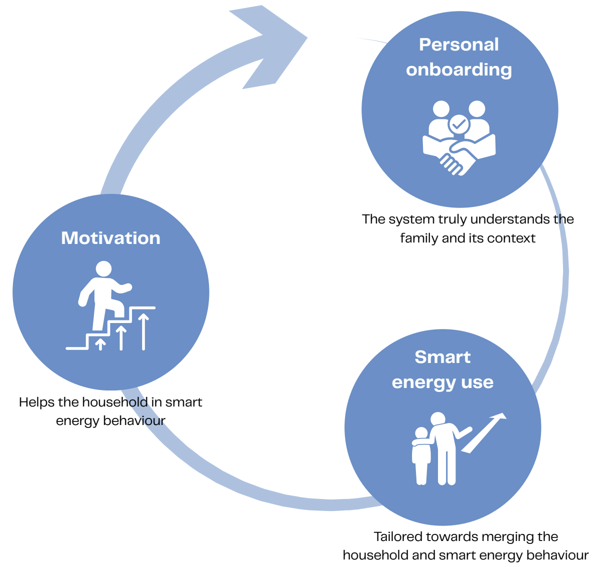


Figure 18.2: The system

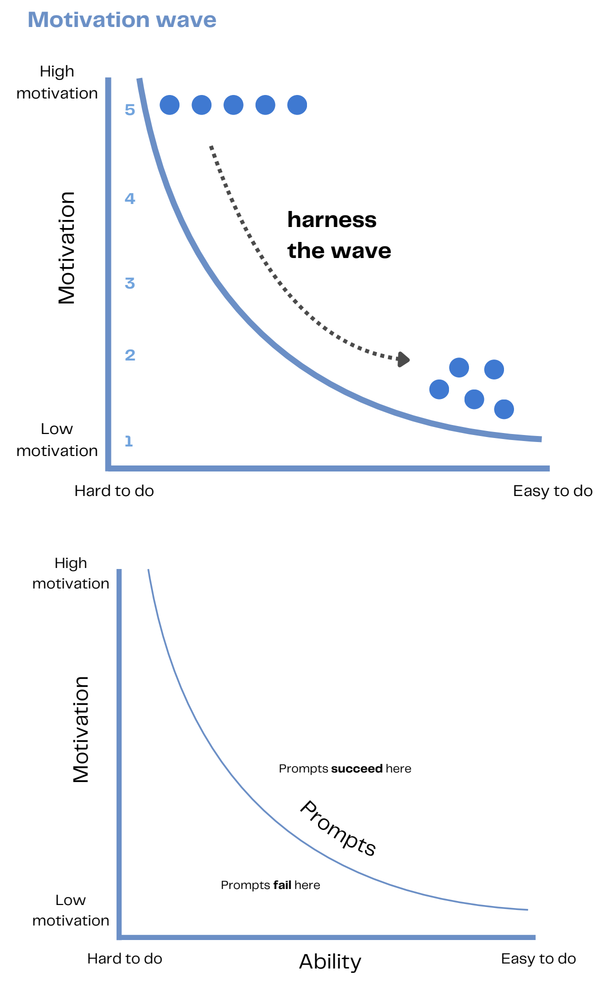


Figure 18.3: The FBM

18.3.2. Transtheoretical Model of behaviour Change (TTM)

Framing behaviour change as a proces

Where the FBM focuses on the moment, the Transtheoretical Model (TTM) takes a longitudinal view (Siddharthan et al., 2021). It is one of the most established models for understanding behaviour change and is often used in interventions involving lifestyle and health.

TTM defines five stages of behaviour change., of which 3 are relevant in this concept: preparation, action, and maintenance.

- **Preparation**: This is where people make a commitment. Motivation and determination is often high. Here, the focus is on getting everything in order for change.
- **Action**: In this stage, change happens. An important assumption here is that people are willing to receive assistance and support. Developing short-term positive reinforcement in the form of rewards sustains motivation (Raihan & Cogburn, 2023).
- **Maintenance**: The behaviour has become more stable but still needs attention to prevent relapse or detachment. This is typically after ± 6 months (Raihan & Cogburn, 2023).

The strength of this model lies in the core idea that change is a process, not a single moment. For this project, the model provides a useful lens to structure the concept in phases, each with its own empahsis. However, the model lacks detail in how to support users dynamically within a stage. That's where FBM and the Hook Model add value.

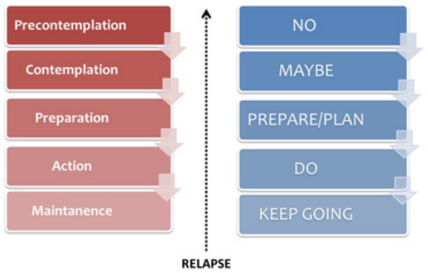


Figure 18.4: The TTM

18.3.3 Hook Model

Sustaining behaviour over time

The Hook Model is widely used in product and UX design to create habit-forming services.

The Hook Model consists of four stages: trigger, action, variable reward, and investment. These repeat in a loop to build user habits over time (Lukyanchikova et al., 2023).

The Hook Model builds on FBM but adds two key ideas:

- Variable rewards: These introduce unpredictability, which can make experiences more engaging.
- Investment: Users put effort into the system (time, data, attention), which increases its personal relevance and enhances its performance.

In this project, the Hook Model supports the idea that every user action is an opportunity for the system to learn and improve. For example, if a user shares their schedule, this is not just data; it's an investment that can be rewarded and reflected in the system's guidance. The model therefore helps operationalise how feedback loops can grow stronger over time.

Figure 18.5: The HOOK model

18.4 The steps of the behaviour loop

The visual overview on the next page explains the steps of the system in more detail and links it with the behaviour models. It illustrates how the steps build on one another, creating a layered approach where each element reinforces the next.

Their combined logic shapes the behaviour loop, the onboarding design, the motivation strategy and the system's long-term adaptability.

18.5 Conclusion

To design an effective concept, we need to understand how to support each part of the behaviour loop, as they are deeply connected. A strong onboarding process creates the conditions for a system grounded in relevant motivation. Prompts are the system's way of thinking along with the user. Feedback ensures that behaviours are not only triggered, but sustained. If one part falls short, the others lose effectiveness.

This means working out how the onboarding process can surface meaningful input, like specific, goals, needs and family routines, so the system can truly adapt to the household it supports. It also means designing a motivational strategy that makes smart energy behaviour feel achievable and relevant for the household.

The next two sections zoom in on these two pillars:

- **Onboarding**: How the system can tailor itself to the household and provide the right foundation for behaviour nudging.
- **Motivation:** How the system can make energy behaviour feel rewarding, relevant, and worth repeating, at both the individual and family level.

1. Onboarding – start of the loop

The loop begins with the onboarding process, which forms the backbone of the system. This step allows the system to learn from the family: how they live, what they need, and how the system can help. The aim is to **prepare both the user and the system** for the behaviours that follow.

While this phase requires the most effort from users, it is essential to the system's ability to adapt meaningfully over time. Crucially, onboarding **coincides with a naturally high moment of motivation**: users have just installed a home battery and are anticipating its benefits.

This step also **plays directly into the motivational aspect** of behaviour design. To be effective, the system must first discover what the household wants: what outcomes they value, what problems they face, and what motivates them. Only then can the system start enabling those goals by offering relevant, easy, and well-timed support.

2. Prompting

Once the system has learned from the household, it can begin to prompt energy-related behaviours. Prompts are the mechanism through which the system activates action. **Without a prompt, behaviour does not occur,** even if the user is motivated and able to act. This makes prompting a critical link in the behaviour loop.

What makes a prompt effective is not just its presence, but its timing, tone, and relevance. The system must decide what behaviour to suggest, when to do it, and how to frame it. These decisions are based on earlier onboarding input and real-time factors such as weather, energy usage, or schedule data. Poorly timed or generic prompts often lead to frustration or inaction. In contrast, well-timed prompts can turn passive intention into action with minimal effort.

Prompting is also a moment to **show that the system understands the user.** When suggested actions clearly support personal goals, such as saving money or reducing waste, the prompt feels more relevant and is more likely to be followed.

3. Performing the action

After the prompt, the user either **performs** the suggested **behaviour** or not. This step is where the intended energy-related action takes place. Examples include shifting appliance use to a specific time, adjusting routines to achieve goals, or engaging with system insights. The actions must feel **feasible, relevant, and worthwhile**. If it feels too complex or disconnected from the user's goals, it risks breaking the loop.

4. Feedback – reinforcing behaviour

Once a user has performed a behaviour, the system must **recognize and acknowledge** it. This is a crucial step for reinforcing the action and building a sense of progress. If users take action and hear nothing in return, the loop breaks. The behaviour remains invisible and may feel pointless.

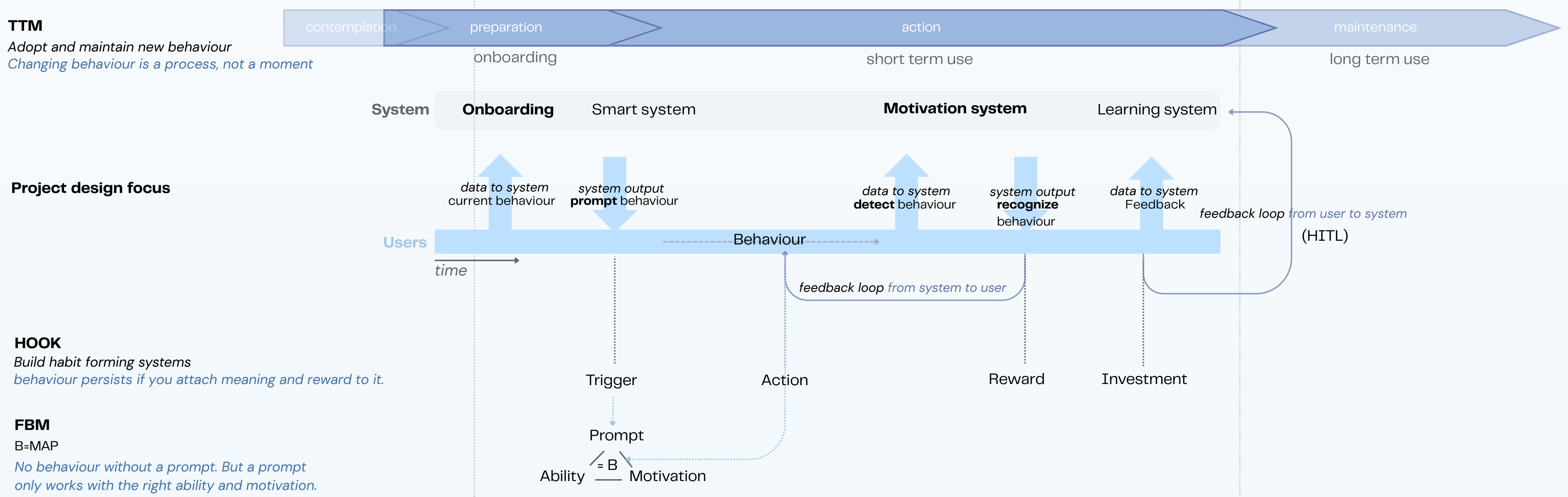
Feedback can take many forms. What matters is that it feels timely, relevant, and appropriate to the effort the user made. It should make the behaviour visible and confirm that it mattered.

This moment is directly tied to motivation. Reinforcement strengthens the likelihood of repeat behaviour. Feedback must feel meaningful to the user. That's where the system needs to integrate all it knows about the user's goals and motivation into this feedback.

5. Learning – adapting the system

At the same time, feedback flows from the user back to the system. This might be through direct input (e.g., responding to a feedback message) or passive behaviour patterns (e.g. ignored prompts) It helps the system keep learning and adjusting.

Loop explanation



Behaviour models

FBM
Wave of high motivation: system can ask more effort from users. This makes completing the onboarding feasible.

the onboarding in turn **structures the system for further use**, lowering the effort / increasing the ability for future actions.

It also captures the users' motivation and prepares for future prompts

Hook
at the same time, this effort is an **investment** from its users, making them connected to the system

TTM
Preparation stage: stresses the importance of getting ready before change can happen. The system gets in place by learning from its users during onboarding

FBM
When prompting aligns with motivation and ability, it's most likely successfull

TTM
Action stage: the system assists the users in their goals

FBM
When feedback and recognition is grounded in the users' motivation, it's meaningful

TTM
Maintenance stage: Reinforcing behaviour makes it more likely that is it maintained

Hook
A satisfying **reward** keeps users engaged and builds habit strength

Hook
Every user interaction is a small **investment** that makes the system smarter and more relevant.

TTM
Maintenance stage: Sustained change requires ongoing adaptation and support, especially when user context shifts.

The concept

The concept section presents the base of the final design. It lays the groundwork for the final design

19. Onboarding and learning as the foundation for adaptation

19.1 Introduction and strategic role

Where the previous chapter explained the behavioural reasoning behind the system, this chapter focuses on how that thinking is translated into the design of the onboarding experience. It shifts from theory to practice, detailing how the system starts learning from the household, and how that learning is used to deliver tailored support.

Onboarding is the system's entry point into the household. It plays a key role in enabling adaptive behaviour support.

To do this, it must understand who the family is, how they live, and what they want from the system. This understanding starts during onboarding and grows over time.

Since the system needs time and input to understand the household, onboarding is not treated as a standalone setup moment. It is the beginning of an ongoing learning process that unfolds over three phases (see Figure 19.1): onboarding, learning period, and optimized system.

This chapter outlines how onboarding is designed to enable learning. It introduces the structure, logic, and interaction principles behind the flow, supported by a service map of the system and screen designs developed in Figma. It also describes what the system needs to learn and how that information is surfaced in a way that's feasible.

The second part of the chapter covers how the system continues learning after onboarding and how this leads to increasingly relevant support over time.

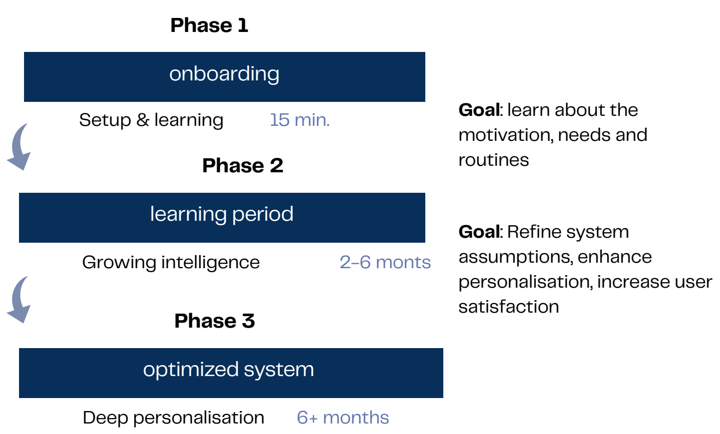


Figure 19.1: System development phases

The full development of the system is presented in the development roadmap in chapter 25.

19.2 Defining system capabilities

Before defining what the system needs to learn from the user during onboarding, it is essential to first define its scope: what it already knows and is what its capabilities are.

19.2.1 Available data

Vattenfall's system can already access and process a wide range of data. An overview is shown in Figure 19.2. Regarding transparency, it is important that users are made aware of this during onboarding and are encouraged to check whether the available information is still accurate and reflects their current situation.

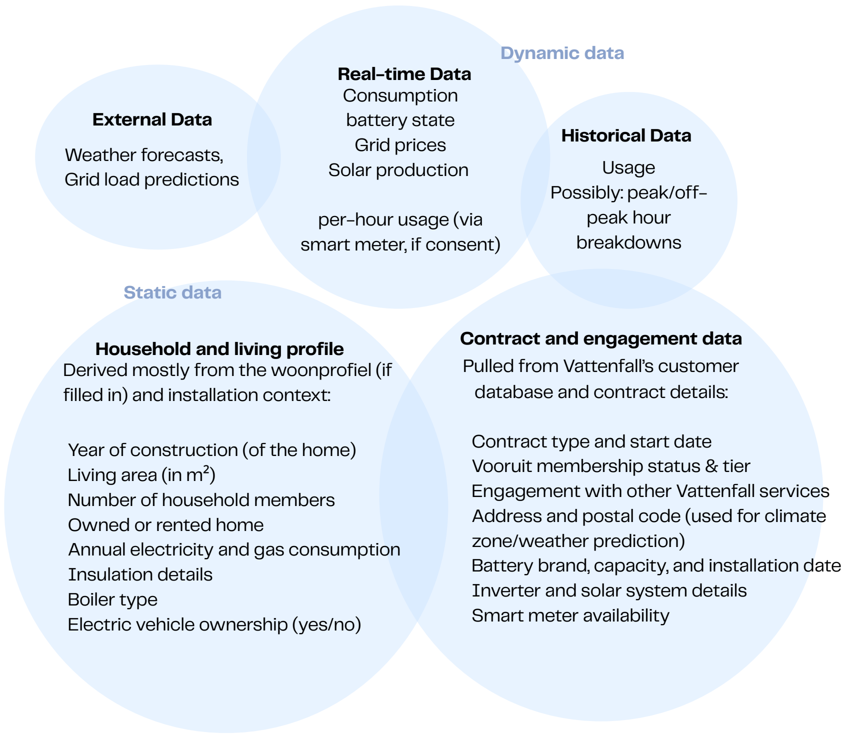


Figure 19.2: Available data

19.2.2 Capabilities

The data streams are interpreted through various artificial intelligence and machine learning (ML) techniques. The system is designed to be 'smart', leveraging data to support energy decision-making. This will be explained in further detail in chapter 27.

19.3 Identifying relevant gaps & onboarding needs

Now that the system's capabilities are defined, we can establish what it still needs to learn.

While Vattenfall already holds access to (detailed) energy data and basic user profile data, they lack insight into how energy use is embedded in household routines, decisions and motivational preferences. These are precisely the factors that shape energy behaviour.

So what does the system need to know, and why?
A complete overview is shown in Figure 19.3.

19.3.1 The effort-output balance

A key design challenge is the tension between user effort and system intelligence. The target group has a clear desire to be unburdened (low effort), yet supporting smart behaviour requires a system that truly understands the household it supports. That means asking for input, which requires effort.

Effective onboarding must strike a balance: it collects just enough input to enable meaningful personalisation, without demanding too much effort from the user. That's why a great deal of effort was put into what information to collect, how to structure the flow, and how to keep the experience light. Not every question should be asked directly. Where can the system pre-fill information? Where can it make educated guesses? And where can it elicit input in a more playful, indirect way?

These considerations led to a set of core design principles, which are outlined in the next section.

Figure 19.3: Onboarding needs

1. Household composition

Why it matters: To know who to address, who is home when, whether suggestions are feasible, and when certain usage peaks can be expected

Needs to learn:
- Who lives in the household (number, name, age)
- Typical presence schedule (per family member)

2. Appliance usage & flexibility

Why it matters: To understand current challenges , which activities can be shifted in time, and what the potential impact would be.

Needs to learn:
- Which appliances are present and relevant
- Which tasks the family is open to shifting in time
- Existing appliance-related routines
- Known pain points

3. Family preferences, goals & motivation

Why it matters: To shape system's focus, approach, and framing of both guidance and feedback.

Needs to learn:
- What motivates the family, what the household values most
- What their long term energy goals are
- What they expect from the system, what role it should play
- How much and what type of guidance they want
- What kind of feedback feels meaningful
- Preferred communication tone/style

4. Energy awareness & involvement needs

Why it matters: To match users' level of understanding and interest in involvement.

Needs to learn:
- The amount of detail in information wanted
- Whether users want to stay involved in certain system processes
- Whether simplified units are helpful (kids/admin)

19.4 Design principles

These design principles led the design of the onboarding flow. Each is linked to a number, that can be found back in the annotated prototypes.

Minimize effort

1 • **Keep it short and visual:** Each step should be concise, with visual support (e.g., icons, progress bars) to keep the flow intuitive.
2 • **Only ask what's needed**
3 • **Use defaults where possible (nudging theory):** Pre-fill fields or estimated guesses

Minimize friction

4 • **Reassure flexibility:** Make it clear that answers can be adjusted later. This reduces the perceived risk of being "locked in."
5 • **Elicit information naturally:** Whenever possible, design questions as subtle prompts, tasks, or playful activities rather than a formal questionnaire.
6 • **Show where they are:** Use progress indicators to give users a sense of control and help them track how far they've come.
7 • **Friendly, playful tone:** Use a light, smart tone with moments of cheeky humor. Keep it casual, never childish.
8 • **Choice within structure:** Users get control, but always within curated, predefined pathways that avoid complexity.

Make it feel personal

9 • **Show impact of answers:** Provide interim feedback like: "Based on your answers, we'll help your family mainly with..."
10 • **Address all family members:** Use names where possible. Consider how children engage with the process, even if indirectly.
11 • **Play with family dynamics:** Incorporate elements that make the system feel aware of and responsive to household interactions.

Show the value of the system

12 • **Be transparent:** Clearly explain why information is being asked, how it will be used, and why it's valuable.
13 • **Start with action**: At the end of the onboarding, users are already 'hooked' in a practical first energy goal
14 • **Highlight key features:** Use moments in the flow to briefly introduce how the system functions, such as setting own goals

Communicate with respect

15 • **Avoid stereotypes**: Don't assume who does what. Use inclusive terms like "parents" instead of "mom/dad".
16 • **Respect intelligence**: Keep the experience accessible, but not oversimplified—families want to feel understood, not talked down to.

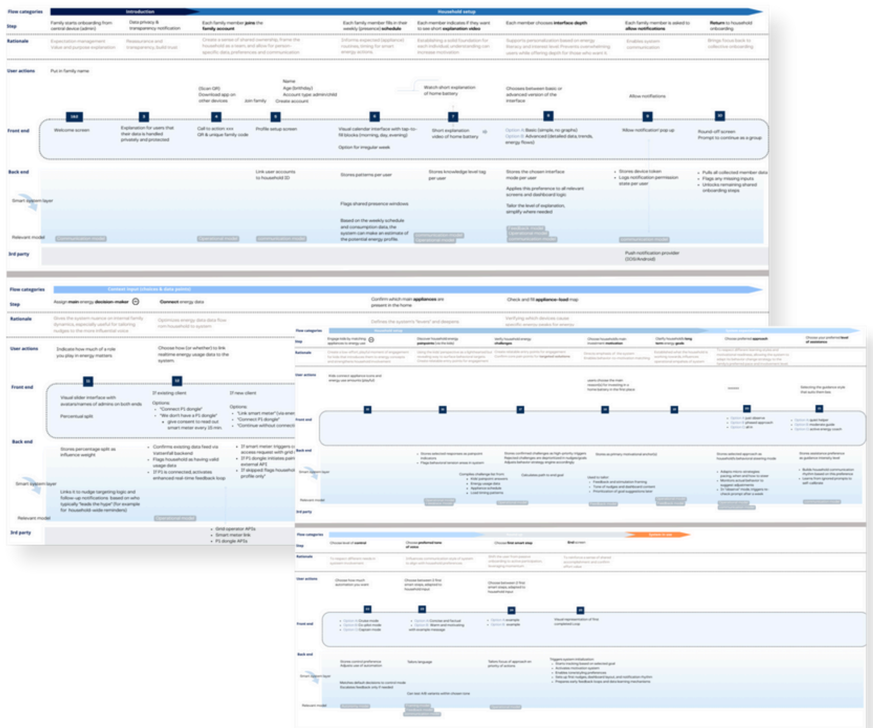
19.5 The onboarding flow

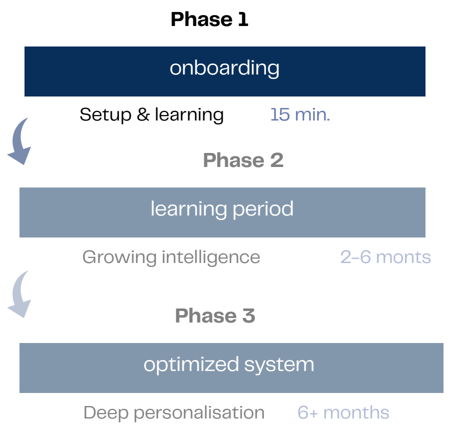
19.5.1 Flow diagram

To bring these principles to life, the onboarding process was translated into a visual user flow. This **flow diagram** outlines what the user does during onboarding: the key steps they move through, the front-end and back-end actions, smart system translation and the logic behind them.

The full flow map can be found in Appendix P. Each step of the map is linked to the corresponding screen, detailed in chapter 22

Figure 19.4: Screenshots of the onboarding map





19.5.2 Onboarding interface

A prototype of the onboarding flow was created by designing high fidelity (HiFi) interface screens.

Note: The interface is presented in Dutch, as the design is developed for Vattenfall NL.

From LoFi to HiFi

The visual below shows the iteration flow used in this project, from early concept sketching to a high-fidelity prototype. A LoFi prototype was first created in Miro Beta, enabling quick exploration and iteration of structure and logic. A fully functional prototype was then built in Lovable, allowing for optimal testing. The final concept was designed in Figma, aligned with the Vattenfall design system.

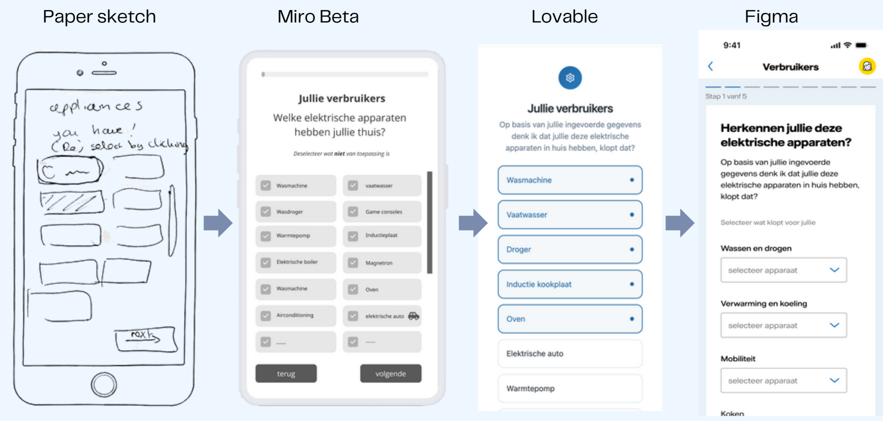
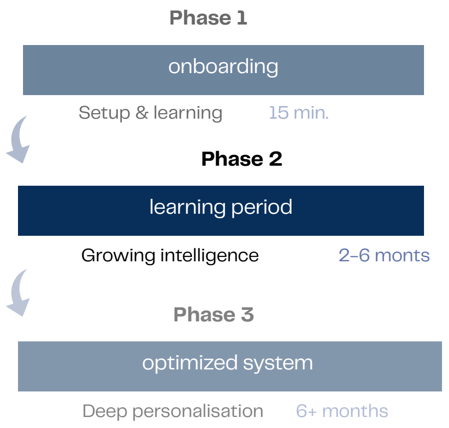


Figure 19.5: From sketches to HiFi prototype

19.6 Learning period: adapting through use

As outlined earlier, the system evolves across three development phases: onboarding, learning period, and an optimized system. Each horizon builds on the one before it, gradually increasing personalisation and performance over time.

Now that onboarding is tackled, the system enters its second development phase: the learning period.



The initial onboarding phase of the home battery application establishes the foundation and provides the system with enough knowledge to meaningful assist the family. Following this, the system enters a crucial learning period, designed to continuously optimize its operation and user interaction based on real-world usage and explicit family feedback. This illustrates the end of the behaviour loop, as illustrated in Figure 19.6

19.6.1 Purpose

The primary objective of the learning period is to bridge the gap between initial user input and the dynamic reality of household energy consumption. While onboarding provides a baseline, actual actions, patterns and evolving preferences ask for a flexible adaptation mechanism. This phase aims to:

- **Refine system assumptions:** Validate and adjust the system's initial estimations regarding appliance usage, family presence, and energy flexibility.
- **Enhance personalisation:** Deepen the understanding of the family's specific needs, preferred communication styles, and motivational triggers beyond the initial selections.
- **Increase user satisfaction:** Ensure the app's guidance remains relevant, non-intrusive, and genuinely helpful, thereby stimulating long-term engagement and trust.

19.6.2 How the system learns

The system can learn in two primary ways:

1. **Autonomous learning:** primarily occurs through the continuous monitoring and analysis of energy consumption and generation data. The system combines the capabilities (defined in chapter 27)
2. **Human-in-the-loop (HITL):** Actively asking the user for feedback

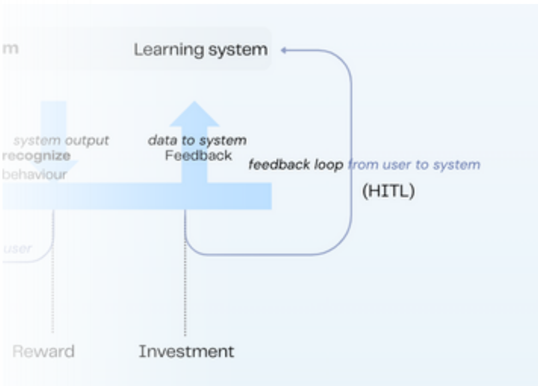


Figure 19.6: End of behaviour loop

HITL within the system
Central to the optimization process is a Human-in-the-Loop (HITL) learning mechanism (bron). This approach leverages the family's direct input as an important data source, allowing the system to learn from their explicit feedback and behavioural patterns.

The system actively seeks user feedback, which is then integrated to refine its models and adapt its behaviour. This iterative feedback loop ensures that the system's intelligence is continuously aligned with the complex and often unpredictable dynamics of a family household.

Importantly, every time the user contributes feedback, whether explicitly or through their behaviour, they invest in the system. This aligns with the Hook model's investment phase, where user input increases the likelihood of future engagement.

The HITL learning in this system is facilitated through two primary categories of feedback mechanisms, detailed in the overview on the right

Inspiration from other systems
The design of these learning mechanisms draws inspiration from various modern interfaces, particularly those employing adaptive AI. Appendix M shows how different systems leverage user feedback to refine their performance and interaction style. Platforms like ChatGPT, for instance, utilize explicit user feedback about preferred responses or corrections to improve future outputs and align more closely with user expectations.

By integrating such human-centric feedback loops, this home battery application aims to achieve a comparable level of adaptive personalisation

19.6.3 Feedback modes: trigger-bound and system-initiated

the system elicits feedback in two distinct ways: system-initiated (not trigger-bound) and trigger-bound feedback. This distinction clarifies when and why the system seeks user input.

To design the learning feedback system, it was considered per onboarding input category, how te system could best improve itself.

! Important to note is that these represent possibilities for the system to learn, not fixed actions. Which type of feedback to deploy, and at what frequency, should be carefully considered to avoid user fatigue while maintaining meaningful adaptation.

The overview on the next page outlines concrete examples of how the system can solicit feedback during the learning period. Each row represents a specific category of feedback, illustrating the situation that might trigger it, the backend condition that prompts it, and the corresponding question or mechanism presented to the user. Together, these examples show how the system targets different input categories to refine its understanding and improve performance over time.

19.7 Optimized system

In this final phase, the system has developed a rich understanding of the household. In the optimised system, the primary learning stream shifts decisively toward autonomous learning. Human-in-the-loop (HITL) feedback is minimized.

By this phase, the system should have reached the family's preferred mode of operation. While the core configuration stabilizes, the system remains adaptive in its day-to-day operations. It continues to monitor real-world conditions, adjust to seasonal or lifestyle changes, and optimize based on updated energy data, all without requiring active user input.

System-initiated feedback (not trigger-bound)

These mechanisms are designed to allow families to provide feedback on an ongoing basis or in response to general observations, without being tied to a specific, immediate event. This category supports continuous refinement of the user experience.

Trigger connected feedback

These mechanisms are context-specific, activated by particular events, system observations, or user behaviours. They enable the system to learn from direct interactions and real-time situations.

Category	Feedback question/mechanism
Level of control	Suggested pre-charge for the evening peak. Allow / Don't allow / Don't ask again.
Level of assistance	Example message / Don't show these type of messages again.
Tone of voice and value framing	A / B / Which message do you prefer?
Level of detail	Example message / More explanation
Overall satisfaction	Example message / Change settings?

Category	If	Back-end trigger	Feedback question/mechanism
Verification of appliance run rimes	Uncertainties in coupling usage with appliance	No clear cause-effect pattern detected in data	Look's like you had high energy consumption around 6PM. Was this due to cooking dinner? / Are you cooking dinner right now
Goal progress	system notices household is growing	No clear cause-effect pattern detected in data	Try … this week?
Painpoint assistance	System detects consistent unoptimized behaviour	Persistent pattern of unoptimized behaviour for x period.	We noticed [specific behaviour] might be costing you extra. Would you like a specific tip to tackle this?
Schedule check	system suspects user schedule has changed	Patterns recognition notices new pattern	You haven't updated your schedule in a while / Still accurate? Yes / No, change
Alter timing	System is unsure whether suggested action is feasible	Observed usage deviates from baseline/predicted.	Shall I adjust future suggestions to this time?
Measure performance	System is unsure whether message/nudge is in line with user expectations	Confidence score below threshold	Example message / Is this helpful? Yes / No / How helpful is this message ★ ★ ★ ★ ★
Test ability / flexibility	System is unsure whether suggested action is feasible	Confidence score below threshold	Are you able to / Yes / No

20. Making energy behaviour stick: motivational design in an adaptive system

20.1 Introduction and strategic role

Where the previous chapter focused on how the system learns from the household, this section explores how the system can make smart energy behaviour feel relevant and worth repeating. Not only from a technical or financial perspective, but at a human level, within the dynamics of everyday family life. It closes the loop.

20.1.1 Clarifying terminology

Motivation is a multifaceted concept, and the system's design leverages different psychological levers to support it. Terms such as motivation, stimulation, feedback, and rewards are frequently used, sometimes interchangeably in casual conversation, but they each have distinct meanings. Clarifying these distinctions is important for understanding how the system is designed to influence behaviour.

While often grouped together, they serve distinct roles:

- **Motivation** is defined as the desire to perform the behaviour (Fogg, 2009)
- **Feedback** refers to making the outcome of a behaviour visible in order to reinforce or sustain motivation.
- **Stimulation** involves encouraging action by tapping into pre-existing motivation.
- **Reward** means offering something in return for a user's behaviour (usually extrinsic) which can act as a motivational boost, especially when intrinsic motivation is low.

20.1.2 A shift in strategic focus

In early iterations, the concept emphasized externally rewarding smart behaviour. However, in dialogue with behavioural expert Dr. BJ Fogg (see chapter 21 (test outcomes), the approach evolved. Rather than relying on transactional rewards, the system now focuses on reinforcing identity and personal relevance. The goal is to support motivation in a more durable way.

20.2 Designing within a responsiblity tension

My personal view as a strategic designer

This shift highlights a fundamental design question: whose motivation are we designing for? If motivation is defined as the desire to act, then should the system only support behaviours users already want to adopt? Or should it also try to make behaviour that is essential for the energy system, but less beneficial for households, feel meaningful?

This tension is visualized in Figure 20.1.

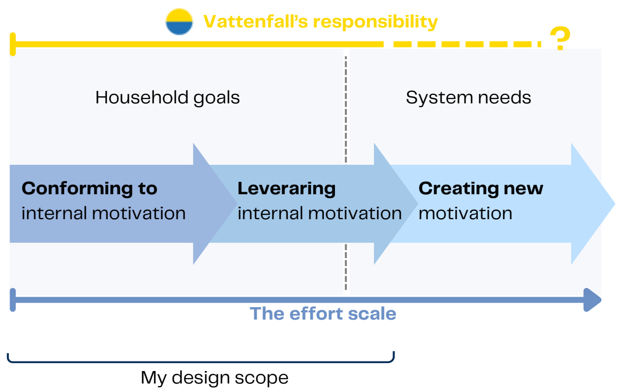


Figure 20.1: The responsibility tension

On the left, where effort is low and personal relevance is high, it's enough for the system to just conforms to users' natural internal motivation. As effort increases, the system must the system must actively leverage that internal motivation. Eventually, there's a point where personal benefit fades while system needs persist. At that point, a new form of motivation must be created.

This system operates across the first and second, and partially the third layer of that motivational spectrum. It supports household-driven goals, but also nudges users toward behaviour that serves the wider grid. However, it does not tap into linking external motivation (like financial compensation) to behaviour.

But just because my design scope stops there doesn't mean I believe Vattenfall's responsibility ends there too. If Vattenfall wants to align with their stance on their responsibility in the energy transition (see Figure 20.2) , it must also invest in aligning user motivations with system goals, beyond what's naturally desired. The current system lays the groundwork, but also raises the question: What could Vattenfall do to make that kind of behaviour more desirable? Due to the design scope, this is further explored in the recommendations.

Onze klimaatambitie

Wij nemen onze verantwoordelijkheid

Als samenleving zijn we het gebruik van fossiele brandstoffen al aan het terugdringen, maar we zijn er nog steeds van afhankelijk. Daar willen we als Vattenfall Groep vanaf.

Om onafhankelijk te worden van fossiele brandstoffen, moeten we met z'n allen in actie komen. Als energiebedrijf nemen we onze verantwoordelijkheid. Vooruitgang staat bij ons centraal. Wij zetten ons in voor een toekomst waarin we voor onze energie minder afhankelijk zijn van het gebruik van fossiele brandstoffen. Stap voor stap bouwen we het gebruik hiervan zoveel mogelijk af. In 2040 verwachten we dat er nog CO_2-uitstoot overblijft. Die willen we compenseren.

Figure 20.2: Vattenfall's climate goals (Vattenfall, n.d.)

20.3 Existing motivational mechanisms within Vattenfall

Before proposing new mechanisms, it is important to review what Vattenfall already offers:

- **Vattenfall loyalty program**: Vattenfall currently operates two reward programs: Vooruit, a loyalty-based point system, and Blijven Loont, a long-term discount scheme.
- **Smart charging compensation:** Users with EV chargers receive financial compensation for allowing flexible charging behaviour.

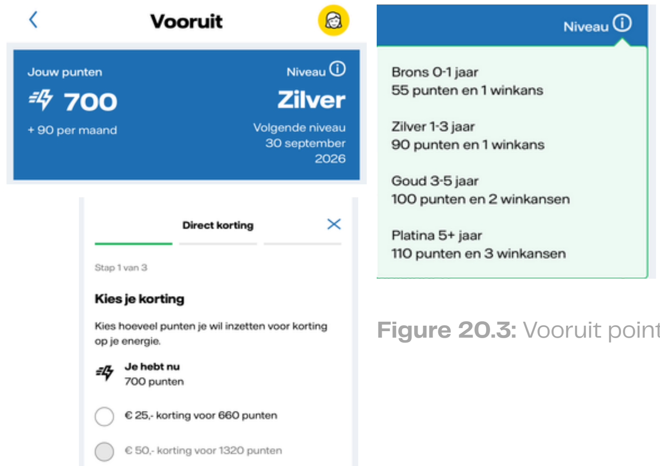


Figure 20.3: Vooruit points

20.3.1 How they work

Vooruit

Vooruit rewards customers with a fixed number of points per month, increasing with the duration of their contract (see Figure 20.3). Points can be:

- Exchanged for discounts on the energy bill (monthly or yearly),
- Spent in a product shop offering energy-related items (and others)
- Used for discounts on larger sustainability upgrades (e.g., solar panels, heat pumps), though no clear pricing information is provided within the program interface.

Additionally, customers receive a number of "win chances" (winkansen) per month, also linked to the number of years as a client. These can be applied to monthly prize draws for energy-related products.

Blijven Loont

Blijven Loont offers a growing discount on the variable energy delivery fee for customers who purchase both electricity and gas (or heat) from Vattenfall.

Smart charging compensation

This is where it gets interesting. Users receive a fixed compensation per kWh for charging their battery "smartly", which means giving Vattenfall partial control over when charging happens. Vattenfall can offer this reward because it earns revenue by using that flexibility on the imbalance market.

20.3.2 Critical observations

While the structure of Vooruit and Blijven Loont provides a sense of continuity and appreciation for loyalty, several limitations become apparent when viewed through the lens of behaviour change:

Vooruit + Blijven Loont

- Passive by design: Rewards are based solely on duration as a customer, not on energy behaviour.
- Low visibility: Points and benefits are buried deep in the interface, reducing day-to-day impact.
- Limited perceived value: Many rewards require significant point accumulation, weakening motivation.
- No household lens: The system treats users as individuals, ignoring family dynamics or shared goals.
- One-size-fits-all: No tailoring to personal values or usage patterns.

Smart charging compensation

- Behaviour-based potential: Unlike loyalty programs, this rewards users for real action.
- Has clear business case: Vattenfall earns money with this service so paying customers is easy.
- Transactional tone: Treated as a purely financial trade-off, rather than part of a motivating or meaningful strategy.

Together, these observations show a system focused more on retention than activation. This project explores how these foundations could be reframed, making sustainable behaviour more visible, valuable, and motivating.

20.4 Approach: building on what motivates families

So, if we want to leverage natural motivation—how do we actually do that? The approach began by mapping what naturally motivates families, and then exploring how those motivators could be meaningfully integrated into the system. This process is visualized in Figure 20.4

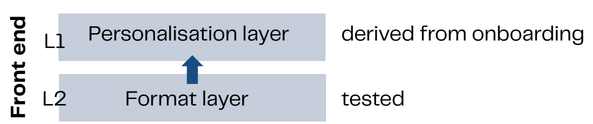
During the interviews, a range of motivating factors emerged, from practical triggers to deeper value-based drivers. These motivators were grouped into two main categories and structured into a layered hierarchy, distinguishing between the different levels of motivation the system can tap into—ranging from everyday cues to more aspirational goals.

20.4.1 How the system leverages motivation

What naturally motivates families
Motivators were grouped into two categories:

- **Outcome-related** motivators: these are highly personal and captured during onboarding.
- **Action-related** motivators: these are more universally human and were derived form interview insights.

Two system layers to amplify motivation



Layer 1: Matching user goals
Outcome related motivation should be matched by the system. This happens in the personalisation layer. Onboarding data can be directly projected onto the motivation mechanisms

Layer 2: Tapping into action-level motivation
The second layer is more interesting to zoom in on., because it's about behaviour, not just results. Beyond outcomes, there are other naturally motivating factors present in the target group. these were: feeling successful, friendly competition, doing it together, setting a good example and working towards something.

Tapping into these happens in the format layer.

Two system strategies to amplify motivation

When looking into which UX mechanisms can be used to fulfill these, 2 clear categories emerged. The system fulfills two functional motivational roles:

1- Stimulation for action (before)
Encourages behaviour by creating momentum.
2- Feedback on action (after)
Acknowledges and reinforces behaviour.

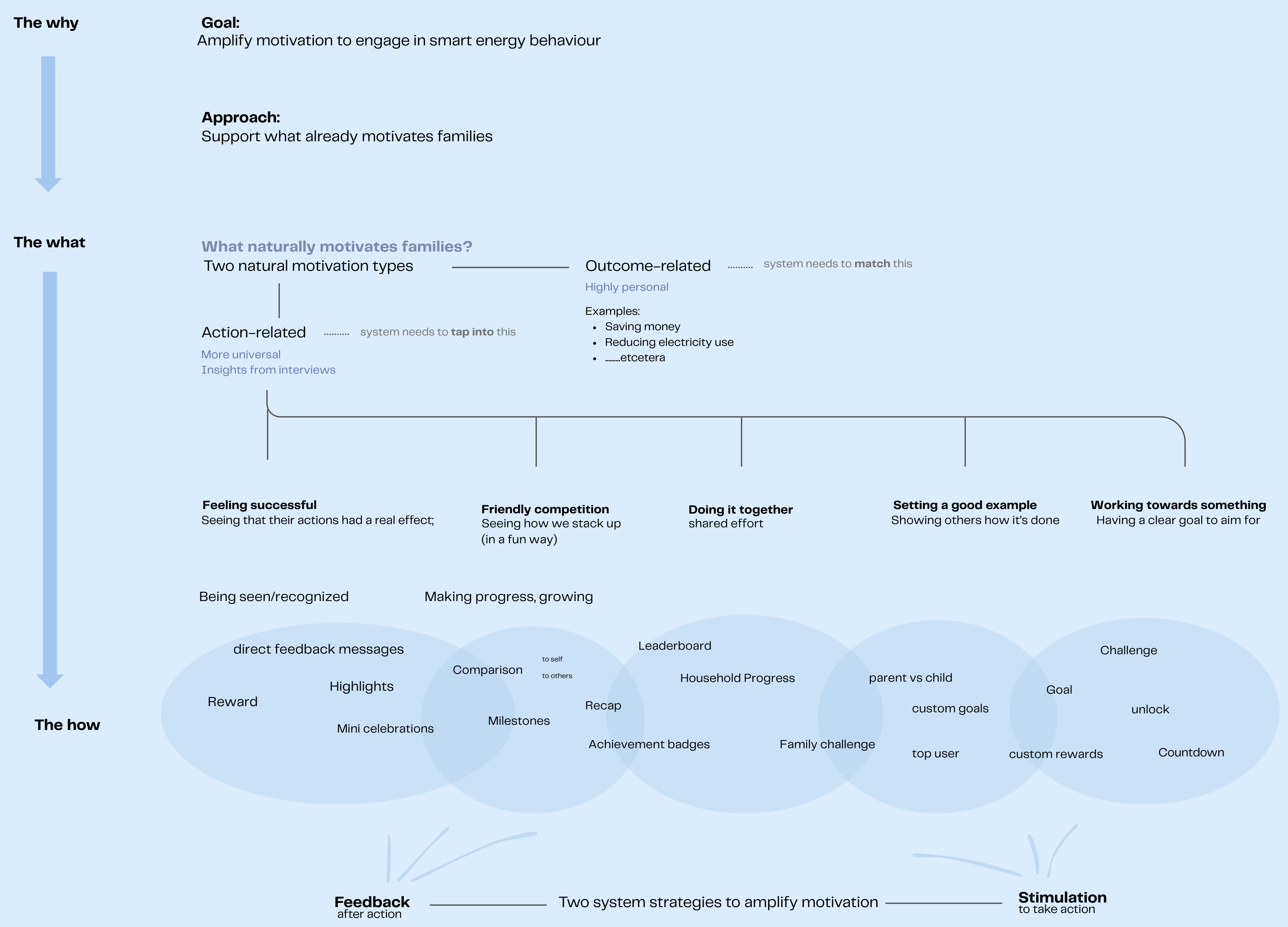


Figure 20.4: Designing a motivation system

20.5 Adapting over time: a phased motivation strategy

The challenge is to align the motivational mechanism with the evolving experience of a household using a home battery for the first time. The strategy must reflect that behaviour change, especially around energy, is not instantaneous, but unfolds over time through a series of motivational and cognitive shifts.

These shifts are explained in the Transtheoretical Model of behaviour Change, a framework that recognizes individuals undertake a journey through distinct stages of readiness when integrating new practices, like smart energy management, into their daily lives.

TTM

Preparation

Individuals are taking steps to prepare for change and are planning to make a change in the immediate future

Action

Individuals are actively making changes and engaging in the new behaviour

Maintenance

Individuals have sustained the behaviour change for a significant period and are working to prevent relapse.

This project distinguishes between three behavioural phases, mirroring the relevant phases of the TTM::

It is important to recognize that motivation is not only important for the execution of smart behaviour, but also to the build-up toward it, such as completing onboarding steps or showing early responsiveness. Motivation is needed across the behavioural journey.

20.6 Defining smart behaviour

In order to design a motivation mechanism, it is first necessary to define what types of behaviour the system wants to see.

Within this system, two types of desired actions are distinguished:

1. **Interactions with the system itself,** such as engaging with features that enable long-term adoption or provide useful input.
2. **Energy-related behaviours that align with system goals.** As touched upon on in the beginning of this chapter, this is partly in the interest of the household and partly in the interest of the dutch energy system

This layered approach ensures that different phases of behavioural development are supported, corresponding to the phased motivation strategy introduced in the previous section.

The following breakdown shows how smart behaviour is categorized across the three behavioural phases. First, the desired types of behaviour are defined; then, how these behaviours translate into specific actions within the context this system.

Phase 1

Goal

Build connection, create a working foundation, lower friction.

The initial focus is on getting the system up and running

Type of behaviour

- behaviours that allow system to work
- showing initial response to system

Translation (translates to...)

- Completing onboarding tasks
- Responding to first prompts

Phase 2

Goal: Reinforce desirable energy behaviour in daily routines. & optimizing the system

Once the system is live, the focus shifts towards actually practicing smart energy use, which in the case of a fixed contract, means maximizing the use of self-produced solar power, minimizing consumption during grid peak hours, and reducing total reliance on the grid.

Type of behaviour

- Actions that result in peak shaving or peak shifting (see table 20.1)
- Providing feedback to the system, allowing it to learn
- Continued responsiveness to system suggestions or nudges
- Using system features

Translation (translates to...)

- Responding to prompts for user input or satisfaction

Phase 3

Goal: Maintain long-term behaviour & adjust system when needed

In the final stage, smart behaviour is (partially) established. Rewards now shift toward consistency, shared effort, and ongoing contribution.

Type of behaviour

- Showing consistency
- Demonstrating family/team effort
- Proactively adjusting system settings to optimize
- Maintaining a helpful feedback loop with the system
- (optional: Showing a learning interest)

Translation (translates to...)

- Keeping up smart patterns over multiple days/weeks
- Achieving streaks or long-term goals
- Contributing to a shared family goal
- Checking in regularly

20.7 Back-end

To make this system technically viable, it is essential to define the basics of te back-end logic, demonstrating how the system can reliably detect the behaviours it aims to motivate.

At its core, the back-end tracks user actions, evaluates them against predefined behaviours, and allocates feedback accordingly

One example to illustrate this logic: If the system detects < x kWh net grid import and a >x percentage of battery use during designated peak hours, it registers this as smart consumption. That behaviour can then trigger a feedback loop.

20.8 Front-end

The final front-end design of motivational feedback is detailed in chapter 22.

Table 20.1: Phase 2 smart energy behaviours

Category	Behaviour	Why motivate it
Peak shaving	Reduce energy consumption during peak hours	Reduces pressure on the electricity grid during high-demand periods and contributes to grid stability.
Peak shaving	Use battery energy instead of grid during peak hours	Shifts use of battery power to moments that... lowers reliance on the grid when demand is highest.
Peak shifting	Shift energy use to off-peak grid hours	Less reliance on the grid when demand is highest.
Peak shifting	Shift energy use to sunny hours	Maximizes use of solar generation and reduces grid dependence by aligning consumption with generation.
Combined	Achieving a Net-Zero Day (No Grid Use)	Encourages full self-sufficiency, reinforcing long-term energy-saving behaviour and battery value.
(Peak) shaving	Reduce total energy consumption	Supports long-term reduction in energy waste, helping both household savings and system sustainability.

Validate

This validation section outlines the steps taken to refine the concept and work towards a final design.

21.Concept refinement

21.1 Validation setup

In order to refine the concept, a series of validation sessions and expert reviews were conducted. These were aimed at evaluating the desirability, feasibility, and viability of the proposition, ensuring it resonates with real users, aligns with organisational capabilities, and holds strategic potential for Vattenfall (as described in Figure 21.1).

Validation was qualitative in nature and carried out with a small group of relevant stakeholders. While the outcomes offered valuable directional insights, they are not directly scalable and should be seen as input for further research (see recommendations).

The refinement process included the following groups, each focusing on different aspects of the concept, contributing to well-rounded validation.

1. **Target group families**: The same four families from the earlier interview phase were re-engaged for testing. As the primary test group, they provided direct feedback on the onboarding experience, motivational mechanisms, and overall clarity of the proposition. Their prior involvement allowed for a deeper, more contextual understanding of how the concept resonated with real household routines, needs, and expectations.
2. **Vattenfall**: The concept was reviewed with the company supervisor and internal UX researchers and designers. The supervisor provided input on strategic alignment, commercial viability, and technical feasibility. The UX team contributed insights on integration within Vattenfall's broader digital ecosystem and the realism of the proposed user experience.
3. **Dr. BJ Fogg:** As the author of the Fogg behaviour Model, his feedback helped test the behavioural foundations of the concept.

The combined insights informed a series of design refinements, resulting in the updated concept presented in section Deliver. For the full test and validation setup and synthesizing materials, see Appendix O.

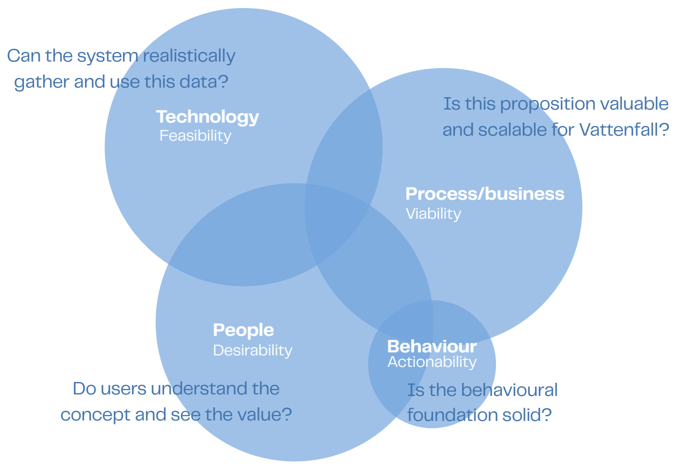


Figure 21.1: Sweet spot of innovation

21.1.1 Test setup summary

For the full version of the setup and materials, see Appendix O.

Test overview
- Duration: ±1 hour per family
- Number of families: 4
- Participant profiles: See Appendix N
- Main goal: Refine and validate the onboarding flow and reward/motivation system based on real-life family feedback.

The onboarding flow was tested through moderated walkthroughs using a fully functional prototype built in Lovable. Participants were guided through the onboarding journey while their interactions were observed and discussed in real time. The session concluded with targeted questions aimed at validating the underlying design principles that informed the system.

Motivational mechanisms were evaluated separately through a rating exercise using a survey created in Lovable. Parents were asked to score a set of motivational levers on a scale from 1 to 10, based on how motivating each felt to them. The mechanisms were grouped into two categories: feedback and stimulation. Ratings were collected from parents only, as they are considered the primary users of the system. Children, while involved in the onboarding process, are not expected to use the system actively.

See Figure 21.2 for screenshots of the Lovable models.

Table 21.1: Participant information

Family #	Participant #	Age	Gender	Participated in interview	Participated in testing
1	1	56	M	x	x
	2	48	F		x
	3	15	F	x	x
	4	13	F	x	x
2	5	40	F	x	x
	6	42	M		x
	7	14	M		
	8	10	F	x	x
3	9	44	M	x	x
	10	41	F		x
	11	13	F	x	x
	12	11	F	x	x
4	13	41	M	x	x
	14	40	F	x	
	15	12	M	x	x

21.2 Outcomes

The most important outcomes, feedback and action points for each of the groups are highlighted below.

Legend
Outcome
Additional explanation
Observation
"Quote"

21.2.1 Target group families

Onboarding test N = 4 families

Overall outcomes

*Only substantial outcomes are highlighted here, small adjustments can be found in the list of changes in Appendix O)

Outcome 1: Onboarding felt intuitive and respectful of their time
Most users felt the onboarding was short enough to complete in one sitting (±10 minutes).
The order of questions generally felt intuitive, moving from simple (name, age) to more contextual (routines, preferences).
P9: "It's good that it's not too long, because then the kids will lose attention"

Observation: moments of laughter and spontaneous discussion
PX: "It didn't feel like a chore."

Outcome 2: Experience felt light, playful and engaging
Participants noted that the onboarding experience avoided the usual dry or bureaucratic tone often associated with utility apps. This lowered the threshold to participate and making the app feel more approachable.
P13: "I was afraid that it was going to be one of those boring forms, but not at all. That was nice"

Observation: all family members, including children, participated actively during onboarding.
P2: "It was fun doing it together"

Outcome 3: Everyone felt involved in the process
This was largely because the questions addressed household routines and used names, which made the experience feel personal and inclusive.

Outcome 4: Relevance to daily life made onboarding enjoyable
By tying questions to family life, the app avoided feeling abstract or irrelevant.
P8: "It was kind of cool that it asked about how we do things at home"

Outcome 5: Clarity in communication can be improved in some steps
Families occasionally misunderstood certain wording
Action point: Rephrase or simplify certain questions

Outcome 6: Appreciated smart predictions and prefills
Participants liked that the app prefilled certain answers or made educated guesses, as it reduced effort and made the system feel intelligent.
P9: "It was nice that it already knew some things. Felt like it saved time."

Outcome 7: Clear purpose increased willingness to share
Several participants explicitly said they appreciated the small explanations about why certain info was being asked.
The transparency increased their willingness to share data.

Outcome 8: Users wanted a clearer sense of purpose from the start
Participants noted that while individual steps were understandable, the overall goal of the onboarding wasn't immediately clear. They were unsure how their input would impact the app's functionality.
Action point: Introduce a more clear message at the beginning of onboarding that explains how the information will be used to personalize energy advice

Outcome 9: Willing to invest effort in real life (if real product benefit is clear)
Participants said they would complete the onboarding if they had just installed the actual app.
P1: "If this were the real app and I just got the battery, I'd go through this. It makes sense."

Outcome 10: Shared device use poses a risk of excluding family members
In one case, where the family completed steps together on one device, not everyone was able to clearly read or follow along. This occasionally led to parents rushing through or answering on behalf of others.
Action point: Consider adding a read-aloud function to further support inclusivity.

Outcome 11: Data handling concerns
Some families expressed concerns about who their their personal data will beshared with
Action point: Add a notification that reassures household that their data is private and protected

UX-specific outcomes

Outcome 12: Appliance placement step felt difficult to complete

P15: "I didn't really know where exactly to put it... I just kind of dropped it somewhere in the evening."

Several participants described the drag-and-drop activity to map appliance usage onto the load profile as "a bit hard" or "unclear." The level of detail expected was not always obvious, which led to hesitation or rough guessing.

Action point: Simplify this step by pre-filling likely time blocks and only asking users to confirm or adjust specific sections of the graph.

Outcome 13: Delayed family invitations risk incomplete onboarding

P5: "If it's optional, I'll probably just skip it and forget."

Several participants noted that in reality, the option to "invite family members later" , might result in never actually inviting others to join the app.

Action point: Nudge users to complete the household setup immediately or follow up with timely reminders and benefits of full family participation.

Outcome 14: Schedule input felt time-consuming and not always realistic

Filling in the weekly calendar took the longest of all steps. Families expressed concern about how well their irregular routines could be captured, especially for children with changing school or sports schedules.

Action point: Explore ways to reduce the input time, such as suggesting default templates. Allow users to indicate variability.

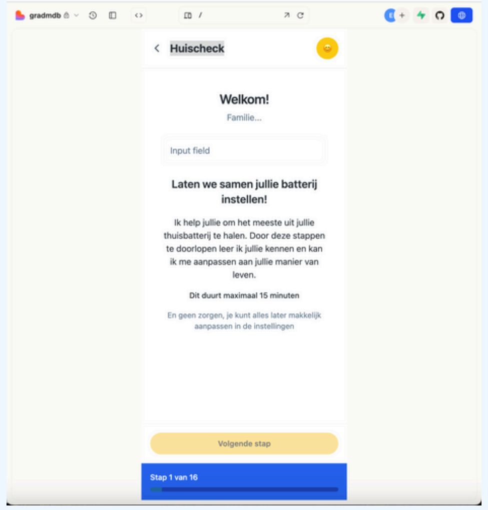
Motivation test N = 7

Outcome 15: Mechanisms that show the most motivational value – feedback

- Direct notification after action 9.3/10
- Cumulative progress overview 8.1/10
- Self-define rewards 8.7/10

Outcome 16: Mechanisms that show the most motivational value – stimulation

- Goal-aligned system-generated challenges 7.4/10
- Collective platform-wide challenges 8.0/10
- User-created household challenges 8.3/10



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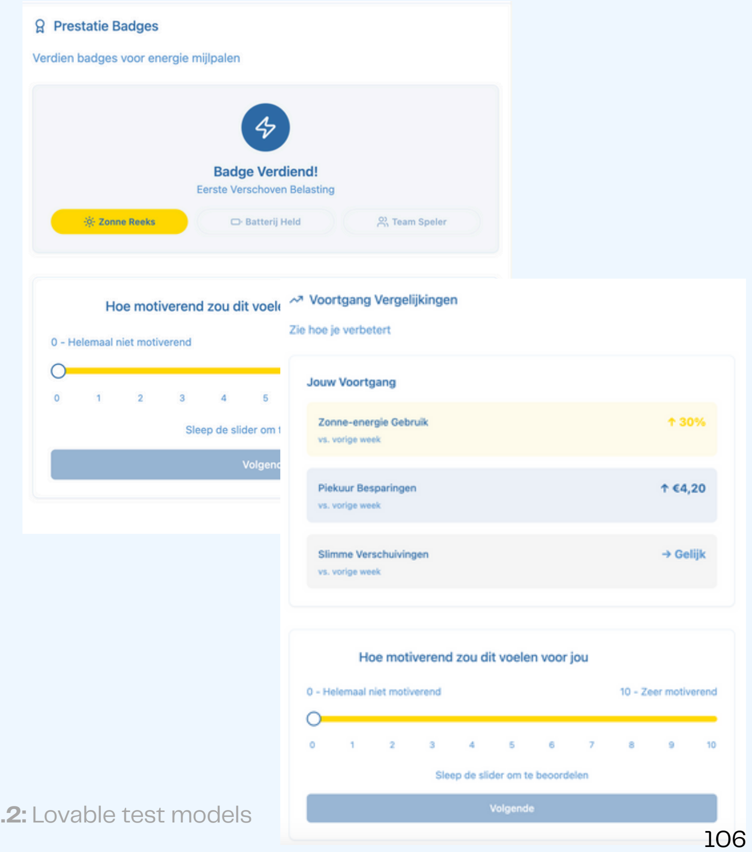


Figure 21.2: Lovable test models

21.2.2.Vattenfall

Outcome 17: Broad scaling potential with personalisation logic

The adaptive nature of the concept was recognized as a strength. Feedback highlighted opportunities to extend the personalisation logic to other energy assets such as heat pumps, EV chargers, or solar monitoring. The approach was seen as strategically aligned with Vattenfall's ambition to become a broader energy partner within households. However, big developments steps have to be taken to achieve this.

Outcome 18: Continued commitment to one-app strategy

Despite the layered functionality and new interaction model proposed by the concept, Vattenfall indicated a continued preference for maintaining its one-app strategy. The implication was clear: any new system must be embedded within the existing app environment, which adds constraints to interface design, but strengthens integration with current services.

Outcome 19: Challenges in linking monetary value to points

The idea of connecting behavioural points to financial rewards raised questions about long-term viability. Specifically, how such rewards would be funded, and whether this might lead to customer expectations that are hard to maintain. Caution was advised in attaching too much value to externally rewarded behaviour without a clear business model.

Outcome 20: Confirmation of necessary data infrastructure

It was confirmed that the (energy) data required to support most of the concept's functionality is available.

Outcome 21: Confirmation of necessary data infrastructure

It was confirmed that the (energy) data required to support most of the concept's functionality is available.

Outcome 22: Alteration of onboarding steps

While walking through the onboarding steps, certain feedback and considerations caused for changes in the flow.

Adjustments & takeaways;

Based on this input, the monetary ties to reward were reconsidered. Additionally, the visual and interaction design was revisited to ensure compatibility with Vattenfall's existing app structure and navigation logic. The broader potential for cross-asset integration has been flagged for future research and product development.

21.2.3. Dr. BJ Fogg

As part of the design process, the concept was discussed with behavioural scientist Dr. BJ Fogg, author of the Fogg behaviour Model. His feedback emphasized the importance of aligning external motivation with what families already want, rather than relying solely on monetary incentives.

"The best products help people do what they already want to do."

Dr. Fogg advised caution in tying point systems too directly to financial value, noting that this risks reducing intrinsic motivation and repositions the system as transactional rather than supportive.

Instead, reinforcement should focus on helping users feel successful in ways that matter to them.

"People don't just want a discount. They want to feel like they're doing something right "

In line with this principle, he described the idea of parent-defined rewards as "smart and promising," especially because it allows parents to model the values they already care about. "It helps them set a good example for their kids, which is something they already want to do."

Adjustments & takeaways:

This feedback prompted a re-evaluation of of the role of points within the system. Rather than focusing solely on financial conversion, the system should explore non-monetary motivation formats that align with what families already value

As a result, the reward system was shaped to a motivation system, and an additional step was added to the onboarding process to better understand each household's underlying motivations.

21.3 Synthesizing validation outcomes

The validation process combined user testing, expert reviews, and internal stakeholder feedback to assess the concept from behavioural, strategic, and practical angles.

For the onboarding, outcomes with clear value and low implementation effort were immediately integrated into the final design. Larger questions or system-wide implications that require further exploration are addressed in the recommendation chapter.

For the reward (now 'motivation') system, more fundamental shifts were needed. Based on the combined insights, the entire reward logic was redefined, moving from transactional incentives toward layered, personalized stimulation and feedback built around the concept of Loops.

Deliver

This final part outlines the rounded-off design proposal, presenting the end result of the development process. It is divided into two sections. The first outlines the rounded-off design proposal, focusing on the final concept and how it translates into real life. The second addresses the strategic and technical implementation, showing how the concept integrates into Vattenfall's digital ecosystem and supports long-term vision for smart energy services.

The design

Implementation

22.The onboarding interface

Annotations are used to highlight relevant design features of the onboarding system. The legend below shows the build up.

For deeper explanation on how the system uses user input to adapt onboarding output, see the onboarding map in appendix P

Legend

x	= Link to corresponding design principle (section 19.4)
Step	= Step in the onboarding
Change	= Changes after concept refinement (testing)
Goal:	= Main goal(s) of screen
Purpose:	= Underlying purpose

Points for further development

Welcome and intro to onboarding

Goal: Explain what the user can expect and why it's valuable for them

Purpose: expectation management, reduce friction to starting, and make the experience feel personal from the first moment.

1

Change: new onboarding screen
This screen was added for synthesizing purposes.

Introducing the smart system 'Loop'

10 Emphasizing importance of completing onboarding together

12 Explaining value of onboarding

2

Putting in family name

Explaining how onboarding input leads to output

Communicating estimated duration

4 Reassuring flexibility in changing settings

Data privacy notification

Goal: Explain users that their data is handled privately and protected

Purpose: Reassurance and transparency, build trust

3

Change: new onboarding screen
This screen was added due to raised privacy concerns

Transparency on data use

Reassuring data privacy

Option to get more information on data handling

Add household members

Goal: Let every household member register to the family account by downloading the app.

Purpose: Create a sense of shared ownership, frame the household as a team, and allow for person-specific data, preferences and communication

4

6 Progress bar shows where you are in the process

Chatbot Nina, for all questions

Emphasize value of joining the family account

12

Link to app store

Emphasize value

Lower threshold for downlaoding

Change: household members are asked to download the app to join

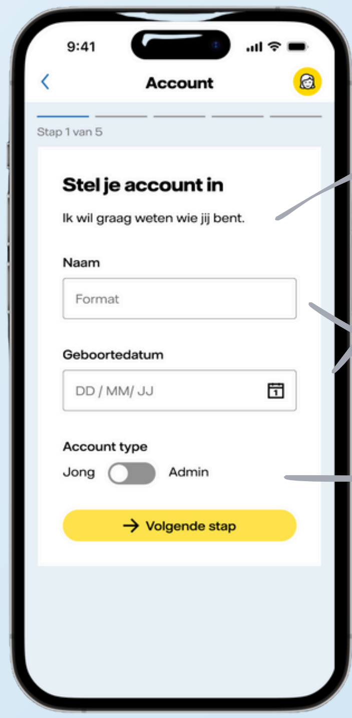
- Differentiated accounts are preferred for system operations
- At the same time, it allows for individual level ...
- Enables some time-consuming steps to be completed individually, saving on shared time

Setup personal account

Goal: Let each family member create their personal profile by entering their name, age, and role.

Purpose: To enable tailored guidance and ensure the system can differentiate between users for more personalized support.

5



Create feeling of relevance

Age allows for estimation of knowledge and involvement level

Allow for personal communication

Differentiated account types or kids and parents (feature access, interface depth)

Weekly schedule
Goal: Map out basic routine of each household member
Purpose: to inform expected (appliance) routines, timing for smart energy actions.

6

Change: step completed individual instead of together
Due to time and focus concerns

Explain purpose of step

Pre-fill indicates what systems expects users to do

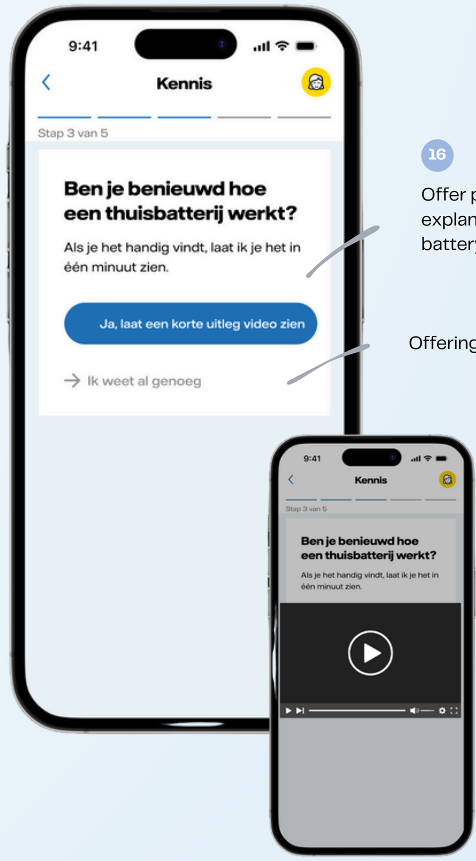
Change: optimized UI
Pressing box in order to change statu, lowering effort

4 Making it feel less permanent and challenging

Option to indicate highly irregular week. Causes system to adapt

Explanatory video on home battery
Goal: Assess how familiar the idnivdual is with the home battery and if there's a need for extra explanation
Purpose: establishing a solid foundation for each individual, understanding can increase motivation

7



16 Offer possibility of short explanatory video on the home battery

Offering the possibility to skip

Choose interface depth
Goal: Allow each individual user to choose preferred level of detail
Purpose: Supports personalisation based on energy literacy and interest level. Prevents overwhelming users while offering depth for those who want it.

8

Change: decision is now on individual level instead of household level
Complementing different needs within household

4 Making it feel less permanent and challenging

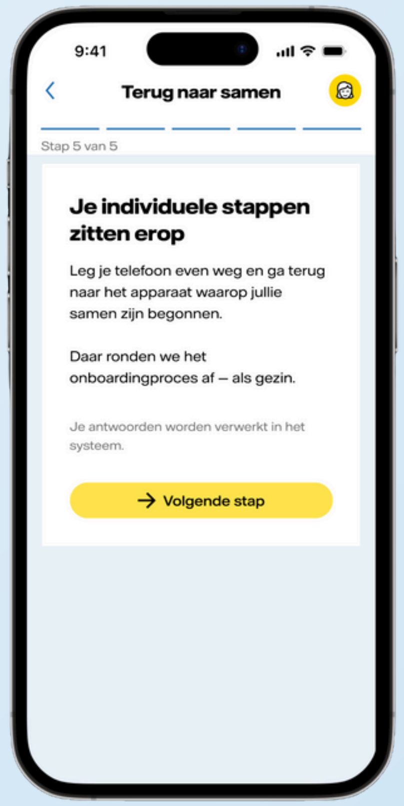
Ask notification permission
Purpose: Enables system communication

9

Allowing notifications from Vattenfall Loop
Change: place in flow
Permission is now asked at a later point, to prevent a 'suffocating' feeling at the start

Round off
Purpose: Bring back attention to collective onboarding

10



Main energy decision-maker
Goal: Understand who typically makes energy-related decisions in the household
Purpose: Gives the system nuance on internal family dynamics, especially useful for tailoring nudges to the more influential voice

11

11 Playful, funny moment

Not an absolute decision, but percentile division, to avoid friction

Includes users who selected 'admin' account 15

Connect energy data
Goal: Optimize energy data data flow rom household to system
Purpose: Optimize system workings as much as possibe

12

Data transparency

Explain its value 12

Offer additional explanation

Offer option to skip

Change: New onboarding step
Added for technical viability

Indicate appliance presence
Goal: Verify relevant appliances in the home
Purpose: Defines the system's "levers" and deepens system understanding of load profile

13

9 explain where estimations stem from

3 default list with prefilled appliances to lower effort

8 **Change: Divided into manageable categories**
To lower perceived effort

Appliance-load map
Goal: Fill in system gaps on which devices cause specific energy peaks
Purpose: Optimize energy profile understanding

14

Ask friendly

12 Explain where inormation comes from

Users only have to fill in what they know to prevent them form being overwhelmed

12 Explain value

1 Make step as visual as possible

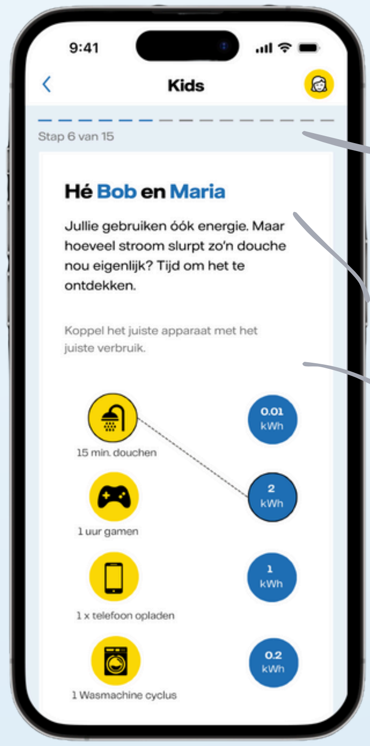
Change: Only certain points of uncertainty indicated by system
Users are not asked to fill in everything, just a select few points to lower effort

Change: Option to match multiple appliances to one point 2

Allowing default: Option to copy previous day to lower effort

Mini game: match appliance to usage
Goal: Let kids match right appliance to right kWh
Purpose: create a low-effort, playful moment of engagement for kids that introduces them to energy concepts and strengthens household involvement

15



10 Address the kids speficifcally

Personal communication

low-stakes interaction

shift the attention to prepare for the next question

Household painpoints
Goal: Get first indication of friction points in the household
Purpose: using the kids' perspective as a lighthearted but revealing way to surface behavioural targets.

16

11 create relatable entry points for engagement

will spark converstation

a 'light' way to uncover painpoints

Household energy challenges
Goal: Confirm core pain points together
Purpose: Identify specific areas for behavioural change and allows for targeted solutions

17

Shows estimated challenges

2 3 explain where estimation stems from

encourage shared praticipaition 9

explain value 12

Home battery initial purchase motivation
Goal: Uncover household's intrinsic motivation for buying the home battery
Purpose: directs value framing and emphasis of system

18

explain value 12

can only select two options to give system clear value indication

Energy end goals
Goal: Gather end goal of household regarding battery and energy use at home
Purpose: established what the household is working towards, influences operational empahsis of system

19

emphasis on 'together'

Explain options and nudge household to think about them

explain value 12

Change: New onboarding step
Added to account for variances in expectations from the system

Preferred approach
Goal: Let household choose the guidance style that suits them best
Purpose: To respect different learning styles and motivational readiness, allowing the system to adapt its behaviour change strategy to the family's preferred pace. Prevent overwhelm and set expectations.

20

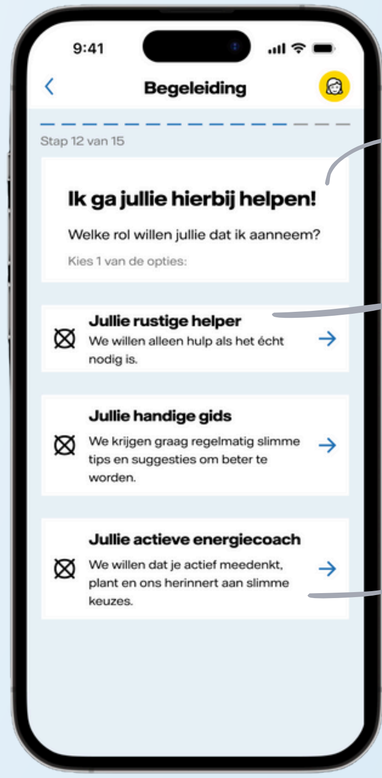
emphasize personalisation value

offer 3 clear options to allow for choice within limits 8

formulated from p.o.v of household to make relatable

System role
Goal: Let household select how hands-on they want the system to be in guiding them
Purpose: To tune system intensity and proactivity. Avoid over or underwhelming users

21



frame system as unburdening

Use metaphor titles to increase clarity

offer 3 clear options to allow for personality within limits 8

clearly explain difference

Control preferences
Goal: Let household select their preferred level off system automation
Purpose: To respect different needs in systeem involvement

22

Change: Provide example
To enhance clarity

Use metaphor titles to increase clarity

offer 3 clear options to allow for personalisation within limits 8

Tone of voice
Goal: Let users choose preferred tone of voice
Purpose: Influences communication style of system to align with household preferences

23

explain value

Provide example message

Change: Merged 2 steps into one
Offering fewer, but more distinctive options is better than little nuances (users don't understand the difference)

Choose first challenge
Goal: Invite household to select their first energy-related challenge and begin acting on their setup
Purpose: shift the user from passive onboarding to active participation, leveraging momentum.

24

Create anticipation

Offfer low treshold start 13

Frame it as 'smart'

explain personalisation logic 9

goal are personalised to the household using onboarding input

Choice makes them feel in control and increases willingess of choosing

reassurance avoids users feeling 'trapped' 4

End screen
Goal: Celebrate the completion of onboarding and mark the transition into active use of the system. Show household they completed their first energyLoop
Purpose: To reinforce a sense of shared accomplishment and confirm effort value.

25

10
Personalise communication

emphasize value

emphasize 'smart' and 'unburdening'

Celebrate accomplishment, acknowledge effort

14 Introduce the Loop motivation system

23.The system in real life

23.1 From onboarding to adaptation

Now that the system has collected key input from the household, the question becomes: how does it translate that data into meaningful, adaptive system? The answer lies in how the system organizes and applies this input across different internal models.

Rather than relying on a single static profile, the system uses onboarding input to configure multiple behavioural and operational models. These models work together to tailor the user experience, not just once, but dynamically, as the system evolves.

To explain, the the system is split up into 3 tiers:

The table below shows how specific onboarding inputs activate different system models (Tier 1), and what aspects of the system each model controls (Tier 2). Within the system, these models are interdependent, constantly influencing and adjusting to one another based on user behaviour and system performance. This dynamic interaction is visualised in Figure 23.1. For a more detailed explanation of the technical workings behind these models, see the technical implementation section.

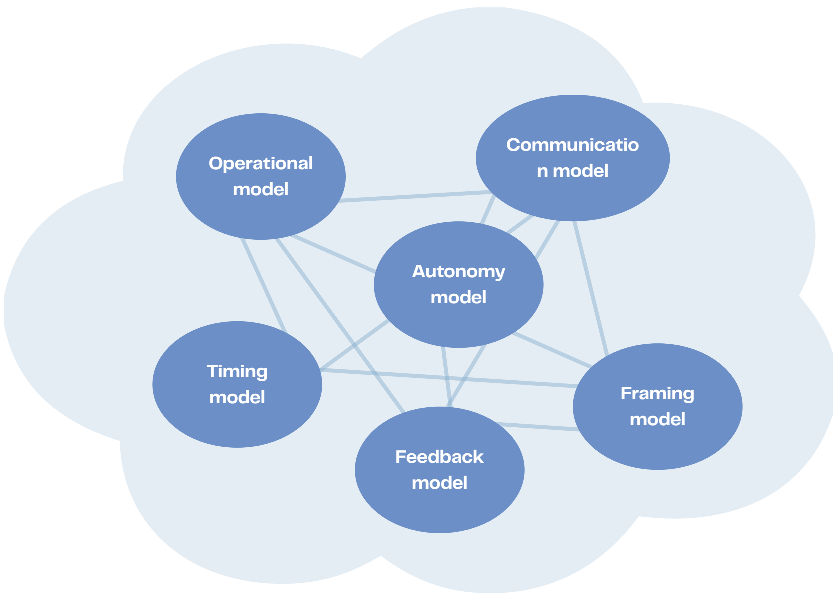


Figure 23:1: Smart system model collaboration

Tier 1: Onboarding input categories **Tier 2: What the system adapts**

Table 23:1: The Smart system models

Input	System model	ConFigures....
Motivation & values	Framing & feedback model	Goal framing, challenge tone, framing of progress, feedback emphasis
Painpoint & challenges	Operational model	constraints, challenge design, priority setting, pacing logic,
Goals & approach	Operational model	(sub) targets, priority changes, change pacing, order of action stimulation
Tone & assistance	Communication model	Message language, frequency of nudges
Energy profile	Operational & timing model	predictive actions, optimizing opportunties
Control level	Autonomy model	autonomy vs system-led flow, automation levels, opt-in autonomy features
Roles & schedule	Communication & timing model	who to activate, when to intervene, personalized nudging windows. ownership messaging
personal profile	communication model	detail level, optional insights shown,

Tier 3 shows an example adaptive system profiles
This can be seen in the visual on pages 120,121.

23.2 Real life intelligence

How the system adds value in daily life

Where earlier chapters introduced the system's design, architecture and behavioural logic, this chapter brings its intelligence to life. The goal is to move from technical potential to everyday experience: what does it actually mean, for a family, to have this system in the home?

The system operates on two layers of intelligence: operational and behavioural. This chapter illustrates both through four real-life scenarios. These are just a few examples to show how the system can think ahead, adapt, and support daily decisions.

Figure 23:2: Intelligence scenarios

23.1 (Tier 3) Adaptive system profile scenarios

Scenario 1

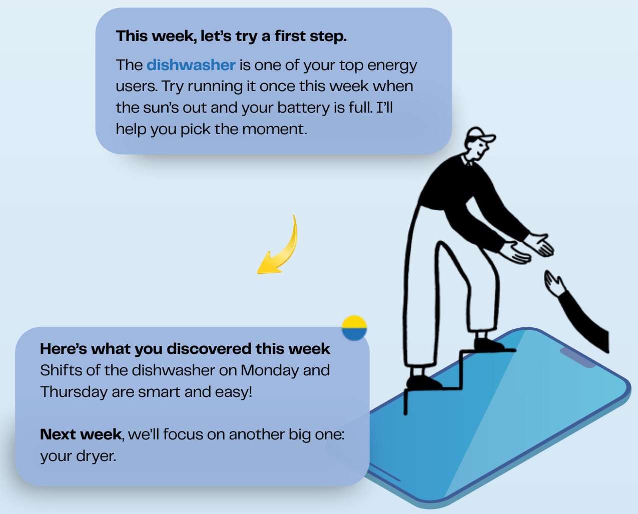
Ron and Paula, along with their two children, have just finished installing Loop. They're not particularly tech-savvy, but they do feel a strong sense of responsibility toward their energy use. For them, this isn't about trends or gadgets; it's about doing the right thing, in a way that fits their everyday life.

They wanted to take a **phased approach** to smarter energy use. They didn't want to be overwhelmed with data or have to make big changes overnight. Instead, they preferred to start with simple steps they could understand and try out as a family.

Their long-term ambition is clear: becoming fully self-sufficient, or "**0 op de meter**." But they know that will take time. For now, they've asked Loop to help them **tackle their biggest energy users**, without requiring too much technical know-how.

One thing they shared during onboarding is that they find it hard to judge **which appliances really matter.** The house is always full of life, and energy gets used all over the place. They simply want someone (or something) to help them focus.

Loop steps in as a **trusted guide,** not pushing them, but gently pointing out what matters most. It listens first, then acts. Loop has started by proposing a **small, specific challenge** to get started. The tone is warm, encouraging, and collaborative, just like they asked.



Scenario 2

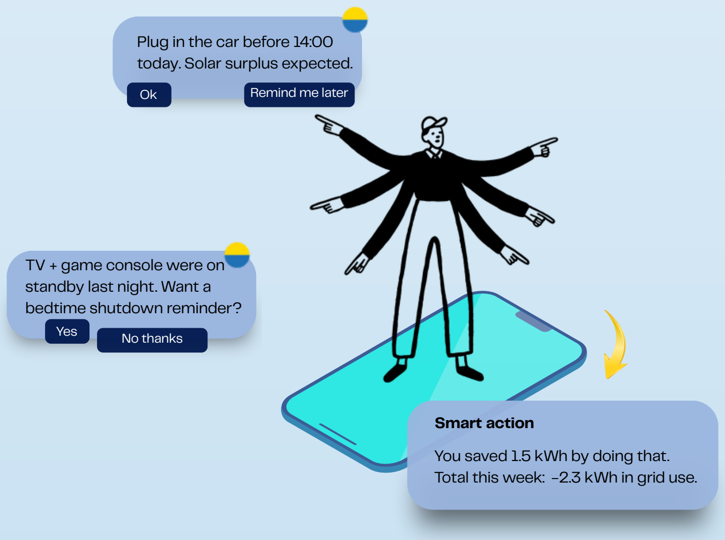
In Sam and Lisa's household, **energy decisions are Sam's domain**, and he's totally fine with that. He likes keeping an eye on things, tweaking settings, comparing graphs. During onboarding, he selected the advanced interface, full of real-time data, flows, and trend lines. Lisa, on the other hand, prefers to keep things simple. She chose the basic interface.

The couple also has a **dynamic contract**, meaning their rates vary throughout the day. That **opens up** a lot of **opportunities**, and they **want to make full use of them.**

During onboarding, they made it clear: they want to **waste as little energy as possible**, and they're willing to change their behaviour to make that happen. As long as it's clear and efficient, they're on board. Their system has therefore entered **Optimal Suggestions mode**, where every opportunity for smarter use of electricity is surfaced, nudged, or handled automatically if allowed.

They also indicated that they currently **don't think** much about **timing appliances.** They typically run things when convenient. Based on this, the system **focuses first** on identifying their biggest energy peaks, and suggests shifts that fit within their current routine.

They **trust the system to act on their behalf** whenever it makes sense. They don't want to deliberate, they **want to act.** That's why the system communicates with them in a **concise and factual** manner, while taking on the role of an **active energy coach.** It tells them exactly what to do and when, so they **don't have to think about it;** all they have to do is act. After every action, the system gives direct feedback, **framed around measurable savings in kWh**.That's what motivates them .



Scenario 3

This family installed a home battery **out of necessit**y, mainly because of the end of net metering. It felt like the right thing to do given the changing policy, but they **haven't thought much about their long-term energy goals yet.**

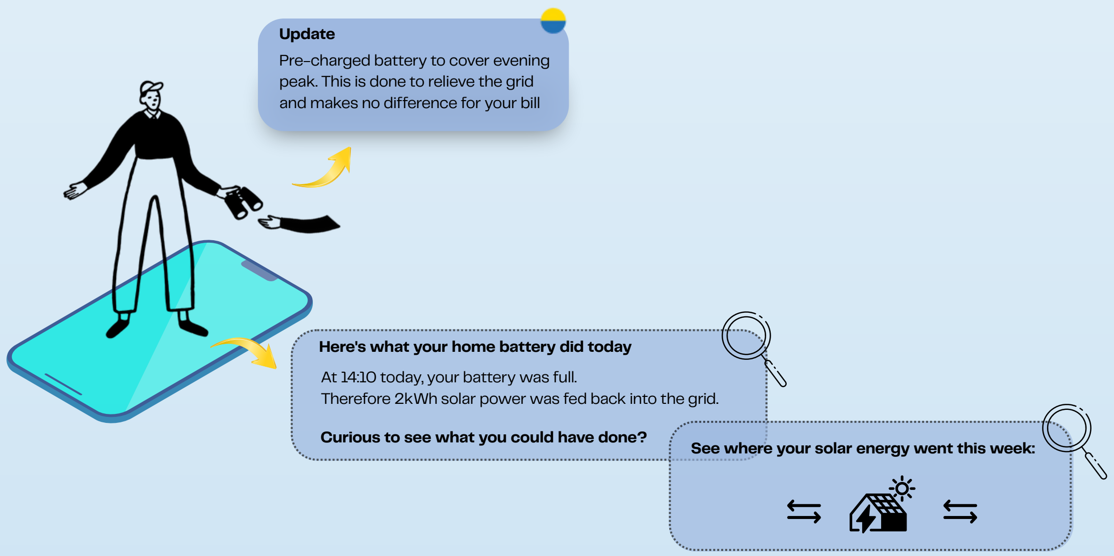
They're **not entirely sure how the battery affects their outcomes**. One thing that came up during onboarding is that they are not sure if they're doing well or not. They know solar production varies and that they're probably not using it optimally, but they don't yet know what "good" looks like.

Instead of jumping into new habits, they decided to **observe first.** Learn what the battery does. Understand how the system thinks. Then maybe make changes.

So during onboarding, they opted for **co-pilot mode**. That means Loop can make suggestions, but **never acts without checking first.** This allows them to create an understanding of what the home battery is doing and why.

Loop respects this. It doesn't make proactive suggestions yet. Instead, it **focuses** on providing a **clear overview of what's happening** and makes space for questions. They can open the app whenever they want for insights about the battery.

The system's tone is calm, helpful, and observant. It behaves less like a coach and more like an **calm energy translator**: patiently building understanding until the family feels ready to make smart changes.



24: The motivational system behind Loop

Where the previous chapter explored the rationale and development behind the motivational system, this section presents the final outcome: a layered, adaptive feedback and stimulation system built around the concept of **Loops**.

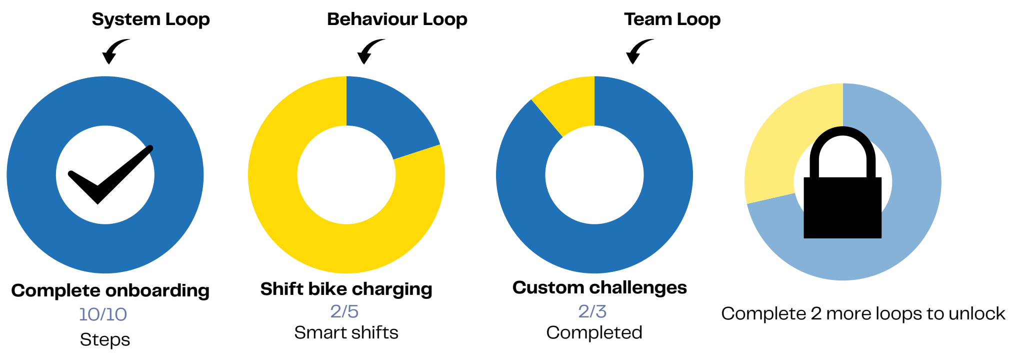
Its core ingredients were developed through testing of key feedback and stimulation strategies. These tests explored the perceived value of different motivational mechanisms. The highest-scoring formats were then combined, adapted, and unified under the symbolic Loop model.

The result: a system built around Loops, combining layered stimulation and feedback without relying on extrinsic incentives.

24.1 The Loop format

At the heart of the system is the Loop. A Loop represents a completed cycle of smart energy behaviour. A moment where the household's actions and system goals align. Every time a Loop is completed, the household has taken a meaningful step toward smart energy use.

Loops are visualised as circles that close progressively with each small action. This symbolic model avoids gamified language or points, yet still creates a clear sense of progress and positive reinforcement. Different kinds of Loops represent different types of behaviour, aligning with the ones defined in the motivation strategy over time (chapter 20).



24.2 Layered feedback

Making effort feel seen

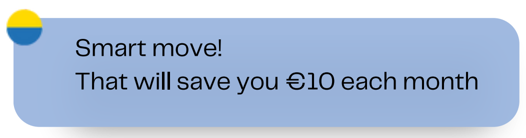
The system uses three types of feedback, direct, delayed and variable, to strengthen motivation over time and at different behavioural moments.

24.2.1 Direct feedback

This form of feedback appears immediately after a smart behaviour is detected. Its goal is to create a quick, contextual recognition of effort: not only showing that something happened, but why it mattered.

This plays a central role in helping users feel seen, and builds the confidence needed to sustain behavioural momentum. In early adoption phases especially, such confirmation reduces ambiguity and reinforces that smart actions don't go unnoticed.

Direct feedback is always adapted to the user's tone preference (warm vs. concise), and contextualized based on energy goals (cost, CO_2, self-sufficiency) and system role (silent, active).

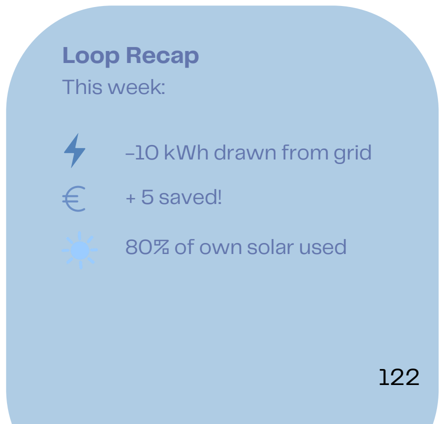


24.2.2 Delayed feedback

In addition to immediate reinforcement, the system also provides delayed feedback: reflective summaries that highlight longer-term impact. This layer is essential for helping users connect individual actions to bigger outcomes.

Where direct feedback is emotional and immediate, delayed feedback is strategic and reflective. It helps users track alignment with their longer-term goals. Every week (or month), the system shares a clear visual overview (see the Figure below) summarizing progress across key dimensions such as total savings, peak reduction, or percentage of solar energy used, adapted to the household's outcome-related motivation.

The value of this mechanism lies in showing that small steps add up. While a single shifted load may seem insignificant, seeing the collective impact of multiple actions over time makes the behaviour feel more worthwhile.



24.2.3 Variable reward

This final feedback layer builds on the variable reward principle from the HOOK model, which describes how unpredictable outcomes can reinforce user habits over time.

In this system, the variable reward takes the form of unlocking new Loops (see the visuals below). After a household completes a certain number of Loops, a new one becomes available, slightly more advanced, focused on a new domain.

This adds a sense of progression and emotional payoff without relying on gamification. Importantly, the user does not know in advance which Loop will be unlocked, only that something new will appear. This subtle uncertainty strengthens the feedback cycle, reinforcing the sense that smart behaviour builds up over time.

The experience remains light and symbolic, but meaningful. Rather than chasing points, households build a sense of energy competence, one Loop at a time.

24.3 Layered stimulation

Creating smart action momentum

Three distinct mechanisms were developed to support stimulation, each offering a different level of initiative, ownership, and social dynamic.

24.3.1 System-generated household goals

These challenges are automatically proposed by the system and based on household onboarding data. They align with the household's stated energy painpoints, goals, preferred approach, and current behaviour.

By matching challenges to what users already care about, the system removes the need for external pressure and instead turns energy management into a personalized journey.

This reflects the insight that people are far more likely to act if the action connects directly to something they value, even if the behaviour itself is unfamiliar.

24.3.2. Collective platform-wide challenges

Families can join broader time-based challenges offered across the platform, similar to platforms like Strava. These are themed around energy goals or seasonal needs. An example is shown in the visuals.

These create a sense of shared momentum without rankings or competition. They also serve to normalize behaviours that otherwise feel niche or effortful.

The system can propose challenges that it estimates suit the household, joining is optional.

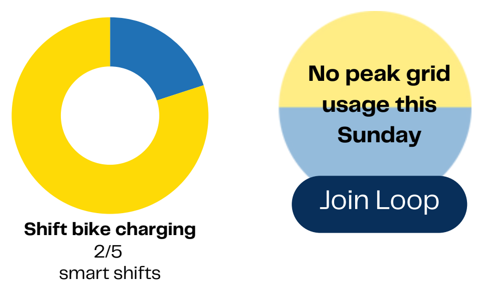
24.3.3. Create your own Loop

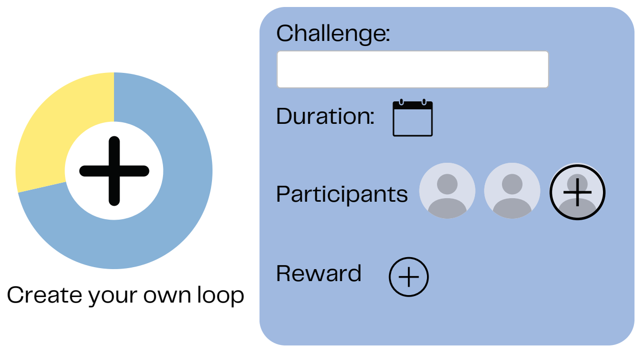
The system allows admins (typically parents) to create their own challenges for the household, or even just for the kids. These can be linked to self-defined rewards.

This responds to the insight that children are rarely direct users of the app, but parents do wish they were more involved. By allowing parents to set up household-level mini-challenges, the system can indirectly engage children.

These types of user-defined rewards:

- Empower parents to decide what's appropriate and motivating in their context
- Tap into existing household routines and pain points (e.g. long showers)
- Introduce light-hearted competition or collaboration between siblings
- Make the energy topic more relatable and engaging without relying on children to use the app themselves





Together, these mechanisms form an adaptive motivational system that builds on user insight, personal goals, and shared energy challenges. Rather than pushing behaviour through external pressure or gamification, it nudges through relevance, reinforcement, and symbolic progress. . By unifying everything under the visual and symbolic model of Loops, the system maintains a cohesive identity across different households.

25: Loop development roadmap

The roadmap on the next page shows how the Loop system is built up over time, combining both the learning system and the motivation system into a single evolving framework. It provides a structured overview of how different system aspects mature and gradually merge to deliver a seamless, adaptive experience for the household.

The roadmap is organised into three phases, aligning with the previously defined development stages:
Phase 1 (onboarding), Phase 2 (short-term use, ±1–6 months), and Phase 3 (longer-term use, 6+ months). Each phase describes the system's goals, the evolving role of user input, backend logic, and motivational strategies.

At the bottom of the roadmap, key risks per phase are highlighted. These have been explicitly considered in the design process.

25.1 Category overview

25.1.1 Motivation system

This section explains how Loop strategically motivates behaviour change in a phased way.

System goal
Describes the motivational intent of the system per phase , from triggering interest to reinforcing new habits.

TTM stage
Indicates which phase of the Transtheoretical Model of Behaviour Change (TTM) aligns with each system phase , from awareness to long-term maintenance.

Motivation focus
Defines which behaviours are encouraged in each phase.

Motivation authority
Refers to the degree of user control over motivational settings. For example, selecting personal goals, defining rewards, or adjusting feedback style.

System detection abilities
Outlines how well the system can detect user behaviour or motivational triggers, based on technical capability and available data.

25.1.2 Learning system

This section describes how Loop becomes more intelligent and personalized over time.

System goal
Defines the overarching role of the system in each phase , from understanding the household to delivering fully optimized support.

System knowledge
Describes how the accumulation of knowledge builds a complete household overview.

What the system needs to learn
Highlights which pieces of user data or contextual insight are needed in each phase to grow the system

Learning stream
Refers to the structured onboarding and learning sequence (see the Learning Phase section of this report) through which data is collected and verified.

Smart logic
Describes how the system's intelligence evolves, starting from simple rule-based models, then incorporating hybrid mechanisms (e.g., fallback logic and heuristics), and gradually moving toward machine learning-based personalisation as more household data becomes available

Model accuracy
Visualizes how different system models improve over time as more user data becomes available. Some models reach accuracy quickly through predefined rules, while others rely on gradual learning and require larger datasets to perform effectively.

User effort
Represents the level of input expected from users. This effort decreases as the system learns.

System maturity / User maturity
Tracks how both the system and the user evolve together. As the system matures technically, user behaviour is gradually supported, nudged, and reinforced, leading to user and system growing together

VATTENFALL LOOP

	Phase 1	Phase 2	Phase 3
	Onboarding	Fully functional system	Optimized system
Learning system	**Setup & learning** First use	**Growing intelligence** 2-6 monts	**Deep personalisation** 6+ months
description	Is heavy on manual setup but establishes the foundation for learning	The system is now observing and adjusting based on behaviour and input	User input is minimal, experience feels embedded and personal
System goal	Build a foundational, personalized profile that enables relevant guidance	Refine assumptions, enhance personalisation, increase satisfaction	keep support continuously aligned with real life, with minimal effort or disruption
System knowledge	contract & usage data	rich energy and user profile	Complete household overview
What system needs to learn	Household composition & routine; Painpoints & challenges; Motivation & goals; What users want and expect from system	What works? What doesn't; Which nudges succeed or fail (and why); Detect behavioural momentum and drop-off points; How routines evolve in real life	Maintain accuracy while minimizing user burden; Detecting shifts in routines or priorities; Recognize long-term patterns and (seasonal) variations
Learning stream	Active elicitation	HITL	Automised
Smart logic	Rule based agents	Machine learning modules	Autonomous ML with confidence-based fallback
Model accuracy (Operational model, Autonomy model, Timing model)			
User effort / **System maturity** / **User maturity**			
Motivation system	**Activation & Confidence** First use	**Smart energy behaviour** 2-6 monts	**Sustained engagement & emotional ownership** 6+ months
description	Relies on clear framing and low-effort actions to build early momentum and establish a sense of relevance.	Motivation is now tailored to values and goals, reinforcing behaviour and showing visible progress.	As behaviour becomes normalised, motivation shifts from creating momentum to supporting consistency, ownership, and long-term dedication.
TTM stage	Preparation	Action	Maintenance
System goal	Build connection, create a working foundation, lower friction.	Reinforce desirable energy behaviour in daily routines	Maintain long-term behaviour & adjust system when needed
Motivation focus	Initial response	Steps towards personal energy goals; Actions that result in peak shifting; Actions that result in peak shaving; Providing feedback to system	Showing consistency; Demonstrating family effort; Ongoing contribution; Mainting a feedback loop
Framing model / Communication model			
Motivation authority	system only	System / Admin	System / Admin
System detection abilities	Usage level	Usage level, appliance level	Appliance level
Risks	Overload; Drop-off; Unclear value; Too many questions	Misalignment; Inaction; Misinterpretation	Relapse; Blind spots; Overconfidence

26: Vattenfall product page

VATTENFALL Thuis Zzp Mkb Grootzakelijk Over Vattenfall Inloggen Contact

Aanbiedingen Onze producten Onze klimaatambitie Klantenservice Typ hier je zoekwoorden in

Thuis > Thuisbatterij

Slimme energie begint met jullie verhaal

Een thuisbatterij wordt steeds populairder bij huishoudens die efficiënter met stroom willen omgaan. Zeker nu de salderingsregeling voor zonnepanelen per 1 januari 2027 stopt, zoeken veel mensen naar manieren om meer van hun eigen opgewekte stroom te gebruiken. Energie opslaan is slim. Maar weten wánneer en hóe je die energie gebruikt? Dat is pas écht slim.

Maak kennis met LOOP
Ons slimme thuisbatterij systeem

Ons revolutionaire systeem leert van jouw gezin en past zich aan aan jullie gewoonten, doelen en voorkeuren. Zo krijg je energiebeheer dat echt bij jou past.

- **Op maat**
- **Jouw doelen centraal**
- **Realtime optimalisatie**
- **Veilig en betrouwbaar**

Alles wat je wil weten over een thuisbatterij

Zo werkt het
Wat is een thuisbatterij en hoe werkt die?
We leggen het uit

Is je huis geschikt?
Wat is een thuisbatterij en hoe werkt die?
Bekijk alle criteria

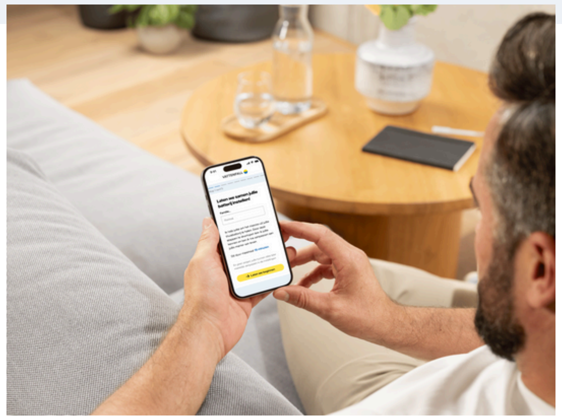
Kosten thuisbatterij
De prijs hangt af van een aantal factoren.
Meer over thuisbatterij kosten

Het eerste systeem dat zich aanpast naar jullie huishouden

Hoe werkt dat?

Loop is een slim energiesysteem dat voor jullie meedenkt. Het leert van jullie routines, doelen en voorkeuren, en past zich daar stap voor stap op aan.

Het systeem kijkt vooruit, herkent slimme momenten en helpt jullie om zonder moeite betere keuzes te maken. Dat is niet alleen fijn voor jullie portemonnee, maar ook hard nodig voor een toekomstbestendig energienet.



In 4 stappen naar een thuisbatterij

1. **Is mijn huis geschikt?**
   Controleer of je huis aan de criteria voldoet voor een thuisbatterij. Bekijk hier de thuisbatterij criteria.
2. **Vraag een adviesgesprek aan**
   Vraag hier aan.
3. **Advies & offerte**
   Onze thuisbatterij adviseur geeft je gratis advies op maat en en voorlopige offerte.
4. **Installatie**
   Blij met de offerte? Onze partner maakt een afspraak om de installatie van je warmtepomp in te plannen.

Daarom een thuisbatterij via Vattenfall

- We werken samen met experts in thuisbatterijen
- Je krijgt gratis advies en een offerte op maat
- Heb je Vooruit-punten? Zet je gespaarde punten in en ontvang tot **€200 extra voordeel.**
- Onze partners installeren door heel Nederland

Klaar voor slimme energiekeuzes?

Ontdek wat onze slimme thuisbatterij voor jouw gezin kan betekenen. Vraag een persoonlijk advies aan.

Vraag adviesgesprek aan

Strategic and technical implementation

27. Technical implementation

27.1 Intelligence in the system: how AI enables adaptation

The system is designed not just to collect data, but to conFigure the behaviour engine to each household and act as a but as a smart behaviour engine. What results is not one app for everyone, but many tailored systems running on one platform.

How does it do that? This chapter outlines how artificial intelligence enables that adaptive capability. It introduces the core AI mechanisms and layered architecture that power the system

A 27.1.1 layered view on AI and personalisation

To grasp how artificial intelligence enables personalisation and behaviour support in this system, it's helpful to understand the layered structure of AI technologies. The Figure below illustrates this hierarchy:

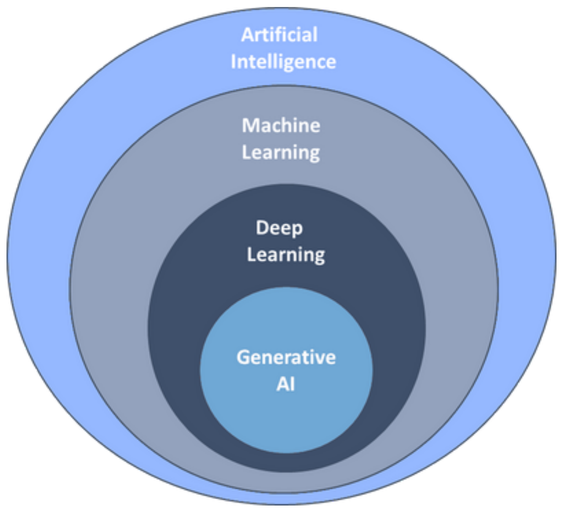


Figure 27.1: AI layers

- Artificial Intelligence (AI) is the broadest layer, It refers to systems that can perform tasks typically requiring human intelligence — such as decision-making, pattern recognition, or adaptation.
- Machine Learning (ML) is a subset of AI that learns from data to improve future performance.
- Deep Learning refers to ML systems using layered neural networks for highly complex tasks.
- Generative AI is a class of deep learning models capable of producing new content (text, images, decisions), rather than just analyzing or predicting.

27.1.2 AI principles and smart system architecture

The system operates using a multi-tiered intelligence model, balancing different levels of "smartness" depending on data availability and confidence. This ensures reliability while scaling personalisation.The AI design of the system follows a layered architecture (see Figure 27.2), made up of four interconnected layers:

1)User input layer
Where onboarding data is gathered

2)Smart logic engine
Where rules, machine learning, and fallback strategies drive decisions

3)personalisation & interface layer
Where guidance, feedback, and rewards are tailored to each household

4)Learning and adaptation loop
Where behaviour patterns are detected, and the system adapts accordingly

This structure allows the system to work reliably from day one, using rule-based logic, but also evolve into a dynamic coach as it learns more about the household.

System intelligence architecture

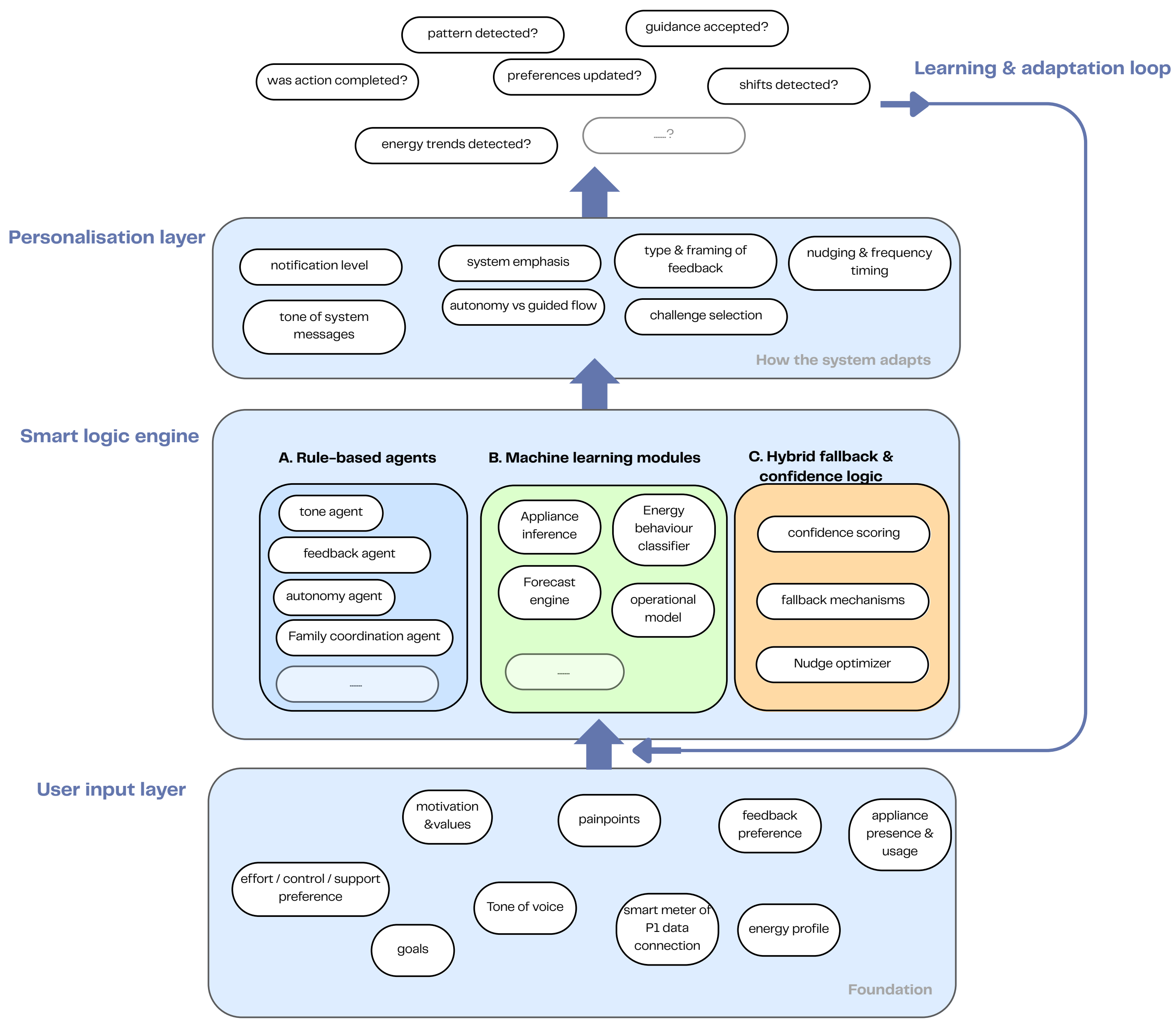


Figure 27.2: System intelligence architecture

27.1.3 Smart system architecture layers explained

1.The user input layer
The system uses onboarding inputs (such as household routines, motivation, energy usage, and preferred tone) to build an internal **user model.** This model acts as the foundation for all decision-making.

2. The smart logic engine: three AI modules

A. Rule-based agents (deterministic logic)
These agents operate on structured onboarding inputs and known rules. It uses conditional rules (e.g. "if control level = high, offer passive guidance only"). They act quickly and reliably, especially in early onboarding. F or example, the tone agent: Adjusts messaging style based on selected tone of voice and user reactions.

These agents ensure responsiveness even with limited data, and their behaviour is both explainable and adjustable. While their initial structure is based on if-then rules, agents evolve by integrating machine learning logic as more behavioural and usage data is collected.

B. Machine learning modules
Once data is available (e.g. from smart meters, weekly schedules or external sources), lightweight ML modules kick in:

- **Appliance inference engine:** Estimates which appliance causes which consumption peaks using time-series clustering and usage patterns.
- **Energy behaviour classifier:** Profiles household routines, pain points, and engagement styles (e.g. passive vs active).
- **Forecast engine:** Predicts sunny hours, peak tariffs, and possible shiftable loads.
- **behaviour-driven forecast engine:** Beyond pure energy forecasting, the system includes a behavioural forecast layer which predicts likelihood of user acting on a nudge and suggests timing for interventions based on prior engagement
- **Engagement model:** Learns when and how often to prompt based on response history. Uses:
    - Real-time + delayed feedback loop integration. To enable effective learning and trust-building, the system combines:
        - **Real-time response:** confirms impact of actions shortly after they occur (e.g. "Nice move — that shift saved 0.9 kWh")
        - **Delayed pattern recognition:** identifies trends over time ("We've noticed your solar use is increasing each week")
    - **Smart sequencing and scenario-based guidance: behaviour** change is not only about what to do, but when and in what order. The system applies optimized sequencing, ensuring actions are:
        - Timed to match user presence and energy context.
        - Ordered accordingly
        - Adjusted dynamically if a user shows resistance or indifference (e.g. not acting on 2–3 nudges)

C.Confidence scoring and fallback logic
Not all data is reliable. When user-provided input is missing or ambiguous, the system assigns confidence levels to its assumptions. In cases of uncertainty, the system relies on fallback options. These confidence scores affect whether to intervene, and for example, the tone of voice: For example, if appliance usage is estimated but not confirmed, it suggests a "likely" guidance with lower assertiveness ("This might be a good time to…").

3. personalisation layer: turning intelligence into experience
Once logic is processed, the output is passed to the personalisation layer, where the experience adapts. This is visualised in chapter 23

4. Learning and adaptation loop

Every interaction becomes a data point. This loop ensures long-term alignment between user behaviour and system guidance, without constantly requesting input. This is explained in chapter 19.

27.2 Privacy and security considerations

Because the system collects and processes personal household data, including names, schedules, and preferences, privacy and security are critical design requirements.

That's why all data handling must comply with GDPR standards. User data is collected with informed consent, stored securely, and used only for clearly defined purposes. Users maintain control over their inputs and can review, modify, or delete data at any time.

Open API integrations introduce additional risks. These connections, while valuable for functionality and real-time insight, create potential vulnerabilities in the system's data flow. To mitigate this, all API connections should be vetted, encrypted, and designed with access controls that restrict data sharing to only what is essential.

Transparency is also embedded in the user experience. During onboarding, users are clearly informed why each question is asked, what the system will do with the input, and how privacy is protected, reinforcing trust from the first interaction.

By combining technical safeguards with ethical interaction design, the system ensures that personalisation does not come at the cost of user privacy or data security.

27. 3 Integration into Vattenfall's digital ecosystem

27.3.1 Positioning

The system developed in this project introduces a new layer of intelligence and personalisation to household energy management. It is designed around behaviour change, contextual guidance, and adaptive support, features that go beyond what Vattenfall's current digital platforms are built to deliver.

This raises a strategic question: where should this system live within the existing Vattenfall UX landscape?

Vattenfall currently follows a one-app strategy, combining all customer-facing services in a single platform. While this unified structure has internal efficiency benefits, it presents a challenge: the app is already dense, and the addition of a behavioural guidance layer risks cluttering the experience and overwhelming users.

Yet launching a separate app is not the answer either. A standalone app risks confusing users, and fragmenting the digital experience, especially since Vattenfall's customer base is broad, and many households are not tech-savvy. They might value the familiarity of the current platform.

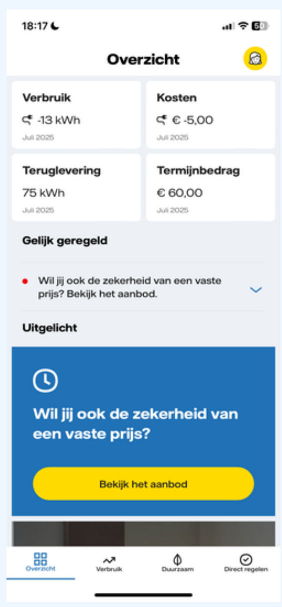
Zooming out, this concept is part of a broader smart home energy strategy. What it learns from the user could strengthen other touchpoints, such as the energy dashboard. Keeping this intelligence and propositions in one place makes it easier to build a cohesive, evolving relationship between the household and Vattenfall.

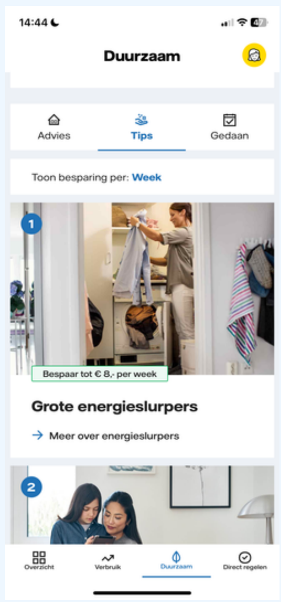
The strategic recommendation: integrate the system into the existing Vattenfall app, but only if the interface is restructured. That means reassessing which features deserve priority, removing or relocating less critical content, and giving the adaptive layer a clear and visible role within the overall user experience.

27.3.2 Cross links

The adaptive system does not stand alone, it can strengthen, and be strengthened by, existing initiatives within Vattenfall's ecosystem.

- Smart charging:
- 'Persoonlijk bespaarplan'





28. Strategic implementation

28.1 Stakeholder value

Circling back to the starting point of this project: a national energy system in transition, end users on the sidelines, and energy provider who only sends you your bill. This concept aims to close those gaps. By embedding adaptive, behaviour-based intelligence into daily life, it creates value at multiple levels. Helping users act, helping Vattenfall evolve, and helping the system balance.

This chapter focuses on the non-financial value created across stakeholders. For economic implications, see the business case (section 28.2).

Figure 28.2 summarizes how the concept generates aligned value across these three key stakeholders.

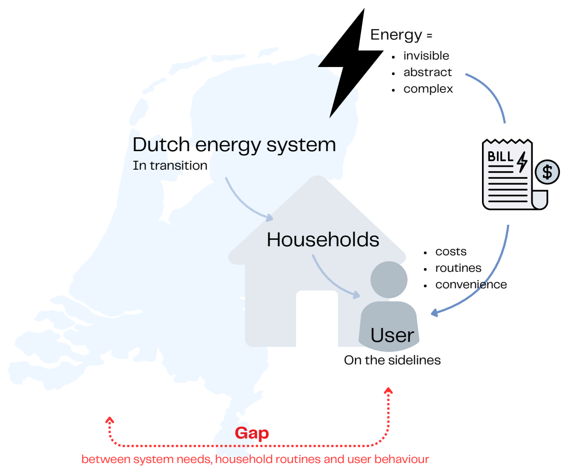


Figure 28.1: The starting point of the project

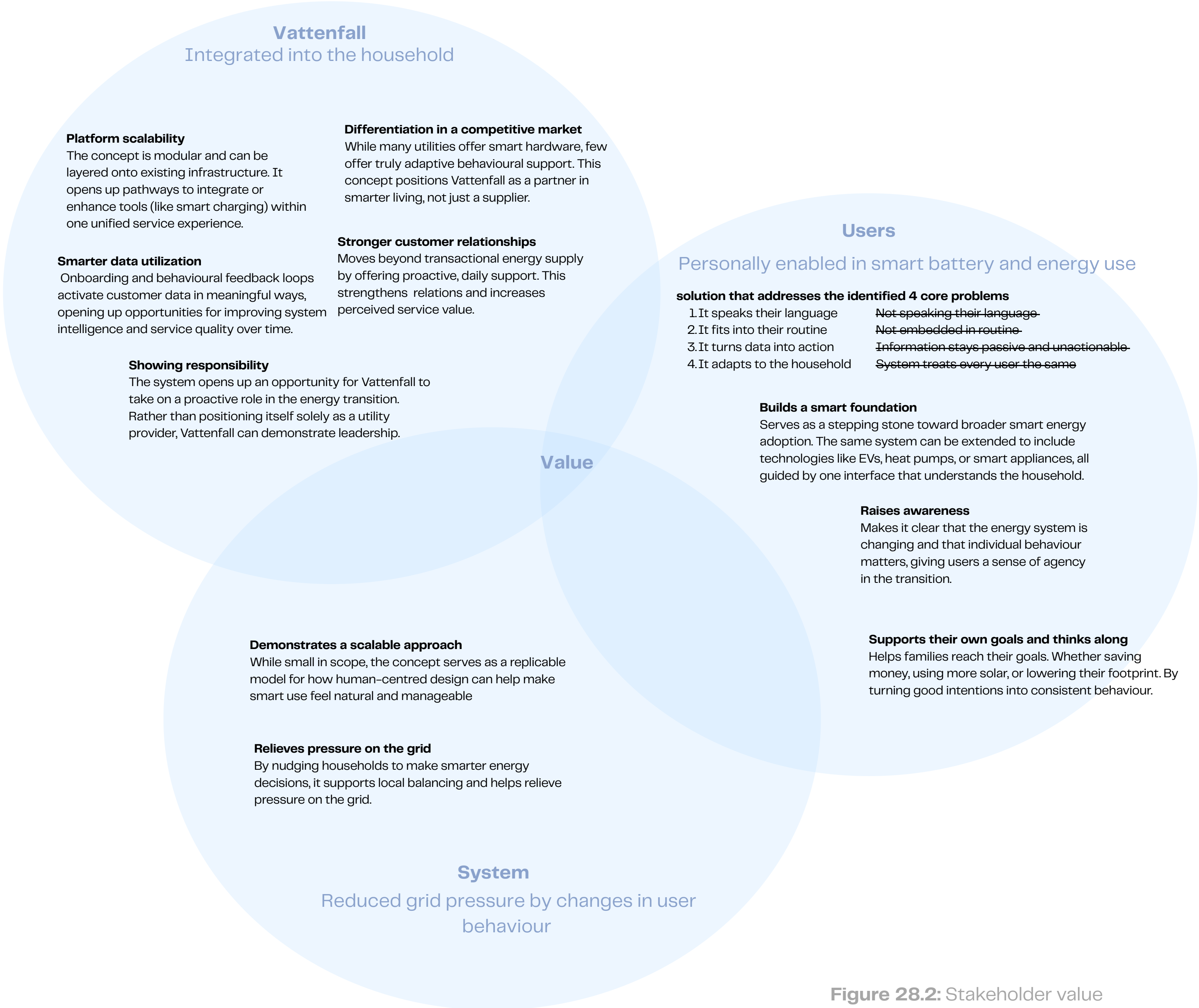


Figure 28.2: Stakeholder value

28.2 Business case

To complement the stakeholder value chapter, this section outlines the financial considerations behind the concept. While the core focus of this project is behavioural and user-centered, any strategic innovation must also consider business viability. The table below summarizes the main financial levers for Vattenfall.

Revenue gains	Cost savings	Strategic investments	Lost revenue
Revenue from battery sales	Lower procurement costs through load shifting	Development of onboarding and personalisation UX	Risk of reduced electricity sales (if users consume less from grid)
Improved customer retention and lifetime value	More accurate load forecasts → lower imbalance costs	AI development and model training	
Participation in flexibility markets (if partial ownership)	Avoided grid congestion penalties (in congested areas)	Ongoing system maintenance and updates	
Upselling potential of smart home assets		Internal rollout	
Internal margin gains from smart shifting			

(*Note: This high-level overview outlines potential financial levers associated with the concept. Actual business value depends on adoption scale, regulatory environment, and internal implementation choices.)

Upfront development costs for onboarding, AI training, and system integration are expected to be high, but they represent a strategic investment in a scalable platform. The intelligence developed here is not limited to the home battery but can extend to other smart energy products, spreading costs across multiple propositions. On the revenue side, the concept unlocks value through battery sales, shifting gains, and customer retention, while also supporting participation in flexibility markets. Operational cost savings and improved forecasting strengthen its long-term viability. Although reduced electricity sales could impact short-term revenue, the overall strategic value (in customer loyalty, system flexibility, and future market positioning) likely makes the case financially viable.

28.3 Branding and symbolic identity

The system is introduced under the name Loop: a title that reflects both its functional role and behavioural ambition. The word Loop symbolically ties together the core elements of the system: energy that flows in and out of the home, the circular nature of battery storage, and the behavioural feedback loops that help households continuously improve their smart energy routines.

Visually, the logo integrates seamlessly with Vattenfall's existing brand identity. The circular symbol complements the round Vattenfall icon and echoes the idea of progress through repeated action.

LOOP

LOOP

VATTENFALL
LOOP

VATTENFALL
LOOP

28.4 Strategic roadmap

This roadmap outlines the strategic development of Vattenfall's smart storage proposition over three horizons: from the present until the net metering phase-out in 2027, the post-phase-out adaptation period, and the long-term vision of becoming a trusted partner in smart home energy management. Each horizon builds on the previous one, guiding Vattenfall from market entry to an integrated, value-driven energy service.

28.4.1 Time pacing strategy

Horizon 1 (2025–2027) aligns with the announced phase-out of net metering. This creates both urgency and opportunity for households with solar panels, making it a critical window to introduce and validate the Loop proposition among existing Vattenfall customers.

Horizon 2 (2027–2030) marks a critical transition period following the end of net metering. A three-year timeframe was chosen because it offers a realistic window for iterative refinement of the Loop system, onboarding a broader user base, and building the internal capacity needed for scalable implementation. At the same time, expansion toward ecosystem support must not be delayed too long. As competitors move quickly and market dynamics evolve, Vattenfall risks losing relevance if it fails to grow beyond its initial proposition

Horizon 3 (2030 onward) looks toward long-term positioning. By then, home energy management systems are expected to become standard. This phase enables deeper integration into grid services, new tariff structures, and a stronger platform role for Vattenfall.

28.4.2 Category overview

To provide a structured overview, the roadmap is organized into four thematic groups:

Proposition
This group defines the core focus of the offering. It captures how Vattenfall transitions from a traditional energy supplier toward a more integrated role in the household. It also outlines the evolving product and service proposition, and how the customer relationship deepens over time.

Market
This section addresses who to focus on first and how the target customer group gradually expands. It includes assumptions about market conditions and an estimation of market potential (see Appendix O for calculation logic).

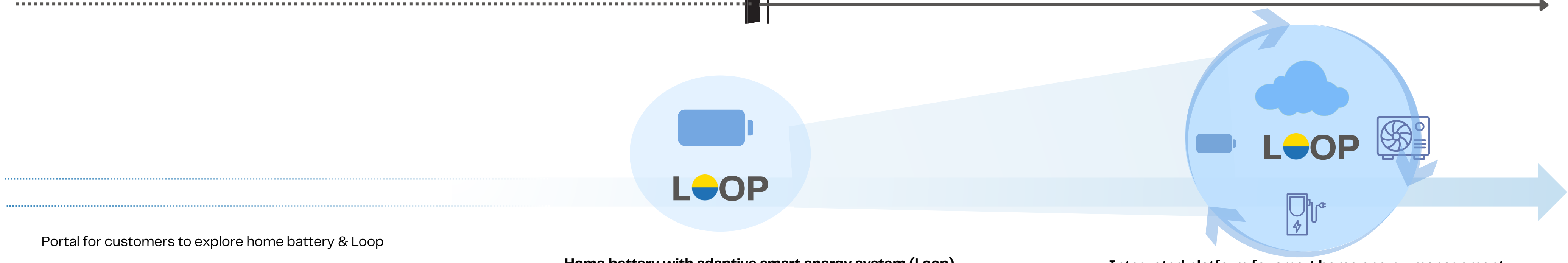
Maturity
Here, the roadmap reflects the readiness of both the customer and Vattenfall. It considers how digital literacy, behavioural engagement, and infrastructure maturity evolve, and how this influences the balance of control between system and user.

Business
This group identifies internal priorities and strategic levers. It highlights key risks, emerging opportunities, partnership needs, and organisational actions required to enable the proposition. Together, these elements guide where Vattenfall should direct focus and investment across each horizon.

STRATEGIC ROADMAP VATTENFALL

From energy supplier to partner in smart energy management

	Horizon 1	Horizon 2	Horizon 3	Future vision
	Laying the groundwork	2027 – Taking on a new role	2030 – Scaling up	
PROPOSITION	Preparation and launch	Proposition live – Adoption and consolidation	Ecosystem integration and leadership	Vattenfall as your trusted partner in smart, effortless energy use, with Loop as the intelligent layer that helps every household make the most of their energy and connects personal behaviour to collective grid needs.
Strategic focus	Preparing for the shift to home battery storage	Scaling personalized energy guidance	Leading in integrated home energy ecosystems	
Relation with customer	Service until the front door	Stepping **into** the home		
Product offering / Service offering	Portal for customers to explore home battery & Loop	Home battery with adaptive smart energy system (Loop)	Integrated platform for smart home energy management with multi asset integration	
	Synthesizing for...	Advising on next steps...		
MARKET				
Target customer focus	Existing Vattenfall customers	Early majority	xxxxxx	
Potential market size	xxxxxx	xxxxxx	xxxxxx	
Market conditions	Net metering still active	No net metering Strong incentive to self-consume	Normalized smart households XXXXXX	
MATURITY				
Readiness (Organisational, Customer)				
Control	Mostly user		Mostly system	
BUSINESS				
Organisational action points	• Product development • System infrastructure • Communication to customers • Legal/regulatory readiness • Initial marketing pilots	• Improve personalisation engine • Data management • Customer service Collect feedback to optimize	• Cross departmental collaboration • Expand partnerships (hardware + data) Stakeholder management	
Key risks or concerns	⚠ Short go-2-market time Taking on a new positioning as company	⚠ Privacy & data protection Market saturation Customers not understanding the system	⚠ Complexity of full ecosystem management	
Opportunities or levers	Involving the customer in proposition progress	Battery contract Smart plug integration	Working towards 0 energy bills Energy budget mode	
Partnerships		Behavioural design expert	3rd party integration parties DSOs: Distribution System Operators Housing cooperatives or real estate developer	



29. Recommendations for further development

This section zooms out from the concept and explores how the underlying system could grow in impact and relevance through further development. Figure 29.1 summarizes the recommendations.

29.1 Scale up potential

29.1.1 Guiding and integrating broader home energy setups

While the current concept focuses on the home battery, its real value lies in what it unlocks next. Once the system understands a household's context, patterns, and energy goals, it can play two increasingly strategic roles:

Coordinating multiple assets
The battery is a starting point, a gateway into the home's energy system. From there, the system can begin to coordinate other assets around the household's routines. Think of integrating smart charging for electric vehicles, managing hybrid heat pumps, or aligning usage patterns across devices. This orchestration unlocks greater flexibility and value, for Vattenfall, the household and the grid.

Advising on next steps
Beyond operating what's already in place, the system could proactively guide families toward smarter energy setups. Based on behavioural insights and situational fit, it could suggest relevant Vattenfall propositions, from insulation offers to smart thermostats. This isn't a generic upsell, but meaningful, timing-sensitive advice grounded in how the household actually lives(as opposed to figure 29.2).

This dual function transforms the system from a product interface into a trusted energy assistant.

29.1.2 Other customer segments

Although this concept was designed around families, with playful dynamics and shared routines as design levers, the underlying system can be scaled to fit other types of households.

Different user segments bring different needs, contexts, and sensitivities. The onboarding and interaction style should reflect that.

To account for this, the system could start with a short persona selector. Such as "who's in your household?" A single-person household might trigger a streamlined, autonomous flow; renters would see a version focused on behavioural actions within their control; and older users could get a slower-paced, more guided experience with simplified choices.

29.1.2 Different contract types

While this project primarily focused on users with a fixed-rate energy contract, the system's potential becomes even greater under dynamic pricing conditions. In those contexts, the incentive to shift energy usage becomes more directly financial.

Current contracts
Vattenfall already offers a fully dynamic contract, as well as the newly introduced TijdPrijs Trend (see Figure 29.3).

This latter contract simplifies dynamic pricing into predictable time blocks, making it more accessible for mainstream users. Still, it adds cognitive complexity, especially when users are left to interpret price signals and adjust their behaviour manually. The responsibility to act smartly still lies with the user.

This is where the added intelligence of the system becomes valuable. By linking the different prices to household routines, device usage, and battery behaviour, the system can proactively suggest or automate smart actions Such as pre-charging the battery during low-price hours to prepare for an expensive evening peak, benefiting both user and grid.

A new contract type
To fully unlock the behavioural and technical potential of the system, a new type of contract could be explored: a smart battery contract.

Key features might include:

- Integrated system logic: Pricing incentives are directly connected to system recommendations and battery behaviour.
- Effort-based incentives: Users are rewarded not just for outcomes (like energy saved), but for taking timely action when it matter, measured via the system's detection logic.

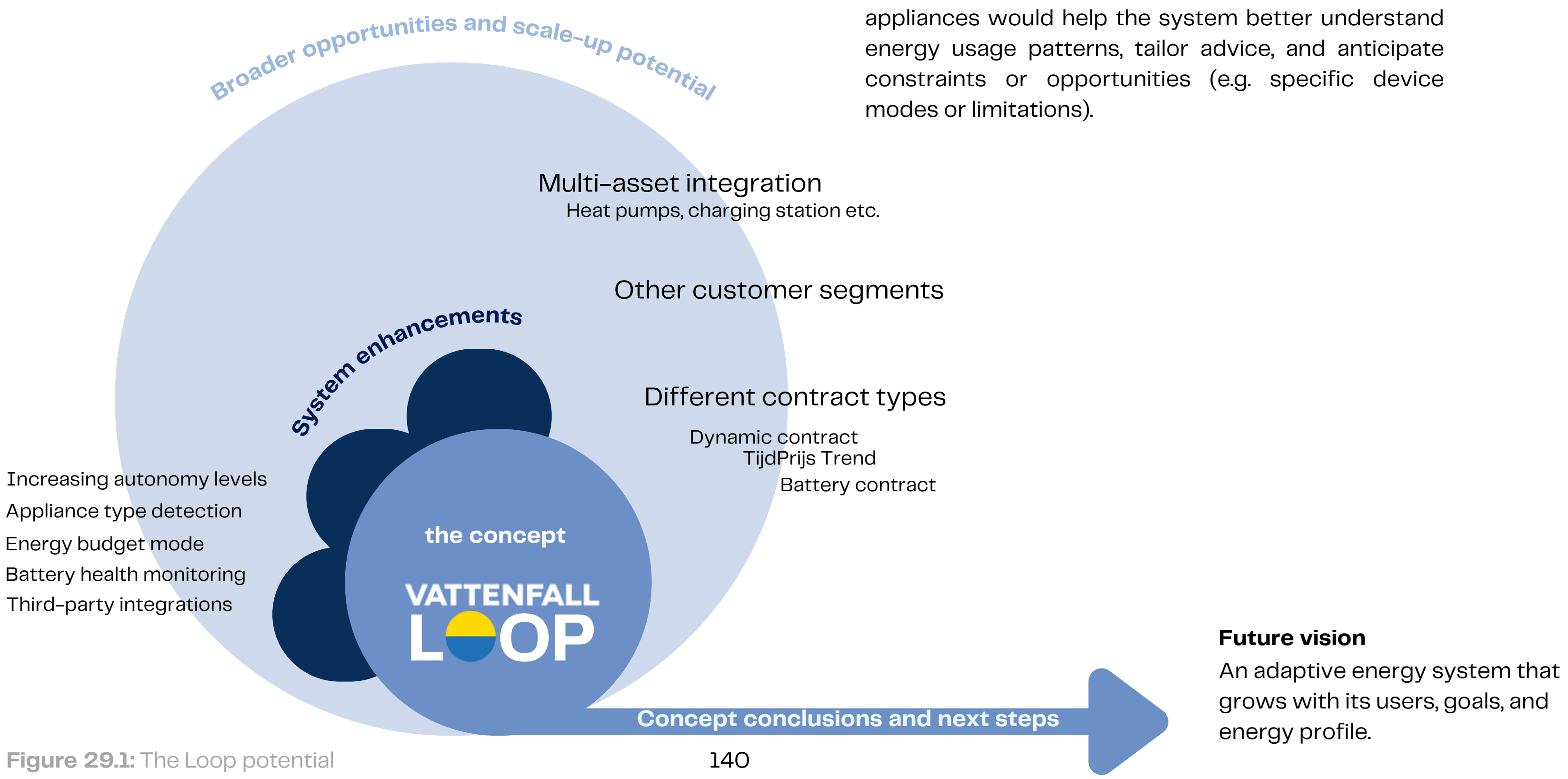


Figure 29.1: The Loop potential

29.2 System enhancements

This section reflects on what could make te system better.

Several technical enhancements stand out for increasing the system's value, reliability, and future scalability.

Energy budget mode
Enables users to set a monthly financial or kWh-based energy target. The system can then adjust its recommendations and scheduling logic to help households stay within this limit.

Battery health monitoring
Tracks battery usage patterns and degradation over time. The system can optimize charging behaviour (e.g. shallower cycles) to extend battery lifespan and notify users when maintenance may be needed.

Third-party integrations
Allows the system to connect with external smart energy platforms (e.g. Homey, Google Home) and non-Vattenfall devices. This enables broader ecosystem compatibility and smarter decisions based on more holistic household data. It does add a security risk, discusses in section FIXME.

Increasing system autonomy
Through integration with smart plugs or controllable devices, the system could actively shift or automate actions, or nudge its users to act remotely (e.g. turning appliances on/off). This could increase the unburdening ability.

Appliance-level detection
Identifying the brand, type, and model of connected appliances would help the system better understand energy usage patterns, tailor advice, and anticipate constraints or opportunities (e.g. specific device modes or limitations).

Figure 29.2: Current advice on assets

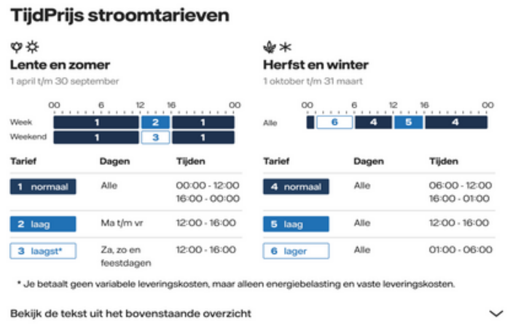


Figure 29.3: TijdPrijs

29.3 Concept specific conclusions and next steps

29.3.1 Action points

To successfully implement this system, several requirements must be met.

Ensure access to real-time data via P1 meters
While the system functions well using standard smart meter data, its performance improves significantly with access to real-time energy data via a P1 meter. Vattenfall already offers the HomeWizard P1 meter in exchange for 800 Vooruit points, yet the actual cost is minimal (around €25). Given the potential upside, it's worth asking: why not provide this by default to battery customers? It's a low-cost enhancement that unlocks a smarter, smoother experience from day one.

Communicate the value of the system upfront
As we have seen, home battery adoption is a high-involvement decision in an increasingly competitive market. This concept offers Vattenfall a distinct advantage, but only if users understand it. Communication must not be an afterthought. The challenge lies in making the system's added value tangible before purchase. Potential customers should be able to see, and ideally experience, how the system supports their household. This challenges Vattenfall to smart storytelling and perhaps even interactive previews during the sales process.

Leverage momentum and involve customers
As discussed in chapter 9, time is not on Vattenfall's side. The home battery market is maturing rapidly, and competitors are already gaining traction. If Vattenfall waits too long, it risks losing customers to other providers who have ready-to-go offers.

This risk is especially critical given that Vattenfall's strongest market potential lies within its current customer base (se chapter 11).

Now is the time to act. Even if the proposition is still under development, Vattenfall should start engaging customers proactively. Communicating openly about ongoing work signals transparency and positions Vattenfall as a transparent and forward-thinking energy partner.

The current battery landing page refers users to a third-party provider for advice. This is a missed opportunity. Instead, Vattenfall could create a branded customer portal to engage users more directly; answering questions, showing progress, and preparing them for future adoption. (see Figure 29.4)

This creates momentum, builds loyalty, and shows clients they're part of the journey.

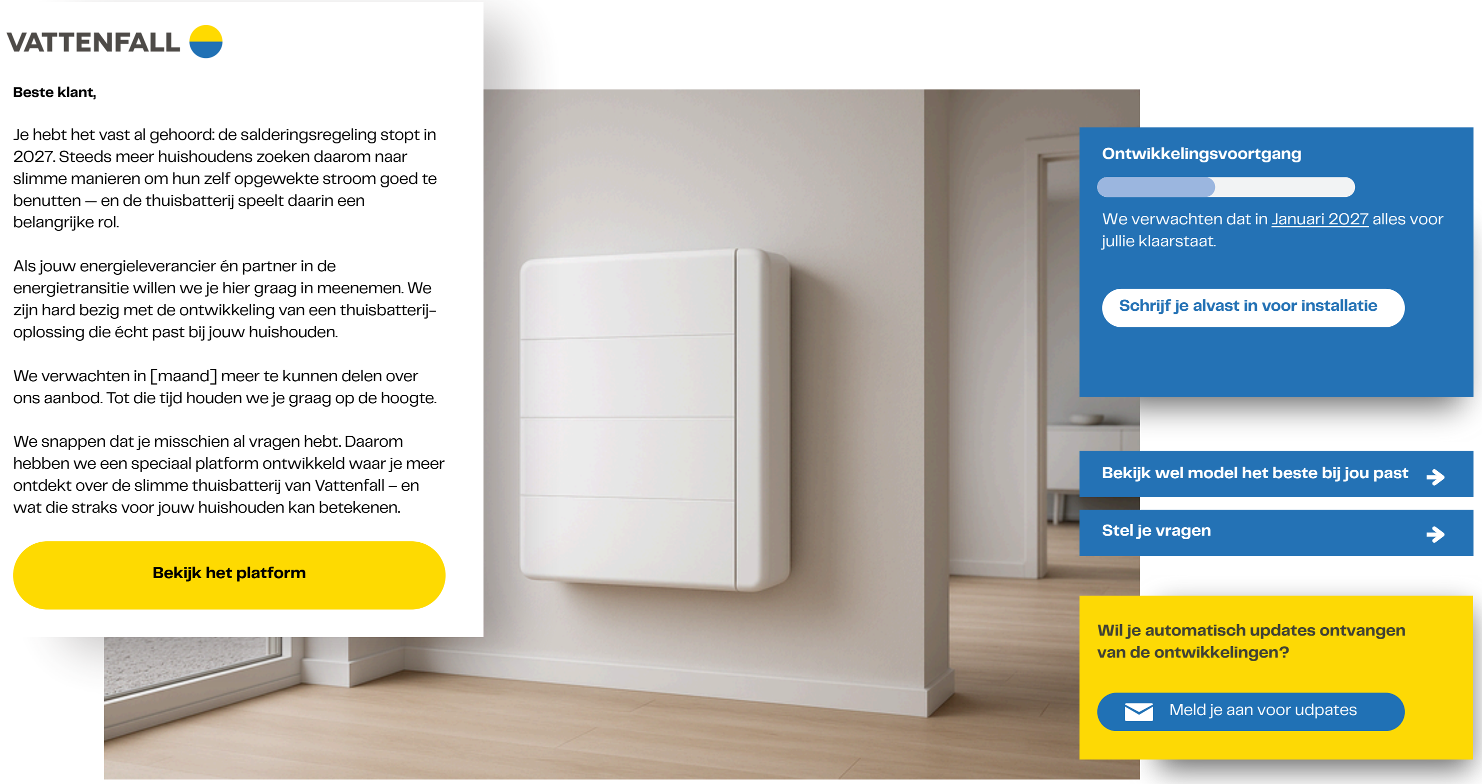


Figure 29.4: Hypothetical customer portal

29.3.2 Recommendations from validation

Exploring meaningful incentives for smart energy behaviour
As discussed in section 20.2, there is a fundamental tension between what is beneficial for the household and what is needed from the household in order to support the energy system. If Vattenfall chooses to take on the responsibility of stimulating smart behaviours that do not directly serve household goals and require too much effort, it must explore ways to make such behaviour more desirable.

One avenue explored during this project was the use of a point-based system to reinforce selected behaviours. While the final design moved toward a more intrinsic, goal-aligned feedback model, the idea of effort-based rewards remains an interesting direction for future development.

To develop such a system, two strategic questions must be addressed:

- The reward logic: Which actions are rewarded, and how many points are allocated? Should this be static or dynamic (e.g., more points during high-demand moments to reflect system urgency)? This logic must reflect both behavioural effort and system value.
- The value layer: What do the points mean to the user? This involves selecting or designing reward formats that are relevant, desirable, and contextually meaningful. Rewards could take the form of discounts, donations, family experiences, or sustainability upgrades — as long as they resonate with the user and maintain motivational integrity.

Ultimately, to stimulate behaviours that require additional effort without immediate personal gain, Vattenfall must carefully balance external incentives with internal alignment. Rather than defaulting to transactional design, the goal should be to frame these actions as meaningful contributions and make them feel worthwhile.

Streamline the schedule input
Although the calendar step has already been optimized (for example by allowing users to indicate weekly irregularities that trigger automatic rechecks), it still proved difficult or time-consuming for some users. Several directions could improve this:

- Allow the system to gradually phase out the schedule once it has learned enough from behavioural data. Over time, it could detect new patterns and adapt accordingly, reducing user effort.
- Optionally integrate location data (e.g. phone-based presence detection) to help infer daily routines. However, this would require careful handling of privacy and consent, as not all users may feel comfortable sharing this.

Offer control over explanation depth
User preferences regarding how much explanation or technical data they want varied significantly. It is recommended to add a step where users can select their preferred level of explanation.

- This setting could be connected to an "advanced" vs. "basic" view toggle later in the app, offering layered complexity without overwhelming users from the start.

Rethink the appliance load step
This step remains one of the most time-consuming and complex, but it also sparked valuable reflection among users about their habits. Rather than removing it entirely, Vattenfall could consider alternative solutions:

- Let the system suggest or pre-fill common loads based on household type
- Use follow-up prompts during the learning phase to refine the data

Introduce account types (admin / kid)
Creating distinct admin and child account types opens the door for a more tailored experience. For example, children could receive a simplified interface with playful visuals and fewer tasks, while the admin maintains full control.

- This is especially relevant for families with older children who are becoming more involved in household routines, and aligns with the system's ambition to involve the whole family in energy use.

Conclusion

30. Conclusion

This graduation project set out to design a household-centred proposition for Vattenfall's home battery system, aiming to unburden Dutch families in their everyday energy management. With the net metering scheme ending in 2027, the urgency to support self-consumption is growing. Yet while the technology is getting smarter, the user remains on the sidelines—confronted with systems that expect new behaviour without providing support.

Through extensive research across system, household, and user levels, four key barriers were identified: the energy system does not speak the user's language, fails to become part of daily routines, offers unactionable information, and treats all users the same. These barriers were reframed into four opportunity areas that explore how Vattenfall's home battery proposition can be positioned from a user perspective rather than a technical one, shifting the focus from product to partner.

The resulting design is Loop: an adaptive battery system that guides families in making smarter energy decisions. It begins with a structured onboarding flow that learns from the household, gathering information about goals, preferences and energy context. This forms the basis for tailored guidance that adapts over time. Loop combines automation with user input, offering feedback and stimulation that fit daily life and reinforce helpful behaviours.

The project aims to demonstrate that behaviour is not a side issue, but central to the energy transition. Smart solutions only work when they align with how people live. Loop shows that by rethinking the starting point - not what the system can do, but what the household actually needs- new opportunities emerge. By designing from the perspective of households instead of individuals, it becomes possible to embed energy behaviour into everyday life, with minimal complexity and maximum relevance.

Ultimately, this project offers Vattenfall a way to move beyond hardware and position itself as a partner in smart, low-effort living. By embedding empathy, adaptability, and household dynamics into the proposition, Loop provides a realistic and user-driven answer to a rapidly changing energy landscape

Discussion

This discussion reflects on the project's limitations, offers my personal perspective on the concept, and explores a more idealistic view of the energy landscape and Vattenfall's potential role within it

31. Discussion

31. 1 Limitations

Prompting within the behaviour loop
The system was primarily developed around the beginning (onboarding) and end (feedback) of the behaviour loop. While some logic for real-time nudging was included, the actual strategies for when and how to prompt users require more targeted development. This is critical for maintaining momentum over time.

Limited user testing scope
The current validation was exploratory and focused on a select group (n=4), limiting the generalizability of findings. To better understand behavioural differences across household types, motivations, and energy contexts, larger-scale testing is needed. This will support te scalability and robustness of the system logic.

Further development of the business case
While a the levers of a preliminary business case were explored to identify value streams, more detailed financial modeling is required. This includes different rollout scenarios, pricing strategies, and long-term return on investment for Vattenfall.

Influence of UI design on user engagement
In this project, careful choices were made to keep the onboarding experience light and intuitive. However, the psychological impact of specific UI elements (like sliders versus tiles) on user motivation and perceived commitment remains underexplored. Further research could deepen understanding of how subtle design choices affect engagement and participation.

Data transparency and user trust
The system makes smart inferences based on behavioural data, which raises important questions about transparency and perceived intrusiveness. Further research could explore how to communicate system intelligence in a way that builds trust, without scaring users.

System integration complexity
Bringing together smart learning, user modeling, and adaptive interfaces involves significant technical integration. These elements were not fully prototyped, and their feasibility within Vattenfall's current infrastructure is still uncertain. It is recommended to initiate technical exploration tracks early, ideally in close collaboration with existing digital teams, to assess architectural fit and identify bottlenecks.

Further develop and test the motivation system
The motivational system designed in this project represents a thoughtful first iteration, grounded in user feedback and behavioural insights. However, motivation is context-sensitive and shaped by how different mechanisms interact in real life. To ensure long-term effectiveness, it is recommended that the system be further developed and tested through longitudinal, real-world use. Future testing should explore combinations of motivational elements, assess their impact on actual behaviour, and evaluate how motivation evolves over time. Special attention should be given to maintaining relevance without fatigue, and to understanding which mechanisms work best for which household types.

31.2 New business models for responsible energy consumption

31.2.1 Rethinking incentives: from unlimited use to conscious consumption

What if we could reduce energy waste not only through smarter devices, but through smarter frameworks? As touched upon in section 29.2, the idea of an energy budget opens up an important and under-explored discussion: what happens when there is no direct incentive to use energy wisely?

For households with financial stability, there's often little incentive to reflect on their energy use, leading to unconscious overconsumption simply because they can afford not to care. When a conscious mindset is lacking, potential for smarter, more aligned behaviour is lost. This has not just individual consequences, but systemic ones.

Now imagine an alternative: a regulated, context-aware energy allowance. Not a restriction, but a fair, tailored baseline based on your household type and infrastructure. Staying within this budget could mean paying nothing extra. Exceeding it would have consequences. Such a structure would shift the narrative from "how much can I use?" to "how can I make the most of what I have?" This challenges behaviour in a constructive way and opens up possibilities for nudging, transparent tracking, and smart automation.

31.2.2 Exploring zero bill structures

A real-world example of this way of thinking is Octopus Energy's Zero Bills proposition. In this model, households with state-of-the-art green tech (solar panels, batteries, and heat pumps) gain access to a tariff that guarantees no energy bills for up to 5–10 years, as long as they stay within a defined "fair use" threshold (Octopus Energy, n.d.).

If Vattenfall explored a similar approach, it could closely align with the behavioural logic of the Loop system. It may sound far-fetched at first, but what if Vattenfall could guarantee stable, affordable tariffs in exchange for predictable, cooperative energy behaviour?

Loop could be the translator in this arrangement: it understands household routines, adapts to preferences, and ensures that any behavioural commitments made to Vattenfall are supported through actionable guidance. In this way, Loop doesn't just serve the household, it serves as the interface between household behaviour and system-level optimisation.

Such a proposition could be especially compelling in a post-net metering landscape, where both system value and user trust are under pressure. It reframes energy as a shared responsibility and makes that responsibility feel doable.

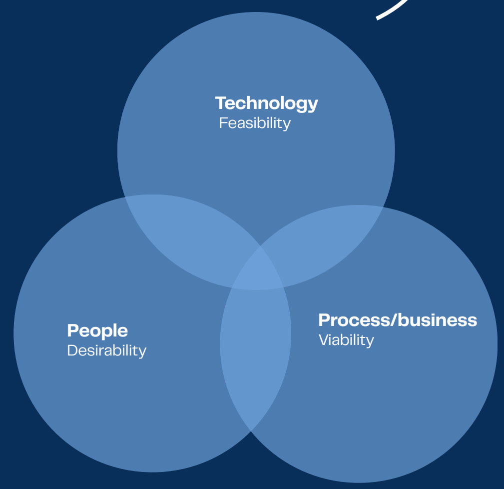
So... what do I really think?

After all the research, design and validation, what's my own verdict on the concept? Based on everything I've learned throughout this project, I've formed a grounded, strategic opinion on its potential.

This reflection isn't based on market data or future projections, but on the accumulated insight of working hands-on with the challenge. Using the same three lenses that guided this project, feasibility, viability, and desirability, I'll outline where I believe the real potential lies, and where the biggest risks remain

Technically, the concept introduces **significant backend complexity**. Combining rule-based logic, machine learning modules, and personalized motivation flows into one adaptive system is ambitious. However, given the rapid pace of AI and system integration technologies, and with the right expertise, **this should not be the main barrier.**

The real constraint may lie within the organization itself. Having worked closely with Vattenfall, I've seen a culture that is layered and risk-averse. Building a system like Loop within such a structure, before net metering ends in 2027, requires not just technical capability, but also strategic decisiveness, cross-functional alignment, and internal prioritization. That is where my **doubts** lie.



This is the **most complex pillar.** Unlike solving a clear, immediate need (like buying an umbrella when it rains), energy engagement sits at the **intersection of current behaviour and future complexity.** People may not feel urgency until they're forced to.

While Loop **addresses real and validated pain points**, **energy remains a low-interest domain**. Many families won't actively engage unless they experience a compelling financial or system-based trigger. But I'll repeat what I've said throughout this project: **It's the designer's responsibility to look ahead.**

The **energy system** is becoming **more complex**; **users are not**. If design doesn't evolve to bridge that gap, the result will be a technically functioning system that **fails the people it's meant to serve. Loop** is a **first step** toward avoiding that outcome.

From a business perspective, an **adaptive system** like Loop holds **strong strategic value.** It can serve as a flexible backbone that **connects to various propositions** and unlocks more **personal, data-driven value** for customers over time.

It also offers a clear way to **differentiate**. Most energy providers still treat customers as passive users of hardware. **Loop reframes that relationship**: from a transactional product to an evolving, supportive service. This fits Vattenfall's long-term ambition of becoming a trusted energy partner in the home.

However, this is **not a low-effort route**. The **development costs** for building such a system , especially the personalisation logic, adaptive AI, and user-facing guidance flows, **will be significant**. These investments are not just technical, but strategic: they **require** a **long-term vision**, budget commitment, and **belief** in building value beyond hardware.

Reflection

Personal Reflection

I came into this project wanting to prove I could do it all—strategic, well-researched, beautifully designed. And in a way, I did. But what I didn't expect was how much of the real work would happen internally.

The biggest lesson: hold your ground

Somewhere early on, I caught myself nodding along in meetings, scribbling down every opinion like it was an instruction manual. Saying 'yes, indeed' on almost everything my supervisors pointed out and trying to adapt and fix it as soon as possible. Not because I didn't have ideas, but because I assumed everyone else knew better.
They were the experts. I was the student. Right?

I often was afraid to go deeper into a statement or push back on an assumption, because I felt I knew too little about it and didn't want to seem unprepared. Better to quietly adjust than risk sounding naive. Or so I thought.

That worked for a while, until it didn't. I ended up with so many external inputs that I lost track of my own point of view.

That moment of friction was probably the most valuable part of this project. I've learned that being the least experienced person in the room doesn't mean you bring the least value. And maybe even more interestingly, just because you're not an expert in something, doesn't mean the other person is.

That also came with learnings in how to present myself. I started to see that confidence isn't about always having the answer. It's about knowing when to ask, when to listen, and when to stand by an idea even if it still has rough edges.

That also came with learnings in how to present myself. I stopped overexplaining an apologising for not knowing something. I grew not just in skill, but in posture: more steady, grounded and honest.

Other lessons: trusting the in-between

Another shift came in how I approached time. I used to fill every hour and chase every detail. As long as I worked really hard, I couldn't be disappointed with the outcome. This project taught me that stepping away often leads to better thinking than pushing through. The best ideas and insights came in the moments I wasn't trying to have them.

I also learned to be more comfortable with my own doubts. I often believe that doubting a decision means it is probably the wrong one and so I tried to ignore that feeling. But doubt, I've realised, does not necessarily point out a weakness in your approach. It's a sign you're taking the consequences seriously. Ultimately, it's what pushes you to sharpen, check and to keep asking whether the thing you're designing still makes sense. Doubt, when used well, is a compass. Just not one that points in a straight line.

Project specific reflections

Of course, next to all these personal lessons, there are also some project-specific ones to reflect on.

I really value working with others. In the beginning, I struggled with doing this as a solo project. I thought working alone meant being alone. But I've learned that doing your own project doesn't mean doing it by yourself. In hindsight, I would have involved stakeholders and supervisors earlier and more consistently, not just for feedback, but to shape the thinking together.

I've learned how important it is to bring people along in your thought process. To open up the messy middle, not just the polished pitch. That's something I can still work on: translating what's going on in my head into something that's easy to follow and react to. There's often a lot happening in there, and letting people in earlier can make the process more collaborative and more strategic.

One last (but important) learning: being honest about time and energy. I have a tendency to overpromise, whether it's to supervisors, stakeholders, or myself. It's tempting to say "I'll have it by Friday" just to keep momentum, but that only works if Friday doesn't turn into a panic zone. I should stop seeing communicating what's realistic as aa sign of weakness and instead see it as a way to protect the quality of my work (and sanity). I've learned that setting honest expectations builds more trust than meeting unrealistic ones.

Final remarks

Looking back, I'm proud of what I made, but I'm even more proud of how I got there. Less about ticking boxes and more about shaping something that actually matters.

So what will I take with me? A better compass. A bit more nerve. And the reminder that growth doesn't come from knowing more, but from daring to trust what you already bring to the table

What's ahead

So what now? What did I discover about the direction I want to go in as a strategic designer? I've learned that I have a natural tendency to make things clearer, leaner, more thought-through. So I'd love to explore areas like process optimisation—how things could run smarter, not just look smarter. I've also discovered that one of my strengths lies in sharpening ideas and turning strategy into something tangible. That space between thinking and doing, that's where I get energy.

I'm curious to see what comes next. But if there's one thing I know for sure, it's this: I want to keep designing things that work not just on paper, but in real life.

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Appendix

Appendix A: Project Brief

DESIGN FOR our future

TU Delft

Personal Project Brief – IDE Master Graduation Project

PROJECT TITLE, INTRODUCTION, PROBLEM DEFINITION and ASSIGNMENT
Complete all fields, keep information clear, specific and concise

Project title Optimizing Home Battery Adoption for Vattenfall Customers

Please state the title of your graduation project (above). Keep the title compact and simple. Do not use abbreviations. The remainder of this document allows you to define and clarify your graduation project.

Introduction

Describe the context of your project here; What is the domain in which your project takes place? Who are the main stakeholders and what interests are at stake? Describe the opportunities (and limitations) in this domain to better serve the stakeholder interests. (max 250 words)

This project takes place within the Home Energy Management (HEM) domain of Vattenfall Netherlands, specifically under the Digital Innovation branch, within the UX Design and Research team. With the introduction of home batteries, Vattenfall is expanding its business model from traditional energy contracts to smart energy solutions that are directly integrated into consumers' home environments(stakeholder overview on next/last page)

Vattenfall anticipates that by 2027, due to the phase-out of the netting scheme, customers will start questioning how to manage their solar energy. Vattenfall positions the home battery as the preferred solution, despite other possible alternatives like solar boilers or grid reinforcements. However, the adoption of home batteries depends on several factors, including customer energy needs, contract type (fixed, variable, or dynamic pricing), and whether their home is fully electric or still reliant on gas. Additionally, the limited storage capacity of home batteries influences their effectiveness in different use cases.

Vattenfall aims to develop an honest and transparent proposition that aligns with customer needs and market expectations. Beyond financial feasibility, customers must understand how a home battery integrates into their energy management and whether it suits their personal situation. While the home energy market offers opportunities, such as financial incentives for grid stability and the rise of decentralized energy solutions, it also presents challenges. Market complexity, evolving regulations, and competing solutions create uncertainties. Additionally, the transition from traditional energy contracts to smart home solutions demands a new way of engaging with customers, ensuring both trust and usability.

To support this transition, this project explores how to bridge the gap between technological complexity and consumer needs, this project aims to develop strategies that enhance the adoption and effective use of home batteries, ultimately strengthening Vattenfall's position in the evolving energy market

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DESIGN FOR our future

TU Delft

Personal Project Brief – IDE Master Graduation Project

Problem Definition

What problem do you want to solve in the context described in the introduction, and within the available time frame of 100 working days? (= Master Graduation Project of 30 EC). What opportunities do you see to create added value for the described stakeholders? Substantiate your choice.
(max 200 words)

The introduction of home batteries presents adoption challenges across the entire customer journey, from awareness to long-term use. Consumers face uncertainties about whether a home battery suits their needs, how it integrates with their energy contract, and whether the investment is worthwhile. Moreover, the perceived complexity of energy management can discourage engagement.

Different customer segments experience these challenges in varying ways. Early adopters are often technology-driven and more willing to actively manage their energy use, while the broader market seeks simplicity and automation. This makes it difficult to develop a one-size-fits-all approach. Beyond consumer challenges, Vattenfall faces uncertainties regarding how to position the home battery in an honest way while stimulating purchase and adoption. Regulatory developments, market competition, and evolving energy policies also influence the feasibility and attractiveness of home batteries.

A key issue is determining which barriers to prioritize and how to balance consumer needs with technological and business objectives. This research will provide insights to structure Vattenfall's approach, ensuring that both proposition clarity and customer adoption are effectively addressed.

Assignment

This is the most important part of the project brief because it will give a clear direction of what you are heading for. Formulate an assignment to yourself regarding what you expect to deliver as result at the end of your project. (1 sentence) As you graduate as an industrial design engineer, your assignment will start with a verb (Design/Investigate/Validate/Create), and you may use the green text format:

Design a strategic proposition for Vattenfall's home battery that is clear, honest, and aligned with customer expectations. This includes identifying key barriers and opportunities along the customer journey and defining how Vattenfall can position home batteries in a way that stimulates adoption while maintaining transparency.

Then explain your project approach to carrying out your graduation project and what research and design methods you plan to use to generate your design solution (max 150 words)

This research follows an iterative, user-centered approach based on the Double Diamond framework: discover, define, develop, deliver. (for Gantt chart & visual of the process, see last page)

Discover: The project begins with mapping the background, context, and key challenges related to home battery adoption. This phase involves gathering insights through a combination of research methods to understand consumer behavior and stakeholder perspectives. Literature review will provide insights into current challenges and opportunities in home battery adoption.
Define: The current situation and desired outcomes will be identified, helping to narrow the focus based on customer needs and key moments in the customer journey.
Develop: Insights from the first phases will be translated into concrete design directions, exploring different product propositions and testing with target users
Deliver: The final phase will synthesize findings into actionable design interventions and recommendations to support Vattenfall in creating a value proposition that optimizes home battery adoption and user experience.

introduction (continued): space for images

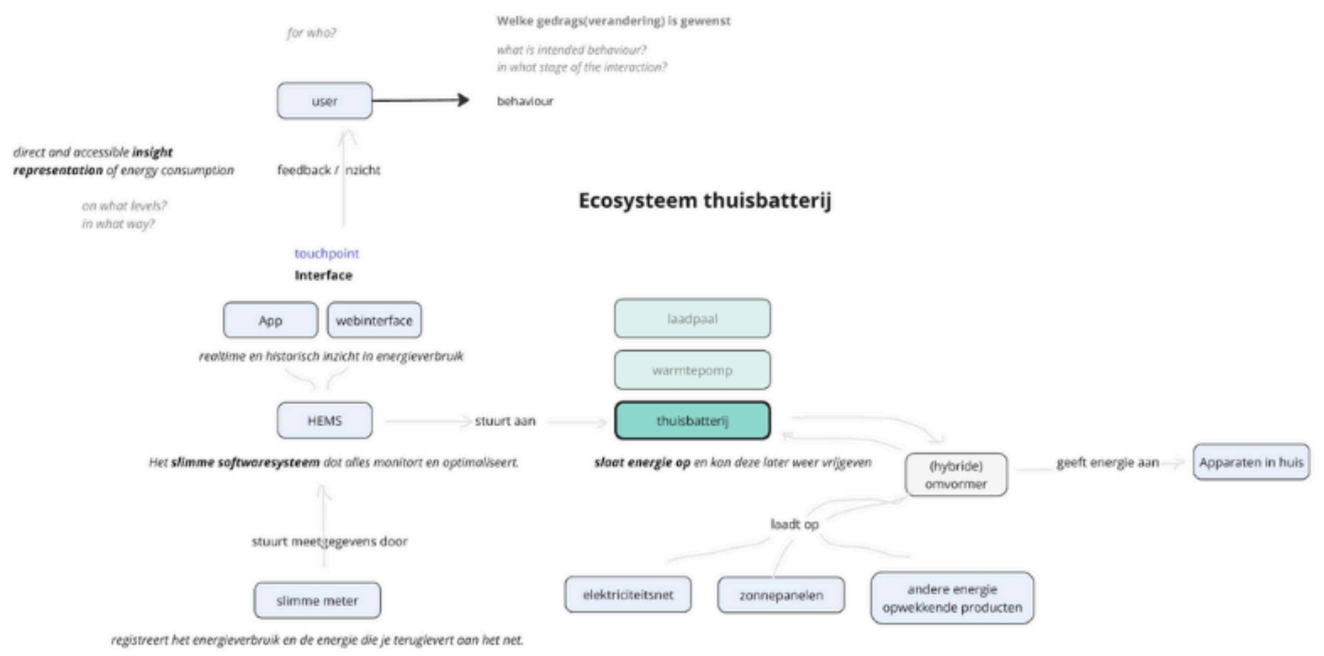


image / figure 1 Home Battery Ecosystem

stakeholder	Role	Interest
Vattenfall (Digital Innovation, HEM Business, UX & Research, Customer Service)	Develops, implements, and optimizes home battery solutions	Increase adoption, improve user experience, and ensure commercial viability
Consumers (Home Battery Users)	End users of the home battery	Seamless, efficient, and valuable energy management experience
Pilot Users	Early adopters testing new solutions	Provide real-world feedback on UX and behavioral interventions
Customer Service	Support users in onboarding and troubleshooting	Ensure smooth adoption and reduce friction in customer journey
Dutch Government & Regulatory Bodies	Set policies and regulations on energy transition and storage	Ensure compliance with energy policies, promote sustainable energy adoption
Feenstra	Installer & (co-)developer of home battery	Installation efficiency, technical integration, product improvement, customer support, regulatory compliance

image / figure 2 Preliminary Stakeholder Overview

Project planning and key moments

*To make visible how you plan to spend your time, you must make a planning for the full project. You are advised to use a Gantt chart format to show the different phases of your project, deliverables you have in mind, meetings and in-between deadlines. Keep in mind that all activities should fit within the given run time of 100 working days. Your planning should include a **kick-off meeting, mid-term evaluation meeting, green light meeting** and **graduation ceremony**. Please indicate periods of part-time activities and/or periods of not spending time on your graduation project, if any (for instance because of holidays or parallel course activities).*

Make sure to attach the full plan to this project brief.
The four key moment dates must be filled in below

Kick off meeting	4-03-2025
Mid-term evaluation	30-04-2025
Green light meeting	2-07-2025
Graduation ceremony	30-07-2025

In exceptional cases (part of) the Graduation Project may need to be scheduled part-time. Indicate here if such applies to your project

Part of project scheduled part-time	
For how many project weeks	
Number of project days per week	

Comments:

Motivation and personal ambitions

Explain why you wish to start this project, what competencies you want to prove or develop (e.g. competencies acquired in your MSc programme, electives, extra-curricular activities or other).

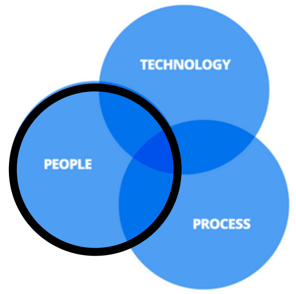
Optionally, describe whether you have some personal learning ambitions which you explicitly want to address in this project, on top of the learning objectives of the Graduation Project itself. You might think of e.g. acquiring in depth knowledge on a specific subject, broadening your competencies or experimenting with a specific tool or methodology. Personal learning ambitions are limited to a maximum number of five.
(200 words max)

Project-Specific: I want to undertake this project because it lies at the intersection of UX design, behavior steering, and strategic innovation within the growing energy management market. Vattenfall's Home Energy Management approach offers a unique challenge, as introducing home batteries requires not only technological innovation but also a shift in consumer behavior. Success depends on how well the product meets user needs and habits, not just its functionality.
- This project presents an opportunity to explore how behavior steering and UX can complement each other and promote sustainable energy adoption. I aim to learn how to translate behavioral insights into concrete design principles, strategic guidelines, and impactful interventions.
- I want to develop a behavioral strategy that aligns with the entire customer journey, touching various touchpoints and usage phases.
- I want to demonstrate that iterative methods, such as Lean UX, Continuous Discovery, and behavioral research, can still lead to a structured process and a strategic final outcome.
Personal Learning Ambitions:
1- I aim to prove that I can independently structure and execute a complex project within Vattenfall's innovation environment, combining insights from UX, behavior steering, and strategic service development to create a practical strategy for home batteries.
2- Learn how to communicate complex insights effectively, making them actionable within product development, UX design, and customer communication.

Appendix B: Qualitative research (discovery)

Method & participants

In the discovery phase of the project, several **user interviews** were conducted. These interview focus on the pillar **people**.



Relevance: The interviews provide a comprehensive understanding of the customer journey, including key pain points, which helps inform and guide the further direction of the project.

Users were selected from segments similar to the quantitative research conducted by Vattenfall.

Goal of interviews: In this stage of the research, the goal of the interviews were to gain a better understanding of user's considerations, attitudes, beliefs etc.

- Knowledge of home batteries
- Barriers and drivers influencing interest or hesitation
- Decision-making criteria and how users prioritize them
- Experiences or expectations of daily use
- Steps, reasoning, thoughts, and emotions during the orientation process
- Perceived risks and trust
- Information-seeking behaviour

Additionally, certain **assumptions** from the assumption matrix were tested.

total N = 11 | owners of HB, N=3 | consider HB, N=4 | No HB, not actively considering, N=3

The interviews were analyzed and insights were clustered into themes

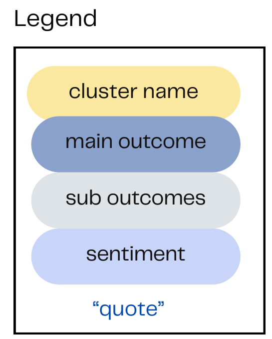
Interview Method

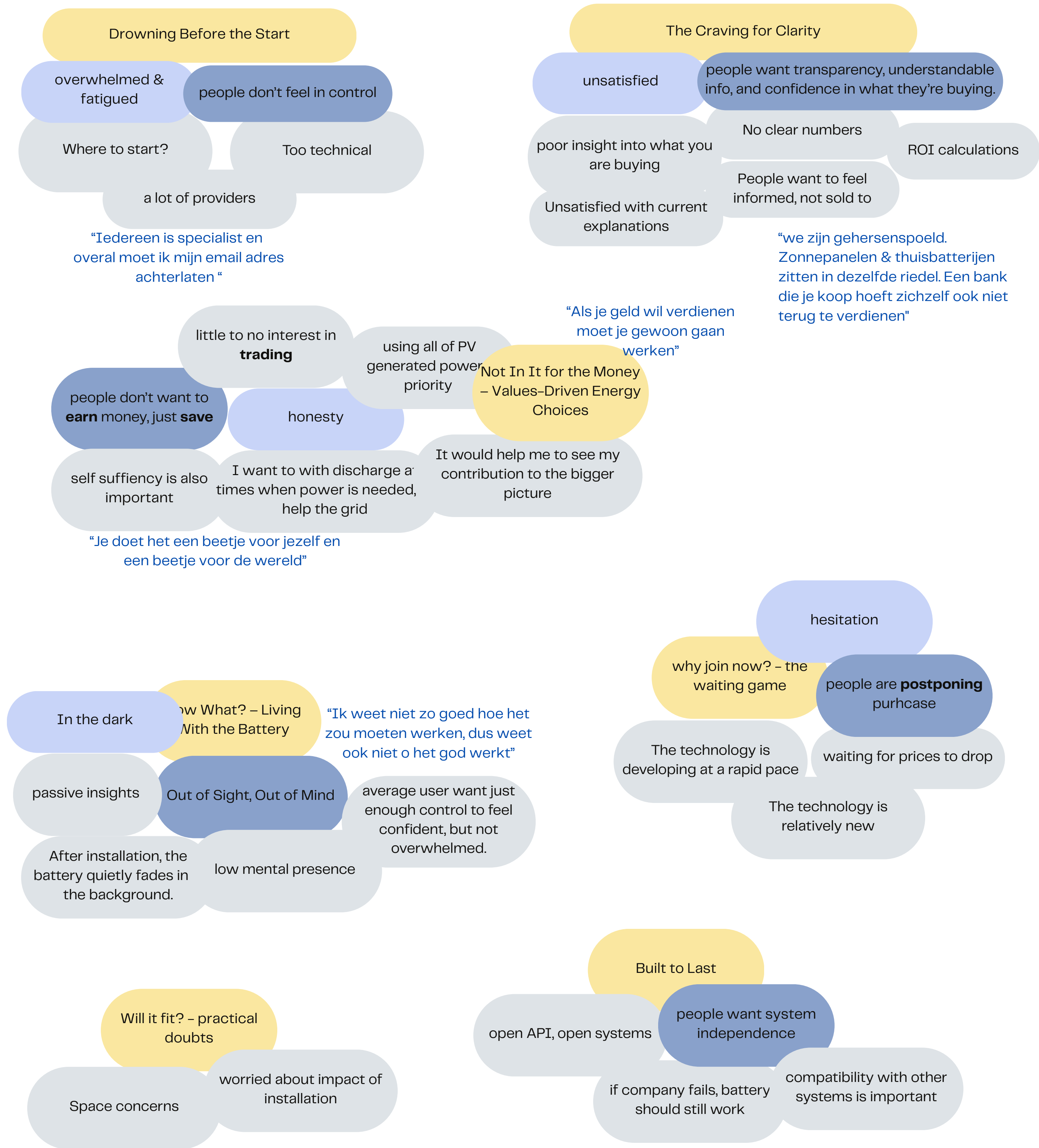
The interviews lasted approximately 30–45 minutes and were conducted via video or telephone calls. A semi-structured approach was used, combining open-ended questions with ranking exercises to understand decision-making priorities. Follow-up probing questions were used to explore underlying motivations and reasoning in more depth.

Participants were recruited through convenience sampling, including personal acquaintances as well as members of online communities and discussion forums relevant to energy and sustainability topics. This approach allowed for a diverse yet accessible pool of respondents within the target group.

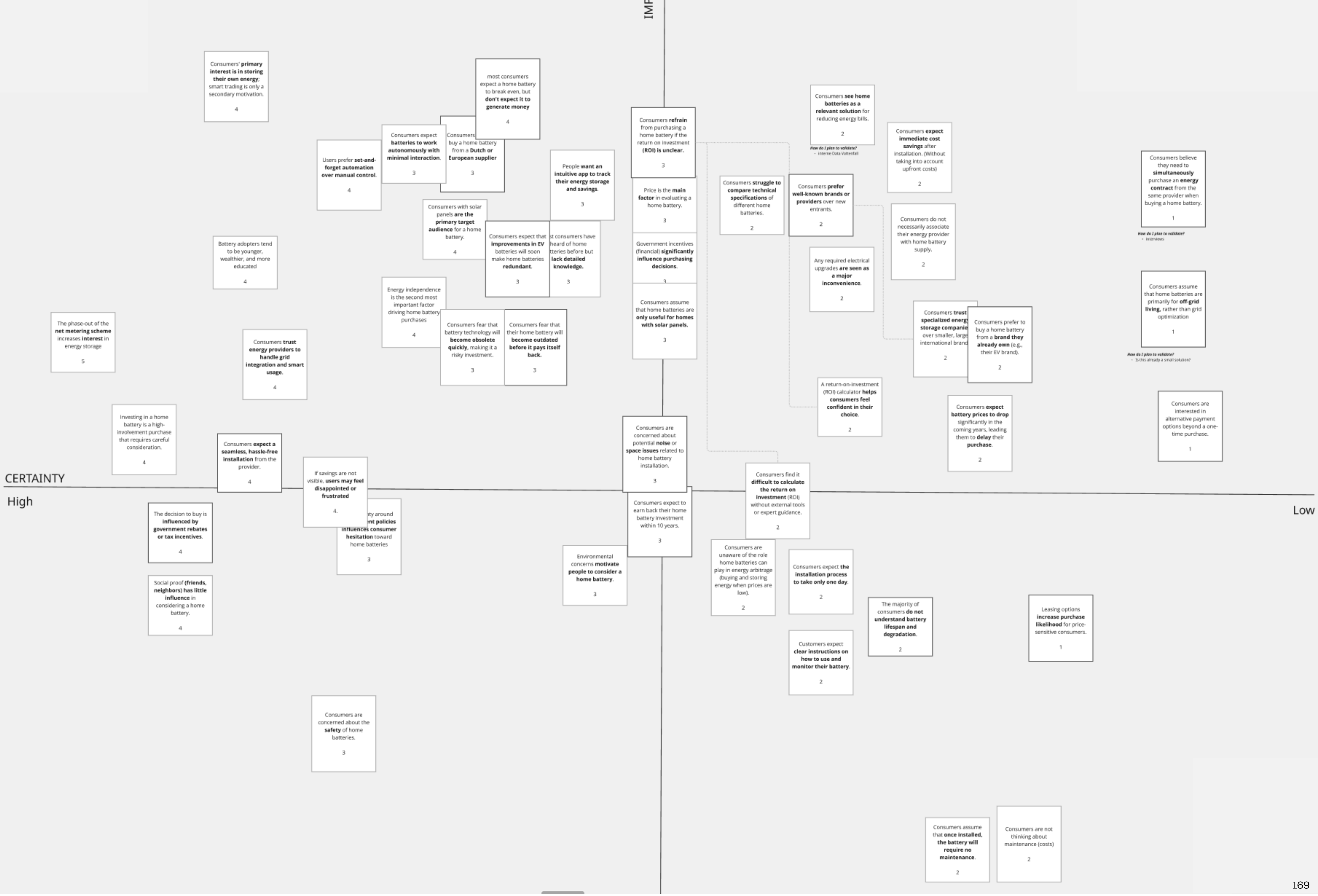
Results

The results were used to inform the customer journey and further strategic decisions.





Appendix C: Assumption map



Appendix D: Value proposition canvas

Customer Jobs
Reduce energy costs – Customers want to lower their electricity bills by optimizing energy use.
Increase energy independence – Less reliance on the grid, especially during peak hours.
Maximize self-consumption of solar energy – Store excess solar power for later use.
Ensure backup power – Protection against blackouts (though this is less critical in stable grids like the Netherlands).
Contribute to sustainability – Customers want to use more renewable energy and reduce their carbon footprint.
Simplify energy management – Prefer automated, hassle-free energy optimization.

Pains (Challenges & Frustrations)
High upfront cost – Batteries are expensive, and ROI can be unclear.
Uncertainty about savings – Customers are unsure how much they will actually save over time.
Complex installation & integration – Setting up a battery with solar panels, HEMS, and energy contracts can be confusing.
Limited battery capacity – Some users worry about whether the battery size is sufficient.
Regulatory & policy uncertainty – Future changes in the net metering (salderingsregeling) phase-out impact battery adoption.

Product & Services (What Vattenfall could offer)
Home Battery System – A modular and scalable energy storage solution.
Smart Energy Management – AI-driven charging & discharging optimisation.
Integration with Renewable Energy – Helps customers make the most of their solar panels.
Flexible Payment & Subscription Models – Lower upfront costs with financing options.
VPP & Grid Services – Earn money by contributing to grid stability.
Seamless Connectivity – Works with Vattenfall's HEMS, dynamic energy contracts, and future energy solutions.

Pain Relievers
Flexible financing options: Lease or pay-per-use models reduce upfront costs.
Clear cost-benefit calculations : Transparent ROI insights to help customers decide.
Easy installation & integration: Plug-and-play, guided onboarding.
Scalability : Modular battery sizes to match different household needs.
Regulatory adaptation: Vattenfall adjusts services based on evolving net metering policies.

Gains (Desired Benefits & Expectations)
Lower energy bills – Store cheap or free energy and use it when electricity prices are high.
Smart automation – A battery that integrates seamlessly with HEMS for dynamic energy optimization.
Flexible energy contracts – Ability to profit from dynamic pricing and grid balancing services.
Sustainability impact – Maximizing use of solar energy and supporting the energy transition.
Resilience & reliability – Security in case of power outages or unstable grid conditions.

Appendix E: Assumptions and calculations

Estimation of feed-in tariff after net metering stop

(used in section 6.2.3 the Proposition in real life)

In 2027, net metering ("salderen") will be fully phased out. Households will receive a feed-in tariff ("terugleververgoeding") for all solar power exported. This tariff must be at least 50% of the bare supply price (excl. taxes and grid fees) until 2030.

Assuming an electricity price (incl. taxes) = €0.2919 per kWh (Vattenfall)
Taxes and grid costs are roughly €0.10–€0.12 per kWh, meaning the bare supply price is about €0.17–€0.19
The minimum feed-in tariff would therefore be around €0.085–€0.095

To stay realistic and slightly optimistic, let's assume energy providers offer €0.10 per kWh as feed-in tariff

Estimation of home battery Adoption in NL

(used in 7.1.1 Current Adoption: quantity and profile)

Total number of Dutch households:
Approximately 8.4 million households in 2025
(Source: CBS)

Solar panel adoption:
As of early 2024, 1 in 3 households (~32%) have installed solar panels
→ That amounts to around 2.6 million households with PV systems
(Source: Dutch News, Jan 2024)

Smart storage trend report 2024/2025:
There was 472 MWh of home battery capacity installed in 2024—more than double the amount from 2023.
Assuming a conservative growth estimate of +30% for 2025, this would result in approximately:
→ 613.6 MWh in 2025

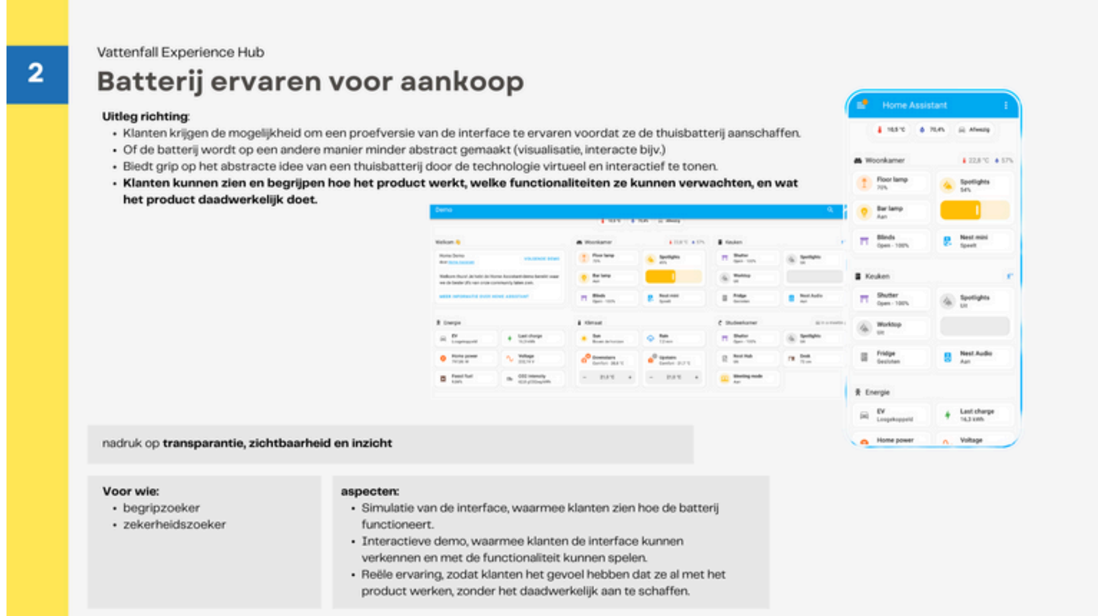
Average capacity per home battery system:
Most Dutch residential batteries fall between 3–8 kWh.
Assuming an average of 5.5 kWh per household:
613,600 kWh ÷ 5.5 kWh = ~111,564 households

Rounded off, this gives a reasonable estimate of ~110,000 households with a home battery in 2025.

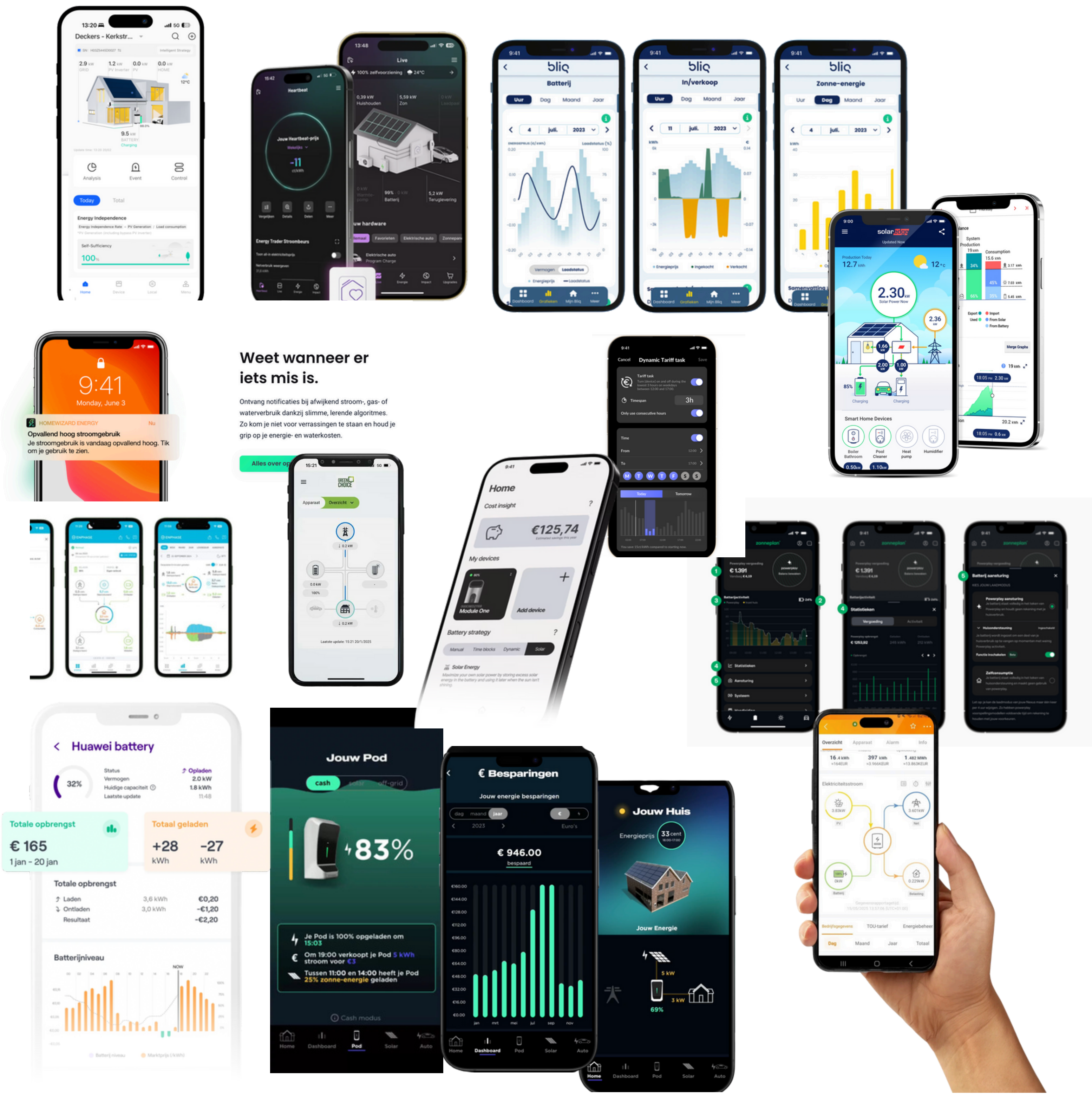
Appendix F: Mapping with peers

Appendix G: Exploring the 2 barriers

(In Dutch, since they were presented to Dutch Vattenfall team)

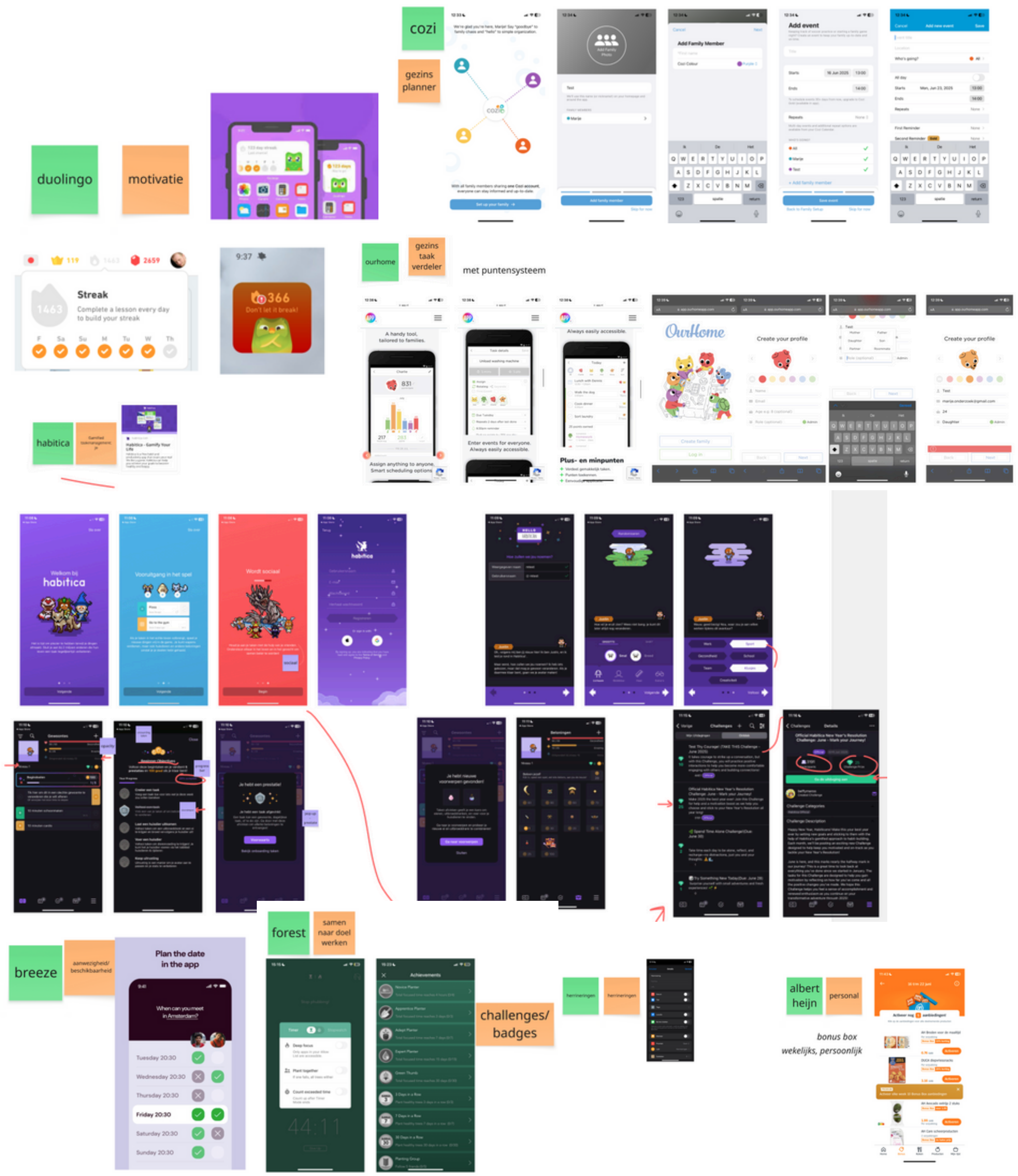


Appendix H: Alternative home battery interfaces

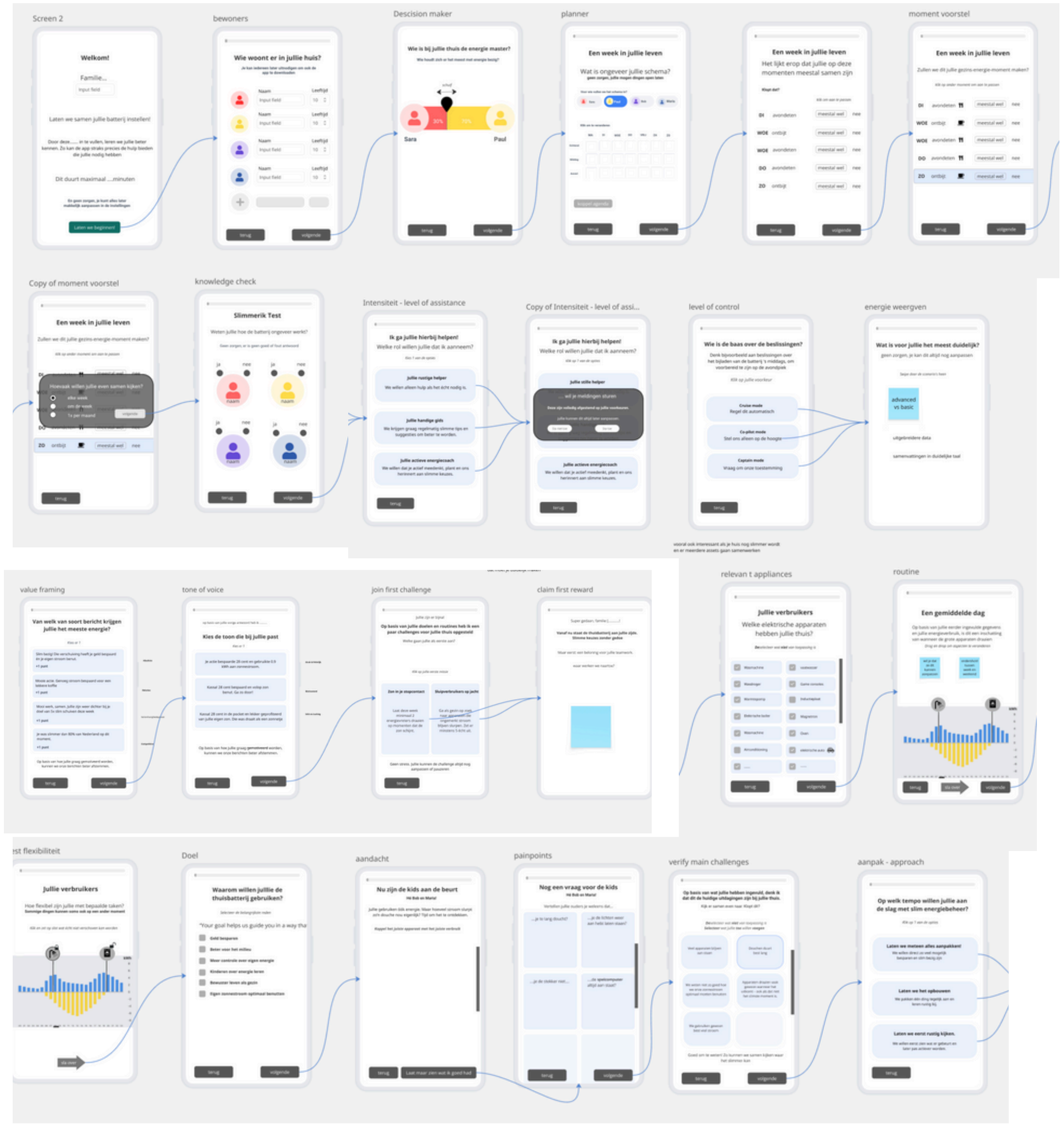


Appendix J: Analysis of Vattenfall's UI

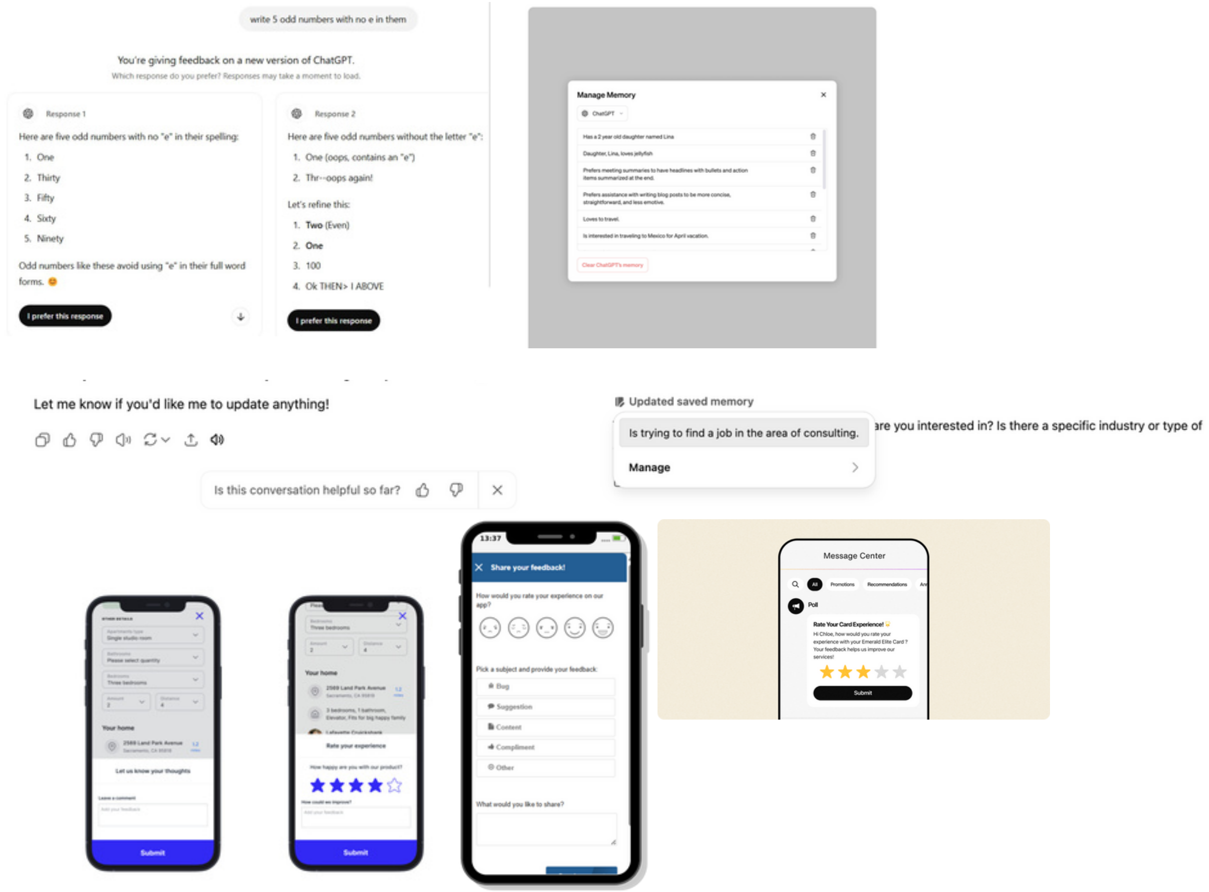
Appendix K: Best UX/UI practices



Appendix L: LoFi onboarding flow



Appendix M: Learning mechanisms



Appendix N: Profiles of families included in concept development

Family A

Composition: 4-person household (2 adults, 2 children)
Live in: Voorschoten
Type of house: Semi-detached (2-onder-1-kap)
Work situation: Both parents have full-time jobs
Energy setup: Solar panels, no home battery yet

Family B

Composition: 4-person household (2 adults, 2 children)
Live in: Voorschoten
Type of house: Terraced house
Work situation: One full-time, one part-time
Energy setup: Solar panels, no home battery yet

Family C

Composition: 4-person household (2 adults, 2 children)
Live in: Voorschoten
Type of house: Semi-detached (2-onder-1-kap)
Work situation: Both parents have full-time jobs
Energy setup: Solar panels, no home battery yet

Family D

Composition: 3-person household (2 adults, 1 child)
Live in: Voorschoten
Type of house: Semi-detached (2-onder-1-kap)
Work situation: One full-time, one part-time
Energy setup: Solar panels, no home battery yet

Appendix O: Concept Refinement

Test setup

Overall setup

To refine and validate the core elements of the concept, a structured user test was conducted with the target group.

Test overview

- Duration: ±1 hour per family
- Number of families: 4
- Participant profiles: See Appendix N
- Main goal: Refine and validate the onboarding flow and motivation system based on real-life family feedback.

Test structure

The test was divided into three parts:

Part 1: Synthesis & scenario framing (±10 min)

Since the target group is not familiar with the use of a home battery, it was essential to begin with a synthesizing step. Participants were guided into a future scenario: it is 2027, net metering is ending, and they have just had a Vattenfall home battery installed. This framing ensured all families could evaluate the concept within a relevant and realistic setting, even if they had limited prior knowledge about energy systems.

Part 2: Testing the onboarding flow (±20 min)

Participants were shown a clickable prototype of the onboarding experience. They were encouraged to think aloud as they progressed through the flow, and were asked questions about clarity, relevance, tone, and effort.

Part 3 : Exploring the reward & motivation system (±20 min)

The second part focused on which motivational mechanisms resonated the most with the target group. Different formats were explored using a functional survey in Lovable. Participant were asked to rate the mechanisms on their motivational effect, on a scale of 0-10.

Synthesis & scenario framing

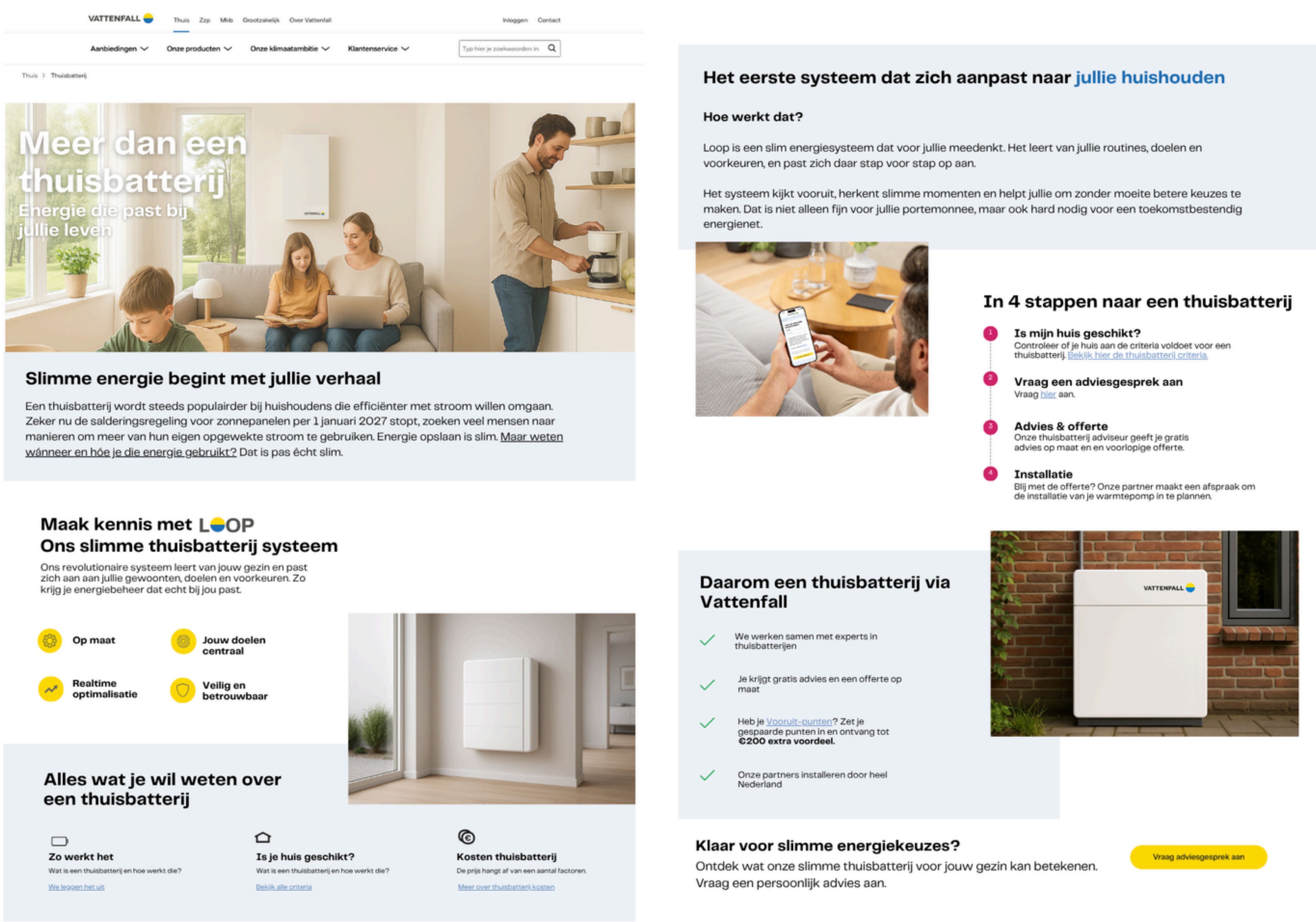
Duration: 10min.

Method:

- Verbal introduction
- Room for clarifying questions from participants

Materials: Visual one-pager (see on the right)

Testing with target group



Onboarding test

Duration: 20min.

Introduce onboarding system

→ "We'll now walk through the onboarding of the app together. This is what you'd see when first installing the battery app. Please imagine that you're doing this as a family at home. You can talk out loud, discuss things among yourselves, and say anything you're thinking. I'm not testing you, I'm testing whether this onboarding works, so there are no wrong answers."

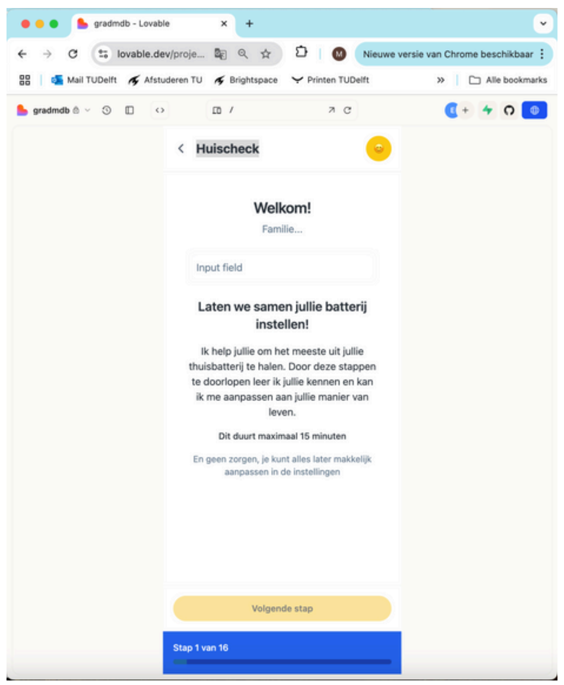
Method:

- Think-aloud walkthrough: Show mock screens or prototypes, ask parents to verbalize thoughts as they interact
- Questions afterwards
- Observation of participant actions and emotions

Materials: Clickable prototype of the onboarding flow (showed on phone)

Ask:

Clarity & Understanding
"Were there any steps or questions that confused you?"
"Did it always feel clear what the app was asking from you?"
Relevance & Personal Fit
"Did the questions feel relevant to your family and how you live?"
"Did it feel like this was designed for families like yours?"
Effort & Completion
"Would you actually go through this onboarding if you had just installed the app?"
"Was the length okay, or did it start to feel too long?"
Inclusion & Engagement
"Did everyone feel included in this?
Flow & Logic
Does the sequence of steps feel logical and intuitive?
Trust & Purpose
"Did you understand why the app wanted this info?"
"Was there anything you didn't feel like sharing?"



Motivation system test

Duration: 20min.

Introduce motivation system

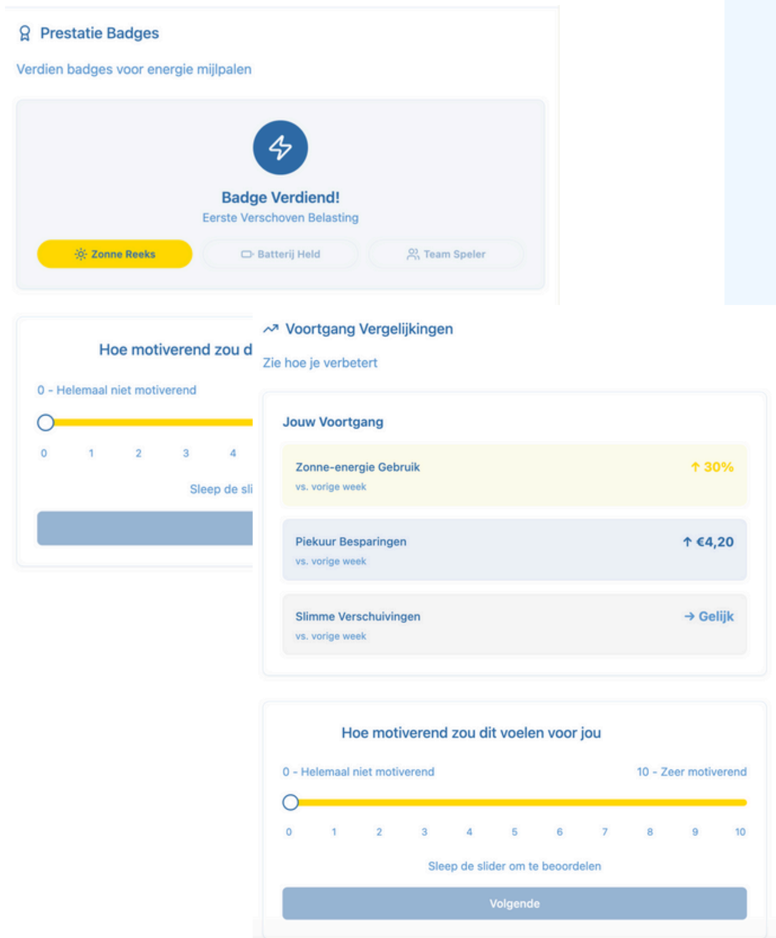
→ "I am also exploring how the system can motivate you to demonstrate smart energy behaviour. You'll now see a few different examples of how the app might give feedback, encouragement, or rewards. These are designed to fit within your everyday life, without being too pushy or childish. Please take a look at each one and rate how motivating it would feel to you."

Method:

- Motivation lever ranking: Participants view a series of motivational examples (visual + brief description) and rate each on a scale of 1–10 (not motivating to very motivating).
- Follow-up questions: Discuss choices.

Materials: Survey with realistic visual representations of different motivation mechanisms. With the question: "How motivating is this for you?" (1-10 scale)

*This part of the test was conducted with parents only, as they are the primary end users of the app. Children are likely to respond to different motivational mechanisms, making it difficult to assess their preferences in the same session.



Test outcomes

Onboarding test

The most important insights from the onboarding test are discussed in the Validation chapter. A full list of smaller observations and resulting design adjustments is included below.

Removed shared family moment step
- Rationale: The intended group moment felt forced and did not add meaningful value to the onboarding experience.

Merged tone of voice and value framing steps
- Rationale: The distinction between the two was not clear enough. Participants struggled to choose between them. Combining the steps improved clarity.

Added stronger emphasis on user motivation
- Rationale: Discovering what motivates users required more attention. A new onboarding step was added: "What are your end goals?"
  - Users can now select up to three motivational drivers
  - This supports personalisation later in the journey

General improvements
- Adjusted wording across multiple steps for clarity and tone
- Ensured that each step explains why the information is being asked
- Reviewed screens one by one to ensure relevance and ease of use

Intro screen
- Clarified that onboarding is something the household should do together
- Emphasized the short duration of the onboarding process
- Highlighted the value of the user's input
- Added a clear step about data privacy and usage reassurance

Adding family members to the account
- Made this a mandatory step at the beginning
- Rationale: Adding members later poses the risk of people skipping it. Early inclusion allows each person to fill in their own details, improving personalisation and saving group time.
- Opened up opportunity for differentiating account types (e.g. admin vs. child account)
  - The potential for a simplified "kid version" is now included in the recommendations

Calendar step
- Now filled in individually after joining the family account
- Partly pre-filled to show different ways users can complete it
- Added an option to indicate weekly irregularity
  - This triggers a system recheck after a set period
- Note: The calendar input still felt like a hassle for some, so this issue has been noted in the recommendations

Permissions for messages
- Moved this step to the end of the individual flow
- Rationale: Although earlier placement is more logical, users felt uncomfortable giving permission before understanding what it was for.

New step added: permission for smart meter (P1 port) access
- Includes a request to allow 15-minute interval data
- Rationale: This step was added due to technical requirements for system feasibility.

Appliance peak input
- Users can now link multiple appliances to the same usage moment
- To prevent overwhelm, only key usage moments are asked. These are clearly indicated with a dot
- Removed the earlier step asking for flexibility
- Rationale: Its added value was unclear. This can be better learned through system prompts during the learning phase (e.g. "Are you able to...?")

Loop system introduction
- The Loop system is now introduced on the final screen of onboarding
- Rationale: This gives users context only after they've shared their input and helps frame the system as something that adapts to them.

Motivation test N = 7

The scores of the motivation test are shown in the table below.

	Mechanism	Feedback/stimulation?	Average score
★	Direct notification after action	Feedback	9.3
	Milestone celebrations	Feedback	6.4
	comparison to last week/month	Feedback	7.6
★	Cumulative progress overview	Feedback	8.1
	Progression levels	Feedback	6.7
★	Self-defined rewards	Feedback	8.7
	Achievement badges	Feedback	6.6
	weekly/monthly recap	Feedback	8.1
	comparing to other households	Feedback	6.9
★	system-generated challenges	Stimulation	7.4
★	User-created household challenges	Stimulation	8.3
★	platform-wide challenges	Stimulation	8.0
	Progressive goal unlocking	Stimulation	7.3

Conclusion and discussion

The results from both tests were used to further refine the design of the Loop system. For the motivational system specifically, a selection of mechanisms was developed into a combined feedback and stimulation layer within the app. This selection was based not only on the average scores from the test, but also on design logic, feasibility, and broader behavioural insights gathered throughout the project.

Mechanisms that were integrated into the final system are marked with an star in the table. These represent a balanced set of feedback loops and motivational cues that aim to reinforce smart energy behaviour without overwhelming the user.

This test should be seen as an early exploration rather than a conclusive ranking of what motivates families most. To draw stronger conclusions, a more extensive and longitudinal study would be needed. Ideally testing combinations of mechanisms in real usage contexts and measuring actual behavioural outcomes.

Motivation is rarely about a single mechanism, but about how different elements work together and fit into daily life. This test offers a starting point, and that starting point has been used to inform and prioritize the first design iteration.

Reflections on this process, along with its limitations, are further addressed in the Recommendations and Limitations chapter.

Flow categories	Introduction		Household setup						
	1&2	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**
Step	Family starts onboarding from central device (admin)	Data privacy & transparency notification	Each family member **joins** the **family account**		Each family member fills in their weekly (presence) **schedule**	Each member indicates if they want to see short **explanation video**	Each member chooses **interface depth**	Each family member is asked to **allow notifications**	**Return** to household onboarding
Rationale	Expectation management Value and purpose explanation	Reassurance and transparency, build trust	Create a sense of shared ownership, frame the household as a team, and allow for person-specific data, preferences and communication		Informs expected (appliance) routines, timing for smart energy actions.	Establishing a solid foundation for each individual, understanding can increase motivation	Supports personalization based on energy literacy and interest level. Prevents overwhelming users while offering depth for those who want it.	Enables system communication	Brings focus back to collective onboarding
User actions	Put in family name		(Scan QR) Download app on other devices Join family	Name Age (brithday) Account type: admin/child Create account		Watch short explanation of home battery	Chooses between basic or advanced version of the interface	Allow notifications	
Front end	Welcome screen	Explanation for users that their data is handled privately and protected	Call to action: xxx QR & unique family code	Profile setup screen	Visual calendar interface with tap-to-fill blocks (morning, day, evening) Option for irregular week	Short explanation video of home battery	Option A: Basic (simple, no graphs) Option B: Advanced (detailed data, trends, energy flows)	'Allow notification' pop up	Round-off screen Prompt to continue as a group
Back end / Smart system layer				Link user accounts to household ID	Stores patterns per user Flags shared presence windows Based on the weekly schedule and consumption data, the system can make an estimate of the potential energy profile.	Stores knowledge level tag per user	Stores the chosen interface mode per user Applies this preference to all relevant screens and dashboard logic Tailor the level of explanation, simplify where needed	• Stores device token • Logs notification permission state per user	• Pulls all collected member data • Flags any missing inputs • Unlocks remaining shared onboarding steps
Relevant model	Communication model		Operational model	communication model		communication model Operational model	Feedback model Operational model communication model	communication model	
3rd party								Push notification provider (IOS/Android)	

Appendix P: Onboarding chart

Flow categories	Context input (choices & data points)				
	11	**12**		**13**	**14**
Step	Assign **main** energy **decision-maker**	**Connect** energy data		Confirm which main **appliances** are present in the home	Check and fill **appliance-load** map
Rationale	Gives the system nuance on internal family dynamics, especially useful for tailoring nudges to the more influential voice	Optimizes energy data data flow rom household to system		Defines the system's "levers" and deepens system understanding of load profile	Verifying which devices cause specific energy peaks for energy profile optimization
User actions	Indicate how much of a role you play in energy matters	Choose how (or whether) to link realtime energy usage data to the system.		(De)select electric appliances from list	Review a system-generated load profile with estimated appliances placed on energy peaks. Drag and drop icons to fill in gaps or adjust
Front end	Visual slider interface with avatars/names of admins on both ends Percentual split	If existing client Options: • "Connect P1 dongle" • "We don't have a P1 dongle" • give consent to read out smart meter every 15 min.	If new client Options: • "Link smart meter" (via energy data consent) • "Connect P1 dongle" • "Continue without connecting"	Prefilled list of common high-impact appliances Option for smart connections	Lightweight UI with simple visual timeline. Drag and drop appliance options
Back end / Smart system layer	Stores percentage split as influence weight Links it to nudge targeting logic and follow-up notifications based on who typically "leads the hype" (for example for household-wide reminders)	• Confirms existing data feed via Vattenfall backend • Flags household as having valid usage data • If P1 is connected, activates enhanced real-time feedback loop	• If smart meter: triggers consent and data access request with grid operator • If P1 dongle: initiates pairing sequence via external API • If skipped: flags household as "synthetic profile only"	Tags relevant devices Smart **predict likely appliances** based on past usage data	Cross-references household load profile (usage data) with: • Weekly schedule input • Appliance presence • Common appliance usage patterns to generate an estimated appliance-load map **links appliance profile** ......(for forecasting, nudging, and energy shifting logic)
Relevant model		Operational model		Autonomy model Operational model	Operational model
3rd party		• Grid operator APIs • Smart meter link • P1 dongle APIs		if connected • EV charger API • Smart plug APIs	

Flow categories	Household setup					System expectations	
Step	Engage kids by matching appliances to energy use ⊖	Discover household energy **painpoints** (via the kids)	Verify household energy **challenges**	Choose household's main investment **motivation**	Clarify household's **long term** energy **goals**	Choose preferred **approach**	Choose your preferred **level of assistance**
Rationale	Create a low-effort, playful moment of engagement for kids that introduces them to energy concepts and strengthens household involvement	Using the kids' perspective as a lighthearted but revealing way to surface behavioral targets. Create relatable entry points for engagement	Create relatable entry points for engagement Confirm core pain points for **targeted solutions**	Directs emphasis of the system Enables behavior-to-motivation matching	Established what the household is working towards, influences operational empahsis of system	To respect different learning styles and motivational readiness, allowing the system to adapt its behavior change strategy to the family's preferred pace and involvement level.	
User actions	Kids connect appliance icons and energy use amounts (playful)	Kids select what's relatable from list	users select challenges that they have in household energy	users choose the main reason(s) for investing in a home battery in the first place	users select their long term energy goals from list	Selecting the approach that suits them bes	Selecting the guidance style that suits them bes
Screen number	15	16	17	18	19	20	21
Front end	connecting game	list of common parent-kid tensions	list of challenges, drafted on data of previous input	list of possible motivators	list of possible goals	• Option A: just observe • Option B: phased approach • Option C: all in	• Option A: quiet helper • Option B: moderate guide • Option C: active energy coach
Back end		• Stores selected responses as painpoint indicators • Flags behavioral tension areas in system	Stores confirmed challenges as high-priority triggers Rejected challenges are deprioritized in nudges/goals Adjusts behavior strategy engine accordingly	Stores as primary motivational anchor(s)		Stores selected approach as household's behavioral steering mode	Stores assistance preference as guidance intensity level
Smart system layer		Compiles challenge list from: • Kids' painpoint answers • Energy usage data • Appliance schedule • Load timing patterns	Calculates path to end goal	Used to tailor: • Feedback and stimulation framing • Tone of nudges and dashboard content • Prioritization of goal suggestions later		• Adapts micro-strategies: pacing, when and how to steer • Monitors actual behavior to suggest adjustments • In "observe" mode, triggers re-check prompt after a week	• Builds household communication rhythm based on this preference • Learns from ignored prompts to self-calibrate
Relevant model		Operational model Feedback model	Operational model	Feedback model	Operational model Feedback model	Operational model communication model	communication model
3rd party							

Flow categories			Round up	System in use
Step	Choose level of **control**	Choose **preferred tone of voice**	Choose **first smart step**	**End** screen
Rationale	To respect different needs in systeem involvement	Influences communication style of system to align with household preferences	Shift the user from passive onboarding to active participation, leveraging momentum	To reinforce a sense of shared accomplishment and confirm effort value
User actions	Choose how much automation you want	Choose between 2 first smart steps, adapted to household input	Choose between 2 first smart steps, adapted to household input	
Screen number	22	23	24	25
Front end	• Option A: Cruise mode • Option B: Co-pilot mode • Option C: Captain mode	• Option A: Concise and factual • Option B: Warm and motivating with example message	• Option A: example • Option B: example	Visual representation of first completed Loop
Back end	Stores control preference Adjusts: use of automation	Tailors language	Tailors focus of approach en priority of actions	Triggers system initialization: • Starts tracking based on selected goal • Activates motivation system • Enables tone/styling preferences • Sets up first nudges, dashboard layout, and notification rhythm • Prepares early feedback loops and data learning mechanisms
Smart system layer	Matches default decisions to control mode Escalates feedback only if needed	Can test A/B variants within chosen tone		
Relevant model	Autonomy model	Framing model Feedback model communication model	Operational model	

Legend

1 = Screen number

⊖ = System works without