

Project report



# Local guardians on the grid's edge

Energy communities,  
household batteries and  
the road to scalable congestion management



## Executive Summary

The NO-GIZMOS<sup>1</sup> project, funded by the Dutch Ministry of Climate and Green Growth, and under the administration of the Netherlands Enterprise Agency, has shown that decentralized assets in the low-voltage grid can effectively resolve congestion problems at the medium voltage (MV) level. Our pilot in Ansen demonstrated that a community-based and algorithmically driven Virtual Power Plant of nine household batteries can reduce MV grid peaks by 3.5% to 6%, potentially freeing up capacity and even deferring the need for grid reinforcement. However, this technical success comes with economic friction: the steering strategies that best protect the grid often yield lower financial returns for residents (i.e., battery owners) under current market conditions. This report, therefore, offers a technical roadmap for this ‘Local Grid Guardian’ model and the necessary changes to market incentives required to make it a sustainable reality.

In doing so, NO-GIZMOS contributes to the MOOI Systeemintegratie programme to create solutions that help large volumes of solar and wind fit into the electricity system, on the path to a CO<sub>2</sub>-neutral energy supply by 2050. Currently, the most urgent and stubborn bottleneck is MV-level congestion, where waiting lists for new renewable connections run into the years. By demonstrating that coordinated household batteries — steered via open-standard software and real grid data — can reduce regional peak loads, the project opens a quickly scalable pathway toward more renewable capacity on the existing grid. The finding that low-voltage assets can meaningfully relieve pressure at a higher grid level had not previously been demonstrated empirically, and the openly published control algorithms and communication protocols developed here make the approach directly replicable. Beyond the technical results, the project's multidisciplinary design — combining grid engineering, software development, behavioural research and community engagement in a single pilot — generated insights into how citizen participation and algorithmic grid support can reinforce rather than undercut each other.

This knowledge is directly relevant to the ongoing crystallisation of the congestion management market and the regulatory frameworks now being shaped under the new Energy Act.

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<sup>1</sup> “NetOptimalisatie voor Grootschalige Inpassing Zon- en windstroom Middels Opslag en Software”, or Grid Optimization for Large-Scale Integration of Solar and Wind Power via Storage and Software.

# Final Report MOOI

Missiegedreven Onderzoek, Ontwikkeling en Innovatie ([RVO](#))

## Project title

NetOptimalisatie voor Grootschalige Inpassing Zon- en windstroom Middels Opslag en Software (NO-GIZMOS)

## Project ID

MOOI52109

## Funding period

1 April 2022 to 31 March 2026.

## Consortium

- CGI – development and management of the Energy Islands platform and the communication infrastructure
- energieKansen (eKa) – local energy cooperative; resident participation, installation support and communication in Ansen
- Enexis – provision of grid data, metering infrastructure and expertise on distribution networks
- Hanze – social and technical research: resident surveys, behavioural interventions and system analysis; simulations
- iwell – development of battery hardware and software; integration with the neighbourhood and Enexis
- Eindhoven University of Technology – algorithm development and control mechanisms
- Enablemi – administrative intermediary

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# 1. Introduction

## 1.1 A systemic challenge: The grid under pressure

The Dutch energy transition has reached a critical inflection point where infrastructure constraints have moved beyond being a technical hurdle and evolved into a systemic crisis. The electricity grid, historically designed for predictable, top-down energy flows, is buckling under the dual pressure of rapid electrification and decentralized renewable generation. This congestion is acutely felt on the MV grid, the regional arteries that connect high-voltage transmission lines to local distribution networks. As recent analyses (such as the Wennink report<sup>2</sup>) highlight, this bottleneck effectively locks down economic growth and sustainability initiatives, with ‘code red’ capacity shortages forcing delays of 5-10 years for new connections for new generation projects, industry and even housing. The MV grid has become a flashpoint where the mismatch between static infrastructure and dynamic energy demand creates a hard limit on national progress.

Compounding this physical scarcity is the rise of the home battery. While potentially a source of beneficial flexibility, the current market model incentivizes individual, profit-driven behaviour that can exacerbate grid instability. Commercial ‘greedy’ algorithms, optimized solely to exploit volatile energy prices, which do not always reflect local grid constraints. This can trigger herding effects where thousands of batteries simultaneously charge or discharge at the wrong time with no regard for local grid conditions<sup>3</sup>. This synchronization can create artificial peaks and dips that the local grid was never designed to handle. Instead of solving congestion, uncoordinated individual batteries risk accelerating grid infrastructure degradation and causing outages at the local level, effectively downgrading the grid capacity they were meant to support.

The NO-GIZMOS project addresses this impasse by exploring a new idea: the coordinated deployment of household batteries (and other sources of LV-level flexibility), to support stability on the local grid and relieve stresses on the regional grid while maintaining benefits for battery owners. In other words, we sought to

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<sup>2</sup> <https://www.rapportwennink.nl/>

<sup>3</sup> E.g., in this project it was observed that local solar peaks consistently occurred around 1 hour later than the minimum electricity market price. This was the result of local solar panels having a primarily south-westerly orientation, causing them to peak later than the rest of the country. The resulting effect was that the national electricity market created a perverse incentive, whereby batteries were fully charged during the hour leading up to the local solar peak, and then had no capacity remaining to reduce the peak itself.

develop durable solutions for the renewable grid rooted in collective action, aligning financial advantages, community values and public goods.

## 1.2 The NO-GIZMOS hypothesis

Technically speaking, the NO-GIZMOS project investigated a decentralized resource to defer heavy infrastructure upgrades, relieve congestion management and reduce the queue for grid connection: the flexibility afforded by household batteries under community management to shave generation and consumption peaks. Our central research question was:

*Can the aggregation and coordination of residential assets (specifically home batteries) effectively mitigate congestion on the electricity grid, and what is the cost of doing so?*

Our biggest ambition – and greatest innovative proposition – was to see whether relatively small assets at the low voltage level could help reduce congestion at the level where it is most urgent: the MV grid. Our tests proved the potential for batteries to reduce grid congestion but also highlighted the current gap between financial incentives and physical grid constraints.

## 1.3 Project scope & location

The project was executed by a consortium of technical partners (CGI, iwell), research institutes (Hanze, TUE), and a local energy cooperative (Eka). The pilot took place in **Ansen** (Drenthe). This location was specifically selected as a pilot site because the local grid is already running up against its physical limits due to a high density of decentralized generation (mostly solar). This made it the ideal "living lab" to stress-test our propositions in a real-world environment where congestion is already a reality, not just a future scenario.

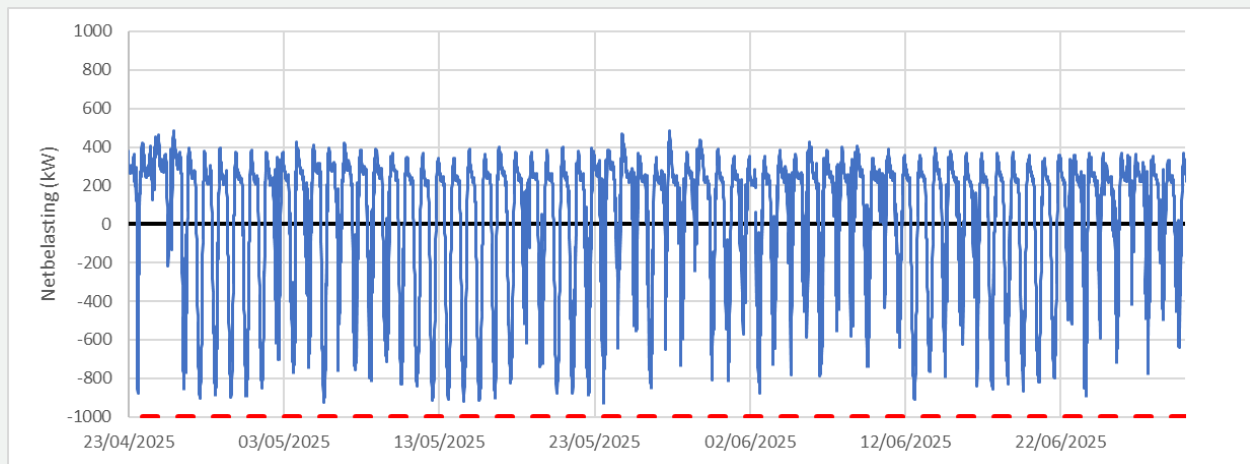


Figure 1 Summer Generation Peaks in Ansen, where negative values represent net generation and positive values represent net consumption on the MV grid; the dashed red line is the grid's nominal capacity.

In Ansen, we installed 9 household batteries of 10kWh<sup>4</sup> each to test various steering strategies in 8 participating households and the town community center. We engaged with the residents to understand their user experiences (social experiment), values, and expectations from this technology. We tested and compared multiple steering algorithms<sup>5</sup> to gain insight into the various trade-offs that each offered, both for the local residents and the grid operator. We then mapped these trade-offs and discussed them with our stakeholders to come up with concrete recommendations needed to make our technical solution a feasible reality.

## 1.4 Reading guide

This report presents the activities and findings of the project in seven chapters.

- **Chapter 1** presents the introductory phase of the project.
- **Chapter 2** details the **Operationalization**: the unique research design where we tested six distinct battery control strategies.
- **Chapter 3** presents the **Pilot Results**: the empirical data gathered from the live tests in Ansen.
- **Chapter 4** explores **Simulation Results** projecting battery impacts both from the present to the future as well as to a wider regional scope.

<sup>4</sup> The batteries also had a maximum (dis)charge power of 15 kW, but were limited to 10 kW in our experiments.

<sup>5</sup> All steering algorithms are available upon request: <https://github.com/CoolJoe86/NOGIZMOS>. All algorithms are thoroughly described in scientific publications written for the NO GIZMOS project and in the appendix.

- **Chapter 5** concludes with the **Synthesis** of the results and the tension between current financial incentives and grid stability.
- **Chapter 6** presents the stakeholder engagement we designed specifically to address that tension and to explore visions of the future.
- In **Chapter 7** we deduce the outcomes of the stakeholder engagement into a set of recommendations and next steps cross the gap from pilot to deployment.

*Please note that the main body of the report is written to be accessible to anyone interested in NO-GIZMOS. For detailed technical specifications, algorithm formulations, and mathematical proofs, please consult the separate Technical Appendix. For a precise understanding of the social research and engagement, please consult the Social Appendix.*

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## 2. Operationalization: Research design and methods

A key innovation of the NO-GIZMOS project was its iterative testing methodology. Rather than deploying a single battery control strategy, the pilot was designed as a sequence of six distinct **Use Cases (UCs)**. Each Use Case represented a different goal for the battery system, where the interests of different stakeholders were given different levels of priority.

### 2.1 The technical setup

An important part of this project was to create a comprehensive software system not only for real-world testing, but also for future adoption, development, and upscaling, by using open ADR communication standards.

At the heart of the system is CGI's **Energy Islands platform**. This platform acts as the central hub, securely receiving, processing, and sending out information. A crucial achievement was establishing a robust, real-world connection between this platform, the iwell household batteries installed in the participants' homes, the grid operator and the algorithms planning the battery schedules. It accomplished this through an API that was based on the SensorThings API standard. This allowed the platform to send steering commands directly to the batteries, instructing them when to charge or discharge based on the active use case.

The direct communication with the grid operator allowed additional information (e.g., local grid constraints and congestion forecasts) to be considered by the battery control algorithms. The connection with the grid operator was built using the **OpenADR** protocol, a standard chosen for its flexibility, which is essential for the experimental nature of the NO-GIZMOS project.

Figure 2 shows the system layout and the links among the various partners.

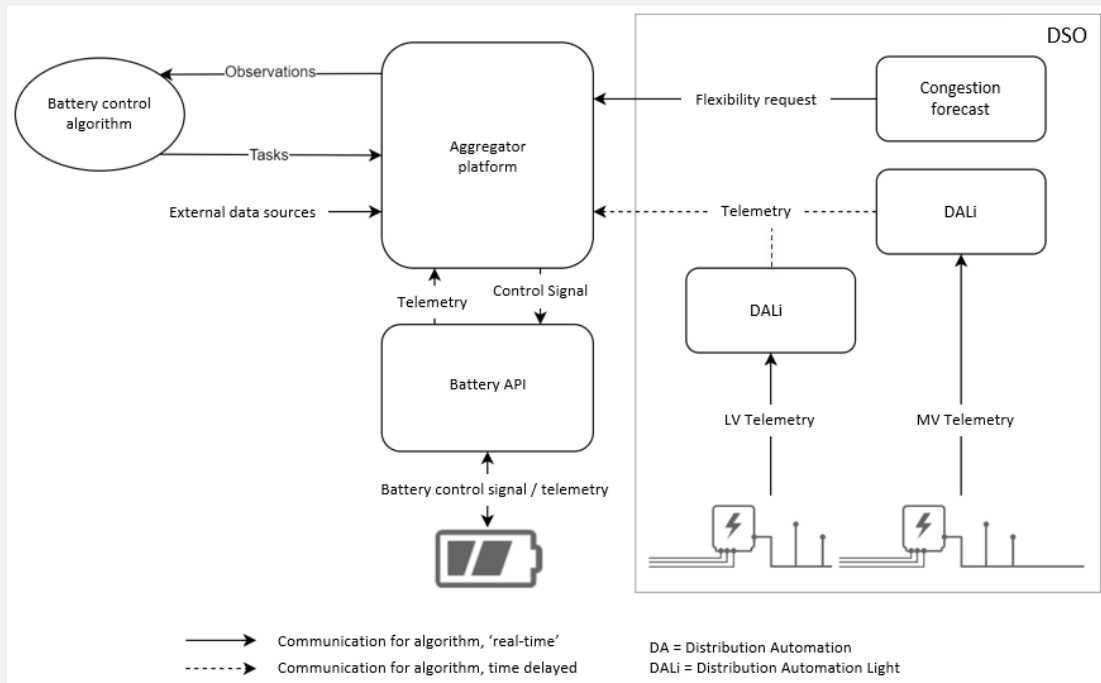


Figure 2 - System layout

To evaluate our demonstrations, we integrated several data sources:

- **Battery:** Battery-specific data was considered in the battery control algorithms. Examples include battery state-of-charge, battery health (Maximum charge and discharge limit), and battery (dis)charge power.
- **Household:** iwell collected anonymized energy data from each participating household, including their total electricity consumption and solar panel production.
- **Transformers:** Enexis installed DALI-boxes on the two local transformers in Ansen. These provide aggregated data on the local energy supply and demand within the village itself, giving us a direct view of local trends and behaviours.
- **Weather:** We also integrated a weather forecast API (from meteoserver.nl). Although not in the original scope, we recognized that weather conditions—particularly solar irradiation—have a significant impact on grid load and are therefore vital for accurate analysis.
- **Market:** Finally, electricity market prices (EPEX) were used to calculate battery profitability.

This integrated architecture provides a rich, multi-layered view of the local energy system, enabling us to test various control strategies and precisely measure battery performance and battery grid impacts.

## 2.2 The six strategies (Use Cases)

The project executed the following strategies sequentially between July 2024 and Autumn 2025. Below is a quick overview of all Use Cases. In the appendix, you will find more detailed descriptions of their set-up and deployment.

| Use Case | Name                                | Objective                                      | Logic                                                                                                                                                                                                                                                          |
|----------|-------------------------------------|------------------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| UC1      | <b>Maximizing Self-Consumption</b>  | Maximize household energy independence.        | Store own solar surplus; discharge for own use. Ignore grid constraints and electricity prices. Serves as the <i>baseline</i> for comparison.                                                                                                                  |
| UC2      | <b>Neighbourhood Coordination</b>   | Maximize community energy independence.        | Aggregates the load of all 9 homes. If Neighbour A has surplus solar energy and Neighbour B has demand, the batteries coordinate to balance the <i>village</i> locally .                                                                                       |
| UC3      | <b>Local congestion management</b>  | Minimizing village imports/exports.            | Minimizing local peaks and troughs forecasted by the DSO by charging or discharging the batteries at these times.                                                                                                                                              |
| UC4      | <b>Grid-Aware Cost-Optimisation</b> | Balance cost savings and local grid stability. | Operates much like UC3, but simultaneously minimizes local electricity costs.                                                                                                                                                                                  |
| UC5      | <b>Regional Support</b>             | Support the MV grid.                           | Batteries respond to signals to collectively shave peaks at the regional level.                                                                                                                                                                                |
| UC6      | <b>The Energy Flashmob</b>          | Test human behavioural flexibility.            | Manual demand shifting to increase the impact of battery operation (UC4). Residents received alerts (e.g., via WhatsApp) to synchronize high-consumption appliances (washing machines) during generation peaks or shift away from (evening) consumption peaks. |

## Use Case 1: Maximizing Household Self-Consumption

- **Purpose:** To use the battery to maximize the consumption of self-generated solar power for each individual household. This use case serves as a crucial baseline, allowing us to measure the opportunity costs and benefits for households compared to when their batteries are used for other, more collective and grid-centred purposes in later use cases. This use case also served as a test to confirm that our communications platform could reliably control the batteries over a longer period.
- **Operationalization:** The battery was programmed to store any surplus solar power generated by the household's own panels that is not immediately consumed, thereby reducing electricity exports to the grid. This stored energy was then consumed later in the day when there was electricity demand but no solar generation, thereby reducing electricity imports from the grid. This strategy is often referred to as a "greedy algorithm" because it single-mindedly pursues the optimal outcome for the individual, without consideration for the wider system (i.e., the battery will charge and discharge with no regard to grid congestion).
- **Data Used:** Household net electricity consumption and production data.
- **Algorithm:** The battery is set to charge whenever there is surplus generation and discharge whenever there is net demand at the household level, based on individual historical consumption profiles and forecasted solar generation profiles.
- **Deployment:** July - early September 2024.

## Use Case 2: Neighbourhood-Level Coordination

- **Purpose:** To coordinate all nine batteries to maximize the self-consumption of the local community, at the transformer level. The goal is to treat the group of households as a single entity and reduce its collective reliance on the grid, similar to the “energy hub” concept<sup>6</sup>. In NO GIZMOS, we refer to this construction as an “energy community”<sup>7</sup>.
- **Operationalization:** The design of Use Case 2 treats all participating households as a single unit. Instead of each battery reacting only to its own needs, the algorithm first aggregates the load and generation data from all

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<sup>6</sup> An energy hub is a collection of consumers and producers which aim to balance their energy needs locally and reduce their dependence on the external electricity grid. In principle, energy hub members pay only for their collective electricity imports/exports.

<sup>7</sup> Note that the energy community was not implemented in practice, but some use cases were run as if the energy community existed to determine the potential benefits of such a construct.

participants at a transformer level, using measurements provided by Enexis. The batteries were then controlled to minimize community imports and exports, with a preference for times with the highest and lowest prices, respectively. In practice, this means that a battery could be instructed to charge surplus solar power from a neighbour's roof, or discharge to meet a neighbour's electricity demand.

- **Data Used:** Transformer measurements, solar irradiation forecasts, EPEX market data.
- **Algorithm:** A rules-based algorithm which aims to:
  - 1) Minimize electricity imports and exports at the transformer level.
  - 2) Minimize electricity costs by charging the batteries when the electricity price is lowest, and discharging the batteries when the price is highest.Crucially, the algorithm included an iterative daily learning component to refine its accuracy based on the previous day's performance.
- **Deployment:** Mid-October – Mid-November 2024; August 2025.

### Use Case 3: Following Grid Operator Signals

- **Purpose:** To test whether the aggregated batteries can be controlled to respect constraints set by the DSO. The primary goal was to keep the total load on the local transformer within a predefined bandwidth, thereby helping to maintain grid stability.
- **Operationalization:** This was the first use case to directly incorporate a signal from the grid operator. Enexis provided a 24-hour forecast of the expected load on the local transformer, along with an upper and lower boundary—a "bandwidth." The algorithm's sole task was to schedule the batteries to ensure the actual transformer load stayed within this bandwidth. This meant charging when there were excessive solar exports and discharging when there was high demand.
- **Data Used:** Transformer load forecasts and bandwidth constraints from Enexis, in addition to the household-level data.
- **Algorithm:** A data-driven optimization algorithm (Quadratic Programming Optimization) designed to calculate the most efficient battery dispatch to meet the DSO's constraints. The batteries effectively acted as a flexible resource to shave peaks and fill troughs at the transformer level.
- **Deployment:** December 2024; June 2025.

## Use Case 4: Balancing Community and Grid Interests

- **Purpose:** To find a “win-win” scenario that simultaneously minimized electricity costs for the battery owners while also respecting the DSO's grid constraints. This use case explicitly attempted to balance the potentially competing interests of the residents and the grid operator.
- **Operationalization:** This use case was built around an optimization model that minimized two costs at once:
  1. Household electricity costs: Based on the day-ahead market price of electricity (EPEX).
  2. The ‘Congestion Cost’: Essentially a fine which would penalize the batteries if transformer loading was expected to go beyond the prescribed bandwidth.

This congestion cost was not a real charge to residents, but a way to guide the batteries to help the grid during forecasted congestion periods. When congestion was predicted, the congestion cost would spike, incentivizing the batteries to prioritize grid stability over arbitrage. This could lead to some opportunity cost for the battery owner, since local congestion profiles do not always align with national electricity market prices.

- **Data Used:** Community-level historical and forecast data, day-ahead electricity prices (EPEX), weather forecasts, and the DSO's transformer bandwidth constraints.
- **Algorithm:** A multi-objective optimization model that dynamically balances the day-ahead market price with the internal congestion cost to produce an optimal 24-hour schedule for the batteries.
- **Deployment:** April; July 2025.

## Use Case 5: Measuring the Impact on the MV Grid

- **Purpose:** To move beyond the local transformer and explicitly quantify the impact of the aggregated batteries on the higher-level MV grid. The goal was to measure the potential for community batteries to mitigating regional congestion.
- **Operationalization:** The primary challenge was detecting the impact of nine household batteries amidst the noise of a large MV grid. The methodology involved a controlled experiment: using day-ahead predictions of MV grid conditions to identify specific windows of peak generation. During these precise times, a coordinated signal was sent to all nine batteries to charge simultaneously at maximum power. By measuring the MV grid load before,

during, and after this intervention, we could isolate and quantify the impact of the batteries.

- **Data Used:** MV grid measurements, battery measurements and solar forecasts.
- **Algorithm:** A control strategy designed to dispatch the full, coordinated power of the batteries during forecasted solar peaks on the MV grid to produce a clear, measurable signal. The effectiveness relied heavily on the recency of MV grid data to accurately forecast peaks.
- **Deployment:** June 2025.

### Use Case 6: Hybrid Control with Behavioural Demand Response

- **Purpose:** To test a hybrid model combining automated battery control with voluntary, coordinated behavioural actions from residents. The objective was to determine if this human element could enhance the grid-balancing performance of Use Case 4, and to see if this more active form of participation could improve resident satisfaction.
- **Operationalization:** This use case augmented the automated control of Use Case 4 with a manual demand response component. The process was managed by a designated Community Manager who communicated forecasted grid congestion profiles (as shown in figure 3) which provided participants information about times when they should preferentially consume electricity (green bars) or abstain from consuming (red bars). Further, participants were given two hours per week when their demand response was considered crucial (a so-called “code red”). This was explained to participants using a "flash mob" metaphor: a synchronized, collective action to either deepen a peak-shaving event initiated by the batteries or to create a secondary peak reduction where battery capacity was insufficient.

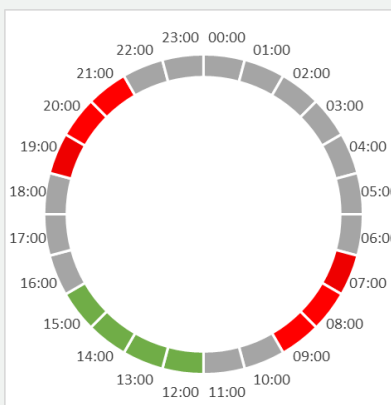


Figure 3 - Forecasted congestion profile

- **Data Used:** Transformer measurements were used to measure the collective impact. Weather forecasts and projected grid loads were used to plan the demand response events. Qualitative data on participant contributions and experience were gathered through logbooks and interviews, respectively.
- **Algorithm:** A hybrid control model. The batteries ran the multi-objective optimization algorithm from Use Case 4 (minimizing electricity cost while respecting grid limits). The human component functioned as a "soft control" layer, translating technical needs into simple, actionable requests for the community to address residual peaks.
- **Deployment:** Autumn 2025.

The logic of our evaluation framework (the details of which you can find in the appendix) rests on a **dual-impact assessment**: how battery steering affects the individual household and how it affects the physical grid. For households, we evaluate performance based on economic efficiency—specifically the ability to lower energy costs and maximize the use of self-generated solar power—while monitoring hardware health through battery cycling. For the grid, we use a suite of technical indicators to measure both “capacity” (how much we reduce the magnitude and duration of congestion peaks) and “quality” (how much we smooth out volatile power swings). By analysing these metrics in tandem, we can quantify the trade-offs between a battery owner’s financial gain and the stability of the regional energy system.

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### 3. Pilot Results: Evidence from Ansen

Nine households. Six strategies. This chapters offer a use-case-by-use-case account of the various things coordinated household batteries can actually accomplish — for residents' energy bills, for local grid stability, and for the regional medium-voltage network. The picture that emerges is not a simple win: community coordination demonstrably reduces grid stress, in some cases cutting transformer load variance by more than a quarter, but the strategies that help the grid most tend to cost residents the most, and vice versa. This chapter also shows what can be achieved if you try to balance grid and community value, as well as what happens when residents become active participants in the action.

#### 3.1 Results: Maximizing Self-Consumption (UC1)

The first use case served as the project's baseline. The batteries operated without regard for grid constraints or electricity prices, focusing purely on keeping solar energy within the home. This use case also served as a test case to confirm that our communications platform could reliably and consistently control the batteries.

##### Highlights

This foundational use case successfully demonstrated the battery's ability to significantly increase a household's self-consumption of its own solar power, in some cases, from a baseline of ~20% to ~35% on average. As a purely individualistic strategy, it provided a direct financial benefit to the battery owner by reducing their reliance on grid electricity. However, it offered no measurable benefit for managing congestion on the local or regional grid, establishing it as the "baseline" against which all other collective strategies were measured.

##### Impacts

- **Household Impact:** The results were positive for household metrics. Average self-consumption rates rose from approximately 20% to 35% (depending on household behaviours and time of year). Assuming residents have a variable-rate energy contract, they would also be able to lower their energy bills, albeit to a moderate extent (the effect ranged from €0.18 to €6.13 per week, depending on household consumption and the amount of solar generation). These gains would not by themselves warrant an investment in a battery at current prices.
- **Grid Impact:** Analysis showed that UC1 reduces the export of solar energy to the grid, especially during sunny months. However, because battery operation was dictated purely by the household's surplus production (and not their peak generation), its effect did not necessarily align with moments

of grid stress. As a consequence, it contributes almost nothing to alleviating peaks on the grid.

## On balance

This self-consumption strategy works well for individuals facing high solar feed-in tariffs<sup>8</sup>, but offers no structural solution for grid congestion, particularly in the darker months, where there is no co-occurrence between grid congestion and rooftop-PV production. The balance of benefits in Use Case 1 is therefore clear and simple:

- **Primary Beneficiary:** The individual household/battery owner, who sees a direct reduction in their PV generation imports/exports.
- **Disadvantaged:** No party is directly disadvantaged, but the DSO and the wider community see little benefit in terms of grid stability or increased grid capacity for new renewable connections.

*Note: we later simulated an alternate version of this UC, where the batteries were not directed to maximise household self-consumption, but reduce household costs (based on wholesale grid prices). Since grid pricing is correlated to congestion, operating the batteries in this way did result in more noticeable positive grid impact: peak load reduction went from 0.6% in the standard UC1 version to 2.2% reduction in this alternate version, while generation peaks were reduced by 1.5% instead of 0% in the standard version. However, these grid benefits came at the expense of lower household self-consumption. See section 4 for more details.*

## 3.2 Results: Neighbourhood Self-Consumption (UC2)

This phase introduced the first step towards collective action, where the nine households were treated as a single entity rather than independent actors. The control algorithm aggregated the load and generation data at local MV/LV transformers to create a community-level profile, coordinating charging and discharging to maximize the community's use of its own generated solar power.

### Highlights

The transition to a community-focused strategy yielded immediate structural changes in energy flow. By coordinating the batteries, the project successfully reduced the community's total export of surplus solar power (PV surplus) by

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<sup>8</sup> Presently in the Netherlands, feed-in tariffs are calculated based on annual net electricity exports (i.e., kWh), not on peak delivery (i.e., kW).

approximately **34%** and increased the community's collective self-consumption by a minimum of **11%**.

This strategy sometimes led to a higher net import of energy from the grid (often due to charging on low-sun days to prepare for community needs), but it simultaneously reduced the overall energy cost for the community. In other words, it decoupled energy *volume* from energy *cost*. This was achieved because the algorithm was intelligent enough to supplement solar charging with grid charging during cheap off-peak hours, subsequently discharging during expensive peak hours. This demonstrated that a distributed neighbourhood battery system can act as a buffer, smoothing out the intermittency of local generation more effectively than individual units could achieve alone.

### Impacts

- **Household Impact** The financial outcome for the residents was positive but nuanced. As a collective, the community achieved a net electricity cost reduction of a maximum **11%**. This financial efficiency was driven by the system's ability to arbitrage energy prices—buying low and using stored energy when prices were high (on no- or no-solar days). However, the distribution of these benefits revealed a potential friction point for this model. Because the algorithm prioritized the "greater good" of the community, individual outcomes varied. Some households saw their self-sufficiency increase significantly, while others saw it decrease compared to the baseline of Use Case 1. For example, a battery might be instructed to support a neighbour's load rather than its owner's, effectively transferring value within the group. While the *average* result was beneficial, the disparity raises questions about internal compensation mechanisms to ensure fairness.
- **Grid Impact** From a technical perspective, the impact on the local grid was measurably positive. By absorbing a larger fraction of the locally generated solar power within the community, the batteries significantly reduced the midday export peaks at the transformer level. This result provides evidence that community-focused strategies can directly alleviate local grid stress caused by high solar penetration, transforming the neighbourhood from a cluster of uncontrolled generators into a managed energy node.

### On balance

Use Case 2 successfully operationalizes the concept of energy sharing and collective self-sufficiency. It shifts the focus from 'my battery and my solar power' to 'our batteries and our solar power'.

- **Primary Beneficiary:** The community as a collective, which achieves higher self-consumption and lower overall energy costs- maintaining solar generation as locally as possible rather than exporting. The DSO also benefits secondarily from the reduction of local export peaks. With respect to the Ansen grid, which had a baseline Transformer line loading of 4.39% during the summer season, use case 2 reduced this loading (caused by excess PV generation in summer) to 0.39%.
- **Disadvantaged:** *Individual* households may be financially disadvantaged compared to the purely self-serving strategy of Use Case 1, depending on how the algorithm prioritizes their specific battery. This highlights the need for a settlement system where the collective savings are redistributed to compensate those who contributed their battery capacity to benefit their neighbours and the grid.

### 3.3 Results: Following Grid Operator Signals (UC3)

This use case represented a fundamental shift in control philosophy, handing over the primary objective-setting to the Distribution System Operator (DSO) to maintain grid stability. The algorithm was tasked with keeping the local transformer load within a specific operational bandwidth provided by the DSO, charging or discharging batteries specifically to shave peaks or fill troughs in grid demand.

#### Highlights

The results were highly effective from a pure grid management perspective. The coordinated action of the batteries successfully smoothed the load on the local transformer, relatively reducing the load variance (standard deviation) by **27%**. The system was particularly effective at managing surplus generation by reducing the community's PV surplus fed to the grid.

Simulations further quantified this impact, showing that compared to the baseline (UC1), this grid-following strategy could reduce peaks on the grid by **4.3%**. The pilot was run during two distinct periods—winter (December) and summer (June-July)—revealing that the battery's ability to influence the grid is highly seasonal. In winter, the focus shifted to peak shaving during high demand, while summer operations focused on absorbing solar generation peaks.

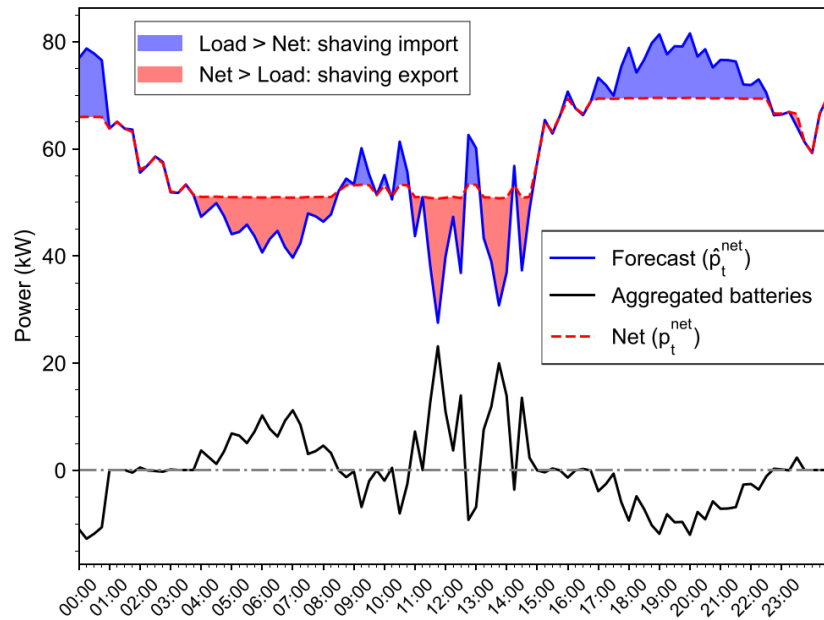


Figure 4 : Optimized grid and battery profiles following DSO forecast. The blue line represents transformer loading without batteries, and the red dashed line represents transformer loading with batteries. The blue shaded areas and red shaded areas represent reductions in electricity imports and exports, respectively. The black line is the aggregated battery (dis)charge profile.

## Impacts

- Household Impact** The financial impact on residents varied starkly by season. In the **winter month (December)**, the financial impact was negative. Because the batteries were reacting to grid needs rather than price signals, they were often instructed to charge from the grid during relatively expensive hours or discharge during cheap hours. Furthermore, the extra charging/discharging cycles incurred round-trip energy losses of approximately 5%. Consequently, energy costs increased by over **8%** during the winter test period (specifically between **€6-24.00** in a typical winter month based on actual electricity bill, a relative variation of 3-8% increase in cost). In the **summer months**, the picture was different. On average, households saved approximately **€16.66 per month**. However, there remained an opportunity cost, i.e., households could have had greater savings if the battery were deployed purely to maximize profits. Essentially, residents were paying—either in direct costs or lost potential savings—to stabilize the grid.
- Grid Impact** The impact on the grid was significant and consistently positive. The batteries effectively flattened the transformer's load profile, reducing the strain caused by sharp peaks and deep troughs. Analysis of import/export data showed a relative import reduction of 6% and an export reduction of 11%, indicating the system was particularly effective at

mitigating solar congestion. Further, the variance in the electricity load profile was reduced by 27% (i.e., the load profile was less volatile), which can help improve local power quality.

### On balance

This use case proves that household batteries can serve as effective grid assets, but it exposes a conflict of interest under current market conditions.

- **Primary Beneficiary:** The DSO, which receives a valuable grid balancing service that helps manage congestion and maintain stability without investing in physical infrastructure.
- **Disadvantaged:** The residents, who incur certain (opportunity) costs as a direct result of providing this service. This creates an imbalance where the value flows to the grid operator, while the cost is borne by the asset owners.

### 3.4 Results: Balancing Community and Grid Interests (UC4)

Designed as a potential "win-win" scenario, Use Case 4 utilized an optimization model that simultaneously minimized the household electricity costs while respecting the DSO's grid constraints. The algorithm assigned a "shadow price" (a virtual penalty) to grid congestion, incentivizing the batteries to help the grid only when necessary, while otherwise pursuing financial savings for the residents.

#### Highlights

This use case demonstrated that community-centric control can deliver grid services without overly penalizing residents. The model successfully kept the transformer load within the DSO's requested bandwidth while still creating financial savings.

The pilot run confirmed that the system could navigate the trade-off between two competing goals: minimizing the "Energy Cost" (electricity prices) and the "Congestion Cost" (grid congestion). By treating congestion as a high-price signal, the system naturally aligned the batteries' behaviour with grid needs during critical moments, while simultaneously maintaining battery profitability.

#### Impacts

- **Household Impact** The financial impact was positive, addressing the key deficit of Use Case 3. The model ensured that the community did not incur additional costs compared to having no battery. During the summer test phase, the community achieved an average monthly savings of 2.85%

(amounting to **€4.30** per house). While this is a modest amount, it serves as a proof of concept that residents do not need pay to help the grid. The relative modest amount is partly due to a seasonal effect: during the UC there was relatively little consumption, which means batteries did not fully discharge, to make room for charging. (It is important to also note that two batteries were non-functional during this phase, which likely dampened the aggregate results; a fully operational fleet would likely yield higher total savings.)

- **Grid Impact** The grid impact remained highly positive, comparable to UC3. The optimization model effectively scheduled batteries to shave peaks and fill troughs. Analysis of the transformer data confirmed that the system respected the specified bandwidths. This confirms that a "soft control" mechanism—using price signals or shadow costs—can be as effective at managing congestion as "hard control" (as in UC3), provided the signals are calibrated correctly and shadow costs are implemented in some form.

### On balance

Use Case 4 represents a viable middle ground, moving away from the confrontational dynamic of purely grid-led control.

- **Primary Beneficiary:** In theory, both the community and the DSO are beneficiaries. The community lowers their energy bills, and the DSO receives a valuable congestion management service.
- **Disadvantaged:** While there is an opportunity cost compared to UC2, no party comes out severely disadvantaged, not even the community. Still, the economic viability hinges on the shadow price becoming real. The *simulated* penalty for congestion turns into a real opportunity cost in the current energy system (where excess grid load does not carry a real-world penalty); for this to work, the DSO would therefore likely need to provide some sort of incentive or benefit for staying within given bandwidths.

### 3.5 Results: Impact on the MV Grid (UC5)

This use case expanded the scope from the local neighbourhood to the regional MV grid. It tested whether a small cluster of nine household batteries could react to forecasts of regional peak generation, effectively reacting to the needs of the **regional** energy system rather than just their local street or household.

## Highlights

The experiment successfully demonstrated that even a small aggregate of batteries creates a measurable impact on the macro grid. During controlled tests, the batteries were able to reduce generation peaks on the MV grid by an average of **4.2%**<sup>9</sup>, with a maximum observed reduction of over **6%** during the relatively high production month of June.

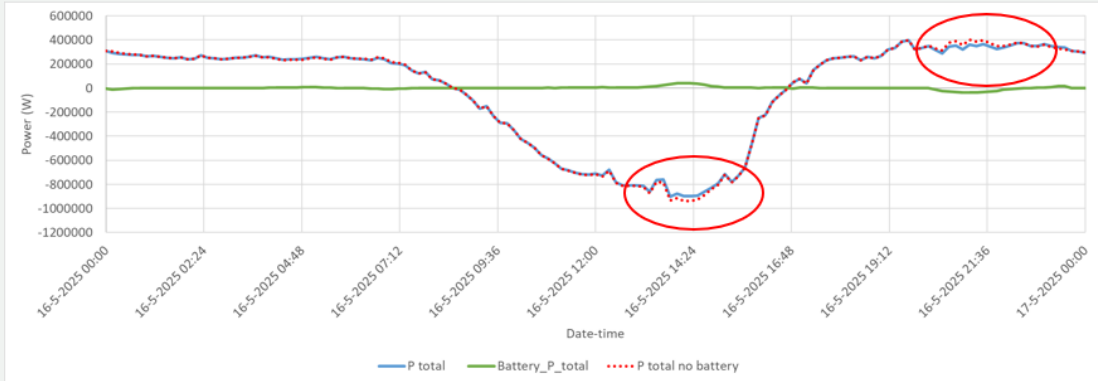


Figure 5 - Employing UC5 reduced evening and midday peaks on the MV grid by ~4%.

A critical finding was the sensitivity of this strategy to data latency. The experiment revealed that using week-old grid data to predict peaks reduced the effectiveness of peak shaving significantly—from a **4.2%** average reduction down to just **1.4%**. This underscores that while the physical assets (batteries) are capable of reducing grid congestion, accurate forecasting based on recent local measurements is crucial for achieving any significant grid impacts.

## Impacts

- **Household Impact** Households continued to see financial benefits during this mode of operation. Net electricity cost savings (excluding taxes/grid costs) ranged between **€24 and €36 per month**, with an average of **€30.26**. In detail, houses with batteries paid **€22.47** monthly on average, while houses without batteries paid **€52.7** on average. This was during a month with good solar irradiance (16<sup>th</sup> April-2<sup>nd</sup> June). Although battery profitability was not explicitly pursued in this UC (as it was in UC4), these savings suggest that reacting to regional grid signals may still align well with market price signals (as regional congestion often correlates more closely with low/negative prices than LV-level congestion), allowing residents to save money while serving the wider grid.
- **Grid Impact** The impact on the MV grid was clearly measurable. The ability to shave peaks by even a few percentage points is operationally valuable for

<sup>9</sup> Simulations indicated a maximum achievable reduction of around 5%.

a DSO, as it can defer the need for infrastructure upgrades, especially if additional assets (e.g., electric vehicles) are controlled. The analysis confirmed that battery control using MV signals significantly influences LV transformer behaviour as a side effect—peak power is reduced, variability is lowered, and the "smoothing index" showed the grid profile was less volatile. Specifically, an average peak reduction of **4.2%** was achieved using up to 90 kW of battery power and 72 kWh of battery capacity on a 1 MW grid with peak power flows exceeding 900 kW<sup>10</sup>.

## On balance

This use case connects local assets to regional problems, proving that "small" solutions can have scalable effects.

- **Primary Beneficiary:** The DSO and wider society. The results demonstrate a potential "non-wires alternative" to grid reinforcement, which could save significant public funds and accelerate renewable connections.
- **Disadvantaged:** Residents incur an opportunity cost. While they saved money, their batteries were optimized for regional issues rather than local maximization. However, unlike Use Case 3, the closer alignment between regional peaks and market prices meant this (opportunity) cost was far less punitive.

## 3.6 Results: Behaviourally Enhanced Congestion Management (UC6)

This final use case combined the technical optimization of Use Case 4 (balancing community and grid) with active consumer involvement. It represents a scenario where the automated systems are augmented by participant engagement, aiming to see if human-in-the-loop strategies could squeeze further efficiency out of the system.

## Highlights

The addition of consumer involvement to the technical optimization resulted in the most stable grid profiles of all test cases (this UC had the highest smoothing effect on the transformer). That is, the power flow profiles were relatively stable,

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<sup>10</sup> These results imply that every 2 kW of battery power can reduce grid peaks by 1 kW, but this is misleading: The main constraint on battery grid impacts is battery capacity. Simulations have shown that achieving greater peak reductions requires increasingly more battery capacity, because the batteries must shift increasingly more energy (kWh). I.e., the area under the curve of peak power flow profiles increases non-linearly as the target peak reduction period is extended over more time.

potentially resulting in less thermal stress on grid assets and less power quality issues.

Critically, the analysis of the power distribution (the frequency of different load levels) showed that this use case also successfully eliminated the extremities. The extreme import or export events were notably absent compared to the baseline. This suggests that combining automated algorithms with consumer engagement creates a highly robust safety net against grid stress.

## Impacts

- **Household Impact** Financially, the gains in this specific test period were marginal. The savings/debt analysis showed a communal cost saving of only 0.50% to 0.82% . This lower financial performance (compared to UC2 or its twin UC4 especially) has to do with the timing of the UC (late October/early November). The system had to charge batteries from the grid to ensure reliability, which incurred efficiency losses (about 20%) and purchase costs. This indicates that while "maximum reliability" is technically possible, depending on the season, it may come with diminishing financial returns for the households involved. (To ensure good financial returns, you need sufficient PV to charge the batteries and also discharge at high prices, at least 20% higher than purchase price.)
- **Grid Impact** The grid benefits were distinct and high-quality. The batteries achieved a mean peak reduction of **10.27 kW** on Transformer 1 and **6.64 kW** on Transformer 2. The ‘flexibility index’— the share of demand energy effectively shifted in time — was **0.14**, comparable to the purely technical use cases. The results suggest that user participation can work effectively work together with the technical operation of the batteries: similar or better effects on the grid can be obtained, but with (slightly) more conservative (and thus safer) battery operations.

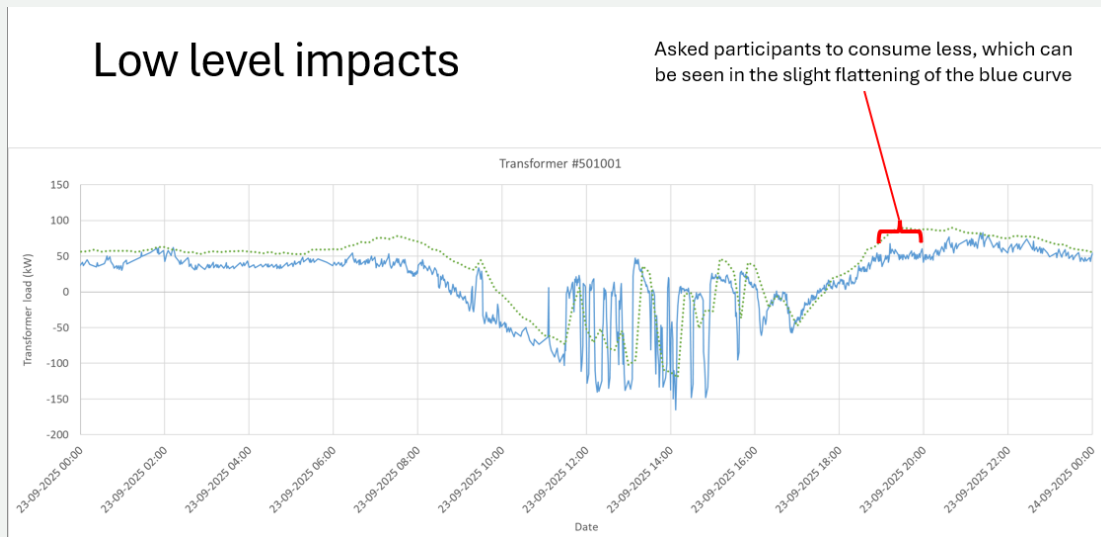


Figure 6 - Expected power flows (green dotted line) and actual power flows (blue solid line), with a "code rood" between 19.00-20.00 where participants were asked to reduce their consumption.

### On balance

Use Case 6 highlights the trade-off between maximum grid security and maximum financial efficiency.

- **Primary Beneficiary:** The Grid Operator (DSO), who benefits from the highest level of profile smoothing and the elimination of extreme load events. (Please note, though, that it is difficult to assess how much of the additional benefit was due to participant contributions.)
- **Disadvantaged:** In principle, the financial returns can be expected to be similar to UC4, since it's at the basis of UC6. Our limited-run experiment (in Oct/Nov) does not allow us to affirm whether the added benefit to the grid through additional behavioural effort also translates into commensurate financial benefits (assuming dynamic tariffs). If not, then it will likely require an additional compensation to sustain people's efforts.

### 3.7 Results: Synthesis

Putting our grid-aware use cases side to side (leaving out of consideration here the two 'max self-consumption' models), what do we see in terms of their financial performance for households?

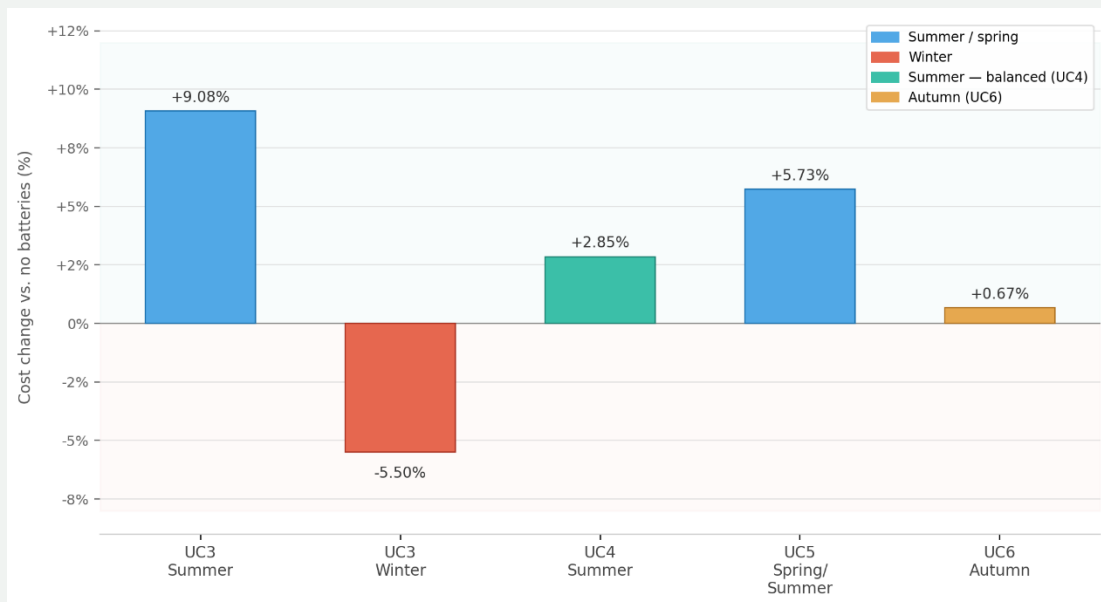


Figure 7 Timeline of use case runs across the Ansen pilot (2024–2025), with seasonal solar context

As the figure above makes clear, financial performance does not depend uniquely on the steering logic. Just take the difference between UC4 and UC6, which have the same underlying battery steering logic. Indeed, if we match the use case runs against the (average) solar irradiation in that period, it becomes apparent that season matters almost as much as strategy: without PV panels to feed into the batteries, the ability of the batteries to generate benefit to the community is severely constrained. In the case of UC3, the lack of PV electricity in winter even resulted in a considerable financial penalty for the resident, because the battery had to be charged from the grid in order to complete its steering logic.

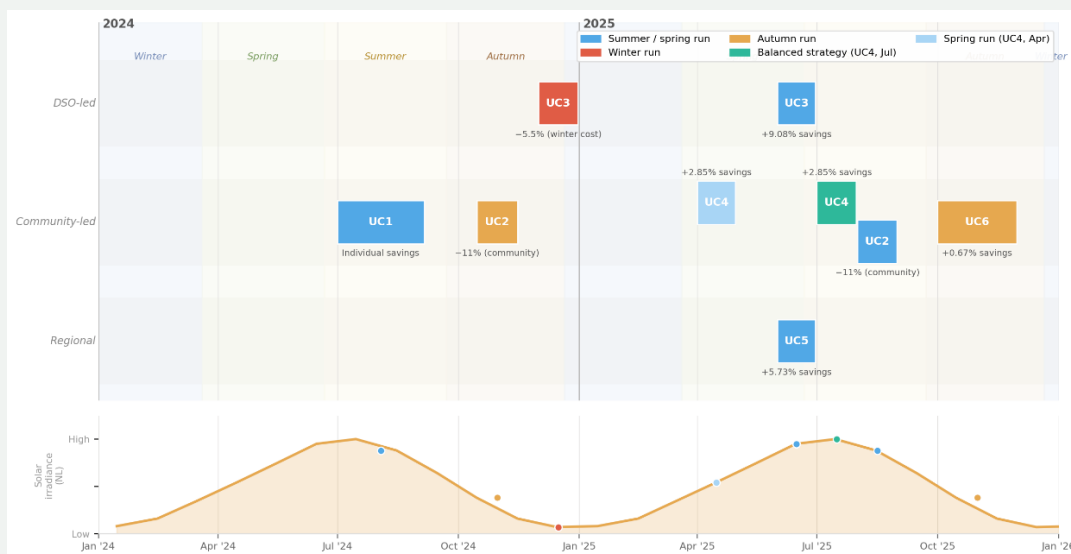


Figure 8 Steering logics and grid volatility reduction, mapped against solar irradiation

Grid impact is also affected by season, but differently and to a lesser degree. Let's take the smoothing index for both local transformers. The smoothing index captures how much the action managed to reduce grid load volatility, an important indicator for grid managers. You can see below that we split the grid impact of UC3 by when we ran it in winter and summer. The difference is definitely there, but much less stark than for the financial impact.

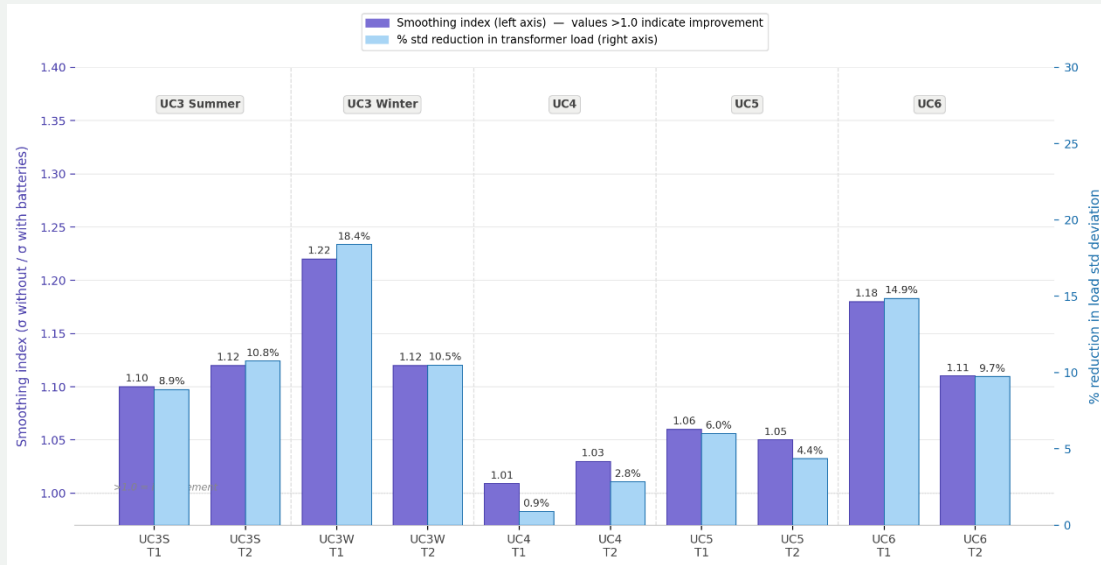


Figure 9 Smoothing of the two MV-LV transformers by UC run

If we put all of these data points together (by approximation) to get a sense of the interaction between steering logic, PV irradiation, on the one hand, and their financial and infrastructural impacts, on the other, we get something like the graph on the following page.

Each bubble represents one use case run. Its horizontal position shows the change in household electricity costs compared to an equivalent period without battery coordination (right = savings, left = added cost). Its vertical position shows the average smoothing index across both local transformers (an index for how much the action managed to reduce grid load volatility). Bubble size reflects the relative solar irradiance during the run period, derived from typical Netherlands monthly averages. The upper-right quadrant — residents save and the grid improves — is the target zone. UC3 in June 2025 and UC5 come closest to the ideal; UC6 achieves strong grid performance with modest savings despite being run in autumn. UC3 in December 2024 sits in the upper-left quadrant: the batteries stabilised the grid effectively, but residents paid for it.

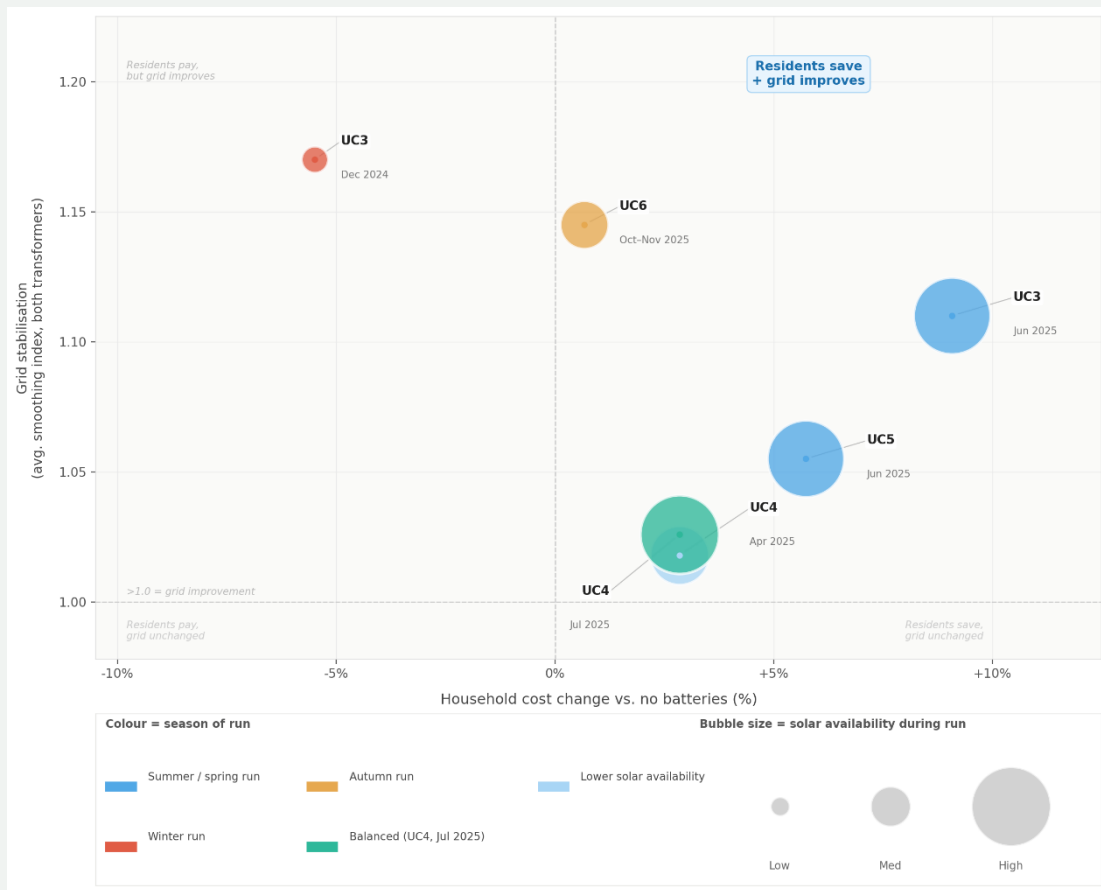


Figure 10 Trade-off between household savings and grid stabilisation across UC3-UC6 runs

Concluding then, there are some caveats and margins of uncertainty in our data. At the same time, **the direction is already clear**. The different types of impacts we measured are real and thanks to our diverse portfolio of use case, we can map out how different steering logics tendentially balance different kinds of values, benefits and costs. **UC4 emerges as the most stable balance of grid and household benefits, while UC5 shows up as a surprising home run to deliver congestion relief.**

Still, to firm up our conclusions, we also ran a set of simulations based on our measurement data, to model the impact of different input conditions. We also used simulations to think through the longer-term implications of our results. All this is the subject matter of the next chapter.

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## 4. Simulations

Simulations were used to consider the effects of upscaling, future energy pathways and to validate and quantify experimental results.

### 4.1 Simulation methodology

Simulations were also performed to test different battery control algorithms for a variety of future scenarios. Simulations have the advantage of replicability, making it possible to directly compare the impacts of different battery control algorithms (i.e., use cases) on grid congestion and battery performance/profitability.

In this project, a **Pandapower model** was developed to evaluate battery grid impacts. In this model, batteries were controlled to maximize household self-consumption or maximize battery profitability. Within these overarching goals, batteries were either employed to reduce grid congestion when it occurred, or left to their own devices. For additional insight, simulations also considered the impacts of constraining battery power through regulation or capacity pricing.

The results of these simulations indicate how batteries can contribute to reducing grid congestion, and the opportunity cost of doing so for the battery owner.

In the figure below, we can see that an unconstrained battery focusing on **maximizing household self-consumption (light orange bars) can increase household self-consumption by around 50%, but has no effect on grid peaks**. If these same batteries are required to reduce grid peaks (dark orange bars), then grid peaks can be reduced by up to 4.5%, at the cost of reducing household self-consumption.

In contrast, **a battery focusing on maximizing profitability (light blue bars) will decrease household self-consumption** as the battery buys and sells more electricity than the house would do normally. This leads to more electricity transport on the grid, but crucially it can also help reduce grid peaks if the battery power is appropriately constrained (a battery with too low a power will likely have little impact on grid peaks, while a battery with too high a power could charge the battery too quickly and miss the peak). Notably, requiring these same batteries to reduce grid peaks (dark blue bars) increases household self-consumption (the batteries will trade less) and reduce the grid peak to a larger extent, at the cost of reducing battery profitability (not pictured).

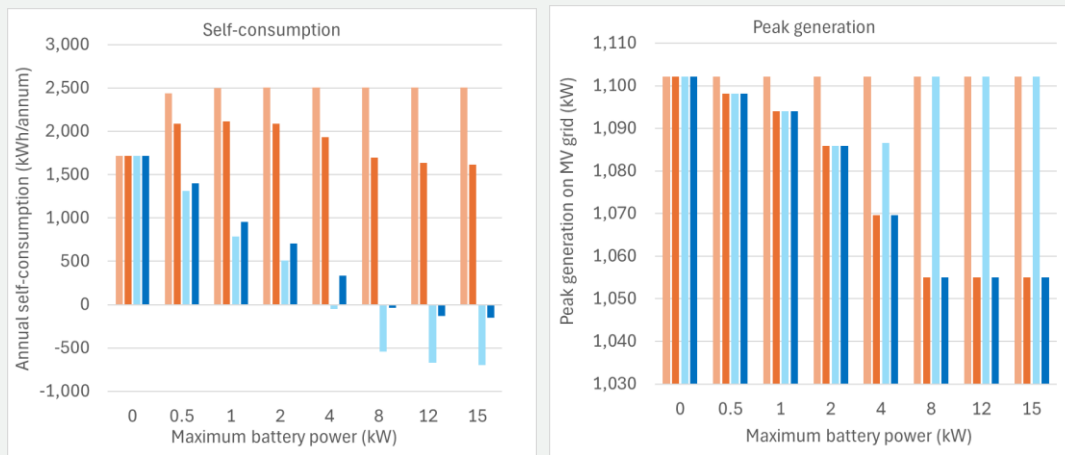


Figure 11 - Effects of different battery control strategies on household self-consumption and grid peaks considering different battery power constraints, where light orange and dark orange bars represent a self-consumption oriented battery without and with grid congestion management requirements, and light blue and dark blue lines represent a profitability oriented battery without and with grid congestion management requirements.

Further examples of the impacts of different battery control strategies in different (future) energy scenarios can be found in the appendix.

## 4.2 Future loads and generation

Pandapower simulations were also done to evaluate the impacts of the growth of both generation (PV and wind) and load (heat pumps and EVs) and the evolution of grid infrastructure and electricity market prices towards 2050. While the growth of PV leads to generation peaks and voltage rise issues in summer, the most critical bottleneck for energy security identified in the models was the **Winter Evening Peak**.

- **The 'Winter Gap' Challenge:** In 2035, grid congestion is driven primarily by electric vehicle charging and heat pumps operating on winter evenings, with reduced renewable generation. In standard "self-consumption" modes (like UC1), batteries are empty during this period due to lack of solar generation. They cannot support the grid by covering some of the demand during the evening peak.
- **Implication:** For batteries to act as a congestion solution in a heat-pump dominated future, they would have to support grid-charging (charging from the grid at night) and working in coordination with heat pumps and electric vehicles, rather than relying solely on solar surplus. However, this means that battery owners must purchase additional electricity, at their own expense. This heightens the need for a business model that can compensate energy communities for grid assistance during winter especially.

### 4.3 Impact on grid reinforcement

Comparing the scenarios revealed the true value of the NO-GIZMOS approach:

1. **Business as Usual:** Without smart steering and grid congestion information from the DSO, the simulated grid breaches safety limits (voltage and thermal limits) by approximately **2035**.
2. **With NO-GIZMOS (UC4):** Applying the UC4 steering logic to local batteries effectively defers the need for physical grid reinforcement by **5 to 10 years** and **reduces the required capacity** of the new infrastructure<sup>11</sup>, buying the DSO time to spend scarce resources elsewhere and reducing societal costs for electricity infrastructure.

It is important to note that smart software is not a permanent replacement for copper. Between 2035 and 2050, the projected load grows sufficiently substantial to require physical upgrades regardless of steering. However, the deferral period may still represent significant value in terms of freeing up capital expenditure and labour for the DSO.

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<sup>11</sup> Assuming that sufficient battery capacity is installed to support local wind and solar generation, on the order of 1.3-1.8 MWh, typical for new renewable energy installations.

## 5. General outlook based technical studies

The NO-GIZMOS project has successfully operationalized and validated decentralized congestion management systems. The project activities demonstrated:

1. **Technical Feasibility:** It is possible to aggregate distributed residential assets into a reliable steering instrument provided that congestion information from DSOs is made available.
2. **Need:** Uncoordinated market incentives pose a threat to grid stability, when market pricing does not reflect local grid conditions or when the total load moved by a ‘herd’ of batteries is simply too large for a local grid to handle.
3. **Two Distinct Solutions:** The project has validated two separate technical pathways that still require validation in the social and institutional domains:
  - **Solution A (Local): UC4** serves as a ‘Do No Harm’ cost-saving mechanism. It solves local safety issues with minimal impact on the resident's business case.
  - **Solution B (Regional): UC5** serves as an active service for the MV grid, addressing broader regional congestion caused by external factors. While technically proven (3.5-6% peak reduction), this solution currently lacks a matching business model to compensate the resident for the value delivered to the grid.

By validating that a balance can be reached between individual benefits and regional grid support, NO-GIZMOS provides the foundation for a future where citizens and grid operators collaborate rather than compete for grid capacity. However, the business model and the institutional bedding is not yet there to do this. We turned to our key stakeholders – Ansen residents and the EnergieKansen members, on the one hand, and Enexis’ Innovation team, on the other – to help us show the way forward.

*For a complete overview of the algorithms, data sets, and simulation parameters, please refer to the Technical Appendix.*

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## 6. Stakeholder Engagement

### 6.1 Framing: What the Technical Results Leave Open

The technical validation described in the preceding chapters established two distinct and viable pathways for community-based grid support. Solution A — Local Capacity Management (UC4) — protects the local transformer while preserving battery profitability, a "do no harm" approach that requires no central coordination beyond a household-level bandwidth constraint. Solution B — Regional Grid Support (UC5) — is an active service for the medium-voltage network, capable of reducing MV-level peaks by 3.5 to 6% and deferring the need for grid reinforcement by five to ten years.

Both solutions are technically proven. Yet both await the social, institutional, and commercial conditions that would make them replicable beyond the Ansen pilot. Solution A requires a governance model and financial framework that energy communities can sustain over time. Solution B goes further: it currently lacks a matching business model to compensate communities for the value they deliver to the regional grid, and it depends on DSO organisational processes — and regulatory frameworks — that do not yet exist in the Netherlands.

This is the space the social engagement programme was designed to explore. The project invited its key stakeholders — the residents and members of EnergieKansen (eKa) on one side, and Enexis' Innovation team on the other — to help define the conditions under which the technical solutions could become a social and institutional reality. The core question guiding the engagement was: *What would it take for cooperatives and grid operators to be willing and able to adopt to this model?*

The engagement programme comprised three activities: a longitudinal monitoring and evaluation strand with battery participants in Ansen; a co-design workshop with eKa members; and a roadmapping workshop with Enexis Innovation. Each is described in the sections that follow.

### 6.2 Monitoring and Evaluation with Residents

#### Approach

The monitoring and evaluation strand was designed to capture the lived experience of battery participants over the course of the pilot — their expectations, frustrations, and evolving understanding of what the technology does and what they value about it. For this we used several instruments: in-depth individual

interviews, surveys and a community dialogue session. The interviews were conducted in three series: 1. With a random sample of Ansen residents at the start of the project, before participants were selected (interviews 2023); 2. With selected participants when the batteries had been installed, but the use-cases had not started yet (interviews 2024) and 3. With participants at the end of the project (interviews 2025). The surveys were conducted in two series: one before the start of the pilot (survey 2024) and one at the end of the pilot (survey 2025) and delivered to all Ansen residents to measure impact and enlarge the sample from participants. The single community dialogue session was conducted to generate collective reflection. Not all inhabitants of Ansen cooperated in the surveys and interviews. The datasets were evaluated on several indices (such as age or whether they are house owners or tenants) which showed that the respondents were sufficiently representative of the whole Ansen population.

## Ansen residents' motivations

### Enthusiasm to participate

In total there are 140 households in Ansen, mostly within the village itself, but also in the surrounding area. Altogether 47 of them either showed interest in getting a battery from the NO-GIZMOS project (8 actually participated) or participated in the behaviour change experiment of use case 6. This means that 33% of the population was willing to actively contribute to the project, to actively contribute to this step in the energy transition. This is in line with the very positive attitude that the people from Ansen have towards the energy transition (figure 11).

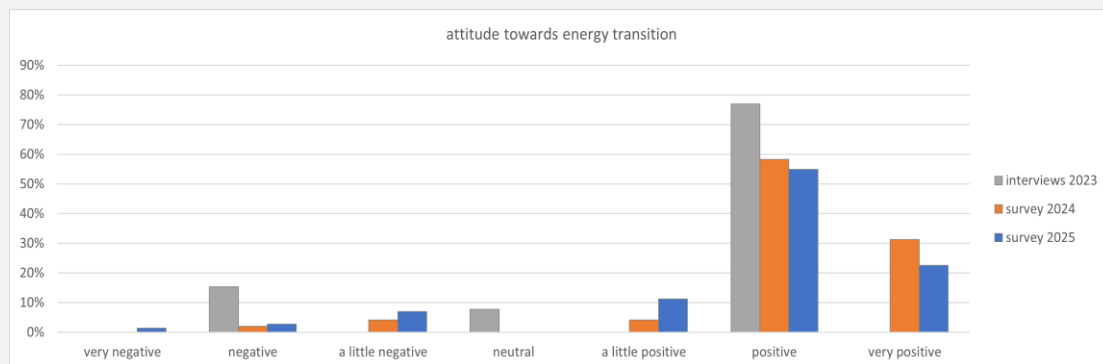


Figure 12 Attitude towards the energy transition measured by interviews 2023 and surveys 2024 and 2025.

### Motivation for using a battery

In the interviews 2024, the participants indicated several reasons for deciding to participate: profit (75%), wanting to help the innovation of the energy transition (63%), reduce climate change and its environmental impact (63%), increasing self-sufficiency (50%) and reducing grid congestion (50%).

In the surveys the respondents were asked to indicate the importance of several considerations for deciding to buy a battery (see figure 12).

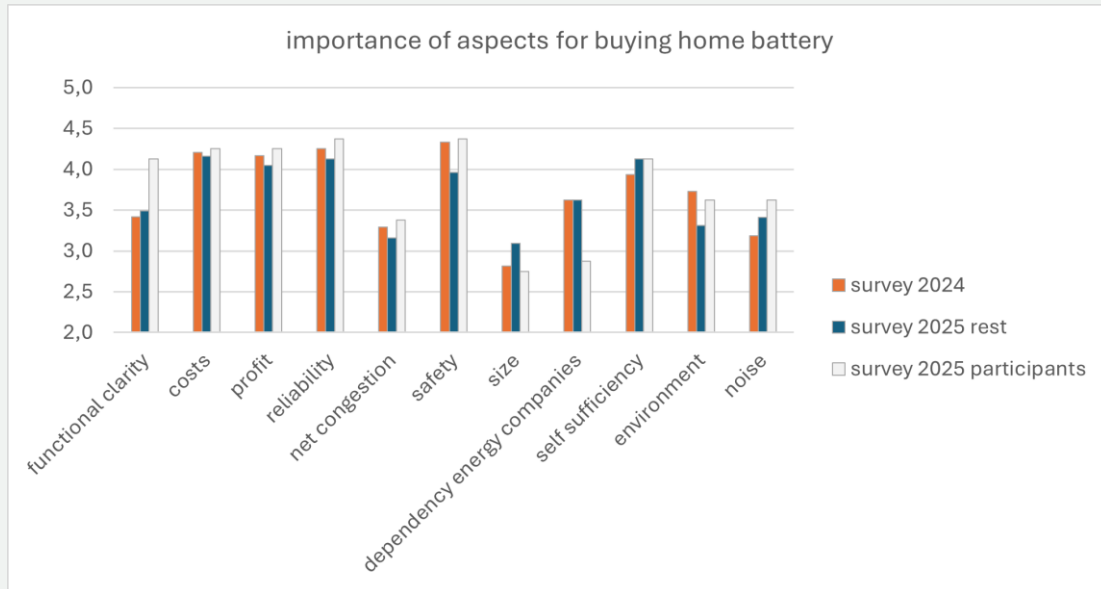


Figure 13 The importance of several aspects for the decision to buy a home battery from survey 2024 and 2025. For the survey 2025 the participants and the rest of the respondents are split.

In line with the reasons to participate in the project, financial aspects (costs and profit) are most important, together with reliability, safety and self-sufficiency, size and the effect on grid congestion are the least important ones with the rest (environment, noise and functional clarity) in between (a score of 3 means they find it of average importance, a score of 4 means they find it of high importance, so even size is considered of average importance). The participants do not differ from the rest of the inhabitants of Ansen, the effects that are visible in the graph are not statistically significant.

During the deployment of the use cases, short questionnaires were sent to the participants in which they were asked to indicate how important they considered four different goals for controlling the batteries (in line with the use cases). This was measured only twice, because the third time only half of the participants responded so it was decided to stop sending them. The results, as depicted in figure 13 show that maximizing profit is less important than maximizing self-consumption and is about equally important as minimizing grid congestion.

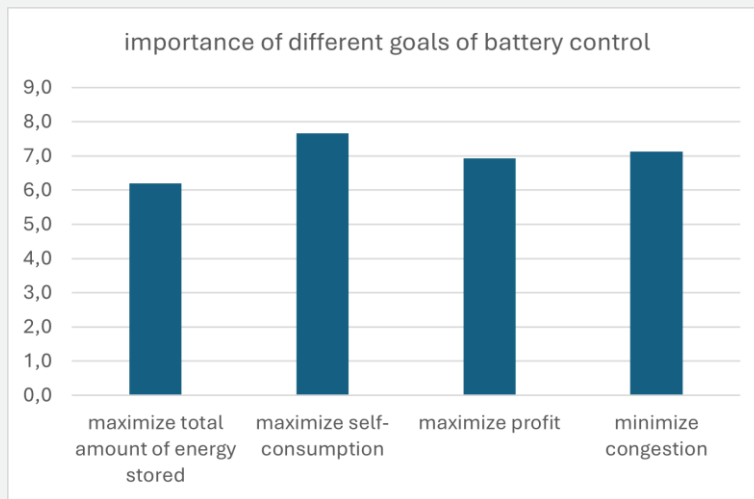


Figure 14 Rated importance (on a scale of 1-10) by participants. Average of measurement after first deployment of use case 1 and use case 3.

The above mentioned results indicate that although it would be needed to compensate citizens for the value they deliver to the grid, it is not only money that drives them and that trading at least some profit for other aspects can be considered in developing a business model.

That it is not only money that drives them also became apparent from the scores on four classes of values that are relevant for the energy transition (Bouman & Steg, 2018; Bouman et al, 2017). Biospheric values concern nature and the environment, altruistic values concern society and other people, hedonic values concern comfort and pleasure and egoistic values concern own interest and money (figure 14). As can be seen in figure 14 both the participants and the rest of the inhabitants of Ansen (the differences between these groups are not statistically significant) consider egoistic values least important, which once again indicates that its not only money that drives them (actually, that seems to be the least important drive).

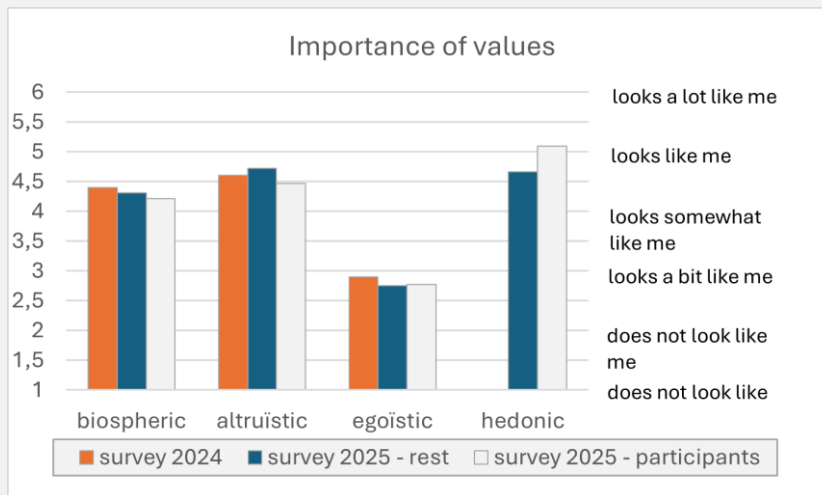


Figure 15 Importance of four classes of values, from survey 2024 and 2025. For the survey 2025 the participants and the rest of the respondents are split.

A final piece of evidence that there is more to the ownership of a battery than financial aspects, comes from the algorithm choice for use case 6. During a participant meeting, the participants were asked which algorithm they wanted to be active during the six weeks of use case 6 deployment. They were elaborately informed about the different algorithms (the different use cases) including the effects on profit, self-consumption, self-sufficiency and grid congestion. They unanimously chose to use the use case 4 algorithm, accepting that that would bring them less profit, but helped keeping the grid stable.

### Experiences with the batteries

The above-mentioned scores of the participants on the different aspects for buying home batteries, are the result of almost two years of experience with the batteries within their homes. All-over they gave an average grade of 6,9 on satisfaction with the battery. Still, none of the participants is completely done with home batteries, they all are open for keeping a battery, although they all have some clear improvements that need to be made and some only want a new, different type of battery. In figure 15 the grades on the overall satisfaction with the battery, that were collected at four moments during the project, are depicted. Directly after the start of the use cases, the satisfaction was lowest (5,9 average), it increased a bit towards an average of 6,4 after use case 3, to decrease towards a 6 after use case 5. Remarkable is that at that moment two participants graded their overall satisfaction with a 4 (and the average is relatively high, because one participant graded it with a 9). Around the same time there was a meeting with all participants in the town hall, where most of them indicated that their enthusiasm and motivation had decreased because they could not control the battery, they could

not satisfactorily see its functional results and they had the impression that the only thing they contributed to the project was hosting the batteries.

That feedback from the participants was an important reason for designing use case 6, where participants got the chance to decide on the algorithm to be used for steering the batteries (with provided them with at least some control) and also gave them the chance to actively contribute to the project by controlling their own behaviour on a daily basis. Although not all participants actively participated in use case 6 (5 of the 8 households did participate), that resulted in an average rise in the overall satisfaction as was measured at the end of the project, shortly after the completion of use case 6 during the final in-depth interviews.

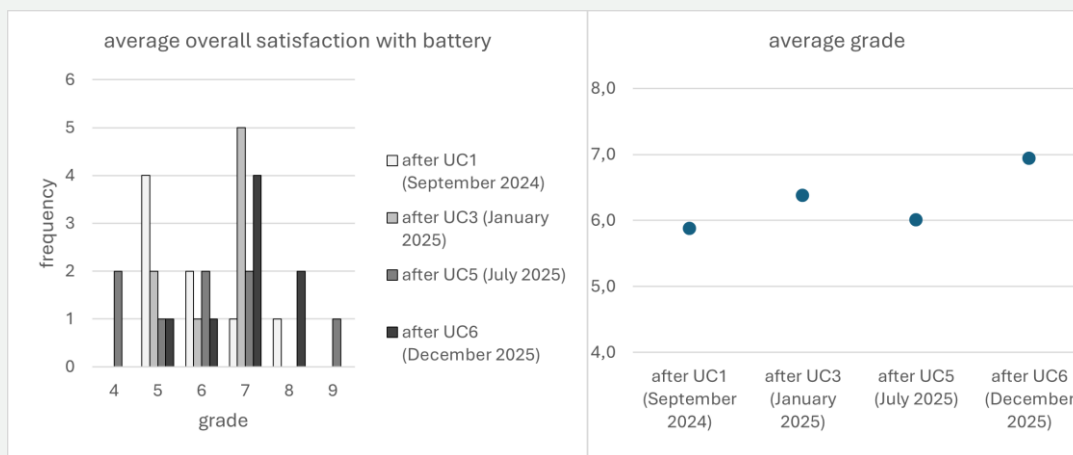


Figure 16 The average overall satisfaction of participants with the batteries at four moments during the pilot (graded on a scale of 1-10).

## Physical aspects, installation and maintenance

All the participants were relatively negative on the noise the batteries made. The noise stems from the ventilators cooling the battery during (dis)charge. This aspect remained negative from the start of the project (interviews 2024) to the very end (interviews 2025). As all participants have relatively large houses and the batteries were installed at locations that were apart from their daily living spaces, the noise did not provide a real nuisance. They all mentioned that, if the batteries would have been closer to their daily living spaces and perhaps not even placed in separate rooms, that would have been inconvenient.

All participants also indicated that the batteries produce a significant amount of warmth, and again because they were placed in separate rooms not near their daily living spaces, the warmth was not providing inconvenience.

Finally, all participants agreed that the batteries were large, for many much larger than they anticipated. Two participants considered that a barrier, the rest did not, mostly because their houses as well as the rooms they were installed in, were quite spacious.

Shortly after the installation of the batteries, the participants were mostly positive about the process of registration and installation. Some mentioned that the communication about when an installer would come to their house, could improve. At the final interviews half of the participants mentioned that maintenance and troubleshooting in cases of malfunction, was a substantive barrier. The proactive monitoring of malfunctions from the central control was considered insufficient as was the speed and communication of repairing malfunctions and maintenance in general.

### **Functional clarity**

In the interviews 2024, 7 (of the 8) participants indicated that they did not have any idea about the actual functioning of the battery (e.g. state of charge, moments of charge and discharge) and they really wanted to get that information. Some (5) wanted that on a real-time basis, some (3) could do with frequent aggregate reports.

Shortly thereafter they all got access to an online monitoring tool that delivered real-time information about the functioning of the battery. After the first deployment of use case 1, only half of the participants had used the monitoring tool. After the first deployment of use case 3 even 5 out of 8 participants indicated that they had not looked at the monitoring tool during the foregoing month. Yet, at a participants meeting that was organized after all use cases had been deployed once (except use case 6), a majority of the participants indicated that they still wanted more insight and a better understanding of the functioning of their battery. At the end of the project (interviews 2025), 2 participants indicated that they did not use the online monitoring tool. Of the other 6, 2 indicated that the interface of the online monitoring tool was unclear.

In the interviews 2025, half of the participants indicated that an important reason for their low satisfaction with the battery was that they lacked insight in the actual functioning of the battery, especially regarding its effect on their own household, despite the accessible online monitoring tool and despite the individual reports they received after the deployment of every use case. The group differed in the type and amount of information they wanted: about half wanted detailed and

technical information on the functioning of the battery as well as detailed and substantiated reports on its effect, while the other half only wanted to know only general information. It turned out to be difficult to serve both groups.

### **Control and results**

All participants indicated in the interviews 2025 that they (more or less) understood the different ways the batteries were steered during the project, although 2 indicated that they did not have a good impression about the different types of algorithms used.

Two participants would prefer to be able to control the battery themselves, instead of the central control that was executed during the project.

Half of the participants indicated that they were satisfied with their insight in the functioning and results of the batteries. They were satisfied with the results that were realized as well as with the reports they received on the functioning and results of their batteries. The other half wanted more information of the functioning or results of their batteries but were not necessarily negative regarding the results of the project. They understood that they participated in a research project which means that they cannot control the way it is performed. That is in line with the fact that in principle all of them are open for keeping a home battery after the project. However, if they would keep a battery of their own, they would require more insight in its functioning and results for their own household.

As the use cases were designed to differentiate between control strategies aimed at individual household yields and grid congestion, in the final interviews (interviews 2025) the participants were asked to reflect on these results. All of them indicated that the results of the batteries for their own individual households were unclear (self-consumption, self-sufficiency, profit). Half of them indicated that these results have been sent and presented to them, but they could not recall them. In addition, 2 participants indicated that their individual results are unclear because their energy consumption changed substantially during the project (e.g. because they installed a heat pump). Finally, 3 participants indicated that they did not pay attention to the financial results of the control of the battery.

Regarding the effects on grid congestion, 7 of the 8 participants indicated that these results had been communicated with them and that these results were clear to them. The other participant indicated that these results were not clear to him/her.

## **Support and information provision**

In the interviews 2024, all but one of the participants considered the support and information provision as sufficiently clear and appropriate. Although they mentioned some possible improvements, in general they were satisfied with it, except that at that moment they did not know how their battery operated and did want to know that.

In the interviews 2025, 2 participants indicated that they were dissatisfied with the information provision (6 are satisfied), which mainly focused on a lack of insight in the operational functioning of the battery (which was also important for 2 other participants, who on average were satisfied with the information provision). In addition, other aspects that participants were unsatisfied about were the speed the project team reacted to their questions, the lack of information in case of malfunctions, the slow information provision regarding their financial compensation and the clarity of the information.

Participants indicated that they highly value the various participant meetings that were organized and the information that was shared at these meetings. They were also satisfied by the opportunity they were given to provide feedback during these meetings. During the project the information provision improved, 3 participants indicated, at least partly because a WhatsApp group was made in which they could communicate with the project leader as well as with each other.

## **Attitude towards home battery**

Naturally the participants had a positive attitude towards home batteries at the start of the project (otherwise they would not have participated). In the final interviews (interviews 2025) they were asked whether their experience with the project changed their attitude. For 5 of the participants the project did not lead to a change in their attitude, for 2 of them their attitude became more positive and for 1 of them the attitude became more negative. Nevertheless these changes, they all remained positive towards home batteries (see also further on).

In addition the participants were asked whether they developed new motives for buying a home battery. In total 4 participants mentioned that profit became a new motive (for them), a change that originated from the future termination of the net metering scheme. In addition, 1 participant mentioned that minimizing grid congestion became a personal motive and 2 mentioned having a backup power supply as an additional motive.

Regarding either keeping the current battery or buying another (new) one after the project they would consider some aspects in doing so, as is depicted in figure 16.

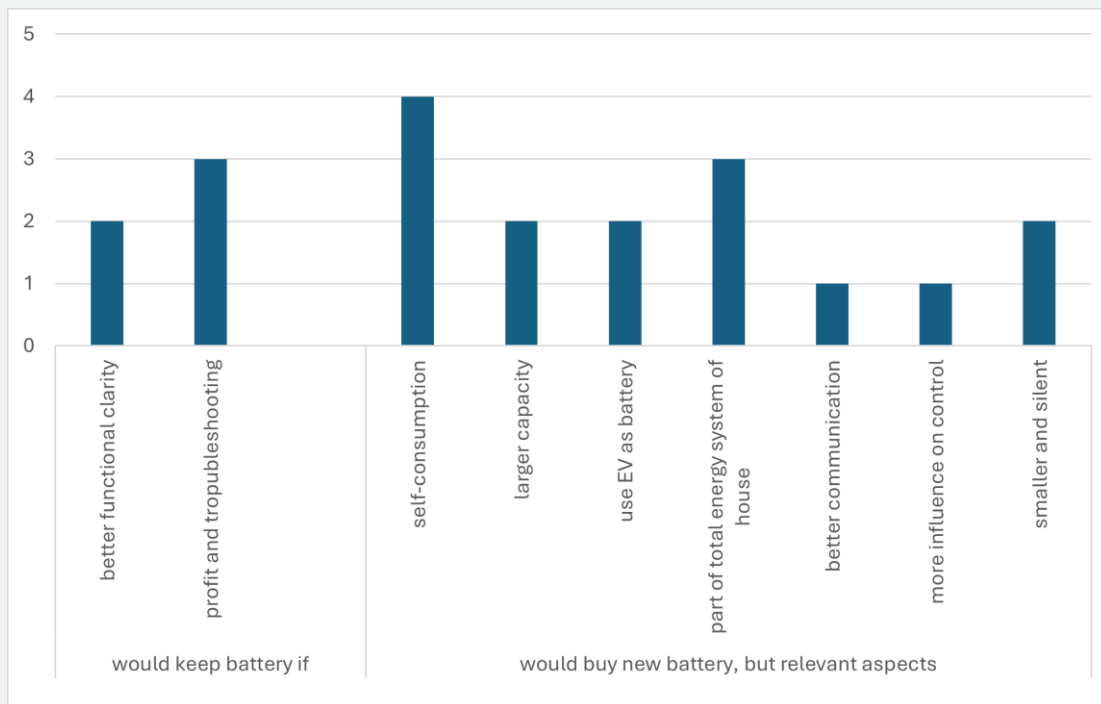


Figure 17 Aspects relevant for the participants in deciding to either keep the current battery or buy a new one. Data from interviews 2025.

## Conclusion on experiences

The overall satisfaction with the batteries was modestly positive, although some were dissatisfied (and it varied during the pilot). Based on the experiences, satisfaction could have been improved by:

- Smaller and more silent batteries
- Better insight in the functional operation of the batteries
- Better insight in the actual results of the batteries for own household
- More control regarding the steering of the batteries
- More frequent and timely communication
- Better and timely reaction to malfunctions

Although the participants are certainly interested in the financial effects of a battery, and more profit would increase their satisfaction, there are other aspects that are at least as important to them (though some are related to profit): the effect on self-consumption or self-sufficiency, the fit between the household energy system and assets and the (capacity and control of the) battery and the functional clarity.

## Generalizability of the results

Since only 8 households participated in the study, the generalizability of these results needs some further consideration.

As already mentioned, the respondents that filled in the surveys (2024 as well as 2025) are sufficiently representative of the whole population of Ansen (see separate social appendix). Therefore, the data collected by the surveys are considered reflecting the whole Ansen population.

In a previous study on home batteries (Lamain & van Rij, 2024) it turned out that the participants were predominantly 'innovators' and 'early adopters' from the diffusion of innovation theory of Rogers. In Ansen, where we estimated the group the respondents belonged to by means of several questions in the surveys, this turned out different (figure 17). Of the participants 3 belonged to the early adopters group, the other 5 to the early majority and late majority. This means that the findings from the experiences are not valid for the small group of inhabitants that are early adopters but that they are valid for the large majority of the population. The fact that members from both early adopters and late majority were participants, could explain the two different groups that were visible in the analysis of the experiences (but that could not be tested because the relationship between the surveys and the interviews could not be made because both were analysed anonymously).

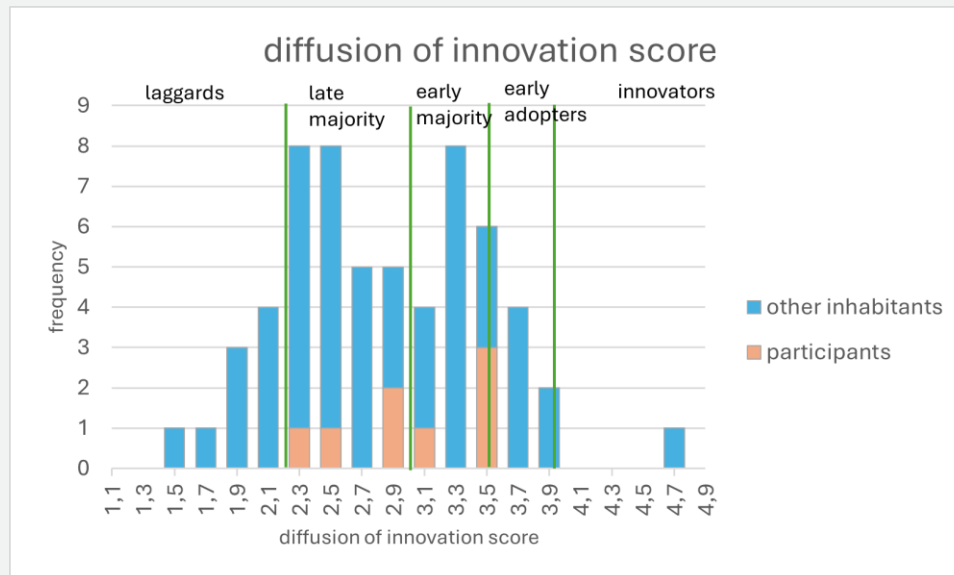


Figure 18 Diffusion of innovation score of respondents of survey 2025 (participants indicated separately).

Needless to say that the participants had a positive attitude towards home batteries. That turned out to be no exception within the village of Ansen. On average the inhabitants had a quite positive attitude towards home batteries and more generally towards the energy transition (figure 18). The participants are much like a large part of the Ansen population which makes the results from the project valid.

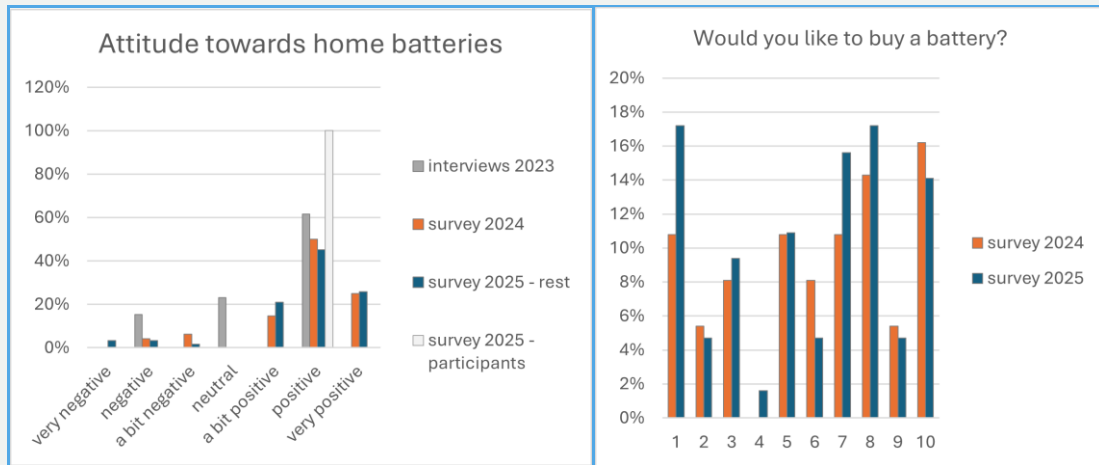


Figure 18 Attitude towards home batteries and intention to buy a home battery (score 1-10) from interviews and surveys.

The technical acceptance score was also calculated based on the information from the surveys, based on the extended UTAUT2 version of the Technical Acceptance Model (Tamilmani et. al., 2021; Venkatesh et al, 2003). The average score for the participants (survey 2025) was 3,62, while the average score for the rest of the respondents was 3,21. Although slightly higher for the participants, the difference was not statistically significant.

### Effect of knowledge

The participants indicated in the interviews and during the participant meetings that they have gained a lot of knowledge regarding home batteries during the project. Despite having experienced several downfalls within the project, they still remained positive towards home batteries, which could partly be related to their knowledge, as some of their reactions in the interviews 2025 seemed to indicate.

The extend to which respondents were knowledgeable about home batteries was also measured with the surveys. In figure 19 is shown that as respondents have more knowledge about home batteries, they are more likely to buy one. The effect is statistically significant for the 2025 survey only (ANOVA  $F(1,63)=10,154;p<0,01$ ).

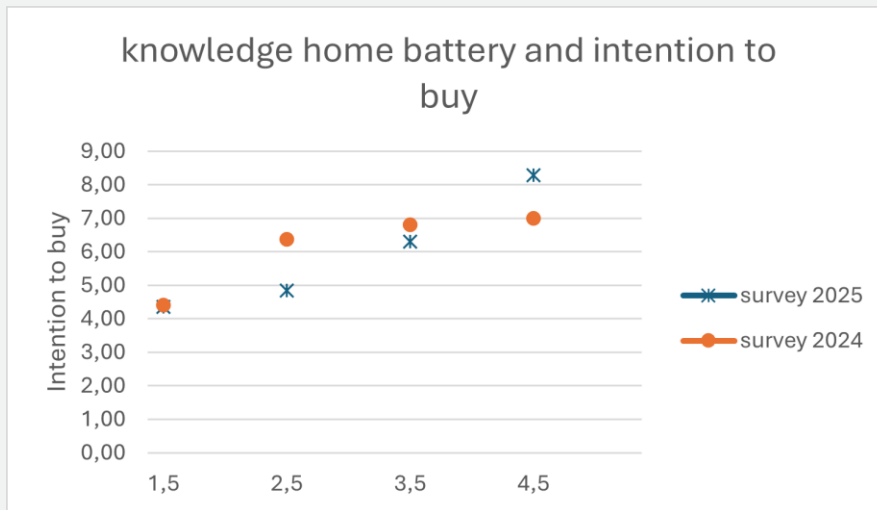


Figure 19 Relationship between knowledge of home batteries (on several different aspects) and the intention to buy a battery from survey 2024 and 2025.

### Impact within community

The impact of the NO-GIZMOS pilot within the community was assessed with the survey 2025. Almost a quarter of the respondents did not know the project at all, 35% did know the project, but were not involved and almost 40% were involved as participants or in use case 6 (changing their energy behaviour). Overall, a substantial part of the population had some knowledge of the project. Of the people being aware of the project, half never or almost never talked about it with other inhabitants and only a very few talked about it frequently or often. It appears not to have been the talk of the town.

Consequently, the effects on the knowledge of home batteries of the Ansen population was limited (figure 20), about one-third of the inhabitants gained some knowledge about home batteries, about 20% gained substantial knowledge (apart from the 8 participants). The project did have an impact within the community, yet the impact was limited.

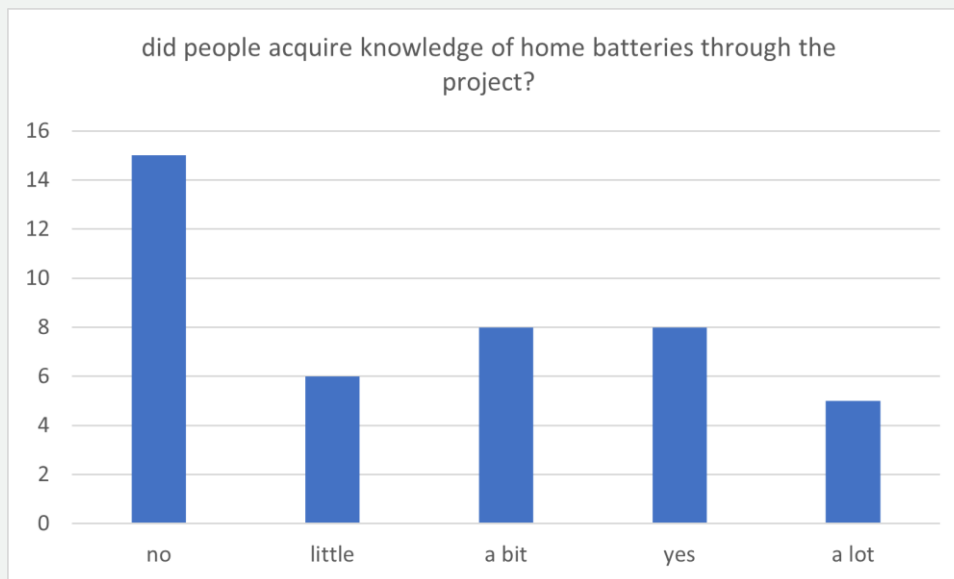


Figure 20 The amount of knowledge respondents gained through the NO-GIZMOS project (survey 2025, participants excluded; respondents who did not know the project were not asked this question).

The local energy community (energy cooperative EnergieKansen) is considered important in several respects. When asked which of several parties bear the largest responsibility in the energy transition, the energy cooperative is given the highest score (4,13 out of 5), closely followed by institutions (local/national government, DSO, housing company (4,05), followed by people themselves (3,52) with the neighbourhood given the lowest score (3,06). So, the respondents think that it is important that the energy cooperative takes the lead in the energy transition.

In addition to that, they consider it important for themselves to be a member of the energy cooperative (and therefore, as a member be in the lead of the energy transition), as is depicted in figure 21. The figure also shows that local energy production is considered relatively important as well as investing profits of the energy cooperative in the local community.

Although the respondents assign the neighbourhood the lowest responsibility in the energy transition, they find it very important that the citizens are being involved in the energy transition (figure 22). Also, they highly value their autonomy, which is served better by the energy cooperative than by institutions.

It can be concluded that the respondents support a leading role of the energy cooperative in the energy transition, and therefore also in creating flexibility in the energy ecosystem (by means of home batteries). That can be considered as a way to engage citizens (members) and they find it important to be a member themselves (and be engaged themselves). Although it does mean that their individual autonomy will be somewhat diminished, it ensures that through the

cooperative they still have a large say (as opposed to decision making by institutions).

However, not all residents of Ansen are either a member of the energy cooperative or were able to participate in the NO-GIZMOS project. When distributing the surveys within the village, the researchers had (sometimes very long and lively) conversations with the inhabitants in order to collect additional information, opinions. Several inhabitants of Ansen mentioned that they would like to be involved in energy transition projects, yet were unable to do that. Especially people who were unable to invest in assets like solar panels or batteries, either because they lack the resources or they rent their house and are not allowed to install assets, could (and often want to) be engaged more. This provides a nice opportunity for the energy cooperative to enlarge its member base.

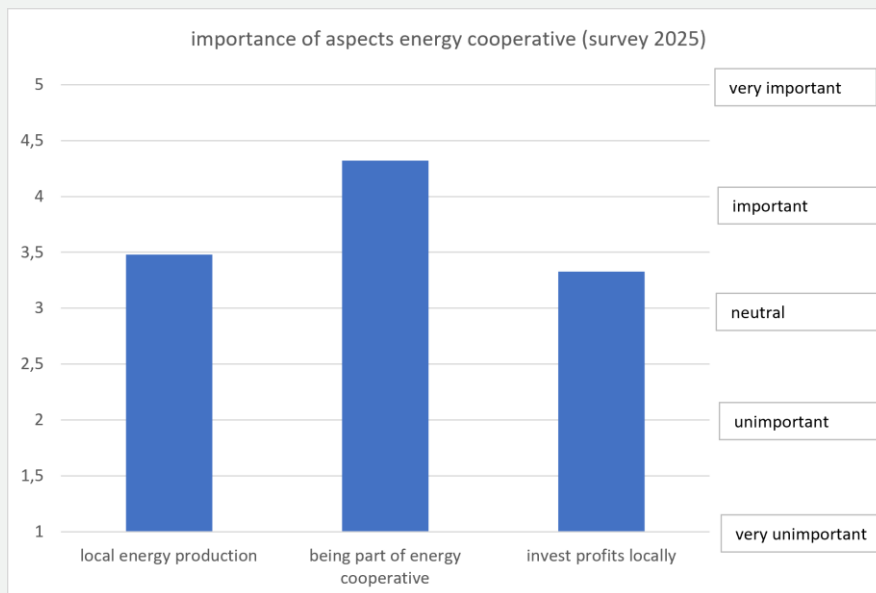


Figure 21 Importance of three different aspects related to the energy cooperative (survey 2025).

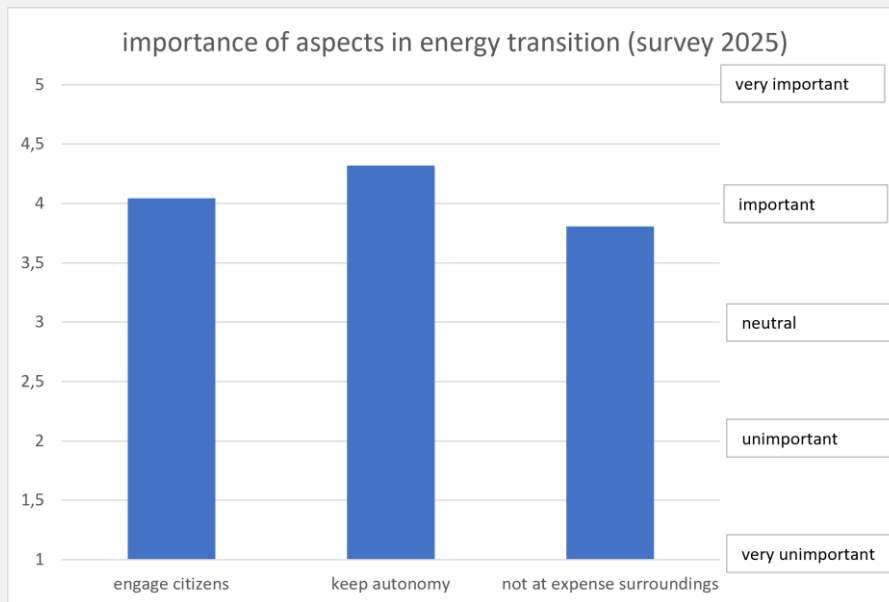
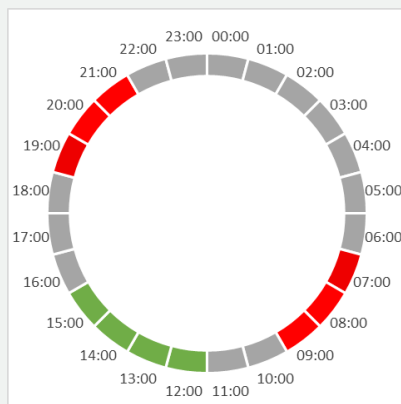


Figure 22 Importance of three different aspects related to the energy transition (survey 2025).

## Changing (energy) behaviour

Use case 6 was aimed at discovering the impact of behaviour change as a means to alleviate the effects of the home batteries on grid congestion. Inhabitants were invited to participate by means of an EnergieKansen newsletter, followed by a townhouse meeting. Altogether 26 households participated in this use case, among which 5 of the participants with a battery. As described earlier they were asked to use energy preferably at moments that there was a surplus of solar power and prevent using energy at moments of high demand. They logged the changes in their behaviour in a logfile, adding the effort it costed them to make the change.



On average every day of the six-week period of use case 6, half of the households managed to change their behaviour (figure 21). The actual behaviour changes they realised were very manifold, ranging from not boiling water for a cup of tea, through changing the time (and thus preparation) of dinner to changing loading an EV. In the analysis only the fact that they changed their behaviour is taken into account, not what the change consisted of.

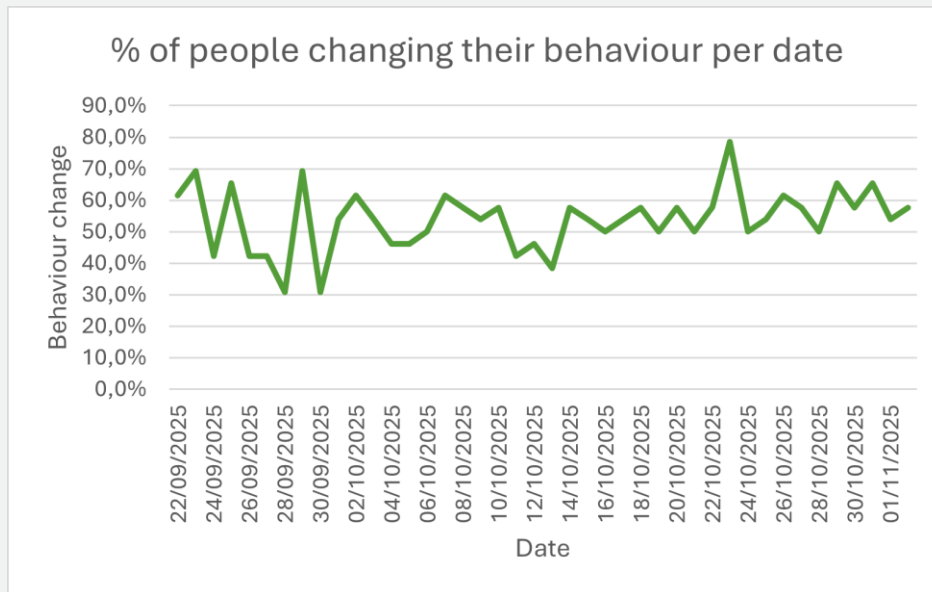


Figure 23 Percentage of the participating households in use case 6 that managed to change their behaviour, per day of the six-week period.

As can be seen from figure 23, the percentage remained relatively stable over the six-week period (actually increased slightly), indicating that the people were quite persistent in their effort. The people that did not change their behaviour indicated that sometimes they just did not feel like it, but predominantly that was due to other factors such as that they were not at home or that they already changed their behaviour prior to use case 6 and already aligned their behaviour with the red-grey-green clock.

Changing the behaviour did not require a lot of effort, on average the effort was 1,48 on a scale from 1 to 10. Most changes were indicated to be almost effortless (score 1), a small amount of changes were a bit more effortful (score 2), and scores above 2 were hardly ever given (figure 24). This might indicate that either changing behaviour was easy for them, or they chose to only make easy changes and let more difficult to change behaviour unchanged. It is save to conclude that asking people to bring their behaviour in accordance with the momentary load of the grid, did not place too much of a burden on them. However, when distinguishing between behaviour changes during green periods (when there is an abundance of solar energy) and red periods (when there is a large energy demand), showed that changing behaviour was more effortful during red periods (figure 25). This indicates that it is more effortful to postpone energy behaviour (not use energy) than to perform energy behaviour when they normally did not (use energy). This also showed from the fact that only 2,7% of the reported behaviour changes concerned red periods.

### Effort to change behaviour in general.

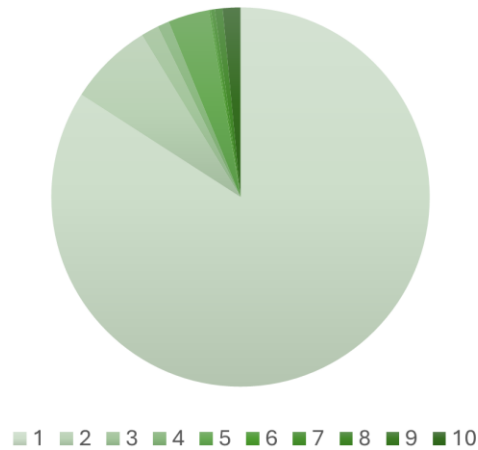


Figure 24 Proportion of reported effortfulness of the behaviour changes.

### Effort to change behaviour for respondents opting for behaviour in red periods.

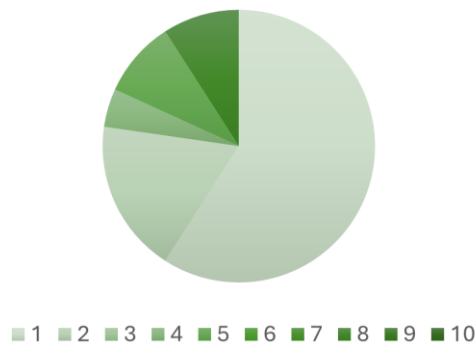


Figure 25 Proportion of reported effortfulness of behaviour changes during 'red periods', when demand is high and energy usage was required to be prohibited.

From the behaviour change pilot it can be concluded that the Ansen residents were on average quite willing to change their behaviour. They managed to do so on half of the days and it costed them little effort and they managed to keep that performance steady over six weeks of time. They mainly started to use energy at moments that they normally would not and there is a surplus of solar power. Postponing energy use at moments of high demand proved to be more difficult, or at least much less performed. The impact on the grid depends on the actual behaviour changed, which was not analysed. A frequent change during red hours was postponing charging of an EV, which is very impactful on the grid, so these much rarer changes still might have had a substantial effect.

## 6.3 Co-Design Workshop with EnergieKansen Residents

### Approach and Design

The co-design workshop with members of EnergieKansen (eKa) was designed to translate the technical results of the pilot into a social reality — to ask, in effect, what governance, financial, and operational model would make the full-blown smart “energy community” scenario workable for the people who would actually live inside it.

The workshop used a serious game methodology — the “Ansen 2030-‘35 Challenge” — in which participants were invited to assemble the design the model themselves, based on a series of choices. The game presented a hypothetical, but reasonably realistic near-future scenario in which the ongoing energy transition had increased the flexible capacity of the village but also pushed the grid to its limit. The community must decide how to move forward. Participants worked through three phases:

- **Fase 1: Path choice** — choosing between a more passive business-as-usual role and a more transformative, active "Energy Community" role, with the associated differences in ambition, complexity, and risk
- **Fase 2: Internal design** — deciding how costs and benefits should be distributed among members, and what governance structure should manage the system
- **Fase 3: Scale and partnership** — exploring how the community might collaborate with other coops in the region, and what it would require from Enexis as a partner

The workshop was structured around four questions that the NO-GIZMOS pilot had revealed as unresolved: the *value question* (what are we doing this for and why?), the *fairness question* (how do we distribute benefits equitably?), the *governance question* (who runs this, and how do we stay in control?), and the *scale question* (how big do we want to get, and with whom?).

Three groups of 6-7 eKa members participated in the November 2025 session, each at their own table and two facilitators to moderate and record the answers. Each tabled worked towards their own design canvas, based on their choices in each phase.

## Findings

### Values: autonomy drives, finance gatekeepers

Participants were motivated above all by a desire for greater energy independence. Solar panels were described as "a step toward self-reliance," and the Energy Hub represented the logical next step in that journey: *"wij hebben ook zonnepanelen om ook onafhankelijker te zijn van allerlei maatschappelijke ontwikkelingen en bij te dragen aan verbetering. En dit is weer een stap verder"* ("we also have solar panels to be more independent of all kinds of societal developments and to contribute to improvement. And this is another step forward"). The aspiration is not to go off-grid — participants understood their batteries remain grid-connected — but to reduce dependence on large, impersonal energy suppliers and to keep energy local and legible.

However, the workshop also produced a clear and sober corrective to purely idealistic framing. One participant stated bluntly:

"Als het **niet** financieel trekkelijk is, doet niemand het. Je moet duidelijk van tevoren aan kunnen leveren. Ja, met voordelen of met zekerheid genoeg" (*"If it isn't financially attractive, nobody will do it. You need to be able to show clear advantages or sufficient certainty upfront"*).

The group's consensus was that values are the *driver* of participation, but financial viability is the *gatekeeper*. The business case does not need to be maximised — residents explicitly said they were not seeking to 'profit', per se — but it must be positive, relatively predictable, and with a safe floor over a realistic time horizon.

### Fairness: the combination model as social glue

One of the most consequential discussions in the workshop concerned how the benefits of the system should be distributed among members. Three models were on the table: equal distribution regardless of contribution; merit-based distribution proportional to invested assets; and a hybrid combination model blending the two.

The pure solidarity model — equal shares for all — was rejected on practical grounds: it removes the incentive for individuals to invest in batteries or solar panels, creating a free-rider problem. The pure meritocracy model — full proportional reward for investment — was rejected on social grounds: it would exclude members with lower incomes or assets, undermining the cooperative's community character.

The combination model emerged as the only viable resolution: a solidarity base (a basic benefit for all members) topped up with a merit bonus for those who

contribute assets. The group was explicit that the appeal of this model was not its mathematical precision but its social function:

"het voordeel hiervan is dat iedereen zich er makkelijker in kan vinden. Omdat je aan alles tegemoet komt" (*"the advantage is that everyone can more easily accept it, because it meets everyone's needs"*).

Equally important was the insistence on radical simplicity in how benefits are communicated. Complex optimisation in the underlying algorithm is acceptable; the interface with members must be transparent and comprehensible at a glance. As one participant put it:

"Het moet gewoon simpel. Simpel uitlegbaar. Anders ga je over eerlijkheid communiceren. Dat gaat nooit werken" (*"It just needs to be simple. Simply explainable. Otherwise you end up arguing about fairness, and that will never work"*).

A financial model that participants cannot explain to their neighbours is not just an inconvenience — it is a social risk that opens the door to distrust and internal conflict.

### **Governance: professionalise without losing control**

Participants recognised — sometimes reluctantly — that an active energy community role is incompatible with a purely volunteer-run organisation. A 24/7 energy service requires professional management, contractual accountability, and legal capacity that the current cooperative structure does not have. As one participant noted:

"Dan is het geen vrijwilligerswerk meer. Dan komen er ook mensen in dienst en daar moet ook betaald worden" (*"then it is no longer voluntary work — staff need to be hired and paid"*).

But professionalisation is only acceptable under strict conditions. Participants feared that hired professionals would "go their own way" rather than following the direction set by the membership. The model they wanted was professional capacity as a service and safeguard — a "professional organisation on the side that supports and advises" — not as a replacement for democratic member governance. The cautionary scenario, consistently referenced, was to become "another Essent": a large, complex energy company that has grown beyond the reach of its members.

## Scale: federation as the only acceptable model

The scale question produced some of the most animated exchanges. All groups recognised that a single village's battery capacity may be insufficient for meaningful medium-voltage grid services, and that some form of aggregation with neighbouring communities might eventually be necessary. But the prospect of merging with other cooperatives was unanimously and firmly rejected:

"dan krijg je een soort melkvee operatie waar mensen uit gaan stappen" (*"then you get a kind of dairy-farm operation where people will walk out"*)

This was a pointed reference to the well-known large, nominally democratic agricultural cooperatives like Campina.

The resolution was a federation model: local communities retain their legal and operational independence (their "front office") but pool resources, knowledge, and technical infrastructure through a shared "back office" — *"individueel blijven als corporatie van Ansen en toch je kennis delen met anderen"* ("to remain individual as the Ansen cooperative and yet share your knowledge with others"). Scale for service delivery, autonomy for community identity.

This is not a compromise born of pragmatism alone. It reflects a deeply held principle: the value of a cooperative lies precisely in its human scale and local accountability. Growing beyond the point where members can still behold (*overzien*) the organisation — literally, see over it and grasp it as a whole — is treated as a categorical loss, not merely a trade-off.

## Three Structural Tensions

Beneath the workshop's outcomes lie three structural tensions — points where the community's stated values come into conflict with each other, requiring explicit choices or creative compromises. These tensions are not resolved by the findings; they are the challenges that the recommendations must address.

**The values–finance paradox.** Residents are motivated by community values and autonomy, but set hard financial conditions for participation. These are not inherently contradictory — a guaranteed base income that is modest but predictable could satisfy both — but they require a business model design that does not yet exist for community flexibility services in the Netherlands.

**The free-rider tension.** The combination model resolves the immediate conflict between solidarity and meritocracy, but does not eliminate the underlying dynamic. Any system that rewards investment will create tension over time with non-investing members who benefit from the collective, but investment cannot

fairly be the only basis for benefits. Governance mechanisms that manage this explicitly — clear rules, transparent accounting, regular democratic review — will be essential for long-term sustainability.

**The scale paradox.** People might be willing to join up with other coops in the region to bundle their flexibility assets, but at the same time, they value their coops because it is local and they can trust it to serve their interests. Distrust in large, impersonal and often commercially driven parties drives a certain hesitation towards the idea of federation. In addition, another fear of scaling up and raising one's ambitions come from people's recognition that certainty on e.g. pricing policy is highly dependent on (inter)national politics and policy development and therefore cannot be guaranteed in the long run.

### Summary of the Community's Mandate

Taken as a whole, the co-design workshop suggests that energieKansen's members are willing — and in some respects eager — to pursue the active Energy Community model, but under clear conditions. Their mandate can be summarised as follows: the community wants to professionalise and scale, but only with financial predictability, governance support that does not displace member control, a fairness architecture it can explain simply to its members, and a federation structure that enables collaboration without merger.

In the workshop's own words, **the community** is deliberately "not going to the casino." It is **risk-averse, cost-conscious (rather than profit-maximising), and oriented toward collective and local benefit rather than individual financial return**. These are not obstacles to be overcome; they are design parameters that define the shape of the business model, governance structure, and DSO partnership the recommendations are intended to specify.

## 6.4 Roadmapping Workshop with Enexis Innovation

### Context and Participants

On 9 December 2025, the NO-GIZMOS team met with five members of Enexis' Innovation team — representing strategy, operations, regulatory affairs, and technical expertise — to evaluate the community partnership model from the DSO's perspective. The session was structured around three questions: Does the NO-GIZMOS proof of concept represent a credible option for Enexis? What would Enexis need from an energy community to enter into a flexibility partnership? And what innovation trajectory would allow this model to be developed and tested at scale?

The discussion built directly on the technical results, exploring their implications for Enexis' operational, regulatory, and organisational context. The findings from this session are treated as substantially complete.

### What Enexis wants from the model

The workshop opened with a clarification of what Enexis would seek to achieve through a community partnership. Three goals emerged as primary.

**Efficient grid utilisation.** The core operational goal is to use the collective assets of an energy community to balance supply and demand locally, before flows reach the MV grid. In Enexis' framing, this is about making the most of existing infrastructure before resorting to new physical capacity. As one participant summarised: "*Het net zo efficiënt mogelijk benutten*" ("Using the grid as efficiently as possible") — energy within the neighbourhood, using the collective.

**Better citizen–grid operator relations.** Several participants noted that the relationship between Enexis and its customers is under strain — a product of congestion delays, curtailment measures, and the perception that the grid is managed in opaque and at times arbitrary ways. A structured partnership with an energy community, in which the rules are transparent and the benefits mutual, was seen as an opportunity to rebuild a more collaborative and trusting relationship from both sides.

**Activating the flexibility potential of energy communities.** The pilot demonstrated that community battery assets represent a real, if currently modest, source of flexibility. The question for Enexis is how to unlock this potential at scale — across multiple communities, with standardised contracts and predictable service levels — while also meeting the new Energiewet obligation to enable energy sharing.

### Requirements and Conditions

**Commitment and accountability.** The Enexis team was clear that any partnership model must be built on firm commitments: communities must be able to "sign on the dotted line" and demonstrate delivery against agreed service levels. A voluntary, best-efforts arrangement is not workable for Enexis' operational planning. This creates an immediate challenge for small, volunteer-run cooperatives, and it underscores the community's own recognition that some degree of professionalisation is a precondition for partnership.

**Transparency even where certainty is impossible.** An important nuance emerged from the discussion of contractual stability. Enexis representatives acknowledged that they cannot guarantee tariff stability over the long term — new

network tariffs are in the pipeline, and their precise impact on community business cases is uncertain. But they emphasised that transparency about uncertainty is itself a form of reliability: communities should know what is knowable, and be told clearly when stability cannot be promised. This is a different kind of assurance from the guaranteed base returns that communities are requesting, and bridging this gap is one of the key challenges for contract design (and might need intermediate steps of building mutual trust).

**Organisational complexity within Enexis.** One of the most candid contributions to the workshop was the acknowledgement that Enexis is not a unified actor with a single view of community partnerships. As one participant put it: *"Je zit met 4 mensen in een project, maar er werken 7000 mensen bij Enexis"* ("you have 4 people in a project, but 7,000 people work at Enexis"). The innovation team's goals do not always align with operational planning departments. A concrete illustration arose during the session: in a neighbouring pilot, a grid reinforcement was carried out without notice in a neighbourhood where a community group was trying to demonstrate that reinforcement could be avoided — a straightforward act of maintenance from one department's perspective, a contradiction of the partnership from another's. This internal complexity is not merely an implementation detail; it is a structural risk for community partnerships that depend on coordinated and consistent DSO behaviour over time.

**Compensation and contract models.** The workshop explored several existing contract types as potential frameworks — including Grid Transport Contracts (GTOs) and Capacity Bandwidth Contracts (CBCs) — as the basis for compensating communities for flexibility services. The group's conclusion was that existing instruments provide useful reference points but require adaptation to the specific context of community-level flexibility. Relevant analogies were drawn to the Alliander "energy budget" proposition for new residential developments and to experimental frameworks for aggregating small consumers. The group noted that routing aggregated flexibility through a cooperative or similar local coordination point would be significantly more effective than aggregating individual households directly. The step-by-step approach was strongly preferred: test existing contract models with a small number of cooperatives, verify delivery, refine based on experience, and then standardise.

### The Innovation Trajectory

The roadmap discussion produced broad agreement on an innovation trajectory characterised by progressive learning rather than immediate scale. Its key features were as follows.

The process should start with two or three existing cooperatives with sufficient organisational maturity to co-develop the model under real conditions — communities that can make and keep commitments, and from which generalisable lessons can be drawn. The approach should build on existing contract frameworks rather than designing from scratch, identifying which elements of GTOs, CBCs, and related instruments can be adapted for community flexibility services.

Professionalisation of community capacity should be treated as a process, not a precondition: communities should be allowed to develop their governance and operational capacity progressively, gaining experience as they go, rather than being required to be "ready" before engagement begins. The innovation trajectory itself is part of the capacity-building journey.

The key unresolved institutional question — what role the energy supplier should play in a community partnership (whether the cooperative acts as a licensed supplier, a third-party intermediary, or through some other arrangement) — was identified as a priority for regulatory and commercial clarification. The Enexis team noted that the new Energiewet's requirement to enable energy sharing makes this question urgent, and saw the innovation trajectory as an opportunity to influence how that requirement is implemented.

A number of specific open questions were identified for further development and for discussion at the final project event: how should grid contributions be verified without imposing an excessive monitoring burden on communities? What role can in-kind compensation play — for example, priority grid connections for communities that provide flexibility? And how can the model be designed to prevent first-mover advantage or the capture of community flexibility services by a small number of large actors?

## **6.5 From Engagement to Recommendations**

The three engagement strands point toward a consistent set of conclusions that the recommendations in the following chapter are designed to address.

From the community side, the primary signal is that residents are willing to commit to a more active role in grid support, but on specific conditions: financial predictability (not profit maximisation, but a guaranteed and simple base return); governance support that does not displace member control; a fairness architecture simple enough to be explained and defended within the community; adherence to environmental and community values; and a federation model that enables scale without merger. Without these conditions, the community's risk appetite is too limited to absorb the complexity and investment that Solution B requires.

From the DSO side, the primary signal is that Enexis' innovation team regards the community partnership model as credible and worth pursuing, but that the conditions for a durable partnership — standardised contracts, organisational alignment within Enexis, and a clear regulatory framework for energy sharing — are not yet in place. The innovation trajectory proposed in the roadmapping workshop represents a practical path toward assembling these conditions incrementally.

These two sets of conditions are not contradictory. They are, in fact, mutually reinforcing: communities need the stability and support that only a committed and capable DSO can provide; DSOs need the organised, accountable community capacity that only a properly resourced cooperative can deliver. The disconnect lies not in the goals but in the current absence of the institutional infrastructure — governance templates, federated contracting models, standardised interfaces, and transparent compensation frameworks — that would allow both sides to commit.

The recommendations that follow are designed to help create that infrastructure, building on what the technical results have proven possible and translating the social engagement findings into a practical roadmap for the next phase of development.

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## Chapter 7: Recommendations

The NO-GIZMOS project set out to test whether coordinated household batteries could resolve grid congestion at the medium-voltage level. They can. The pilot in Ansen demonstrated technical viability: a community-based virtual power plant can reduce MV peaks meaningfully, and doing so without sacrificing local grid stability or battery profitability is achievable — provided the two are combined rather than treated as alternatives.

What the technical results could not settle, however, are the conditions under which this model becomes sustainable and scalable. Those questions were put to our direct stakeholders through the co-design workshop and structured roadmapping session described in the previous chapter. They revealed consistently that the model is deemed credible and worth pursuing, but it requires institutional infrastructure — governance templates, compensation frameworks, standardised interfaces, and regulatory clarity — to become operational.

Importantly, the institutional landscape is quite dynamic. The Energiewet (effective January 2026) provides energy communities with a formal legal status and new market access rights. The congestion management platform GOPACS has lowered its minimum participation threshold to 100 kW — achievable for aggregated home batteries. New contract types are emerging: the Capaciteitsstuuringscontract (CSC) is designed specifically for battery systems, the Groepscapaciteitsbeperkingscontract (G-CBC) enables collective participation in congestion management, and the Groepstransportovereenkomst (GTO) allows groups to share transport capacity structurally. These instruments provide institutional anchoring for the direction we recommend. They do not, however, resolve the practical barriers that prevent residential energy communities from accessing them.

The recommendations that follow are designed to chart the direction of travel and identify what needs to happen — in terms of contract design, organisational capacity, technical standards, and social engagement — for the model we validated to become replicable. Our recommendations are addressed to energy communities, DSOs, regulators, and policymakers, and are organised in strategic, financial, institutional, technical and social dimensions.

### 7.1 Prerequisites for Successful Implementation

Before any cooperative embarks on a trajectory to implement the solution that we advocate, a sanity check is required. Our experience suggests that the NO-GIZMOS

approach cannot be rolled out universally, but will work only under specific conditions. Without the following foundational elements, the technical implementation is likely to fail due to social, regulatory or economic friction.

**Critical grid urgency.** While grid congestion is increasingly common across the Netherlands, the community must experience it as a direct, tangible local problem — such as connection delays, inverter curtailment, or inability to connect new solar installations. In Ansen, the concrete threat of "not being able to connect new solar" or "inverters tripping" provided the necessary urgency to mobilize residents. Without this shared, locally-felt problem, the willingness to accept the complexity of collective battery coordination — and the associated opportunity costs — diminishes significantly. A purely financial business case is currently too thin to sustain motivation without this infrastructural necessity. Similarly, the DSO must face sufficient operational pressure in the area to justify engaging with novel solutions. Given widespread congestion conditions across the Netherlands, this should be an easy prerequisite to meet for most DSOs.

**Sufficient organizational capacity.** The presence of capable coordination — whether through dedicated volunteers, paid staff, or external support mechanisms (e.g., energy supplier outreach programs) — is essential for long-term success. The complexity of the system can breed uncertainty among residents. Trust in the technology is often mediated by trust in a local person who can explain it simply. Furthermore, the energy community must have a level of organizational maturity that goes beyond enthusiasm; they need the governance structure and human resources to handle contracts, data privacy, and member liabilities.

**Digital readiness.** The technical validation of providing MV grid support proved that historical data (weeks old) renders flexibility less effective for regional peak shaving. A hard prerequisite for the DSO is the capability to share near real-time grid data with the aggregator. If the local grid lacks the telemetry — such as near real-time measurement devices or accurate forecasts (like DALI boxes in the NO-GIZMOS project) — to provide this information, the community cannot effectively steer assets to address grid problems. Additionally, household connections must have smart meters with active quarter-hour allocation to be eligible for aggregated participation in congestion management.

**Standardized protocols.** For the NO-GIZMOS solution to be implemented at scale, it will be crucial that flexible, steerable energy assets use a standardized communication protocol. It is not practical to develop unique communication software for every device. Rather, devices must be standardized such that they can all be controlled by the same software.

## 7.2 Recommendations

These recommendations represent the critical path to enabling community-based flexibility. They are drawn from our pilot data and stakeholder dialogues.

### A. Strategic Roadmap

#### **Foundational Recommendation: Combine Local Capacity Management with Regional Grid Support**

*Target/Owner: Energy Communities, DSOs*

Based on the validated results of our pilot, we recommend adopting a layered approach as the model for future community-based grid support. The project started with the hypothesis that household-level assets could solve MV problems, but our results show that combining two modes of operation is more effective than either alone:

1. **Local Capacity Management:** Implement automated logic that ensures community energy trading never violates local grid limits. This model in itself allows an energy community to save on its daily energy costs. However, to address opportunity costs, Local Capacity Management should be met with compensation strategies. The Groepstransportovereenkomst (GTO) — in which a group of parties collectively shares a pool of transport capacity, staying within a shared limit — provides a contractual reference point for this layer. The GTO is currently in pilot phase with several DSOs and will become a mandatory offering from January 2027.<sup>12</sup>
2. **Regional Grid Support:** Layer grid-support logic on top as a paid service. When the DSO signals a regional need (e.g., MV-level peak), the community actively adjusts its baseline behaviour to provide support, in exchange for compensation. The Groepscapaciteitsbeperkingscontract (G-CBC) — in which a group of parties collectively reduces grid usage on request from the DSO, in exchange for a financial compensation —

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<sup>12</sup> The Groepstransportovereenkomst (GTO) is a structural capacity-sharing arrangement in which a group of parties collectively shares a pool of transport capacity on the electricity grid rather than each holding individual capacity rights. At some moments of the day, one party may draw less power, and another has space to step up. Collectively, they stay under a shared threshold. The GTO is currently in pilot phase with several DSOs and will become a mandatory offering from January 2027 per an ACM decision of December 2025. It is currently limited to large-consumption connections (>3×80A); extension to residential communities would require adaptation.

provides a contractual reference point for this layer.<sup>13</sup> Additionally, GOPACS offers further channels: intraday redispatch (where the community provides local load reduction and GOPACS handles the national balancing mechanism automatically) and the new Capaciteitssturingscontract (CSC), which is specifically designed for battery systems and covers bidirectional steering across the full charge/discharge cycle. These instruments offer opportunities for community-based congestion services, but need to be assessed for their applicability to aggregated residential batteries.

This combination addresses a core tension identified in our research: flexibility used to help the grid often comes with an opportunity cost for the flexibility provider. Local Capacity Management protects the local asset (the transformer) at low cost while maintaining battery profitability. Combined with Regional Grid Support, this creates the motivation to compensate communities for providing value at the regional level (e.g., through infrastructure deferral savings).

Pursuing one strategy without the other results in either a potentially profitable model but a lost opportunity to address where the real crunch on the grid is, or a fantastic service provision that is financially unattractive.

**An additional architectural advantage:** *the combination is not merely additive — it is mutually enabling.* The always-on Local Capacity Management logic continuously enforces local transformer limits. This means that when batteries discharge after a Regional Grid Support event (e.g., after charging during a midday solar peak to relieve feed-in congestion), the so-called 'rebound effect' — simultaneous discharge creating a new evening peak — is inherently prevented by the local capacity management layer. Without the base layer, participation in Regional Grid Support carries rebound risk. With it, rebound is managed by design. This makes the layered architecture a precondition for safe participation in congestion services, particularly via intraday redispatch where — unlike in CBC/CSC contracts — the rebound is not contractually managed.

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<sup>13</sup> In a Groeps capaciteitsbeperkingscontract (G-CBC), a group of parties collectively agrees to temporarily reduce its electricity consumption or generation during congestion periods, in exchange for financial compensation from the DSO. The group determines internally which members reduce at any given activation. G-CBC activation occurs day-ahead via the GOPACS platform. The G-CBC is available in the Netcode and has been rolled out from the second half of 2025.

## Organizational model

Energy communities pursuing this approach have two viable paths:

1. *Energy community as licensed supplier*: The community obtains a supplier license under the Energiewet and directly manages energy flows for members. This provides full control over load management and settlement but requires significant organizational capacity that few communities currently possess.
2. *Energy community as intermediary (ESCO model)*: The community acts as aggregator/coordinator between members and their existing retail suppliers, partnering with professional service providers for technical and market operations. This has a lower barrier to entry. The Dutch government is exploring regulatory frameworks that would enable third parties to take on a "local service provider" or "energy sharing organiser" role — intermediaries that could support energy communities in navigating technical and market complexities without requiring those communities to become licensed suppliers themselves.

The NO-GIZMOS solution can function under either model, with different implications for contracting complexity and capability requirements.

## B. Financial & Market Design

### **Recommendation 1: Establish criteria for DSO-community flexibility contracts**

*Target/Owner: ACM (Regulation), DSOs, Policymakers*

Our financial analysis revealed a structural gap: the most grid-friendly behaviours often yield the lowest financial returns for residents due to missed trading opportunities. In addition, residents in our workshop identified a need for financial predictability as a condition for participation. To bridge this gap, DSOs must move beyond passive infrastructure management toward becoming active contract partners with energy communities.

At this time, it is still not possible to define the business model(s) in detail, but based on our experiences, we can provide the outlines. Below, we identify the conditions that workable compensation models must satisfy:

### **Criteria for compensation and contracting models:**

1. *Simplicity for DSOs and communities*
  - a. DSOs need standardized contract packages they can offer without negotiating bespoke terms for each community

- b. DSO contracts should not depend on which retail energy contract (fixed, dynamic, flexible) community members hold with their suppliers
  - c. Administrative burden must be manageable at scale
- 2. *Flexibility over time and location*
  - a. Models must not assume fixed peak hours (e.g., "always 16:00–21:00"): Our Community Coordination Events analysis showed that optimal times shift by season and week-to-week based on solar forecasts and grid conditions
  - b. Instead, compensation should respond to actual grid conditions, not predetermined time windows, to yield most value
- 3. *Compatibility with Dutch energy law and market structure*
  - a. The new Energiewet (effective January 2026) permits multiple contracts per connection point, providing an opportunity to pursue this proposal further
  - b. Flexibility contracts can exist separately from retail supplier contracts
  - c. This legal separation enables DSO-community arrangements independent of supplier relationships
  - d. However, a critical practical barrier remains: the current requirement that all connections in an aggregated flexibility group must share the same Balance Responsible Party (BRP). Since the BRP is typically appointed by the household's energy supplier, this effectively requires all participating households to use the same supplier — which is rarely the case in existing communities. Resolving this constraint, whether through regulatory reform or through a streamlined BRP coordination mechanism for community flex, is one of the most impactful enabling actions available to policymakers
- 4. *Community-level benefits*
  - a. Direct consumer-level (i.e., household level) compensation is likely too small per household and administratively complex to be the primary mechanism
  - b. Benefits should flow to the community organization, which then determines internal distribution (to be democratically controlled)
  - c. Communities that help the grid should see tangible collective benefit (e.g., higher priority for grid capacity allocation if flexibility is provided)

**Why we do not recommend specific payment models at this stage:**

During our stakeholder workshops, several compensation approaches were discussed. Each has trade-offs:

- *Fixed availability payments* (reserving capacity upfront): Simple to administer, but expensive for DSOs and does not reward actual performance. With proper forecasting and asset planning, needed availability can often be produced without upfront reservation.
- *Capacity-based tariffs* (as used in Belgium, based on monthly maximum power usage): Offers simplicity and some incentive to shift load, but is imprecise — it does not change from week to week with seasonal shifts or respond to actual grid stress. Our solution, which actively adjusts flexibility actions with current data, gains little from a static peak-based tariff. In addition, in the Netherlands, this DSO-level compensation does not play well with supplier-level tariffs.
- *Event-driven payments* (compensation per activation): This is the model closest to how Regional Grid Support would work under a G-CBC or via GOPACS redispatch. It is more efficient than fixed availability payments because DSOs pay only for actual service delivery. As a standalone model, event-driven payments are incidental and therefore insufficient to provide baseline financial predictability — which is why we recommend them as a complement to Local Capacity Management, not as a replacement.
- *Guaranteed rate-of-return models* (analogous to wind project funding structures): Could provide financial certainty, but regulatory frameworks for applying this to community flexibility services do not yet exist.

### **Existing contract types as reference points:**

- Groepstransportovereenkomst (GTO): Structural capacity sharing relevant to Local Capacity Management. Currently in pilot with several DSOs; mandatory from January 2027.
- Groepscapaciteitsbeperkingscontract (G-CBC): Event-driven congestion management relevant to Regional Grid Support. Available in the Netcode; being rolled out.
- Capaciteitssturingscontract (CSC): Battery-specific bidirectional steering contract, new in 2025/2026. Covers full charge/discharge cycle. Currently applied to large-scale battery parks; applicability to aggregated home batteries needs to be explored.
- GOPACS redispatch: Intraday market-based congestion relief. The local action (e.g., batteries absorbing surplus) solves congestion; GOPACS handles national balancing automatically through counter-bids. Minimum bid threshold of 100 kW is achievable through aggregation. The Netcode allows kleinverbruik connections with smart meters to participate in aggregated groups via a CSP.

## Open questions for further development:

- How should compensation scale with actual grid benefit delivered?
- What verification mechanisms confirm compliance without excessive monitoring burden?
- How can network tariff structures (as distinct from direct payments) create appropriate incentives?
- What role can in-kind compensation play — for example, expedited grid connections for new community assets? (Current non-discrimination rules may limit this, but regulatory sandboxes could explore it.)
- How can the same-BRP requirement for aggregated groups be resolved or circumvented for community flexibility?
- How to prevent first-mover advantage or monopolisation of grid services?

These questions are proposed for stakeholder discussion at the final project event (see Appendix 3).

## **Recommendation 2: Develop understandable and meaningful value propositions**

*Target/Owner: Energy Communities, Aggregators*

During the co-design workshops, residents consistently rejected complex financial models. Even if an algorithm optimizes perfectly, the lack of transparency generates suspicion ("Who is really profiting from my battery?").

The recommendation is therefore to simplify the value proposition into clear, predictable terms that community members can easily understand. Such accessibility is a practical requirement for scaling beyond technically oriented or innovation-minded participants.

One way would be to create a monthly benefit in exchange for making a defined portion of battery capacity available for grid support. Even if that benefit is generated dynamically, through time-based settlements of kWh shifted, once aggregated, it can then be dispensed individually in predictable, periodic benefits (with a safe margin to community-level payouts or savings), a little like a fixed bank deposit or bonds evens out the returns on money lent the bank through pre-agreed interest payouts.

At the same time, it is not only financial incentives that drive participants. Environmental and community motives are also important, so the value proposition should also address these aspects.

## C. Institutional & Organizational

### **Recommendation 3: Enable federated flex assets for scale without losing local autonomy**

*Target/Owner: Energy Communities, RVO*

A key tension identified in our analysis is between scale and local autonomy. DSOs like Enexis require significant aggregated capacity to make contracting worthwhile (both reliable and impactful) in the case of Regional Grid Support: a single community's battery capacity may be insufficient to materially affect MV-level congestion, whereas pooling capacity across multiple communities tied to the MV grid could. However, residents in our workshop strongly valued local autonomy and community action, and resisted merging into large, impersonal entities.

The solution is to formalize federated structures: small local energy communities retain their autonomy and ownership of assets, but they can pool their flexibility into a larger regional vehicle when they offer it to the DSO. This 'pool' can a) act as the single contract partner for the DSO, b) aggregate the volume needed for professional service-level agreements, and c) send out the appropriate steering algorithm for battery operations. In the meantime, local communities maintain their trusted relationships with members.

The current congestion management landscape offers an institutional vehicle for this: the Congestion Service Provider (CSP) role on GOPACS. A CSP is a registered party that offers flexible capacity on behalf of one or more connected parties. Commercial aggregators already fill this role with large portfolios of assets. A regional cooperative umbrella — a second-tier cooperative whose members are the local coops — could pursue CSP recognition and act on GOPACS on behalf of all member communities. Individual cooperatives would not need to become CSPs themselves; they would focus on their comparative advantage of member relationships, trust, and local knowledge, while the regional body handles market access and operational obligations. To our knowledge, no cooperative-led regional CSP for residential energy communities currently exists, but the institutional infrastructure permits it.

When communities federate for Regional Grid Support, the question of grid topology matters. Assets from communities on the same MV cable all contribute effectively to relieving MV-level congestion. Communities on different MV cables may not help each other. DSOs can provide this topology information, and communities should map their shared grid infrastructure before federating.

It is to be determined what such a federation requires in precise institutional form. A mere technical portal for the DSO, a cooperative federation that is home to an ESCo-like aggregator, or something in between, like a contracting party whose sole responsibility is to administer the proceeds for participating coops. RVO could support the development of standard governance templates for this structure to 'federate' energy communities.

#### D. Technical & Data

##### **Recommendation 4: Standardize the DSO–Community interaction model via open standards**

*Target/Owner: DSOs, Standardization Bodies, Technologists*

While access to current data is a prerequisite, the way that data is shared and acted upon must be standardized to make the business case transparent. In NO-GIZMOS, the team had to write custom code to bridge the specific local grid data with the specific community assets. Relying on bespoke adapters for every combination of assets and grid systems would make scaling economically unviable.

We recommend establishing a defined minimum interface standard based on open protocols for the interaction between DSOs, energy communities, and individual steerable assets. This standard should cover three layers:

1. **Technical semantics and protocols:** Adopting open standards like OpenADR (for demand response signals) helps keep an open market for energy assets and software providers, and, conversely, helps prevent vendor lock-in.
2. **Operational protocols:** A clear specification for roles and responsibilities — defining exactly what triggers a Regional Grid Support request, what the required response time is, and how delivery is verified. This is the 'last mile' that no existing institutional framework standardises: how a market signal from GOPACS or a CBC/CSC activation from the DSO is translated into steering instructions for individual household batteries. Our pilot built this logic; it now needs to be codified as a replicable standard.
3. **Contractual frameworks:** The emerging contract types described above (GTO, G-CBC, CSC) provide commercial anchoring. These standardized legal frameworks should be adapted to Local Capacity Management and Regional Grid Support business models respectively, providing commercial certainty for energy communities.

While core protocols should be standardized nationally, specific parameters (e.g., capacity thresholds, response times) will vary by location. DSOs and energy communities should engage in structured dialogue along the roadmap to determine locally appropriate configurations within the standard framework.

**DSO starter guide:** DSOs could develop a starter guide for energy communities covering both organizational and technical requirements. This would lower the entry barrier for new communities and help DSOs maintain implementation consistency across different projects.

## E. Social Engagement

### **Recommendation 5: Make the grid contribution visible to participants**

*Target/Owner: App Developers, Aggregators, Energy Communities*

Our social research highlighted that the automated nature of battery coordination is a barrier to sustained engagement. Residents often felt disconnected from the system (“I don't know if it's doing anything”), which erodes participation over time. Financial savings alone are often too abstract or too small to maintain interest.

To counter this, user interfaces must evolve to show the social and grid value being created, not just the euros saved. We recommend developing feedback mechanisms that communicate collective impact — for example: “This month, your community's batteries reduced peak demand by X kW. We prevented solar panels from shutting down, which resulted in additional solar energy production.”

Making the contribution visible and celebrating collective impact aligns with the strong autonomy and community values we identified as primary motivators for our participants.

**Grid status notifications:** DSOs could provide location-based grid status notifications (similar to KNMI weather codes) that alert communities to high-stress periods. This would enable voluntary coordination during extreme events and give communities visibility into when their contribution matters most.

**Hybrid control approaches (automated + social):** While the Community Coordination Events showed marginal financial gains compared to fully automated approaches, they generated high social cohesion and engagement. We recommend exploring hybrid control logic where automation handles baseline efficiency, but voluntary community events are used for extreme peak-shaving moments. This keeps the community engaged without burdening them with daily management.

## **Recommendation 6: Build and foster social cohesion around the energy transition**

*Target/Owner: Energy Communities*

People are well aware of the challenges regarding the energy transition and that they have a responsibility in solving them. They are willing to live up to that responsibility but need each other to do that. In NO-GIZMOS, we expanded participation in behavioural demand shifting to beyond not only enrolled project participants, but also beyond the coop members. This helped getting and keeping people engaged, to have them inspire each other and support each other. In other words, joint action can provide a means to strengthen social cohesion while simultaneously enhancing the community's capacity to deliver energy flexibility.

Specifically, innovators and early adopters need an opportunity to deploy their knowledge, skills and attitude to both their own and community benefit. They can adopt new technology (also in the future) that will strengthen the energy flexibility approach and that they consecutively can help disperse through the community.

Meanwhile, people who might otherwise not be inclined to engage, either because they cannot easily invest in required technology or lack the type of energy and digital literacy that current-generation smart energy technology requires, could be included by organising additional actions and could further broaden and stabilize the community base.