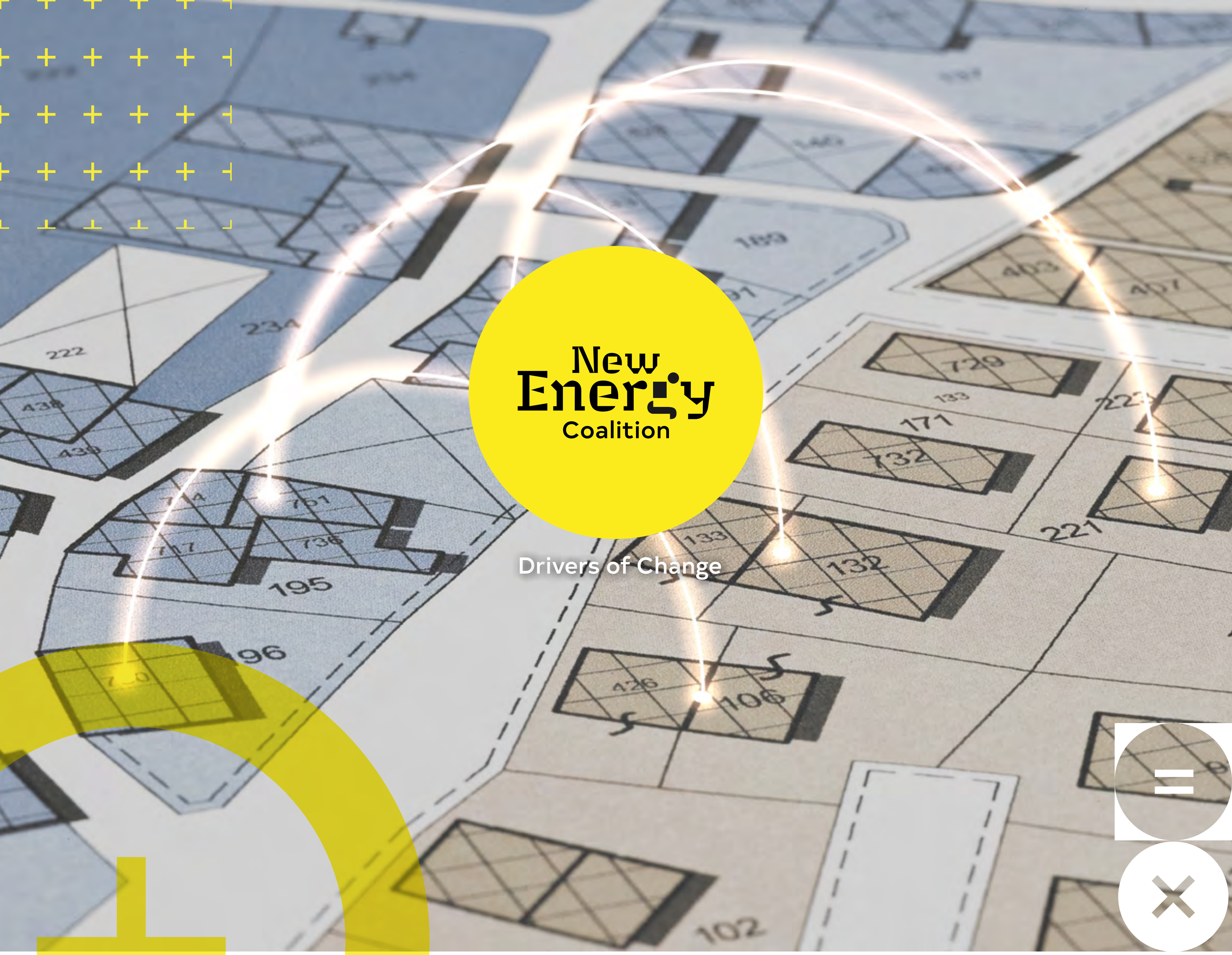

Multisectoral Energy Collaboration in Local Renewable Energy Systems

WHITEPAPER

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Study back-ground

Distributed energy resources have emerged as a solution to involve citizens in local renewable energy production. However, the rapid electrification has outpaced the capacity of existing distribution networks creating severe grid congestion across the Netherlands.

The development of local energy systems (LES) and integration of Battery Energy Storage Systems (BESS) have emerged as part of the solution for the grid congestion challenges, while the new concept of multisectoral energy collaboration, where consumers of different typologies, such as residential and industrial users, collaborate with each other coordinating local renewable energy exchange has shown to improve the LES's efficiency, reducing grid dependency and energy waste, by coupling consumers with diverse demand profiles.

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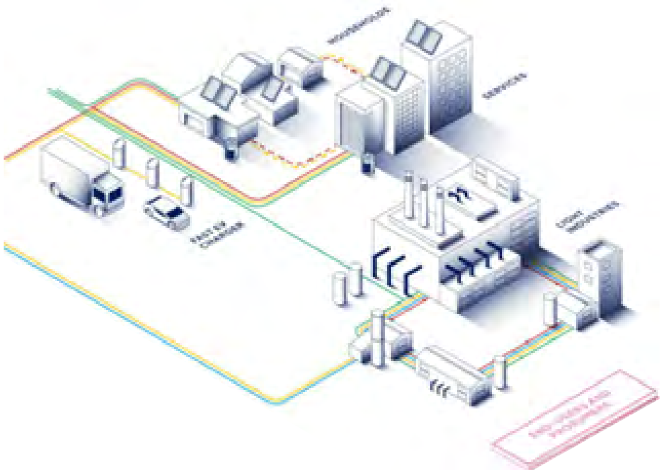
The Research gap and proposed study

Despite the technological maturity, the implementation of multisector LES integrating shared BESS remain underexplored in current research. Most existing studies focus on collaboration among users of similar typology or rely on individual BESS, often overlooking the practical validation and operational constraints that occur in practical applications.

Addressing this gap, Tomás Cardoso, within his Master thesis project, has developed a research on the modelling and assessment of a multisectoral energy collaboration in Heiloo, Netherlands, between a low-voltage (LV) residential area composed of 50 households, from which 10 integrating individual Batteries and Electric Vehicles (EV), and a medium-voltage (MV) industrial park covering 4 companies, an Electric Truck and integrating a 200KW/466kWh building-level shared BESS. Developed under the REFORMERS project, the study explores the technical benefits of direct energy exchange and integration of a shared BESS between two regions integrating different typologies of end-users.



Ultimately aiming to answer to the following research question:

"How does the collaboration between low-voltage residential and medium-voltage industrial networks and the use of a shared battery affect the overall system performance and the planning of a local energy system?"

The Research

The study adopts a four-stage simulation-based methodology to explore the impact of multisectoral energy collaboration in LES. Each stage incrementally builds on the previous configuration to systematically answer the research question and assess the technical performance under realistic conditions.

1. The fist research stage focuses on the current system configuration with the two networks as separate entities. It establishes reference values for the Key Performance indicators (KPIs):
    - Collective Self-Consumption (CSC)
    - Collective Self-Sufficiency (CSS)
    - Net Annual Energy Balance (NAEB)
    - Collective electricity costs.
2. The second stage focus on the networks interconnection and the enabled multisectoral energy exchange. This stage highlights the impact of the networks' energy exchange on the collective KPIs and the reduction in external grid dependency, on an annual and monthly basis.

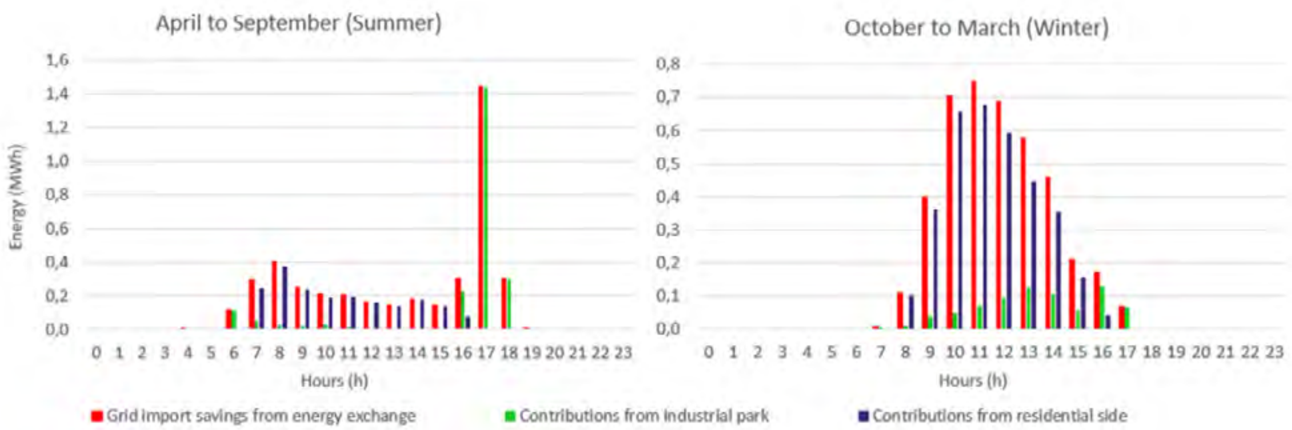
3. The third stage introduces the building-level shared BESS into the local system, located in one of the industrial members. This stage evaluates improvements in KPIs and contributions to grid congestion relief, considering practical implementation constraints such as the power capacity of the BESS host's grid connection capacity.

4. The last stage of the research investigates whether the overall system can meet the performance goals defined by the REFORMERS project of attaining a positive NAEB and over 75% annual self-consumption, under practical technical and spatial constraints. It also estimates the additional infrastructure (PV and storage) required to reach these targets.

Together, these stages provide a replicable and scalable framework to assess urban–industrial energy collaboration. The approach offers valuable insights into how shared infrastructure and coordinated energy management can enhance LES performance in both technical and economic terms.

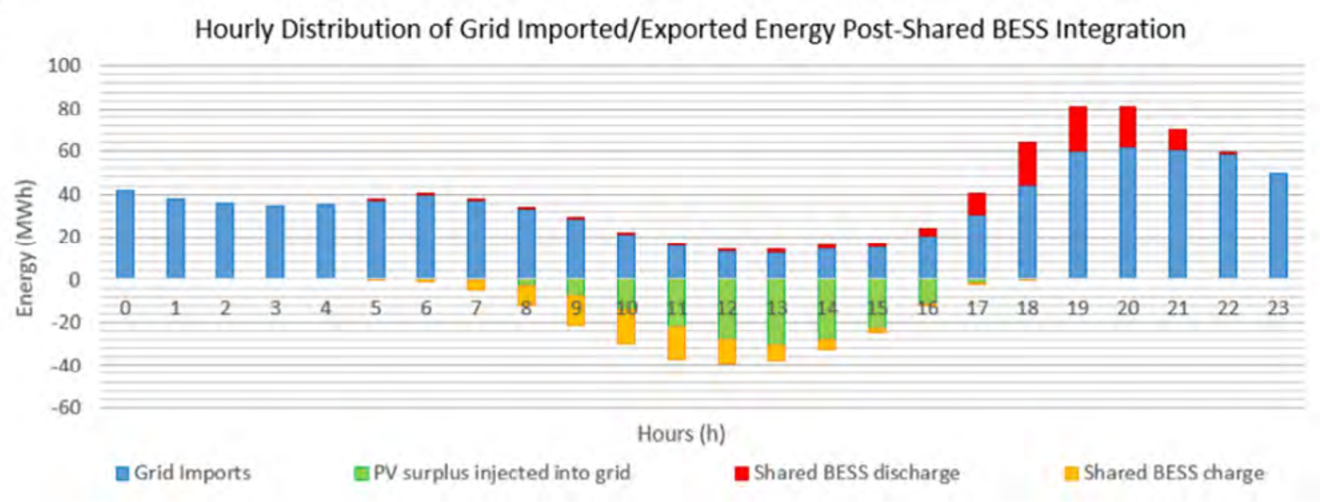
The Results

The case study demonstrated, by comparing results from Stages 1 and 2, that integrating residential users with industrial consumers enables effective use of their complementary demand profiles. This multisectoral setup, combined with the ability to share locally generated renewable energy, led to an increase of approximately 8,3 MWh in local renewable energy consumption. As a result, CSC and CSS improved by 2% and 1%, respectively. While the relative gains appear modest due to the limited scale of the system, the results clearly indicate that multisectoral energy collaboration enhances overall system efficiency and reduces reliance on the external grid.



The integration of a building-level shared BESS, located within one of the low-voltage grid-connected companies, resulted in significant improvements to system performance and operational flexibility. Despite being constrained by the host site's grid connection capacity, the BESS enhanced CSC and CSS by 14% and 7%, respectively. These gains translated into an approximate 10% reduction in combined annual electricity costs for both industrial and residential users.

While the BESS did not directly affect the overall NAEB, it significantly increased system flexibility by enabling the storage of surplus PV generation. This led to approximately 30% reduction in grid imports during peak consumption hours and mitigated PV feed-in to the grid, particularly during the summer months, thereby helping to alleviate potential pressure on the grid during critical hours.



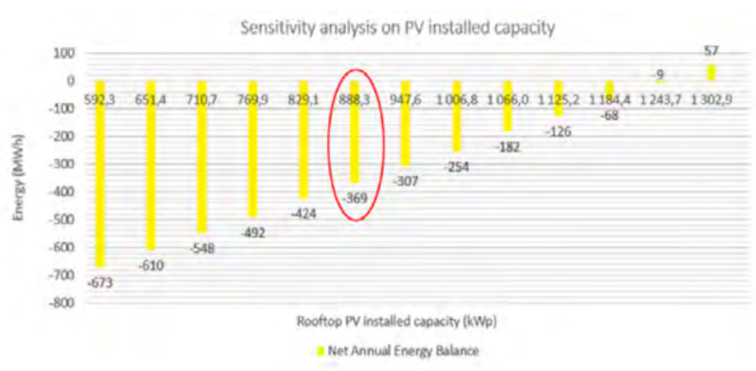
The shared use of the BESS offers not only technical but also significant economic advantages from an investment perspective. By storing surplus energy from multiple sources, the system maximizes battery utilization. Additionally, since residential users face higher electricity tariffs, the value of stored energy increases, amplifying the financial return from the battery system and effectively reducing its payback period.

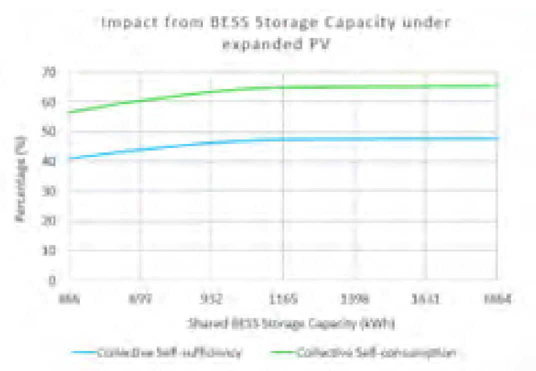
The final stage of the research explored whether the system could achieve over 75% CSC and a positive NAEB. This scenario involved expanding both PV and BESS capacities while accounting for two practical constraints:

- Available rooftop area for PV installations
- Grid connection limits of each participant

However, due to the system's high electricity demand, intensified by the EVs charge and industrial loads, and its reliance on solar PV under Dutch seasonal intermittency, the required PV capacity to fully achieve a positive NAEB proved technically infeasible. Still, with an installed PV capacity of 888,1 kWp, the system achieved a 46% improvement in energy balance compared to the baseline, demonstrating significant progress under realistic deployment conditions.

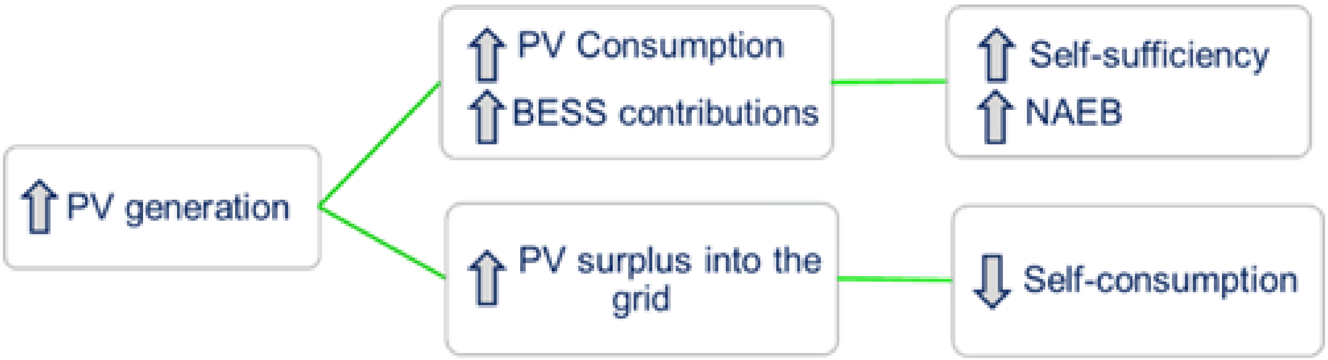
In this scenario, the shared battery storage capacity was expanded to further improve the CSC. While results did show performance gains, the CSC value saturated at 67%, falling short of the targeted 75%.





This limitation was primarily due to the restricted rated power of the BESS, constrained by the hosting company's grid connection capacity. As a result, the battery could not efficiently store the increasing PV surplus during peak generation periods. These findings suggest that locating the shared BESS within a MV grid-connected company, which typically has a higher connection capacity, could allow a more efficient BESS integration and overcoming the observed limitations.

Although most KPIs showed improvement in this stage, the relative gains in CSC were reduced. This was due to the significant increase in PV generation, which resulted in higher excess energy that could not be fully stored under the existing BESS constraints



Key Takeaways

This research presents a strategic pathway for enhancing local energy system performance through multisectoral collaboration and the shared use of battery storage. By integrating residential and industrial networks and co-locating a centralized BESS within the industrial zone, the study demonstrates how energy systems can be optimized for greater efficiency, flexibility, and economic viability.

The main conclusions drawn from the simulation results are as follows:

- Multisectoral energy collaboration significantly improves system performance by leveraging complementary load profiles, increasing renewable energy utilization, and reducing grid dependency. This approach also supports a more effective return on infrastructure investments.
- A shared BESS delivers mutual benefits for residential and industrial users. It maximizes storage utilization and increases the value of stored energy, contributing to cost savings and payback period.
- Achieving ambitious energy autonomy targets requires hybrid configurations, additional renewable capacity, and expanded storage. However, such targets may be constrained by practical limitations like available rooftop space and grid connection capacities.

This work provides a replicable and scalable model for future LES, particularly in urban-industrial mixed-use districts. It also offers valuable insights for policymakers, planners, and investors seeking to align technical feasibility with energy transition goals.

About the Author

Tomás Cardoso is a Portuguese electrical engineer, with a master's degree in the Renewable Energy European Master programme organised by the Association of European Renewable Energy Research Centres (EUREC), specialising in grid integration. His work focuses on the technical aspects of energy systems and the application of proposed solutions. Starting in July 2025, Tomás conducted his thesis research project at New Energy Coalition within the REFORMERS project for a duration of six months.

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