R-E-FLEX

Renewable energy and **E**-mobility as a **FLEX**ibility service

D1.3. Report on impact study

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(DRAFT)

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FPS Economy, S.M.E.s, Self-employed and Energy

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1. Introduction

REFLEX project aims to investigate new technical and business solutions to complete the demand for more renewable energy while supporting the grid and the EV charging. As part of this investigation, the present deliverable (D1.3) focuses on the impact study based on the yearly energy dataset of the first running site provided by Octave.

Section 2 of this deliverable presents this first running site including its description, the yearly energy dataset with the power flow, energy prices, BESS power and SoC and the PV power flow.

Section 3 provides yearly EV charging profile including two single charging sessions using load balancing control.

Section 4 focuses on the impact of different energy systems with qualitative and qualitative analyses. The qualitative analysis provides advantages of EV charging for different players including grid side (DSO, TSO), EV side (EV users, CPOs), other business (e.g. PV, converter and BESS industries), and Environmental and societal benefits.The quantitative analysis provides the impact of grid export but also the benefits of PV and BESS integration.

Section 5 summarises conclusions and future works.

2. First Operating Site

2.1. Site Description

ZuidtrAnt site is the first site that is already running as part of the Reflex's plan to start with one site and then build the rest. The dataset for one year (from 10/09/2024 to 08/09/25) was collected from the Octave platform as depicted in figure 2.1. This platform shows an example of a day without EV charging, and a lot of PV production (216 kW) exported to the grid (171 kW).

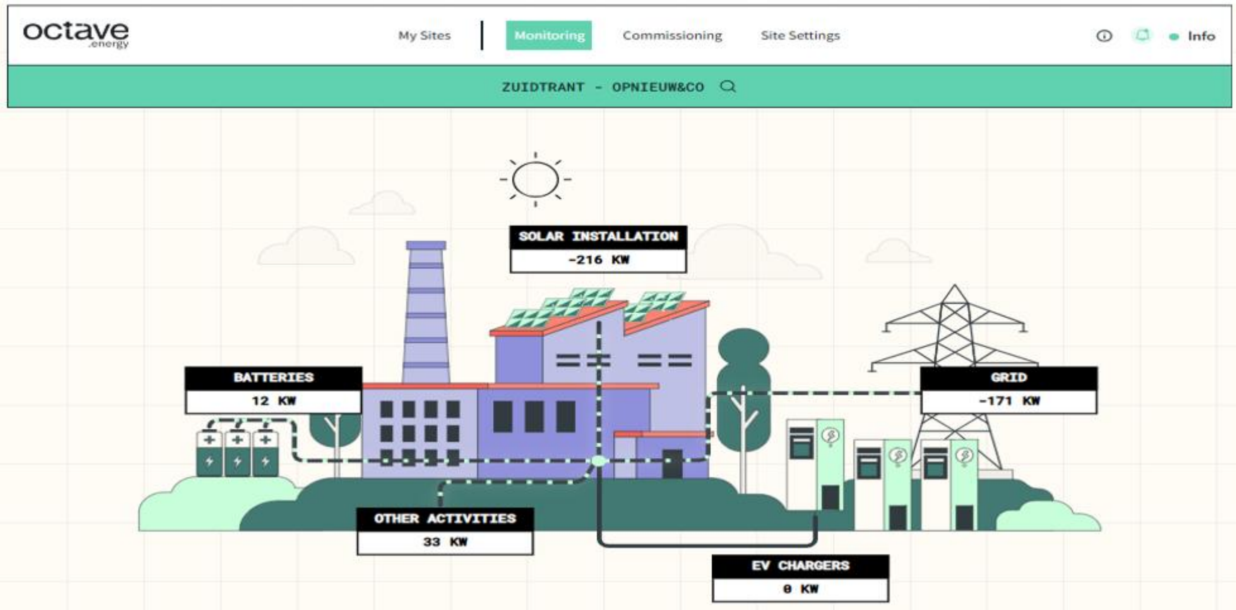
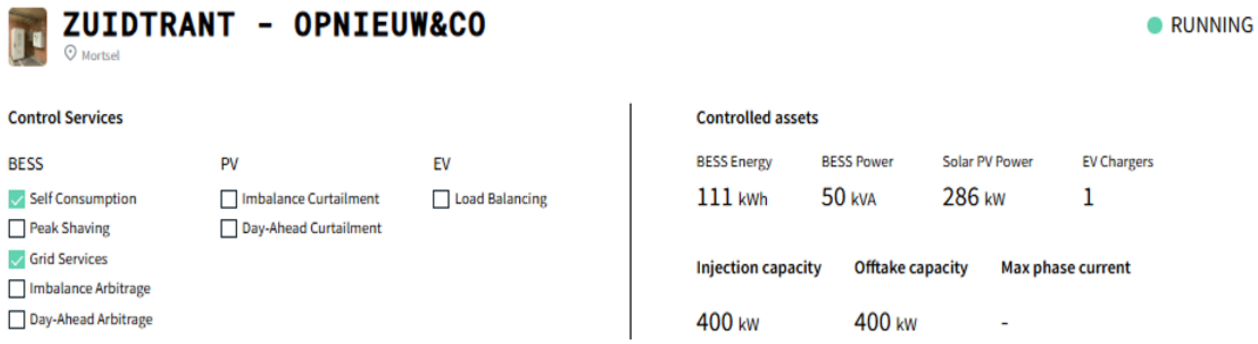


Figure 2.1: Octave platform

Figure 2.2 illustrates the Zuidtrant site which is running with control services across BESS (self-consumption, peak shaving, grid services, imbalance/day-ahead arbitrage), PV (imbalance and day-ahead curtailment), and EV (load balancing). The controlled-asset maximum values include BESS energy 111 kWh, BESS power 50 kVA, solar PV power 286 kW, and 22 kW EV charger. the site's injection and offtake capacities are each 400 kW.



ZUIDTRANT - OPNIEUW&CO

Mortsel

RUNNING

Control Services

BESS
- ☑ Self Consumption
- ☐ Peak Shaving
- ☑ Grid Services
- ☐ Imbalance Arbitrage
- ☐ Day-Ahead Arbitrage

PV
- ☐ Imbalance Curtailment
- ☐ Day-Ahead Curtailment

EV
- ☐ Load Balancing

Controlled assets

BESS Energy	BESS Power	Solar PV Power	EV Chargers
111 kWh	50 kVA	286 kW	1

Injection capacity	Offtake capacity	Max phase current
400 kW	400 kW	-

Figure 2.2: Zuidtrant site

2.2. Yearly Overview

2.2.1. Site Power flow

Figure 2.3 shows the site power flows from Sep 2024 to Sep 2025. As it can be seen, grid export dominates the whole period while the grid import is minimal, appearing only as small positive spikes around late Feb–Mar 2025. The exported power reduces around the season when solar PV production is lower (Nov, Dec, Jan and Feb). The PV systems is integrated into the platform around early March. Overall, the site is a consistent net exporter as the EV load (red) is small, barely affecting the overall balance. This EV charging is further analysed in the following subsection.

Figure 2.3: Site power flow

2.2.2. BESS power and SoC

Figure 2.4 shows the site BESS charge power, discharge power and SoC flows from Sep 2024 to Sep 2025. Until late Feb, the battery mostly charged at 3-12 kW with almost no discharge, keeping SoC around 68-72%. From early March 2025 a new operating mode begins with consistent daily cycling with charge around 10-12 kW and discharge pulses around -5 to -12 kW and occasional larger charge spikes (20-30 kW). The SoC is maintained between 30% to 70 %, indicating different control targets related to the reserve mechanism and ageing. According to Octave, the warranty conditions can be considered to model the ageing (i.e., guaranteeing that the battery will retain minimum 70% of usable capacity after 10 years or 4000 cycles).

Overall, the figure shows a shift from “idle reserve” to active cycling aligned with site operations (e.g., PV), with SoC tightly managed while power stays within the range ±10 kW most of the time.

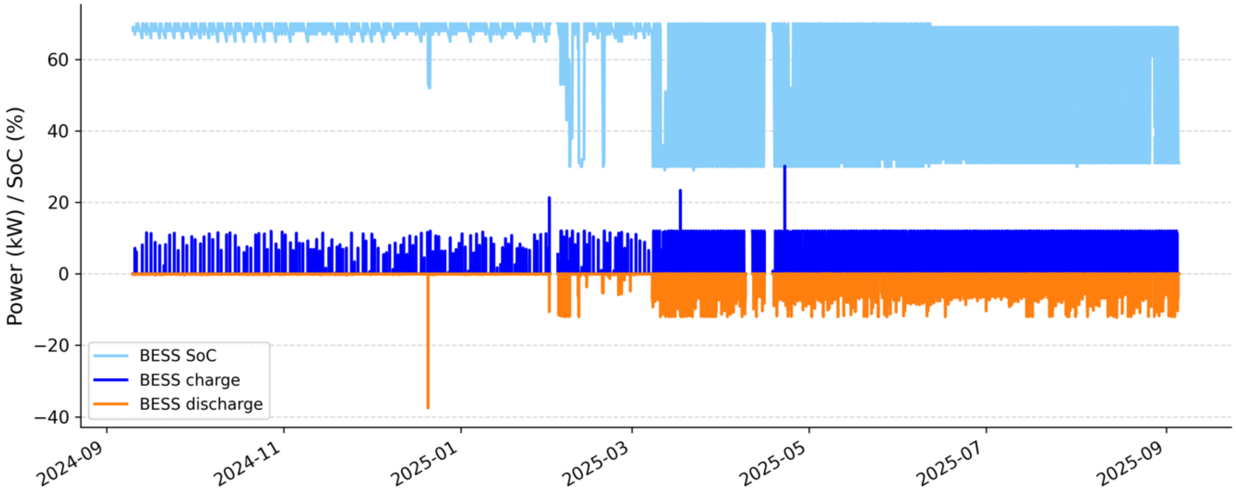


Figure 2.4: BESS power and SoC

2.2.3. Energy prices

Figure 2.5. shows different energy prices including:

Day-ahead price: the hourly wholesale electricity price agreed one day before delivery. It reflects the market’s best forecast of supply/demand. It is mostly around −50 to 200 €/MWh with a few big spikes and some negative hours. This price is used to charge (or shift EV charging) in low/negative hours and discharge/limit charging in high-price hours. It works well for day-ahead optimization with SoC targets and charger limits known in advance.

FCR (Frequency Containment Reserve) price: a capacity payment (€/MW) for keeping the battery ready to automatically inject/absorb power to stabilize grid frequency. It is for being available, not mainly for energy delivered. It is much steadier (25-80 €/MWh equivalent series) than other energy prices. Keeping SoC near mid-range (40-60%) with headroom up/down so the BESS can respond both ways. FCR adds stable revenue with little energy throughput, good for stacking with day-ahead/imbalance when availability rules allow. According to Octave, the battery is delivering FCR up/down in combination with optimization of self-consumption.

Imbalance price: the real-time price applied when actual consumption/generation deviates from scheduled volumes. It can be very high or very negative. The figures shows high volatility once available (Aug–Sep 2025): frequent swings −300 to +400 €/MWh, with extreme negative values (< −800 €/MWh). The control must be designed for opportunistic and fast actions to charge during very negative prices and discharge during very positive prices.

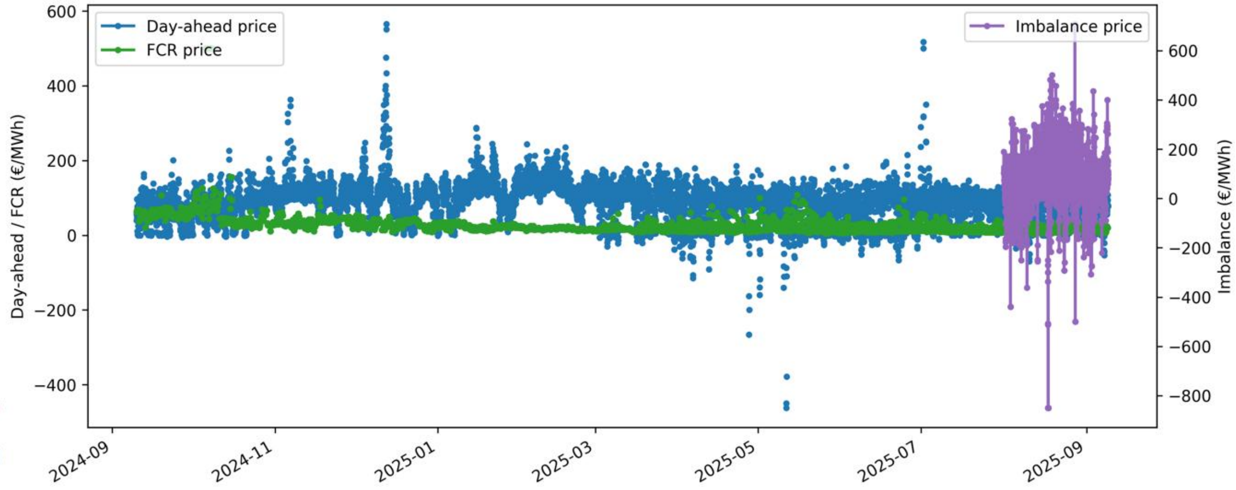


Figure 2.5: Energy prices

2.2.4. PV power flow

Figure 2.6. shows the PV power available which the maximum power that can be generated from that installation. The active power is the actual power produced.

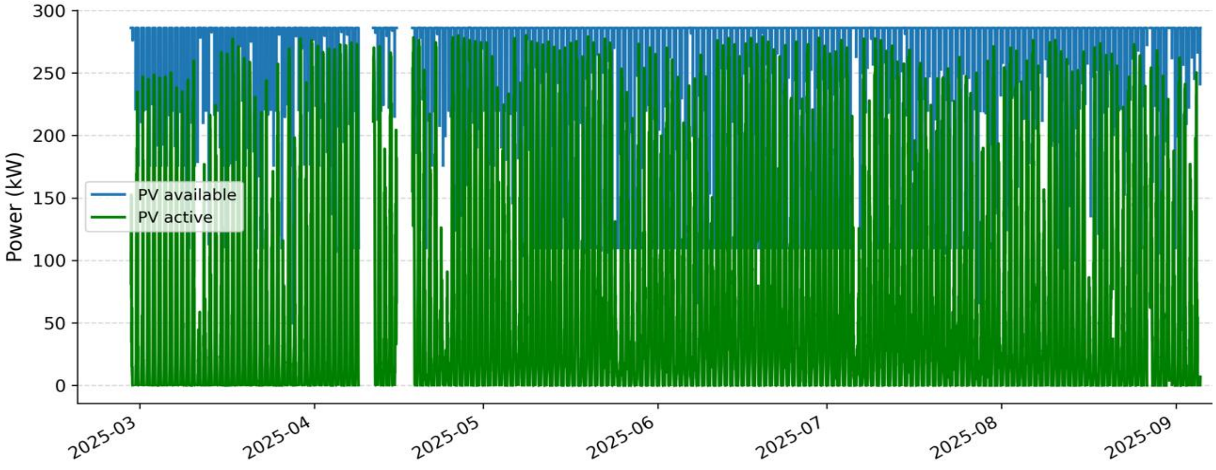


Figure 2.6: PV power flow

3. EV charging

Figure 3.1 shows the EV charging power flow for the period of March to September 2025. Most of the charging sessions were for 22 kW and few 11 kW power levels. This charging power is for now lower compared to the PV production (250 kW), meaning that more cars (almost 10) can be charged using the local energy generation. Single charging sessions are depicted in Figure 3.2 and 3.3. The charging profile illustrated in Figure 3.2 suggests a load balancing control being applied to site energy management system as confirmed by Octave. The charging profile illustrated in Figure 3.3 is a typical charging not controlled by the site management. This charging profile follows the battery charging curve.

Figure 3.1: EV charging power

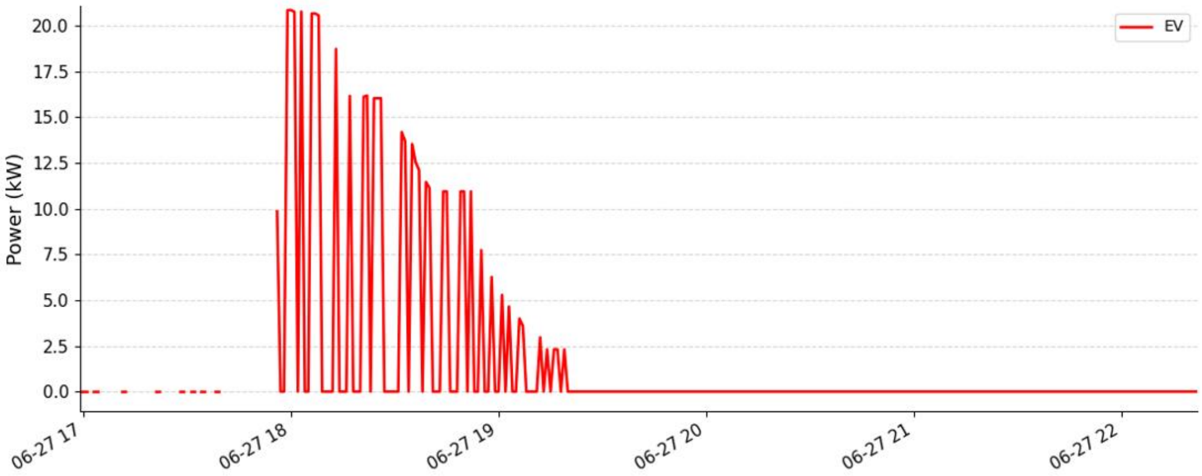


Figure 3.2: EV charging

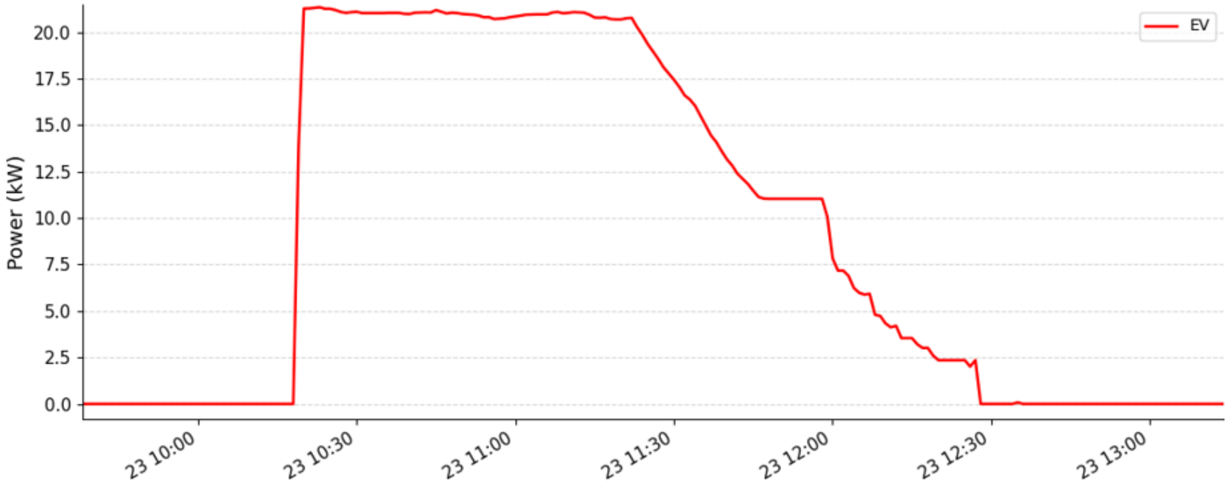


Figure 3.3: EV charging

4. Impact study

4.1. Qualitative analysis

The EV charging ecosystem in the Belgian market was discussed in the previous report (D1.1). In that report, all the stake holders were described. From those stakeholders, the ones with direct impact can be divided in two main parts including grid side (DSO, TSO) and EV side (users, CPO) [1-4]. But other businesses and environmental and societal benefits can be mentioned.

Grid (DSO/TSO) and EV side (users, CPOs)

Smart EV charging delivers clear system and user advantages. For DSO/TSO, managed charging flattens evening peaks, improves feeder load factor, increases hosting capacity and can defer or right-size substation and cable reinforcements. It also provides responsive flexibility for congestion management and ancillary services (e.g., FCR) with limited impact on driver convenience.

For EV users and CPOs, tariff-aware charging reduces energy costs, mitigates queuing through power smoothing and reservations, and improves reliability via grid-friendly setpoints. Where V2X is available, users can access new revenue streams and backup capability, while CPOs benefit from more predictable demand, higher station utilization, and lower network charges.

Other businesses

There is also a positive direct or indirect impact on other industry such as PV, power converter, battery, electrical devices and systems, aggregators and energy-management platforms, fleet depo, retail sites, real-estate operators etc. all these business can turn into new revenue streams.

Environmental and societal benefits

Smart EV charging amplifies decarbonization by shifting demand to PV-rich hours, lowering the grid-average CO_2 intensity of delivered energy. At street level, electrification improves public health. Overall, coordinated EV charging translates electrification into broader climate, air-quality, and resilience gains.

4.2. Quantitative analysis

Based on the data of the Zuidtrant running site and discussion with Octave, grid export and CO_2 reduction can be quantified. There are few sessions collected for BESS and EV charging as illustrated in Figure 4.1. Therefore, it is difficult to quantify its impact.

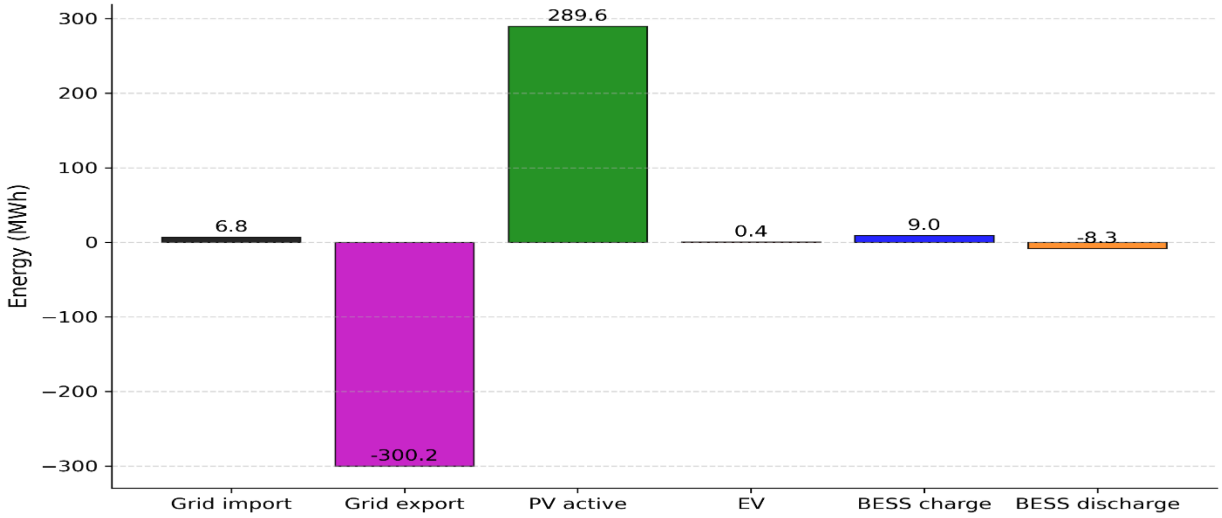


Figure 4.1: Energy balance for the Zuidtrant site

4.2.1. Grid export

The first operating site is a net exporter as illustrated in figure 4.1. The grid import is 6.8 MWh while the grid export is **300.2 MWh**, (i.e. 293.4 MWh net to the grid). This export slightly exceed PV generation (289.6 MWh). This means energy is first stored then re-exported (BESS discharge of 8.3 MWh) and/or small imports that are later exported. Local EV charging is very small (0.4 MWh), so most PV generation is not consumed on site. This data will probably change with more EV charging sessions during PV generation time.

Being a net exporter site means also having positive impact on the electricity grid. Practically, the feeder will see persistent reverse power flow, concentrated in PV-rich hours which can help with low voltage issue. But it raises risks of midday voltage rise.

To quantify the financial impact or gain of this grid export, the final energy bills are needed. This financial gain will also depend on the type of tariff or contract that a site has with the energy providers. Additionally, the control strategy used to avoid peak power and the applied tariff-aware control would important role. Furthermore, in the financial gain calculation, the BESS ageing and the financial benefit of FCR need to be included.

4.2.2. PV utilization

PV active energy totals **289.6 MWh**, which is of the same order as the net grid export, implying very low self-consumption of PV. In practical terms, nearly all PV is back-fed to the grid under the period assessed. This is because there were few charging sessions and the local load consumption is lower compared to the local PV generation.

4.2.3. BESS integration

The BESS absorbed **9 MWh (charge)** and delivered **8.3 MWh (discharge)**, implying a round-trip efficiency of 92.2% and losses of around 0.7 MWh. Given the scale of grid export, the BESS is comparatively small and only modestly contributes to flexibility and grid congestion. Its most added value is in delivering FCR up/down in combination with optimization of self-consumption. With more EV charging, it can be used to participate better in energy balance by optimizing PV and EV charging.

Another quantified impact of the BESS is the CO2 reduction as it can reduce the overall carbon footprint associated with the grid balancing mechanisms. According to Octave, for a conservative back-of-the-envelope calculation of the environmental benefits, it is assumed that second life batteries used for stationary energy storage replace flexible gas fired power plants. Therefore, considering the average emission of a combined cycle gas turbine (**0.36 tCO_2/MWh**[1]) and 500 additional full cycle equivalents performed annually by the second life batteries, the annual CO_2 reduction could be around 63,000 tonnes[2] of CO_2 in 2030 for the Belgian perimeter.

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[1] CO_2 emission factor = 0.18 tCO_2/MWh, Natural Gas; Efficiency average gas turbine: 50% considering a blend of Cycle Gas Turbines.

[2] Performed annually by the second life batteries, the annual CO_2 reduction would be around 63,000 tonnes of CO_2 in 2030 for the Belgian perimeter.

5. Conclusions and future work

The present deliverable (D1.3) summarised the impact study based on the dataset for Zuidtrant case which is the first running site as part of this project's plan. Some interesting additional points shared by Octave (related to the benefit of using BESS) which provided the dataset are also included in the report.

The report provides information on this first running site including its description, the yearly energy dataset with the power flow, energy prices, BESS power and SoC and the PV power flow. The yearly EV charging profile is also given with two single charging sessions using load balancing control. Then, the impact of different energy systems is studied with qualitative and qualitative analyses. The quantitative analysis provides the impact of grid export as this site is for now a net grid exporter but also the benefits of PV and BESS integration.

There is for now not enough data to quantify the impact of EV charging using few sessions for the studied site. With more EV charging sessions, the studied site will result in different energy balance. Whatever the scenarios, the applied control strategy combining BESS control, EV Charging with PV, PV energy export (BESS vs grid) will have a significant impact on the final economic gain.

To quantify the specific economic gain for the site, the final energy bills are needed. This financial gain will also depend on the type of tariff or contract that a site has with the energy providers. Additionally, the control strategy used to avoid peak power and the applied tariff-aware control would important role. Furthermore, in the financial gain calculation, the BESS ageing and the financial benefit of FCR need to be included. **Zuidtrant will further develop and integrate these information into the business model (D1.2) to quantify the specific financial gain**.

Based on the EV charging profile illustrated in figure 3.2 and 3.3, **KU Leuven will develop a smart charging control method that improves the charging efficiency and overall energy management** in future work (D2.1)

References

[1] Powell, S., Cezar, G.V., Min, L. et al. Charging infrastructure access and operation to reduce the grid impacts of deep electric vehicle adoption. Nat Energy 7, 932–945 (2022). https://doi.org/10.1038/s41560-022-01105-7

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[3] S. Deb, K. Kalita and P. Mahanta, "Review of impact of electric vehicle charging station on the power grid," 2017 International Conference on Technological Advancements in Power and Energy (TAP Energy), Kollam, India, 2017, pp. 1-6, doi: 10.1109/TAPENERGY.2017.8397215.

[4] Mahla Shariatzadeh, Marta A.R. Lopes, Carlos Henggeler Antunes, Electric vehicle users' charging behavior: A review of influential factors, methods and modeling approaches, Applied Energy, Volume 396, 2025, 126167, ISSN 0306-2619, https://doi.org/10.1016/j.apenergy.2025.126167.