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REEL Demo – Romande Energie ELectric network in local balance Demonstrator

Deliverable: Green energy credits and virtual power plant battery connection

Demo site: Chapelle

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Short report: green energy credits and Virtual Power Plant battery connection

1 Green energy credits

We applied to the two BES located in Chapelle sur Moudon the algorithm capable to calculate the C02 footprint of the grid and the one associated with the BES deployment in order to establish the best time window to use the renewable energy stored into the batteries.

Two strategies have been tested:

1) The first one has the goal of maximizing the self-consumption before 10 p.m into the evening, so in such case the revenues are maximizing;
2) The second one has the goal of postponing the self-consumption even after 10 p.m in order to maximize the decarbonization of the energy community.

Figure 1 illustrates the time evolution, in one targeted day, of the power flow (load and PV production) as long as the SOC of the battery, the C02 footprint of the grid, the threshold established by our algorithm and the associated C02 savings. For this Figure we applied strategy number 1 namely maximization of the self-consumption regardless the need of taking into account time duration with worst C02 footprint of the grid.

Figure 2 illustrates the same variables but with the goal of postponing self-consumption during the worst C02 footprint of the grid.

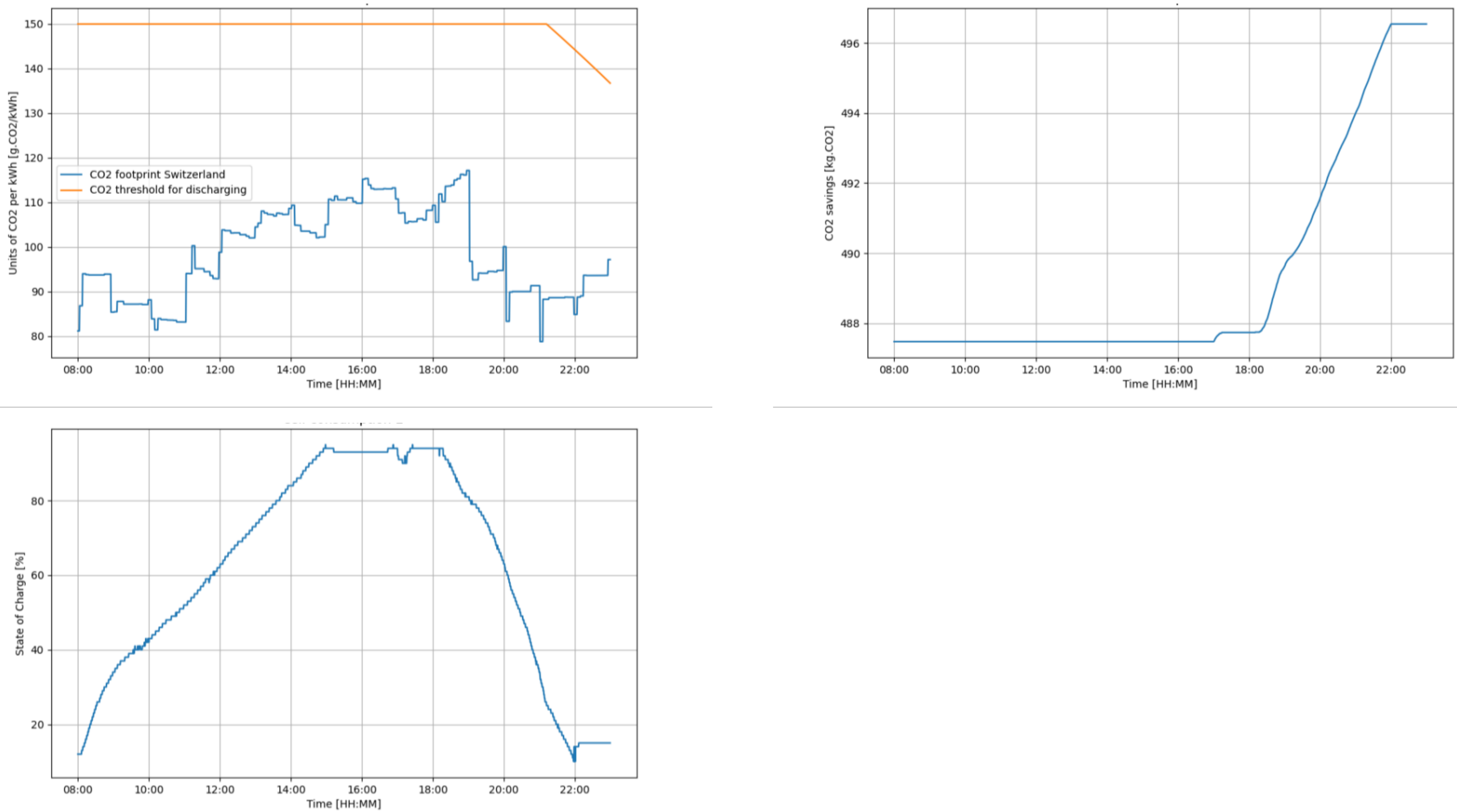

Figure 1: algorithm maximizing self-consumption before 10 p.m, specific day of 26th May 2022

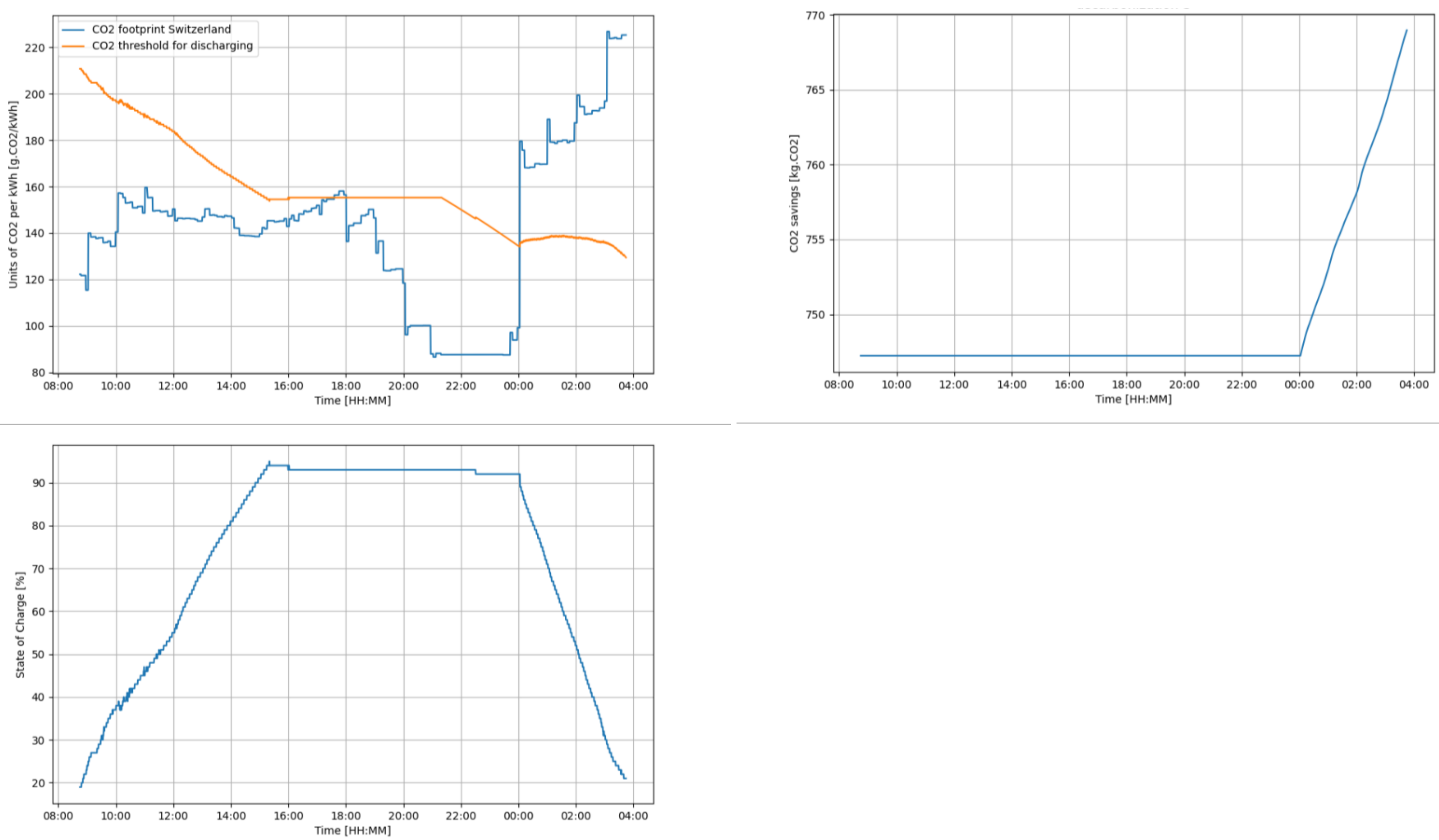

Figure 2: algorithm maximizing the C02 compensation specific day of 26th May 2022

In case of Figure 1 we achieved the following results:

- 10 kg of C02 savings
- Whole self-consumption made before 10 p.m so at the highest retail rate namely highest revenues

In case of Figure 2 we achieved the following results:

- 29 kg of C02 savings
- Whole self-consumption made after 10 p.m but still battery completely discharged
- 190% more of C02 saving compared to the strategy number 1.
- We should also underline that with the strategy 1) the self-consumption between 6 p.m up to 10 p.m would arrive during the lowest C02 footprint of the network and consequently lowest C02 compensation by the energy community.

Appendix A C02 footprint calculation of the grid

The C02 footprint calculation of the energy grid has been performed by the following algorithm

1) Measuring/collecting the power exchange between Switzerland and the surrounding countries (Germany, France, Italy and Austria). These measurements have been collected for the targeted time-window by the web site https://transparency.entsoe.eu. The sampling time is one point of measurement each 15 minutes for Germany and Austria and one point every hour for the other countries
2) Measuring/collecting the energy "produced" and stored by Switzerland, Germany, France, Italy and Austria. These measurements have been collected on https://transparency.entsoe.eu. (same website with the same sampling frequency).
3) Once the configuration of local national energy as well as the energy/power flows are computed, it is possible to compute the C02 footprint of the energy produced nationally from Switzerland and also the C02 footprint of the energy eventually imported from the other countries (as summarized in Figure 1). In order to make this computation we evaluate:

- First the C02 footprint of the whole energy produced in Switzerland, named $C02_{PCH}$ as well as the energy produced in Switzerland named E_{PCH}
- The quantity of the energy produced in Switzerland exported toward other countries (France, Italy, Germany and Austria), named E_{EXCH}
- The C02 footprint of the produced energy by the surrounding countries, named respectively for Italy, France, Germany and Austria $C02_{IT}$, $C02_{FR}$, $CO2_{DE}$, $C02_{AU}$
- The C02 imported, $C02_{ICH}$, by each surrounding countries (via the product of the imported energy per country and their C02 footprint production)

$$C02_{ICH} = C02_{IT}*E_{PIT} + C02_{FR}*E_{PI} + CO2_{DE}*E_{PIT} + C02_{AU}*E_{PIT} \quad (1)$$

- The C02 footprint of the Switzerland taking into account production, export and import is calculated as follow:

$$C02_{CH} = \frac{(E_{PCH} - E_{EXCH}) * C02_{PCH} + C02_{ICH}}{E_{PCH} - E_{EXCH} + E_{ICH}} \qquad (2)$$

So we assume that at each time step the CO2 footprint of the Swiss grid is the one calculated at (2).

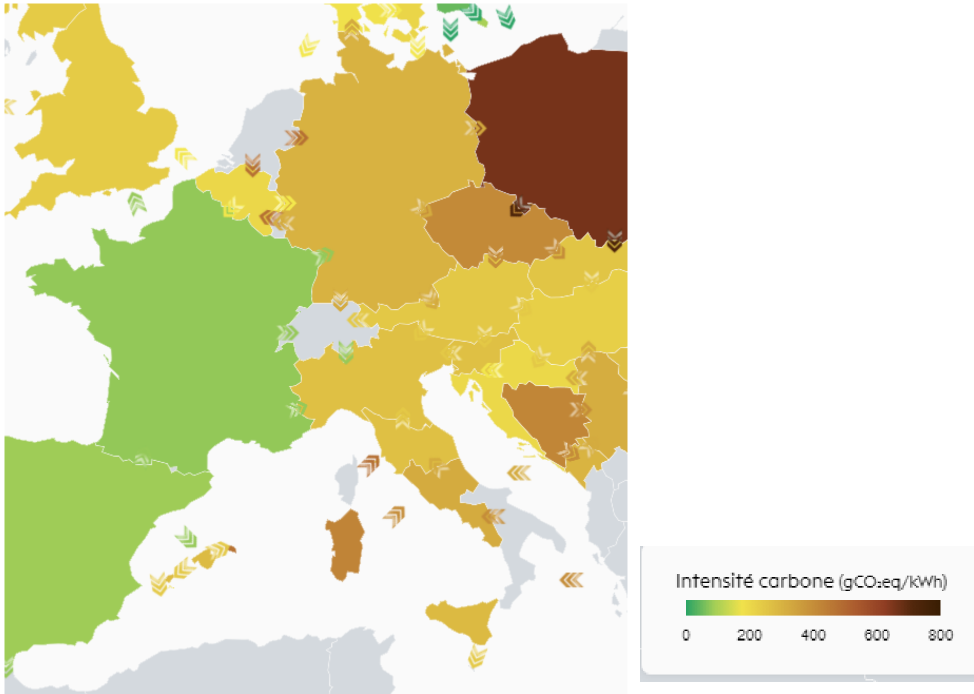

Figure 3: mapping of carbon intensity of area surrounding Switzerland.

The types of energy as well as their C02 impact (https://www.electricitymap.org/) refer to Table I

Table I: type of energy and their C02 impact

Type of energy	C02 footprint
Biomass	230 gr C02/kWh
Fossil Brown Coal	820 gr C02/kWh
Fossil Coal derived Gas	820 gr C02/kWh
Fossil Hard Coal	490 gr C02/kWh
Fossil Oil	650 gr C02/kWh
Geo-Thermal	38 gr C02/kWh
Hydro Pump Storage Austria	173 gr C02/kWh
Hydro Pump Storage Switzerland	301 gr C02/kWh
Hydro Pump Storage Germany	281 gr C02/kWh
Hydro Pump Storage France	48 gr C02/kWh
Nuclear	12 gr C02/kWh
Solar photovoltaics	45 gr C02/kWh
Wind Off-shore	12 gr C02/kWh
Wind On-shore	11 gr C02/kWh

The C02 earning are calculated by the difference of C02 of the grid and C02 associated with BES deployment.

2 Virtual Power Plant

Within this project we also investigated the possibility to connect the two BESs in VPP mode for increasing the peak-shaving capability of the renewable injection toward the grid.

Of course, we kept the following constraints:

a) The smallest battery of 40 kWh has to be charged only with certified renewable energy, so we charged only when net power measurement was positive, namely PV higher than consumption;
b) When the biggest battery is discharged toward the low voltage community the smallest battery cannot be charged.

We made a software platform capable to couple and synchronize the setpoint of the two inverters within a delay time of 10 ms.

Additionally to it, we were capable to deploy simultaneously the two batteries for making PV peak shaving. The main results are:

a) 25 kW more of PV peak power shaving;
b) 40 kWh per day charged with renewable energies and self-consumed simultaneously by the energy community before 10 p.m (maximization of revenues)

This platform could be deployed in the future to use the two BESs having 340 kWh-290 kW of capability for being integrated in a secondary frequency market pool regulation. We were capable to proof the synchronization of the two BESs setpoint to be capable to follow any power profile request by the grid operator for any type of ancillary services.

Figure 4 illustrates an example of VPP connection of the two BESs. It is important to highlight that the peak rejection of 175 kW has been avoided thanks to the VPP connection.

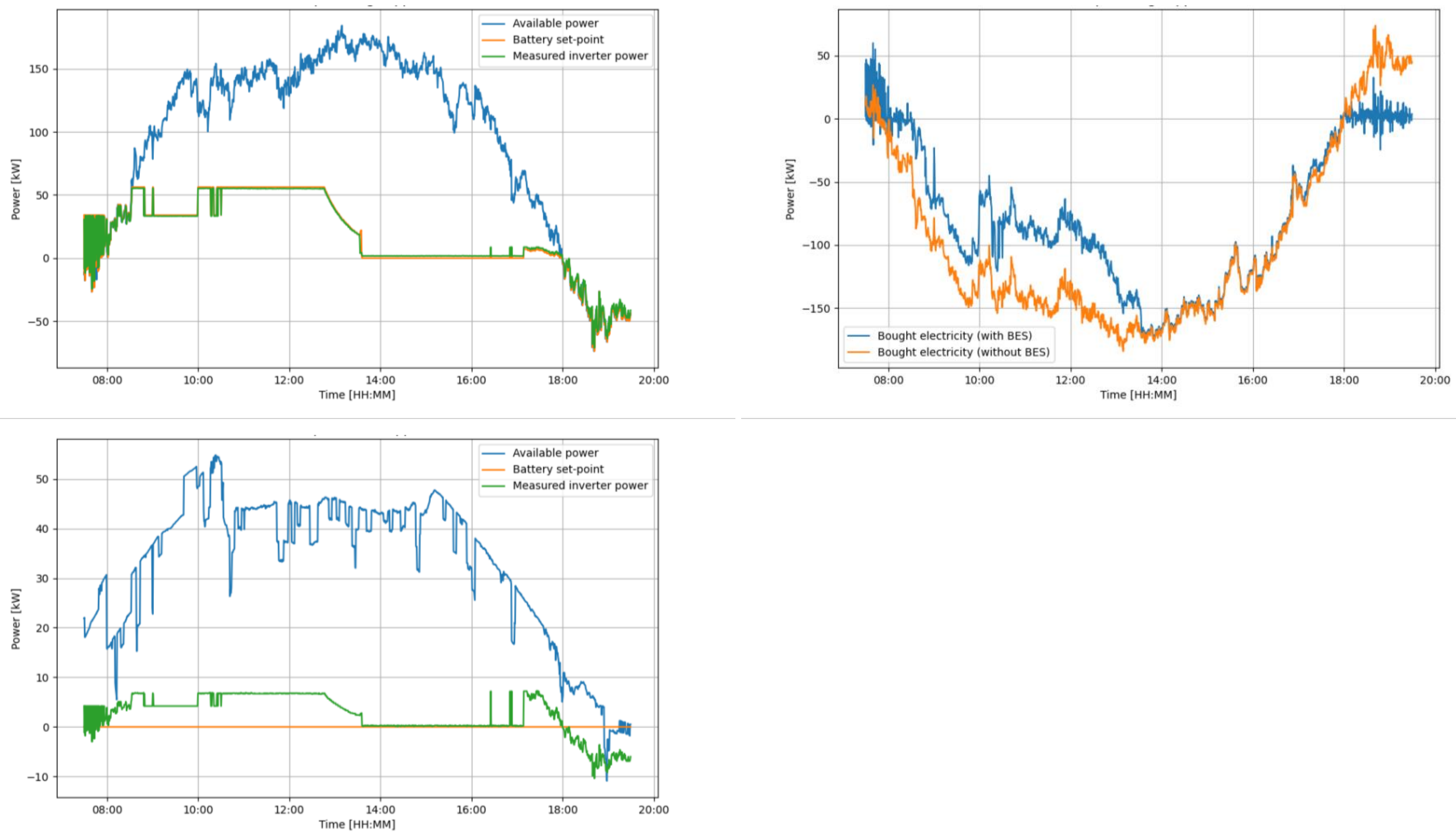

Figure 4: VPP connections of the two BESs, 29th May 2022