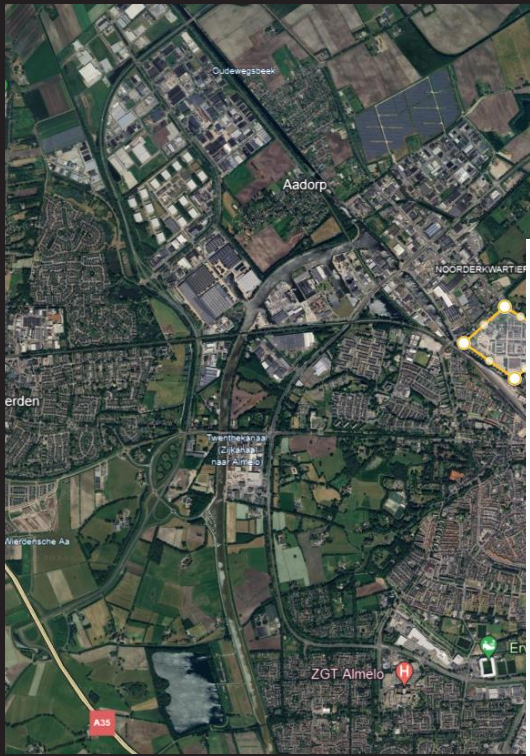
EEMCS | CAES and MOR | Energy Group

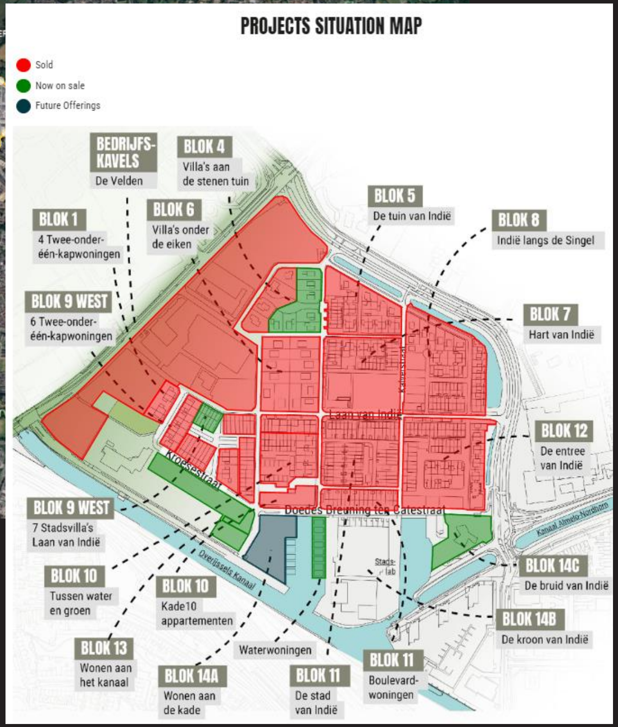
HET INDIË-TERREIN: EEN SLIMME BUURTBATTERIJ IN DE OUDE WEVERIJ

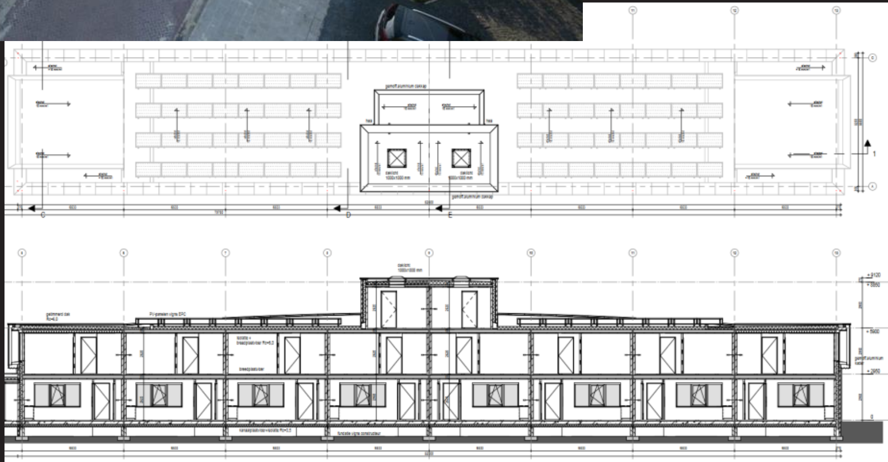
PROJECT RESULTS

UNIVERSITY
OF TWENTE.

CASE STUDY: DE WEVERIJ







OBJECTIVE:

Implement a local flexible multi-energy system at the Weverij, comprise by a PV system, a vanadium redux flow battery, and heat storage coordinated by a smart energy management system. Implementation of organisational/contractual frameworks for a local energy system (including shared use of installations).

ACTIVITIES:

WP1 – Design Phase

WP2 – Construction and installation of prototype at test location

WP3 – Test phase

WP4 – Reporting phase

STAKEHOLDERS:

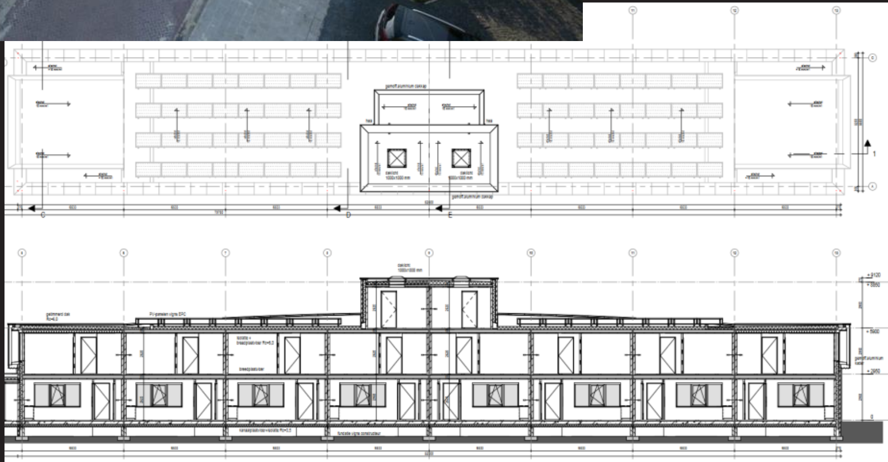
Contour Advanced Systems

loohuis INSTALLATIEGROEP

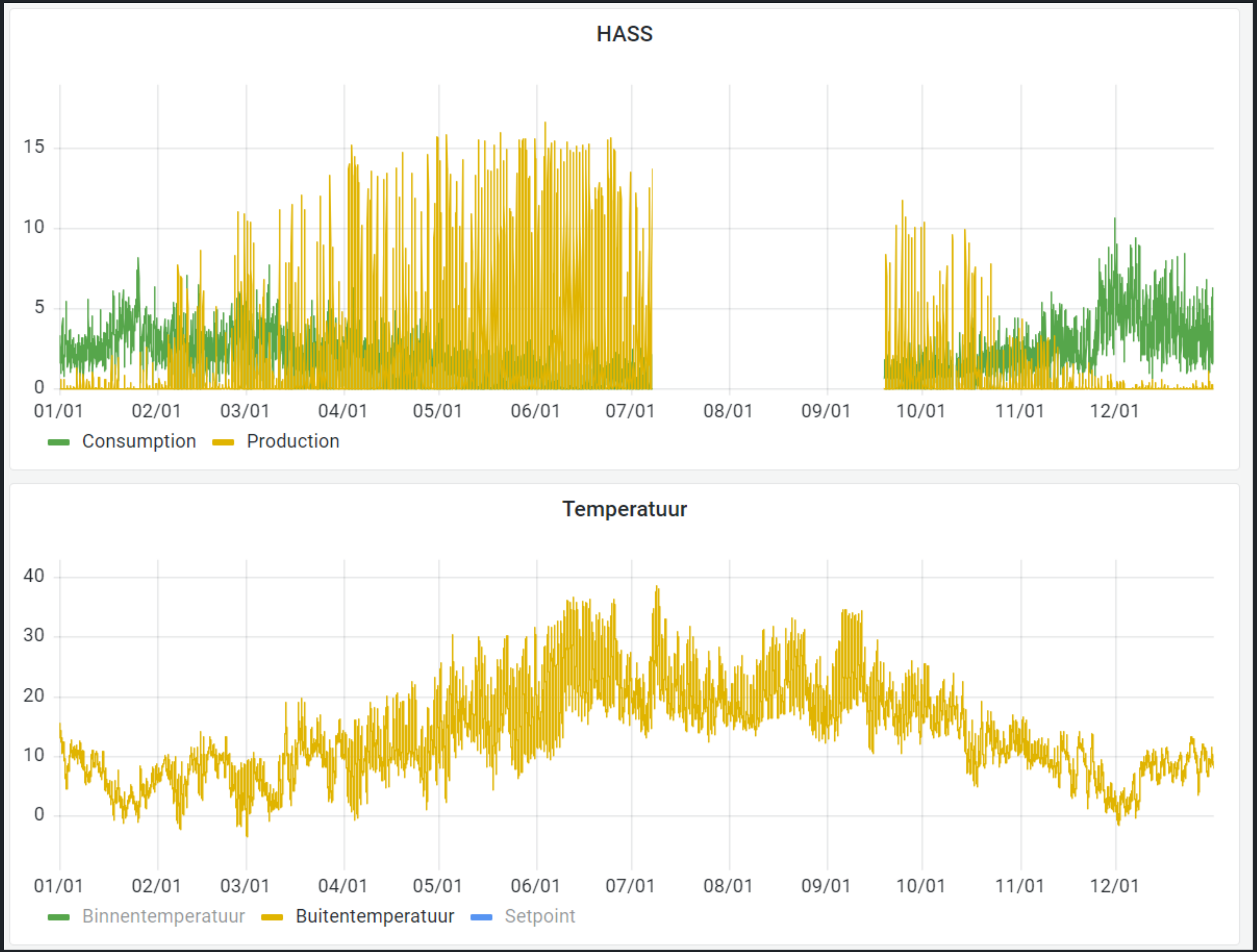
UNIVERSITY OF TWENTE.

coteq NETBEHEER

SOLARFREEZER

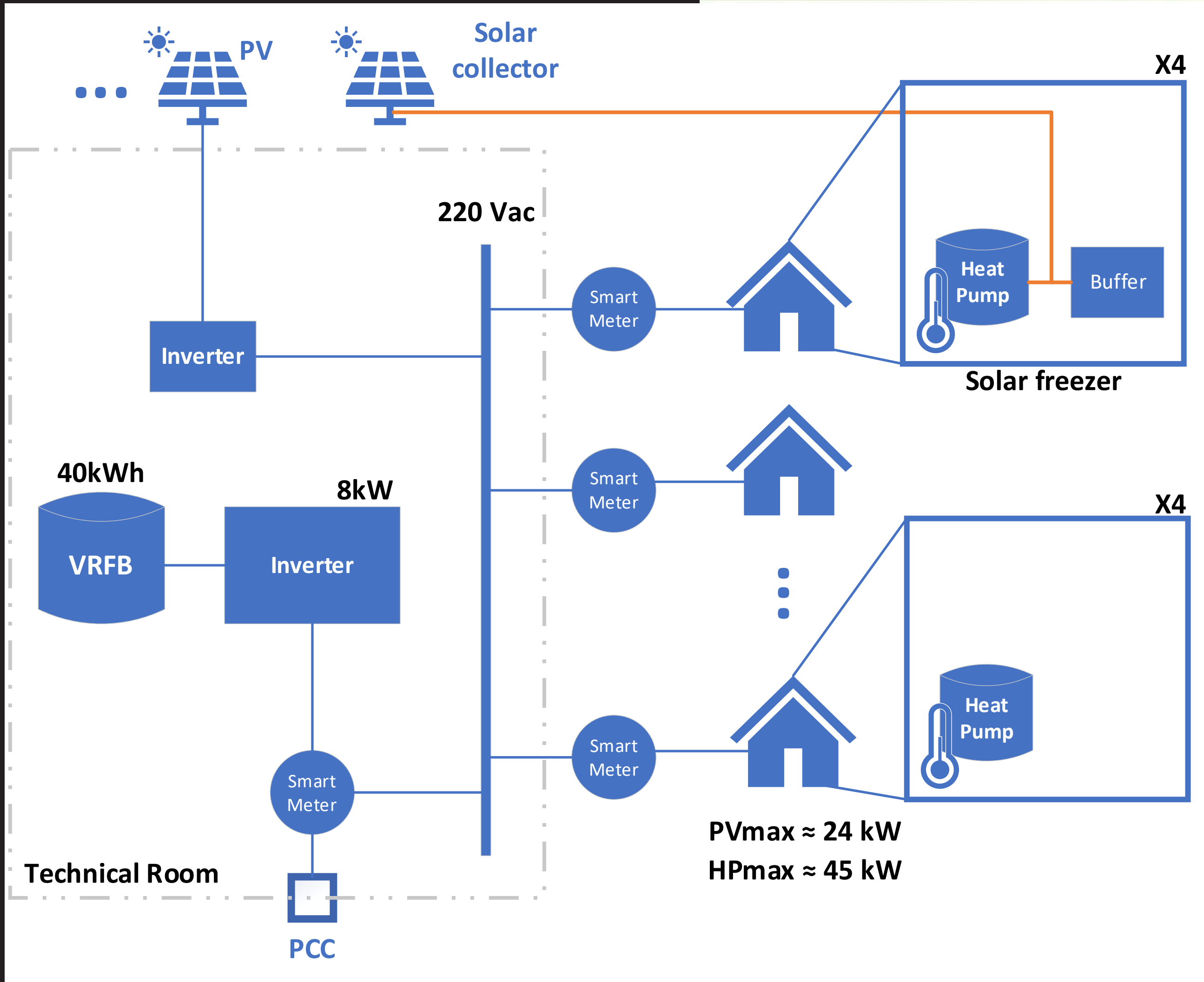


PV PRODUCTION AND HEATING DEMAND



UNIVERSITY OF TWENTE.

PHYSICAL ARCHITECTURE:



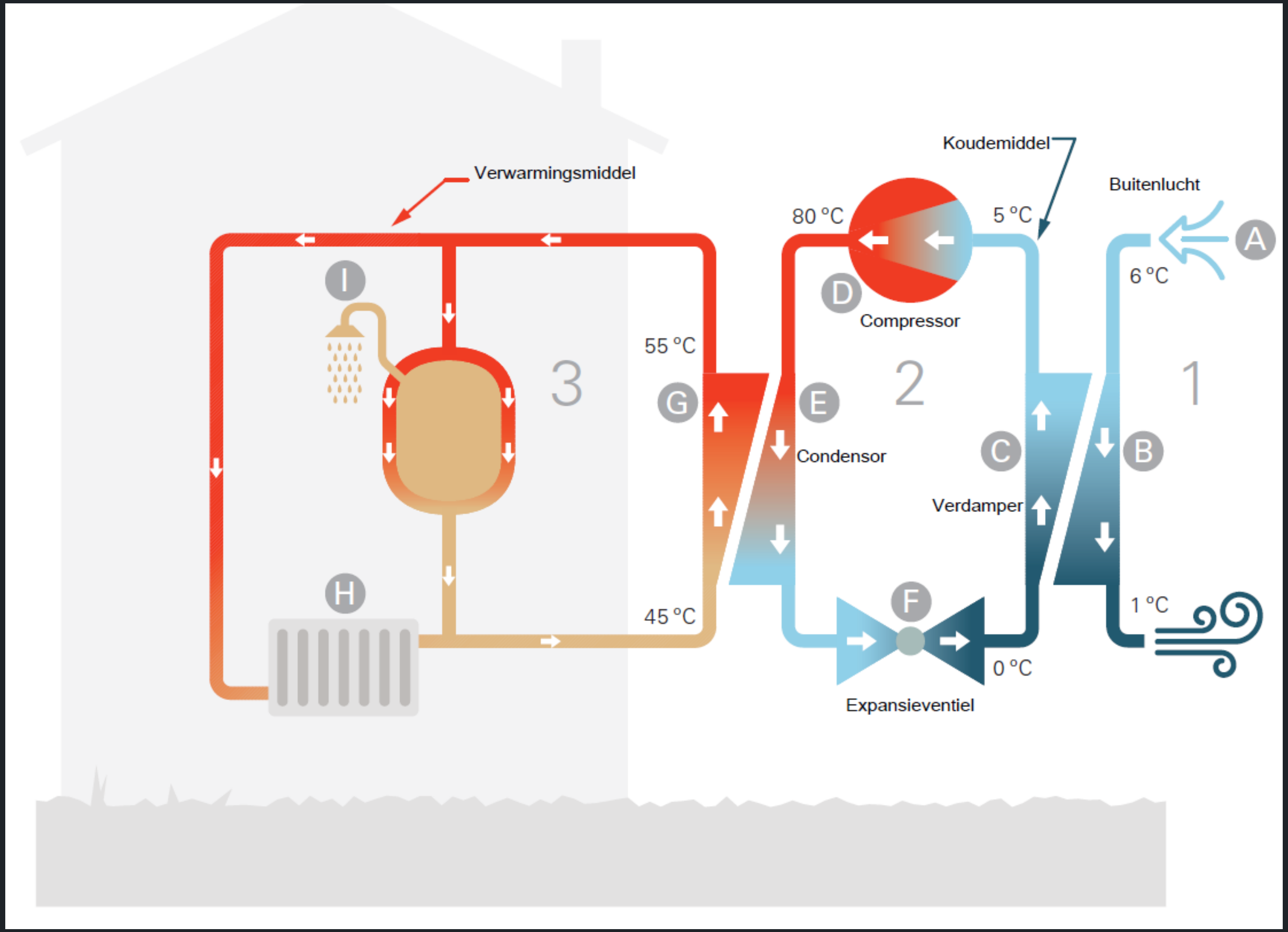
UNIVERSITY OF TWENTE.

VANADIUM REDOX FLOW BATTERIES

- ✓ **Liquid Power Storage**
- ✓ **Long Life and Deep Discharge**
- ✓ **Safety First**
- ✓ **Scalable Design**
- ✓ **Geared Towards Grid Applications**

- X Slower Discharge Rates
- X Bulkier Footprint
- X Cost Considerations

HEAT-PUMPS



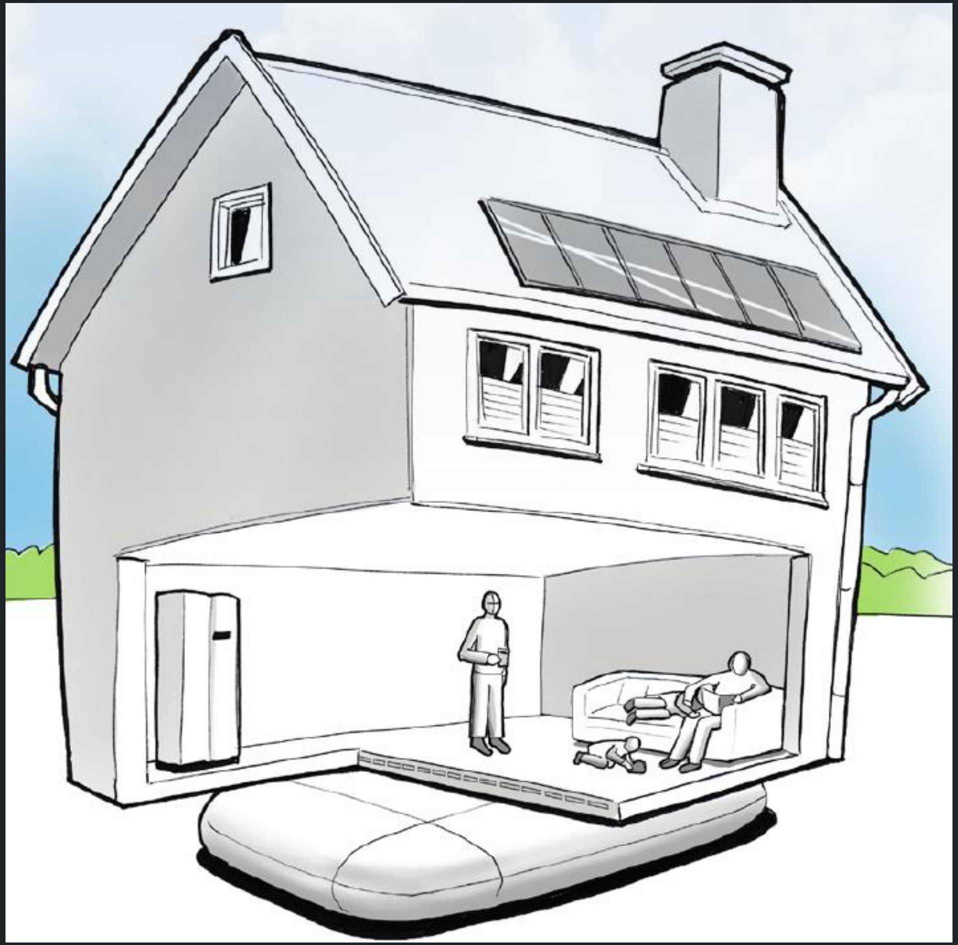
NIBE VVM S320

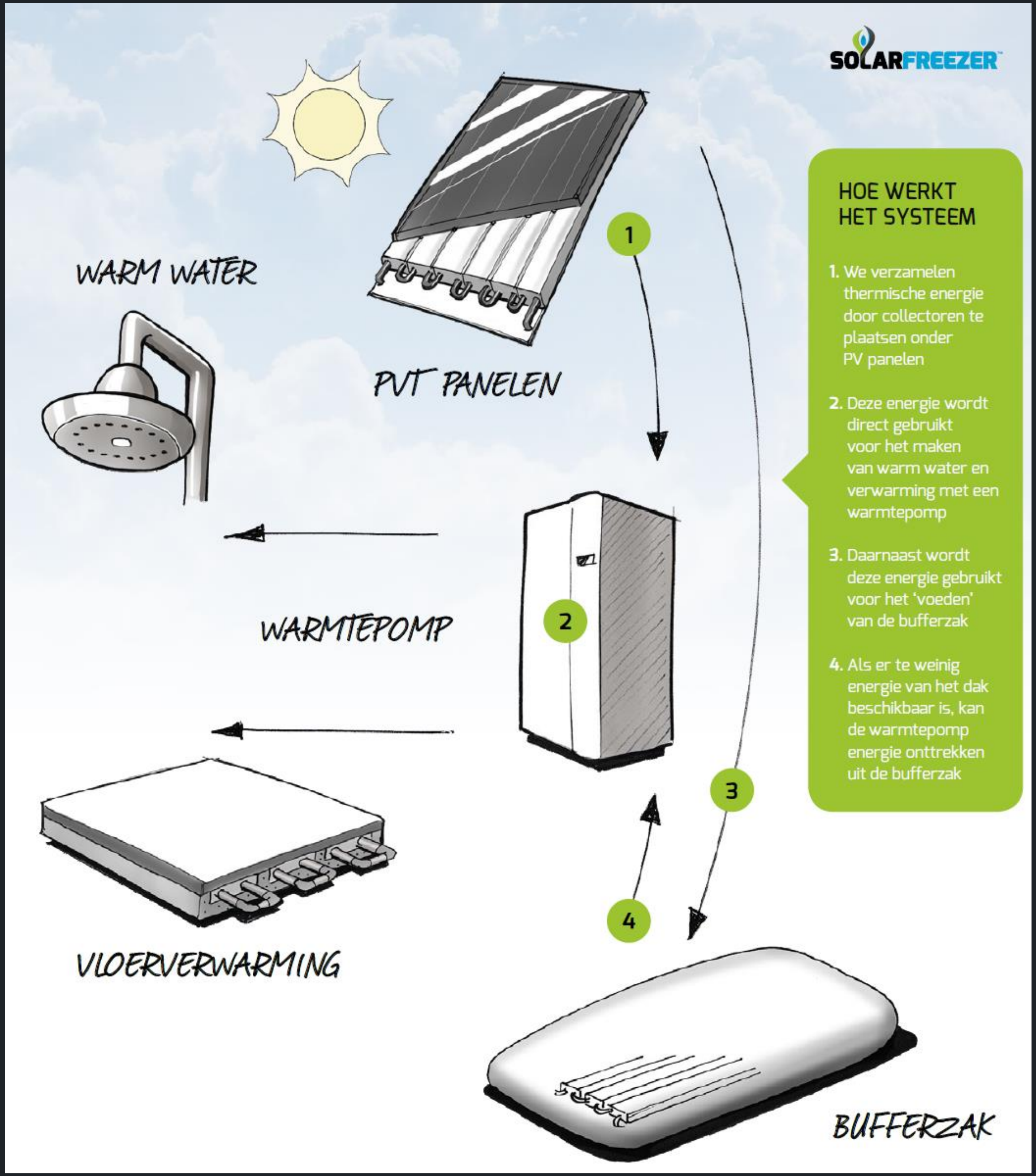
NIBE F2040-6

RMU S4

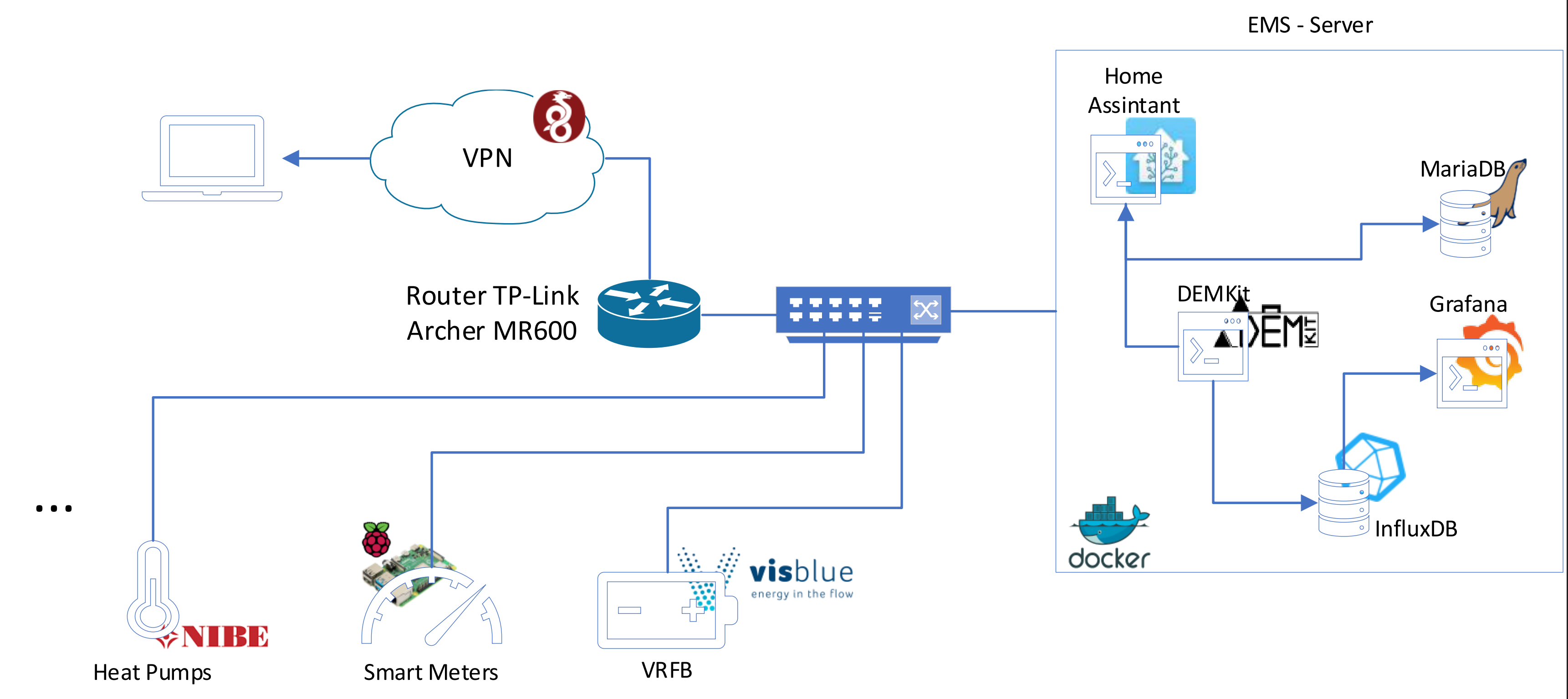
UNIVERSITY
OF TWENTE.

SOLAR FREEZER





CYBER-PHYSICAL ARCHITECTURE



UNIVERSITY OF TWENTE.

CONTROLLABILITY OF VRFB

EMS

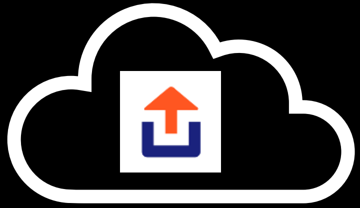
Modbus TCP/IP

battery state
battery Alarmcode
Subbattery 1 power
Subbattery 1+2 DC voltage
Subbattery 1 DC current
Subbattery 1 electrolyte temperature
Voltage phase 1
Voltage phase 2
Voltage phase 3
Current phase 1
Current phase 2
Current phase 3
Active Power phase 1
Active Power phase 2
Active Power phase 3
SOC
Alive signal
Total charge energy since start
Total discharge energy since start
Total charge energy last cycle
Total discharge energy last cycle
Total cycles
Total charge power setpoint
Total discharge power setpoint
Total charge power setpoint
Total discharge power setpoint
Master control
Master Reset
Master Reset ready

CONTROLLABILITY OF HEAT-PUMPS

EMS

REST API

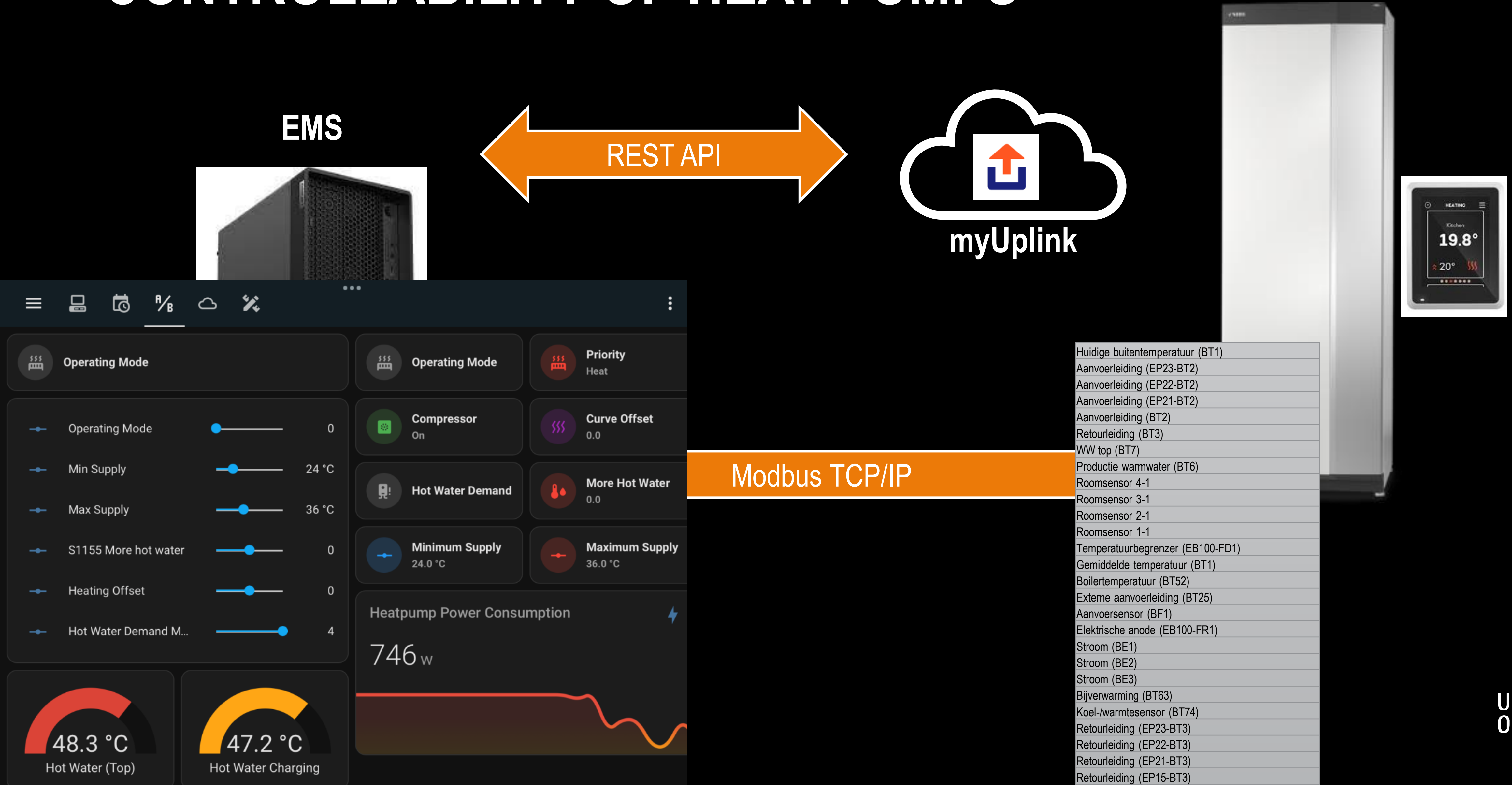


myUplink

Modbus TCP/IP

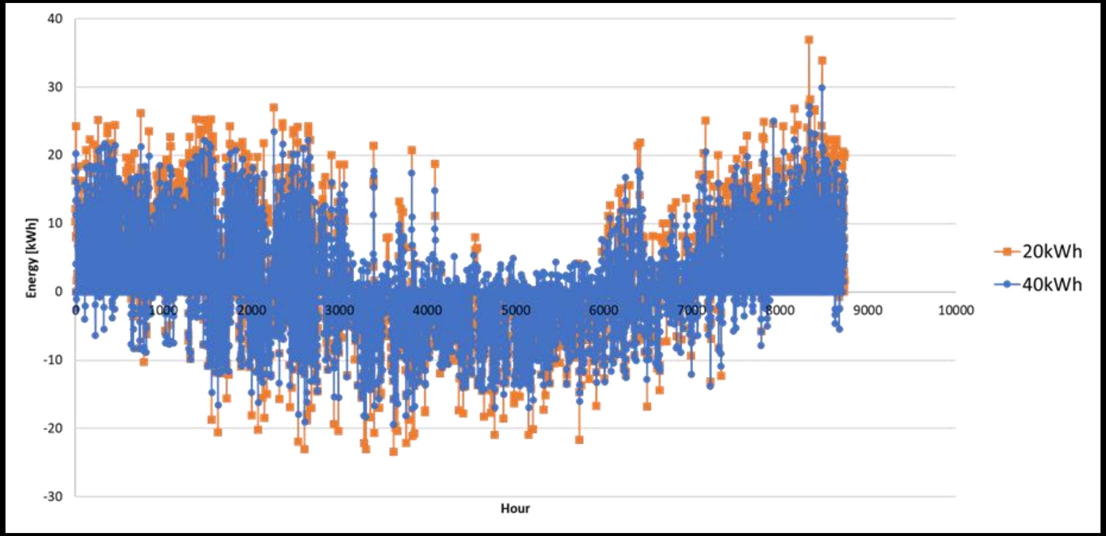
Huidige buitentemperatuur (BT1)
Aanvoerleiding (EP23-BT2)
Aanvoerleiding (EP22-BT2)
Aanvoerleiding (EP21-BT2)
Aanvoerleiding (BT2)
Retourleiding (BT3)
WW top (BT7)
Productie warmwater (BT6)
Roomsensor 4-1
Roomsensor 3-1
Roomsensor 2-1
Roomsensor 1-1
Temperatuurbegrenzer (EB100-FD1)
Gemiddelde temperatuur (BT1)
Boilertemperatuur (BT52)
Externe aanvoerleiding (BT25)
Aanvoersensor (BF1)
Elektrische anode (EB100-FR1)
Stroom (BE1)
Stroom (BE2)
Stroom (BE3)
Bijverwarming (BT63)
Koel-/warmtesensor (BT74)
Retourleiding (EP23-BT3)
Retourleiding (EP22-BT3)
Retourleiding (EP21-BT3)
Retourleiding (EP15-BT3)

CONTROLLABILITY OF HEAT-PUMPS



RESEARCH

BATTERY SIZE ANALYSIS



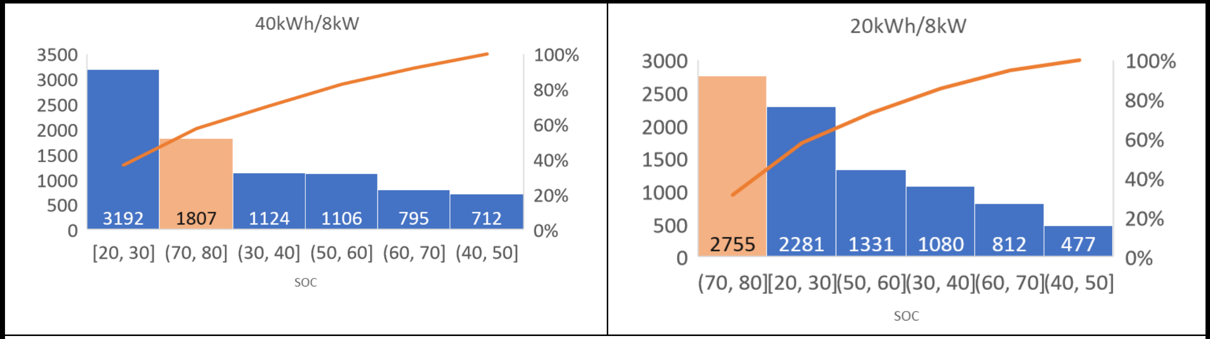
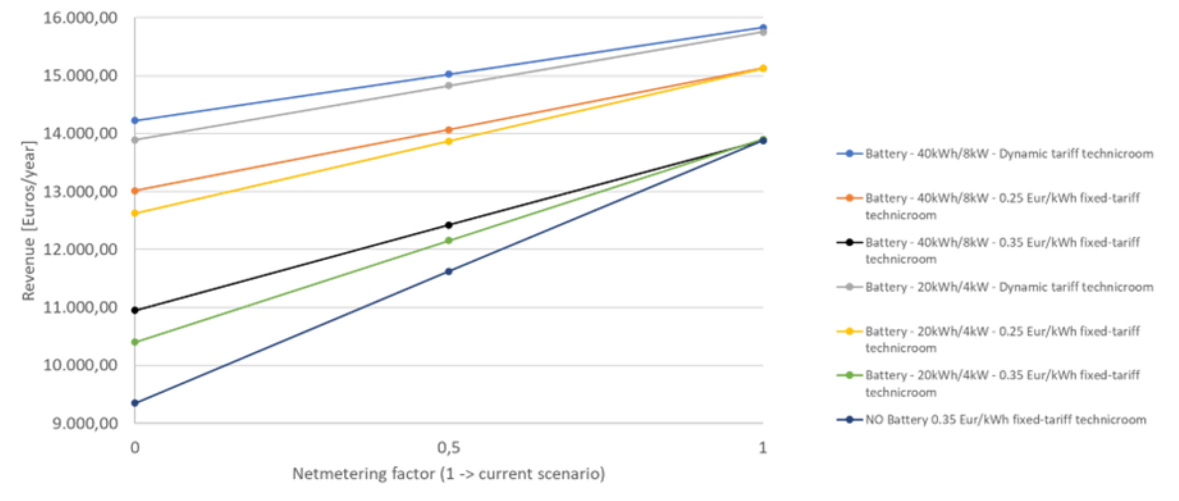


Figure 4. Estimated histogram of the state-of-charge of the battery considering a) a 40kWh/8kW BESS and a 20/kWh/8kW.



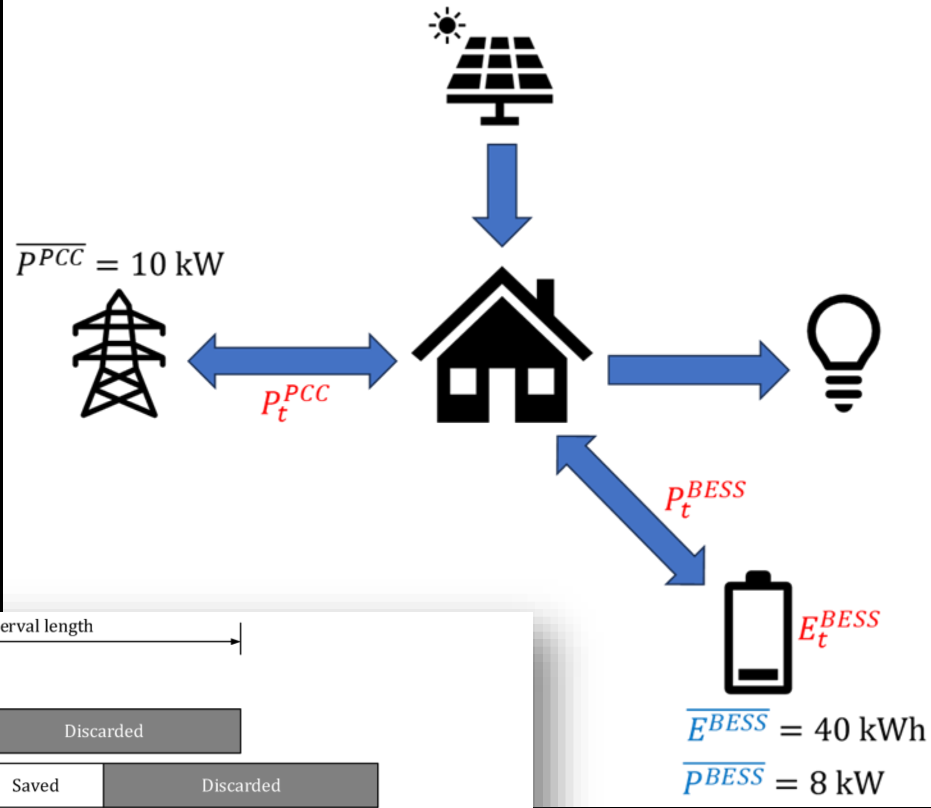
UNIVERSITY OF TWENTE.

HEAT-PUMP CONTROL

Figure 21. Consumption profile and outdoor temperature for the four different modes of operation of the heat-pump. Red area is “Large”, blue area is “Medium”, yellow area is “Small”, and green area is “Smart control”.

UNIVERSITY OF TWENTE.

OPTIMIZATION BASED - EMS



Objective:

$$\min\left\{\sum_{t\in T} c_t^{\text{elec}} \cdot P_t^{PCC+}\right\}$$

Constraints

$$P_t^{PCC} = P_t^{\text{cons.}} - P_t^{\text{prod.}} + P_t^{BESS}; \quad \forall t \in T$$

$$\left|P_t^{PCC}\right| \leq \overline{P^{PCC}}; \quad \forall t \in T$$

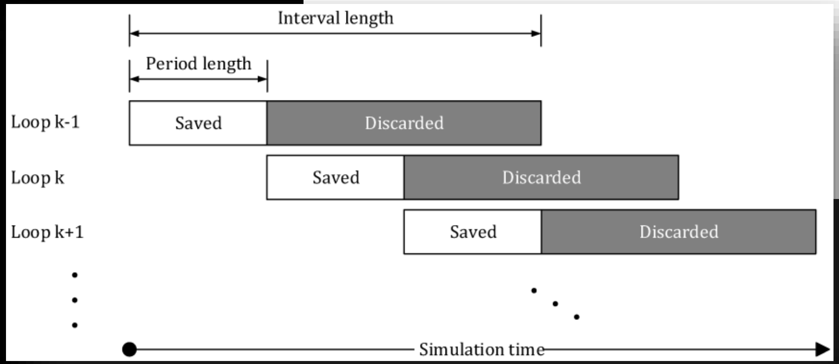
$$E_t^{BESS} = E_{t-1}^{BESS} + P_t^{BESS} \cdot \Delta; \quad \forall t \in T > 1$$

$$\left|P_t^{BESS}\right| \leq \overline{P^{BESS}}; \quad \forall t \in T$$

$$0 \leq E_t^{BESS} \leq \overline{E^{BESS}}; \quad \forall t \in T$$

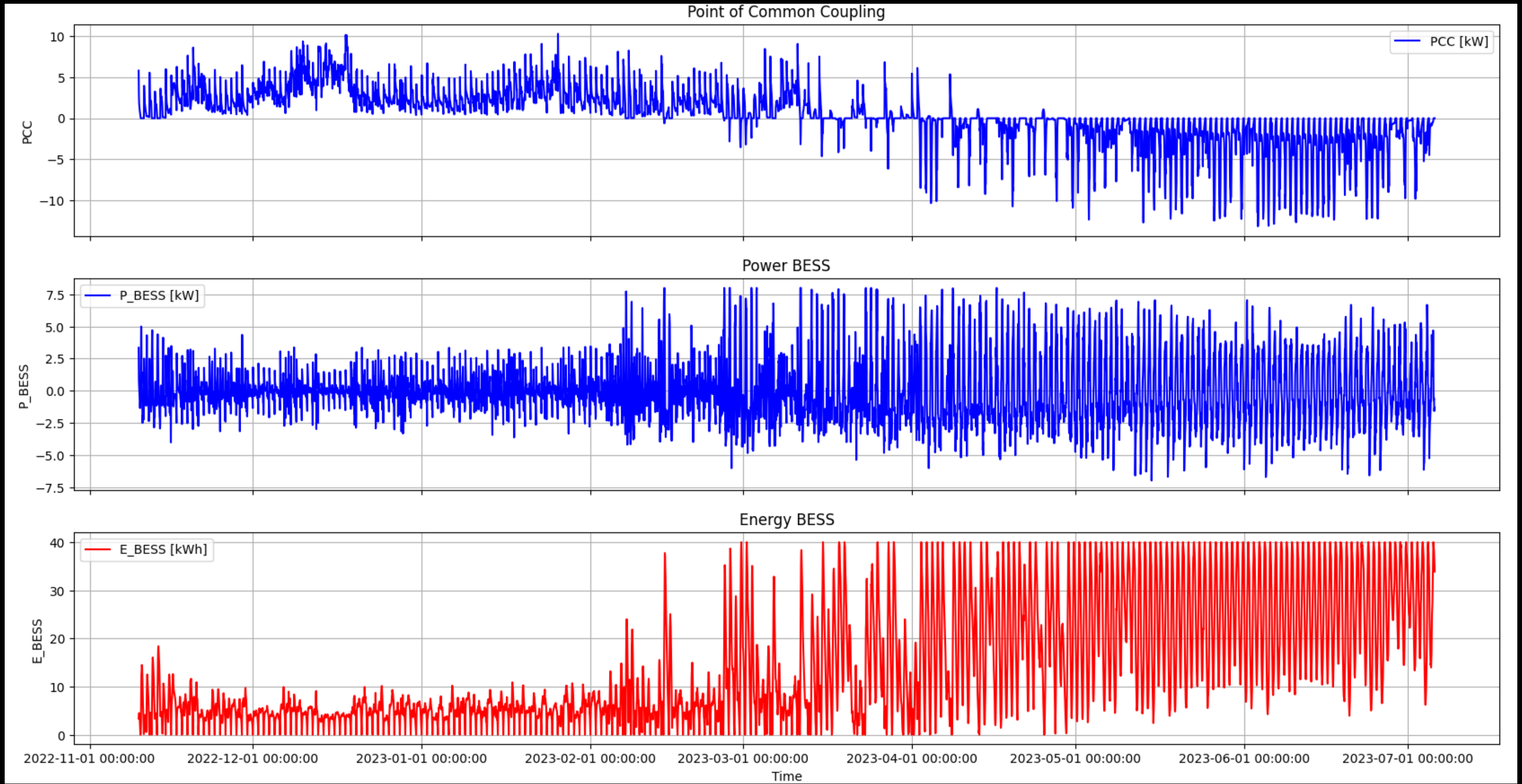
$$E_1^{BESS} = E_0^{BESS} + P_1^{BESS} \cdot \Delta; \forall t = 1$$

$$P_t^{PCC+}, P_t^{PCC-} \geq 0$$



UNIVERSITY
OF TWENTE.

EMS – SELF-CONSUMPTION



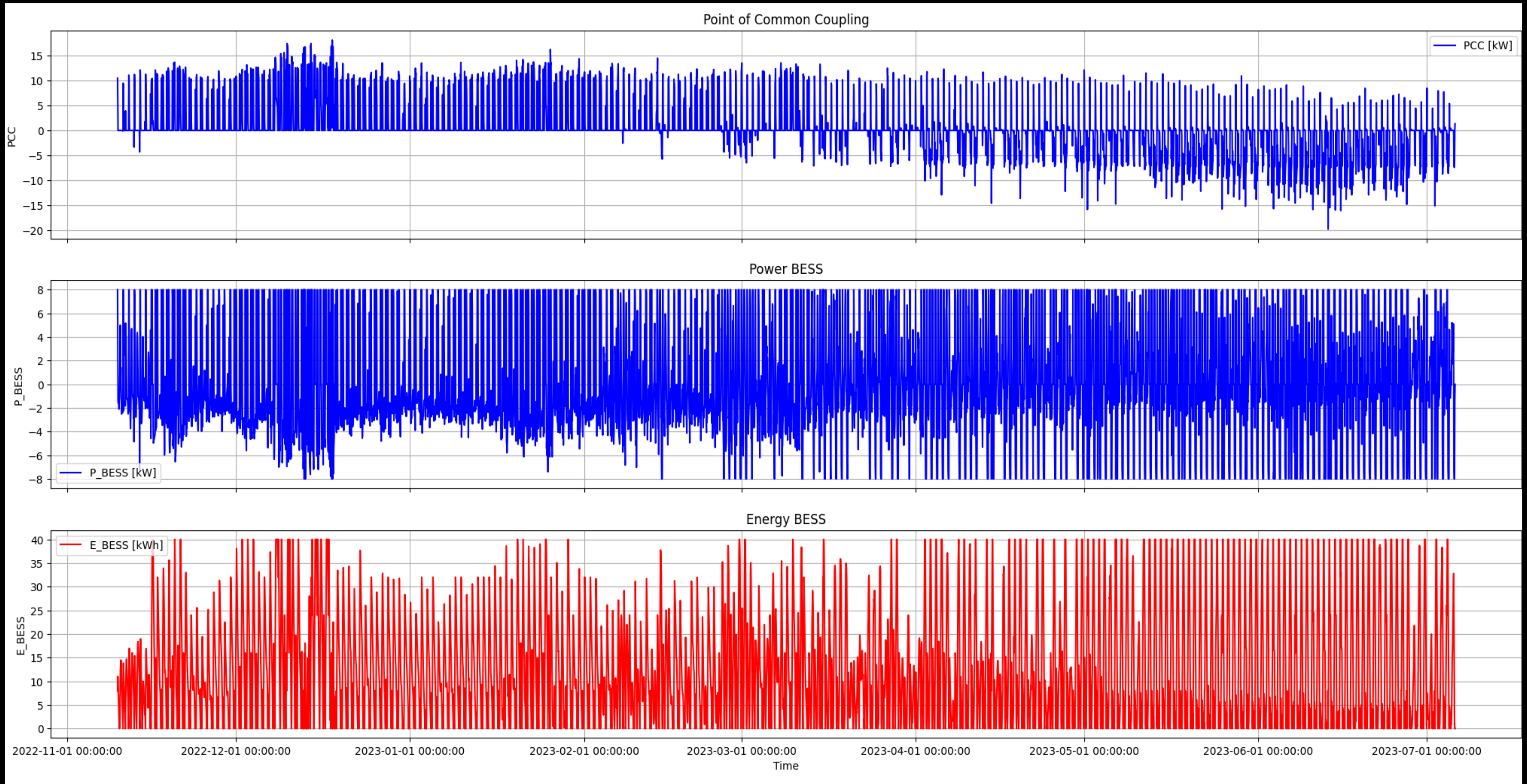
Fixed price (0.250 EUR/kWh)

2444 EUR

-10.0%

UNIVERSITY OF TWENTE.

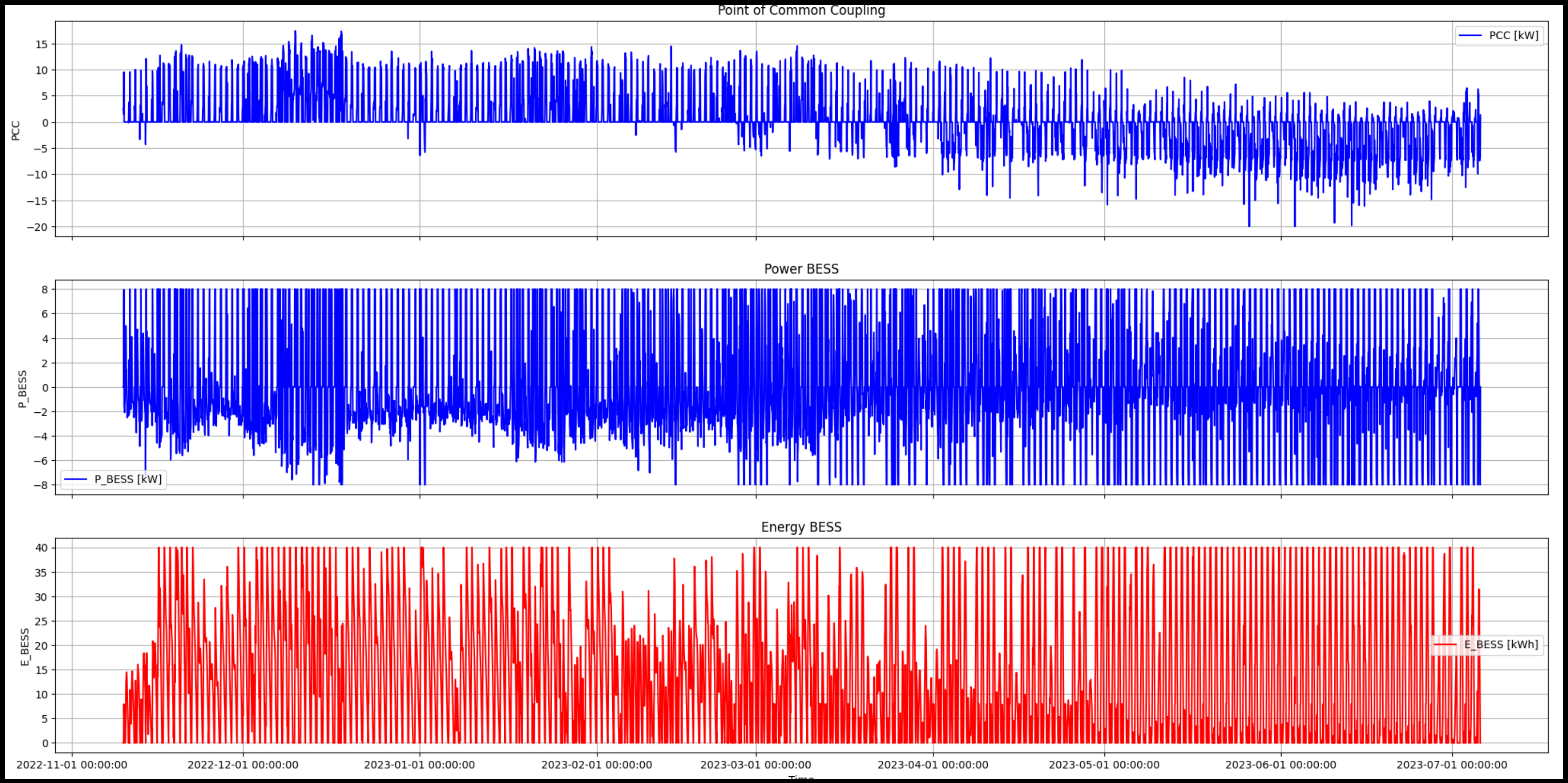
EMS – PRICE STEERING



Fixed price (0.250 EUR/kWh) → 2374 EUR ← -12.6%

UNIVERSITY OF TWENTE.

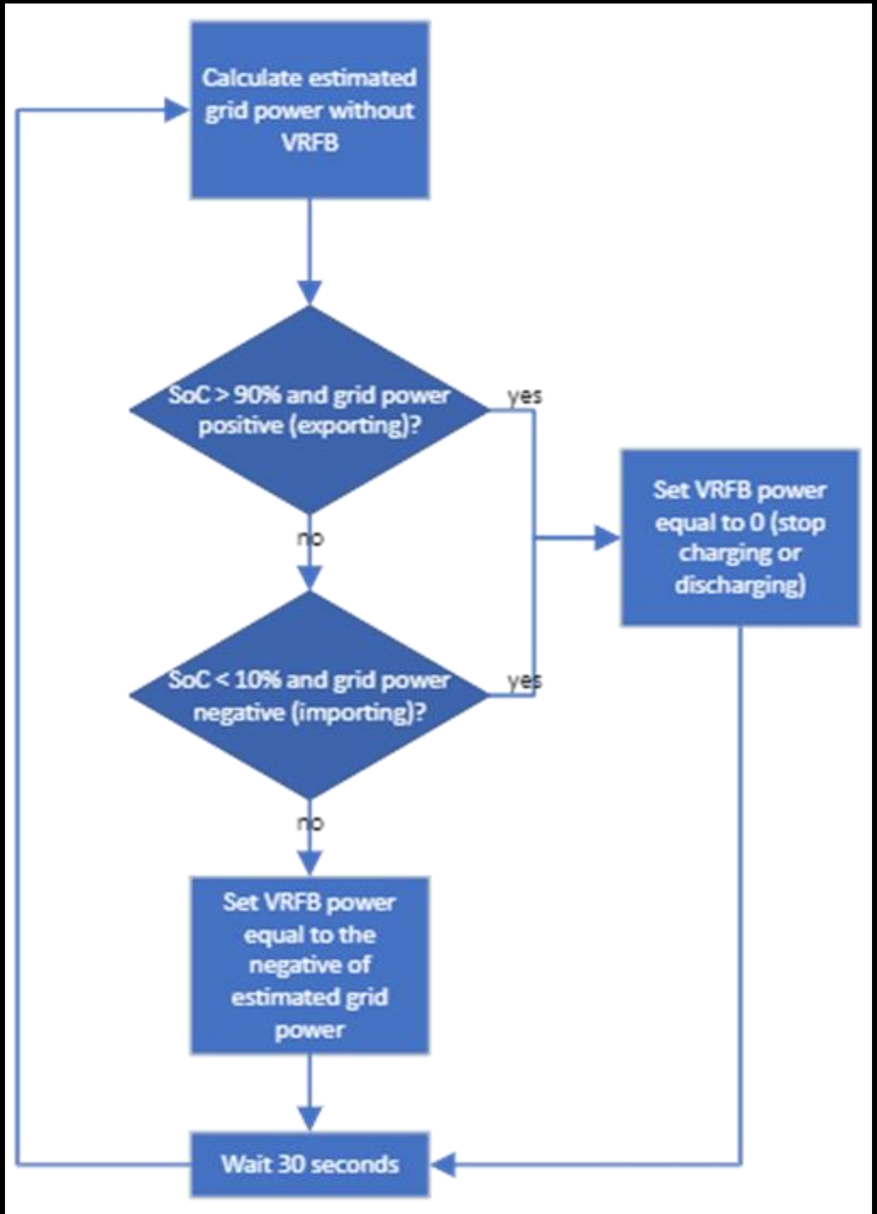
EMS – PRICE STEERING



Dynamic Prices → 1306 EUR ← -51.9%

UNIVERSITY
OF TWENTE.

STEERING ALGORITHM



UNIVERSITY
OF TWENTE.

ENERGY STORAGE SYSTEM MODEL

$$SoC_t = SoC_{t-1} + \Delta_t \left(\eta^{chr} P_t^{chr} - \frac{1}{\eta^{dis}} P_t^{dis} \right) - \Delta_t \beta^{self}$$

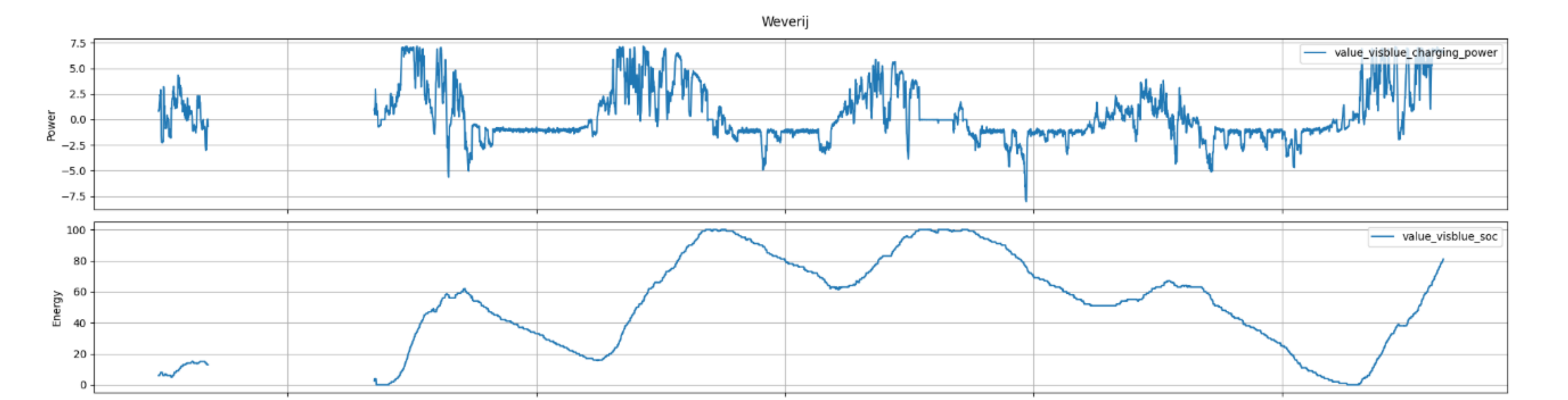


Figure 11. Power and energy profiles of the BESS at the Weverij for one week.

$\eta^{chr} = 0.95466$ p.u.

$\eta^{dis} = 0.83769$ p.u.

$\beta^{self} = 0.21422$ kWh/hour

UNIVERSITY OF TWENTE.

THERMAL LOAD MODEL

$$T_{t+1} - T_t = b\Delta_t x_t + c(O_t - T_t) + d$$

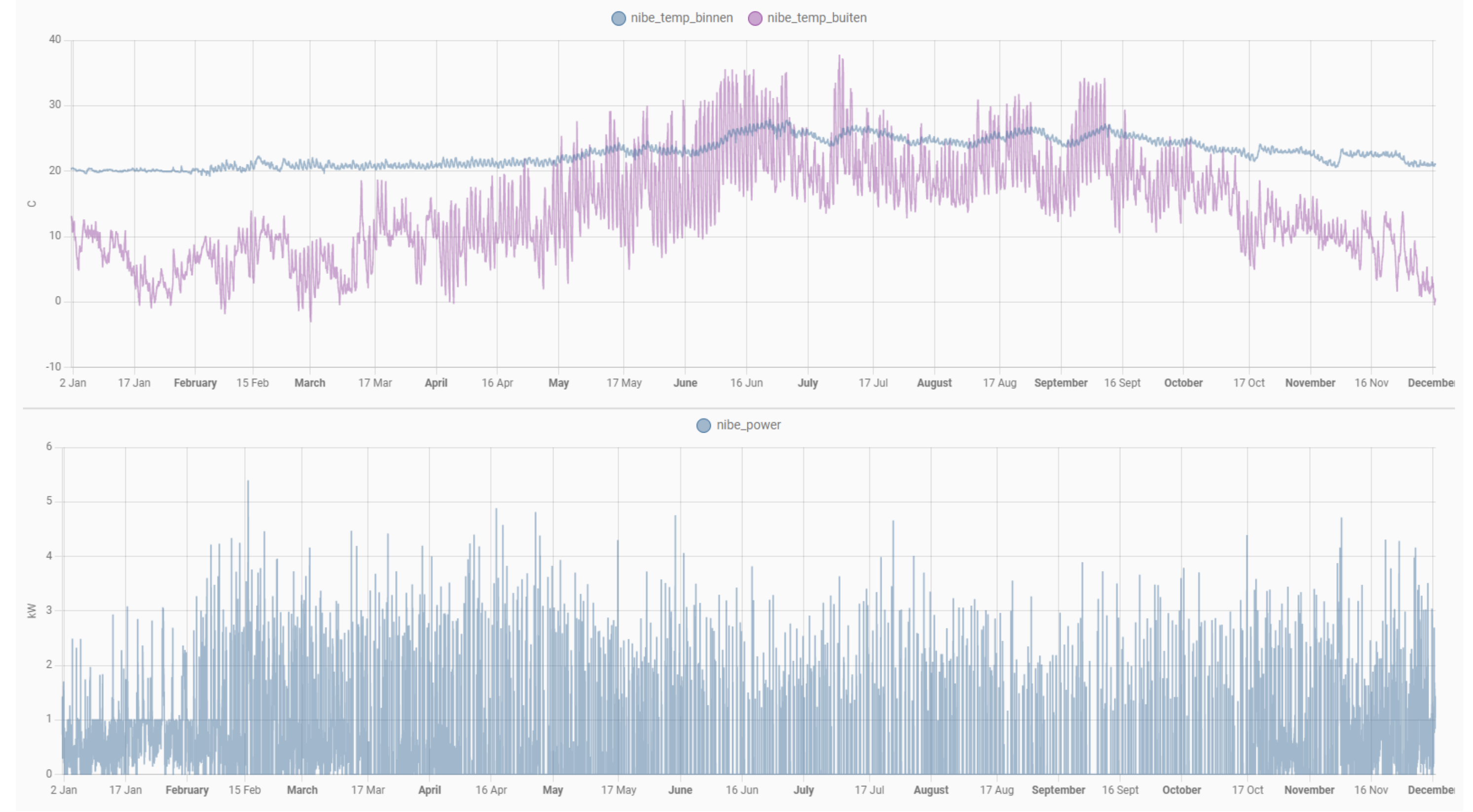


Figure 9. Power and temperature profiles of one heat-pump at the Weverij for one year.

Coefficients of (2)	Winter time
b [°C/kWh]	0.038592
c [°C/°C]	0.002299
d [°C]	-0.041788

UNIVERSITY OF TWENTE.

[Reference: https://ris.utwente.nl/ws/portalfiles/portal/12378855/thesis_T_van_der_Klauw.pdf]

EMS…

LESSONS LEARNED…

Expertise Needed: Projects with new user-facing technologies need integrators with microgrid/home energy management expertise in engineering and finance. Universities are good for prototyping, research, and consulting, but lack expertise for final solutions.

Control Algorithm Complexity: Electricity tariff significantly impacts control algorithm complexity. A simpler reactive algorithm might suffice if price optimization is not required.

Heat Pump Controllability: Involve integrators and manufactures with energy management expertise to address device control limitations and poor documentation/standardization.

Prioritize Human Factors: Consider user interaction, user interfaces, and user-centric control algorithms from the beginning.

Risk Assessment: Consider disruptions like COVID-19 through a robust risk assessment matrix.

Post-Project Responsibilities: Clearly define who monitors, operates, and maintains the system after project completion.

UNIVERSITY
OF TWENTE.