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A multi-agent based approach for energy resource management in energy communities

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Agenda

- Motivation
- Energy Storage Management System
- Connection to the real world
- Results
- Conclusions

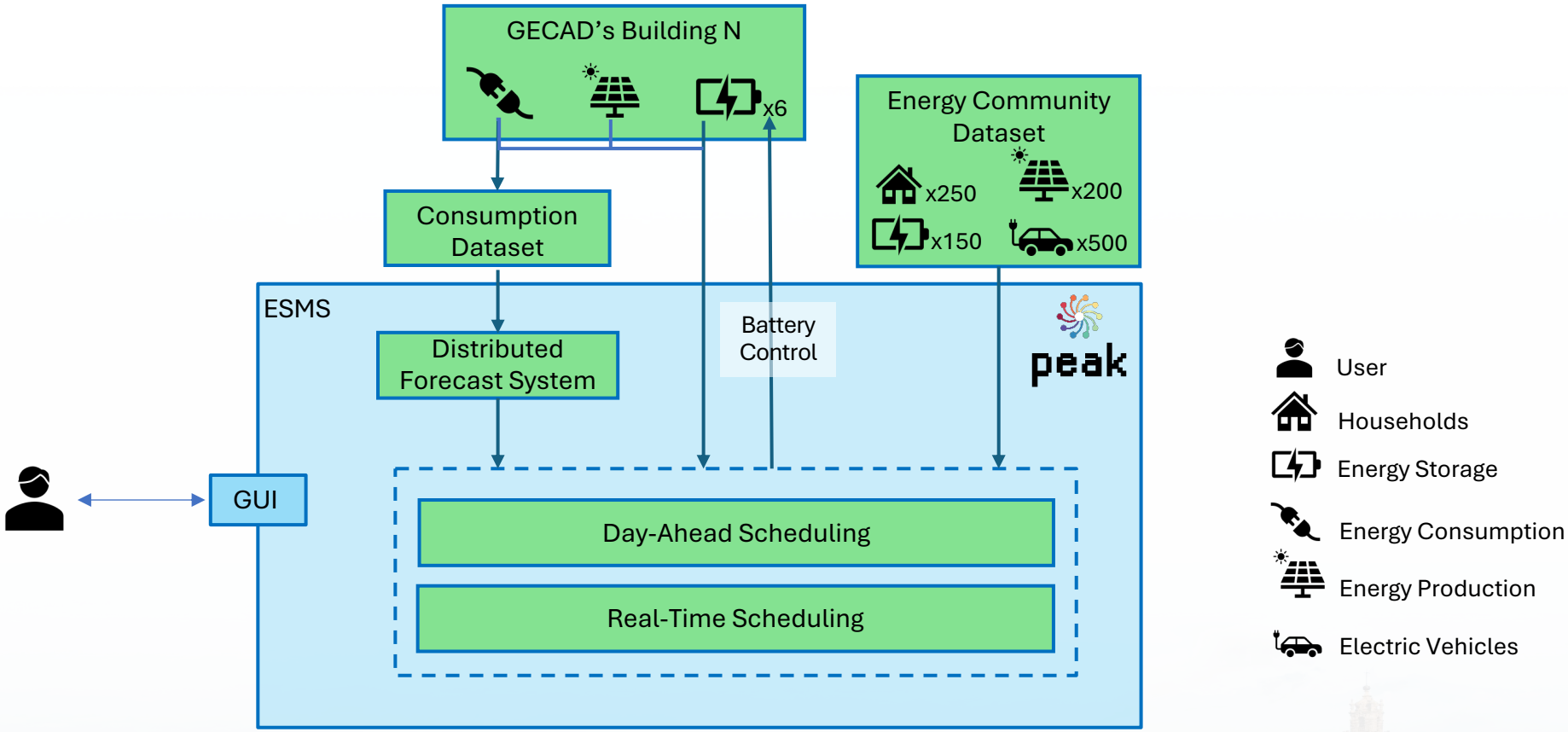
Motivation

There are a lot of multi-agent systems applications in the energy field:

- Modeling energy communities
- Demand and response
- Energy transaction and negotiation

But there are very few works which actually deploy and test the system in real world scenarios.

Energy Storage Management System (ESMS)



ESMS – Energy Community Dataset

Energy Community Dataset

x250 x200

x150 x500

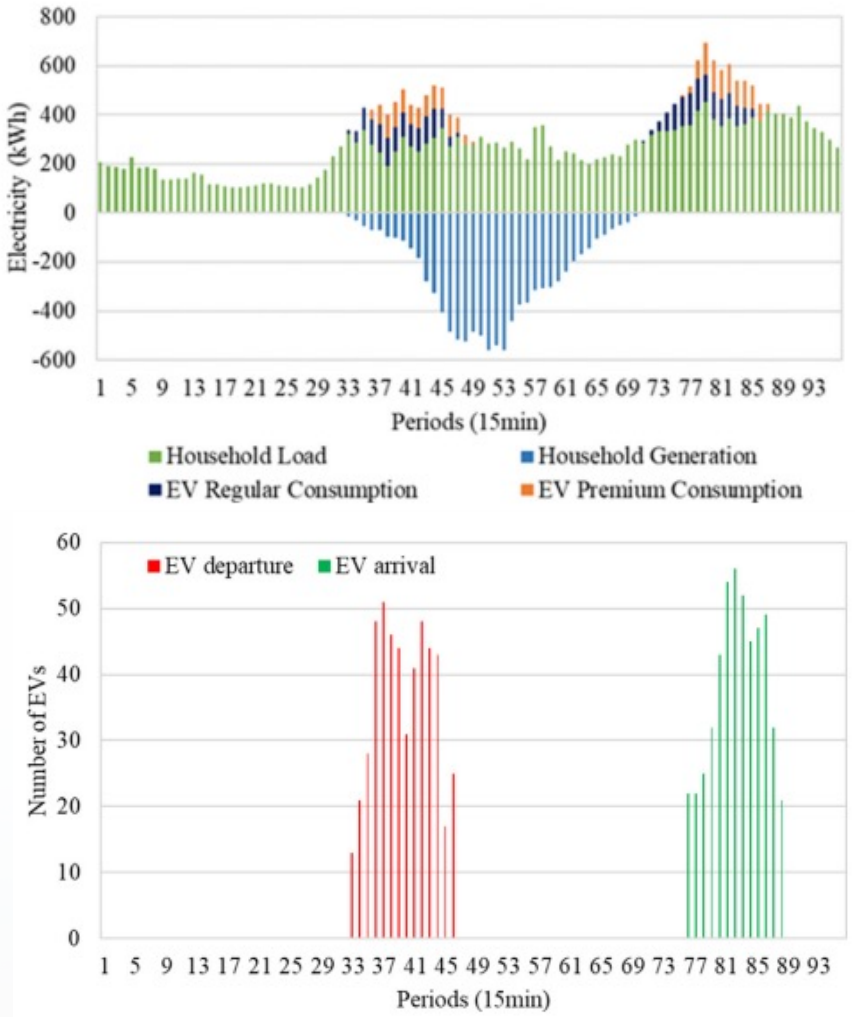
Households

Energy Storage

Energy Production

Electric Vehicles

Data from UK, London, France, Sceaux, and GECAD's building N.

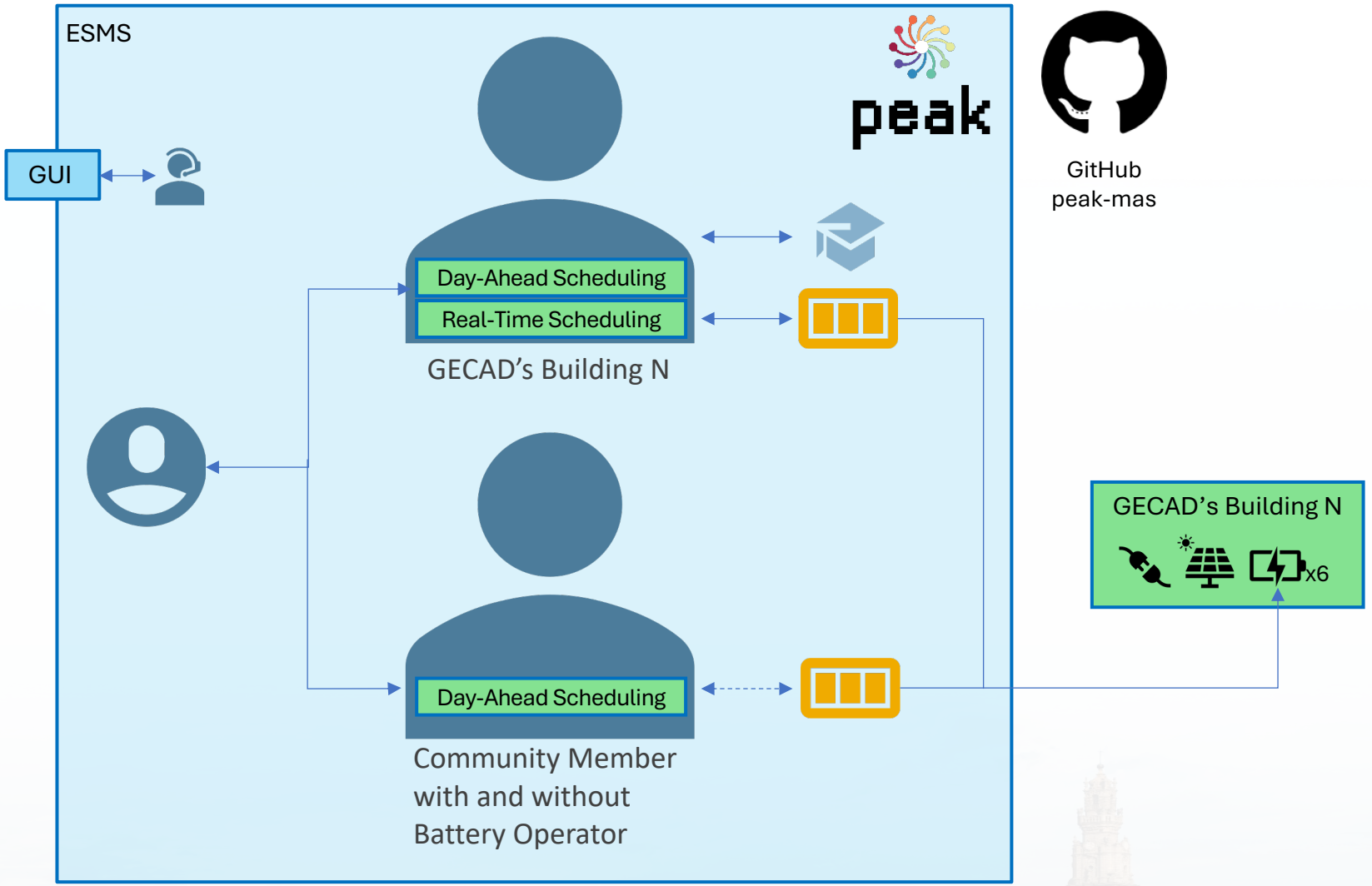


Faia, R., Goncalves, C., Gomes, L., & Vale, Z. (2023). Dataset of an energy community with prosumer consumption, photovoltaic generation, battery storage, and electric vehicles. Data in Brief, 48, 109218. https://doi.org/10.1016/j.dib.2023.109218

ESMS – Multi-Agent System

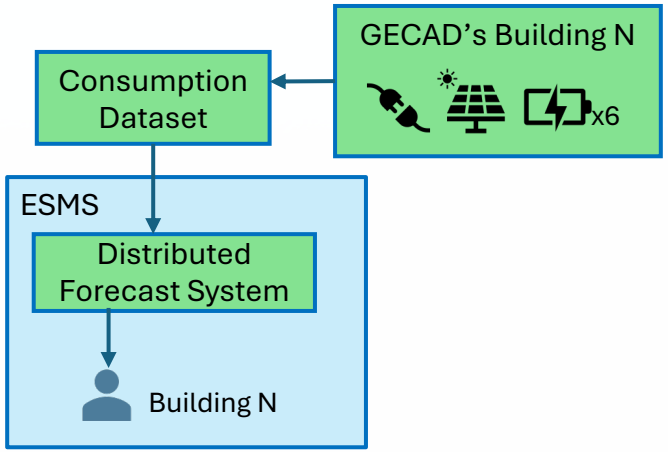
Roles and Interactions

- x1 Community Manager
- x250 Community Members
  - x1 GECAD's Building N
  - x5 with Battery Operator
  - x244 without Battery Operator
- x5 Battery Operators
- x6 Forecast System Agents
- x1 System Manager



GitHub
peak-mas

ESMS – Distributed Forecast System



Forecast System Agents

x6

Forecast Manager	Communicates with outside agents
Forecast Expert	Orchestrates the forecasting service
Data Engineer	Devides data into train, test and validation sets
ANN Engineer	Trains and tests the artificial neural network
Error Analyst	Calculates the error of the model
Learner	Learns the error profile of the model

Deep Neural Network – 2 hidden layers of 64 neurons
Training Data – Consumption from GECAD's Buiding N, 9th October to 15th October, granularity of 5 minutes.

D. Ramos, P. Faria, and Z. Vale, "Multi-agent Decision System in a Building to Coordinate the Energy Forecasting Tasks," in 21st International Conference on Distributed Computing and Artificial Intelligence, 2024.

ESMS – Day-ahead optimization algorithm

	Day-ahead algorithm*	**Real-time algorithm**
Approach	Mixed integer linear programming	Genetic Algorithm
Schedule window	next day starting at mid night	Next 24 hours
Period size	15 minutes	5 minutes
Input	consumption, production, energy market prices, EVs departure and arrivel hours, EVs batteries, Energy storage systems	
Output	Energy market transaction schedule, EV energy usage schedule, Battery schedule	
Execution time	at 8PM every day	Every 15 minutes (0, 15, 30, 45)

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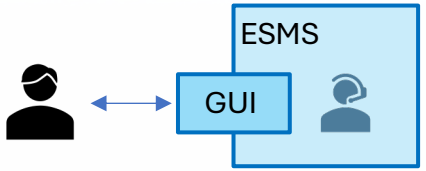
* Faia, R., Ribeiro, B., Goncalves, C., Gomes, L., & Vale, Z. (2023). Multi-agent based energy community cost optimization considering high electric vehicles penetration. Sustainable Energy Technologies and Assessments, 59, 103402. https://doi.org/10.1016/j.seta.2023.103402

Energy Storage Management System (ESM)

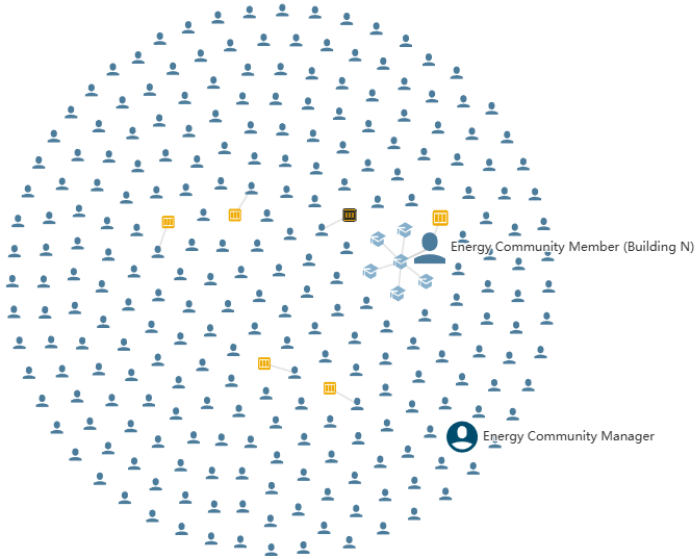


Energy Storage Management

with Evolutionary Algorithms, Machine Learning, Multi-Agent Systems and Real-Time Simulation

Energy Community

Community Manager
Member
Hardware Battery
Forecast System



Battery Operator 2

Grid L1
-0.633 kW

Voltage
48.9 V DC

Current
-13.9 A DC

Power
-0.679 kW

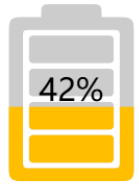
schedule

Target Power (W)

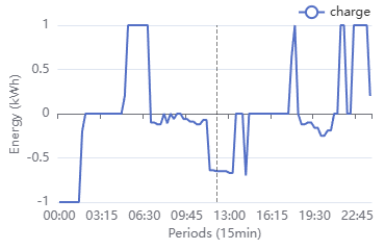
0 − +

Submit

Battery State of Charge



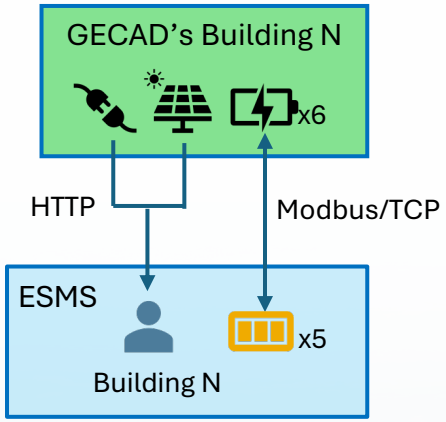
Battery Operation Schedulling (today)



Connection to the real-world – GECAD's Building N

GECAD's Building N

Energy Storage System with six batteries



Consumption and Production

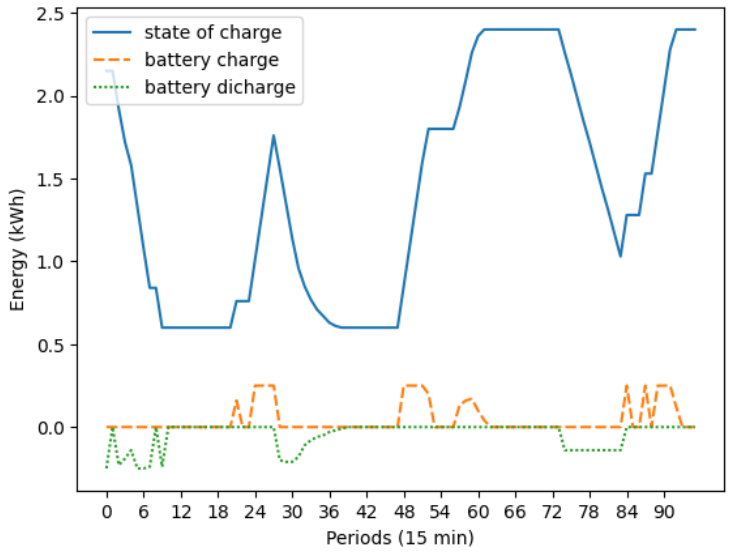
SCADA - supervisory control and data acquisition
HTTP/s
Photovoltaic plant
Consumption

Energy Storage

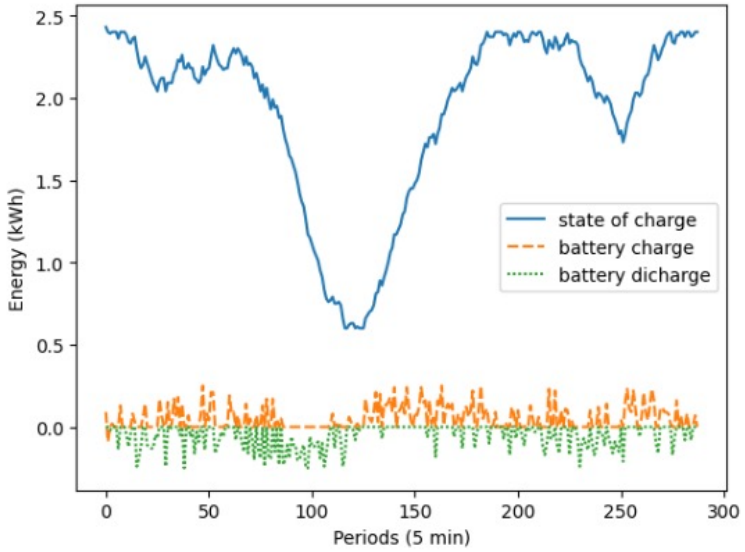
Victron Energy
Modbus/TCP
6 batteries:
- 3 with 2.4 kWh
- 3 with 3.5 kWh

Security layers limits discharge bellow 25%.

Results – Battery schedules comparisson



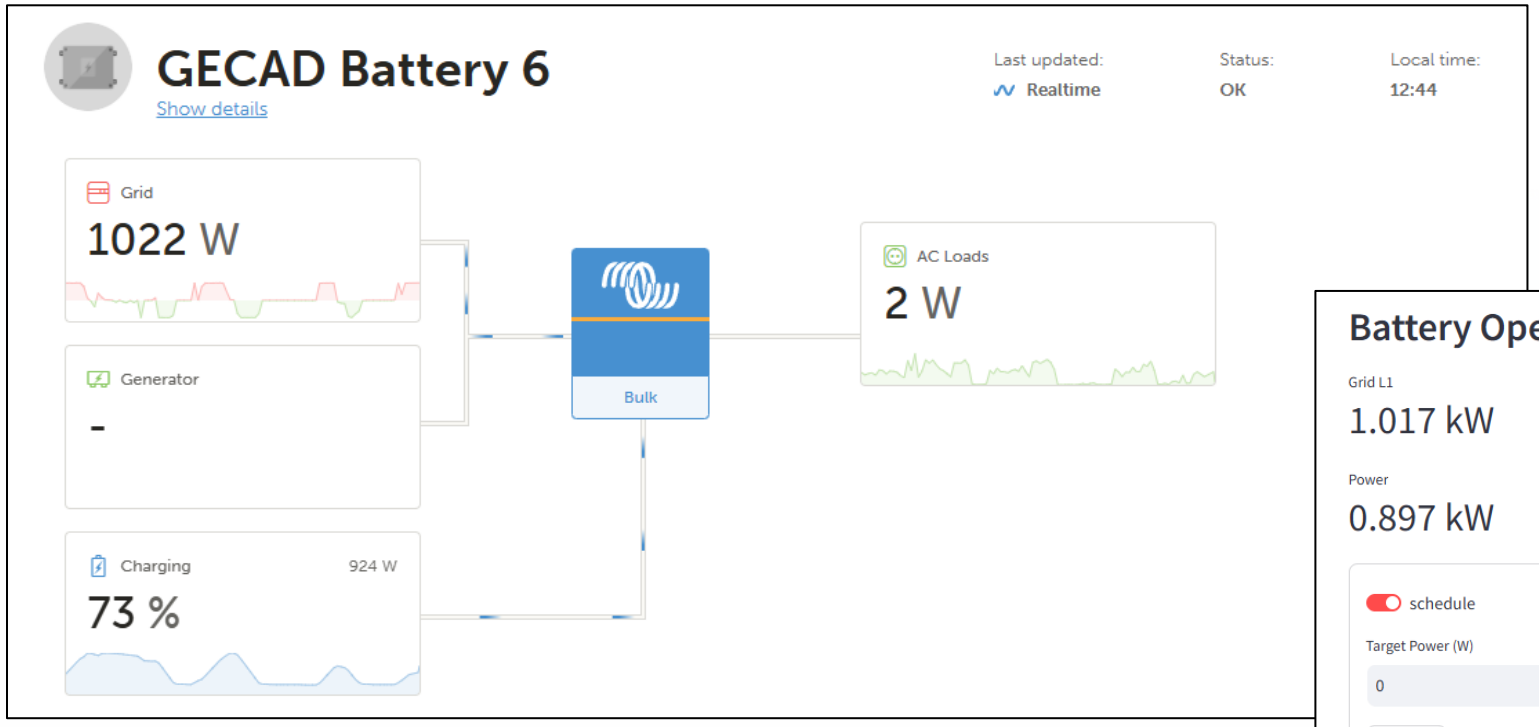
Full day schedule of day-ahead algorithm.



Full day schedule of real-time algorithm.

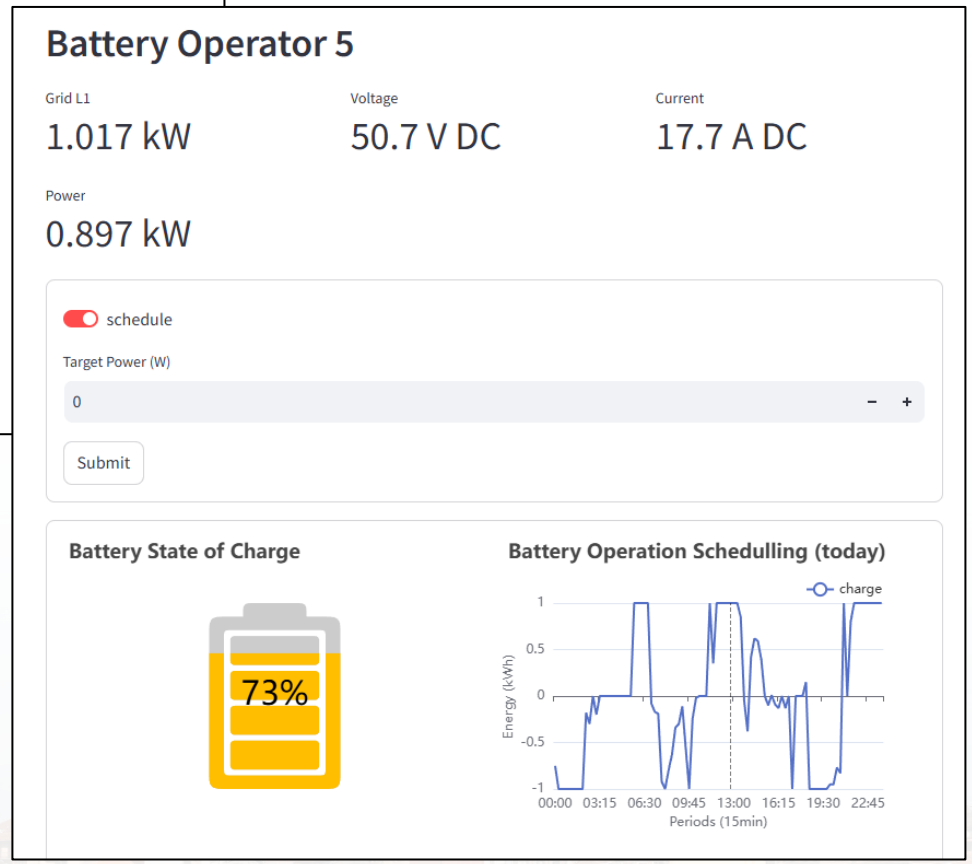
Both used the same 2.4 kWh battery.

Results – Battery usage in real-time

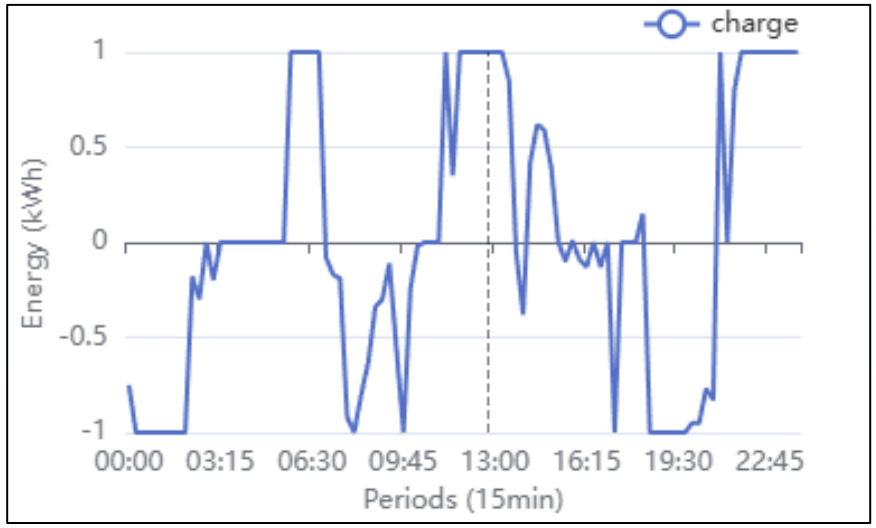


Victron Energy Portal – Battery 6

ESMS Dashboard – Battery Operator 5

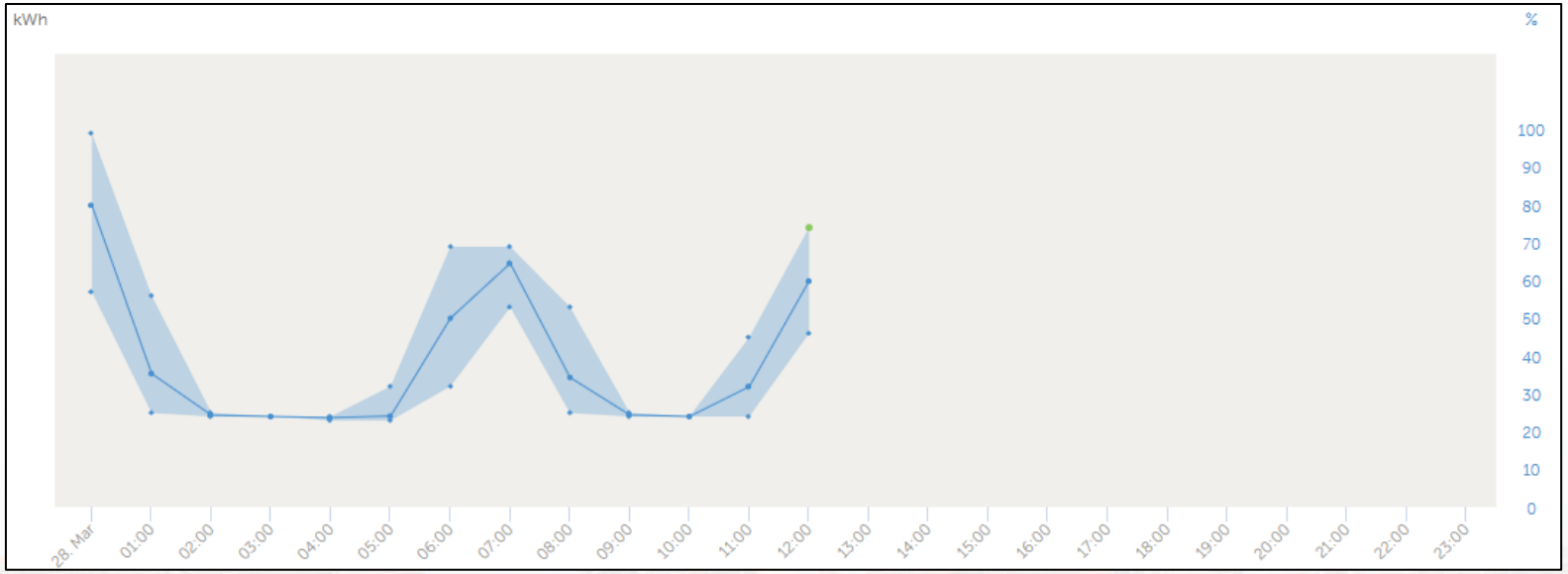


Results – Battery usage in real-time



Battery Operator 5 – Battery Schedule

Victron Energy Portal – Battery 6 – State of Charge



Conclusions

- The scheduling algorithms could adapt to the consumption data of the real building
- The battery schedules were aplied to the physical batteries and produced the expected energy profiles

Future Work

- Feed more data into the algorithms (production forecast, state of charge and current charge of the battery, etc)
- Battery degradation algorithm
- Battery life expantacy algorithm

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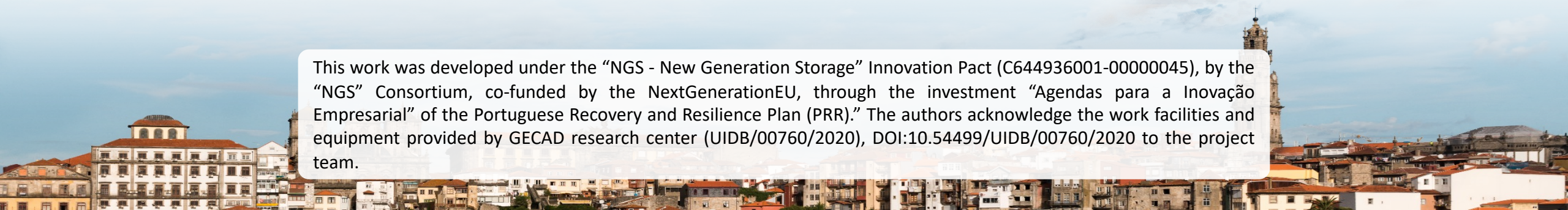

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