INTERNATIONAL
ELECTRIC VEHICLE SYMPOSIUM & EXHIBITION

Performance monitoring and optimization of an electric vehicle charging station

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Performance monitoring and optimization of an electric vehicle charging station

Contents:

1. Starting point and objective
2. Management and communications structure
3. The Energy Box – CIRCE's IoT hardware solution
4. Remote System
5. Monitoring SCADA
6. Conclusions

Starting point and objective

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- **Combustion vehicles** are responsible for a great part of the **pollutants** generated worldwide and **electric vehicles** (EVs) are proposed as a **solution**
- To prevent negative impacts of a massive EV penetration on the electricity grid, **EV recharging needs to participate in Responsive Demand Schemes**
- Most of the **proposals** to achieve these objectives **focus on time-of-use (TOU) rates or real-time pricing**
- Following these ideas, in the Spanish demo of **FLEXICIENCY Project** a **microgrid** composed of a photovoltaic generator, storage system and charging points was **converted into a system that works in a coordinated and optimized way to support the electric grid operation**

Starting point and objective

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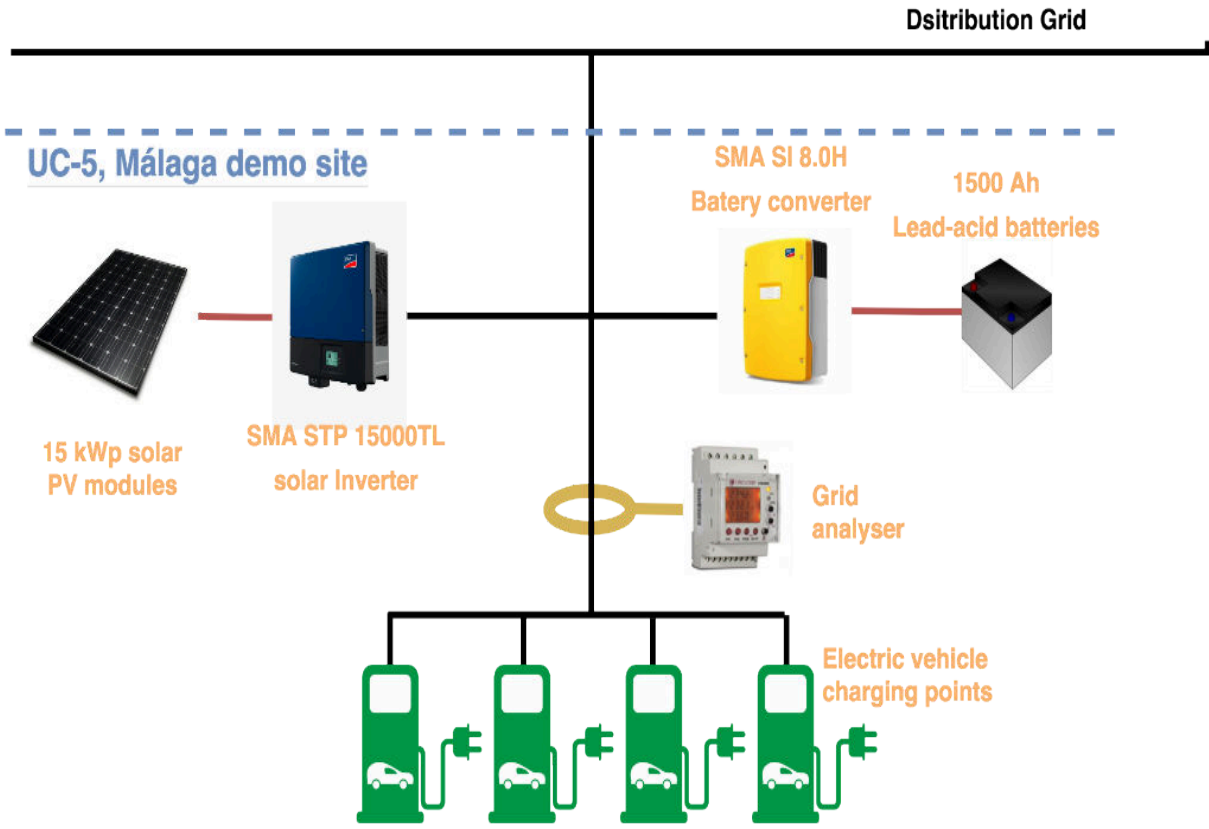
All components operated in an independent way:

- PV inverter only generating active power injecting excess power into the grid
- Energy storage system only for back-up: If the grid fails, stored energy feeds EV charging points
- The visualization and control interface of the inverters and the sensors was carried out with a proprietary development of the SMA equipment



Starting point and objective

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Main objectives:

- Optimise the operation of the whole charging station
- Reduce charging station grid impact
- Enable future improvements to provide flexibility services

Management and communications structure

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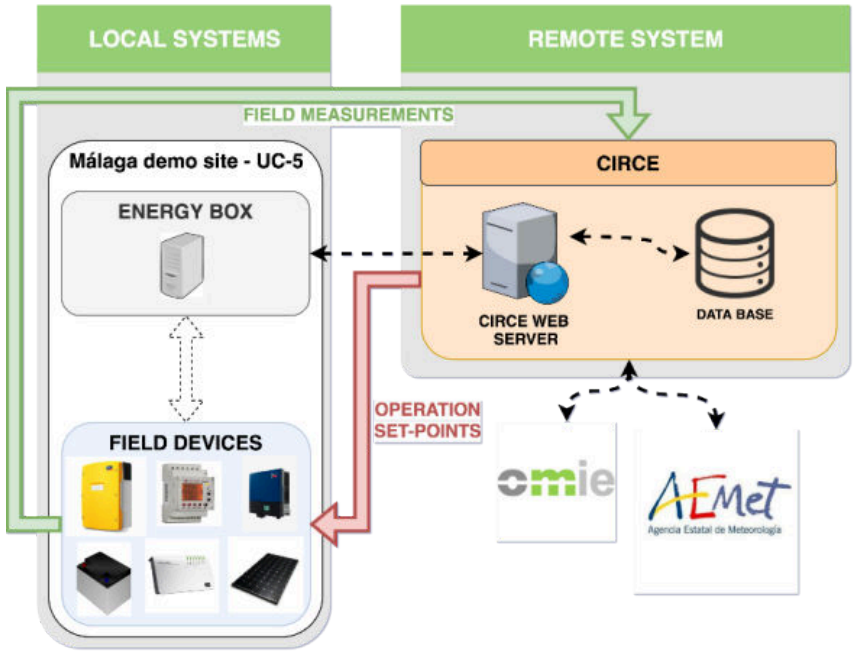
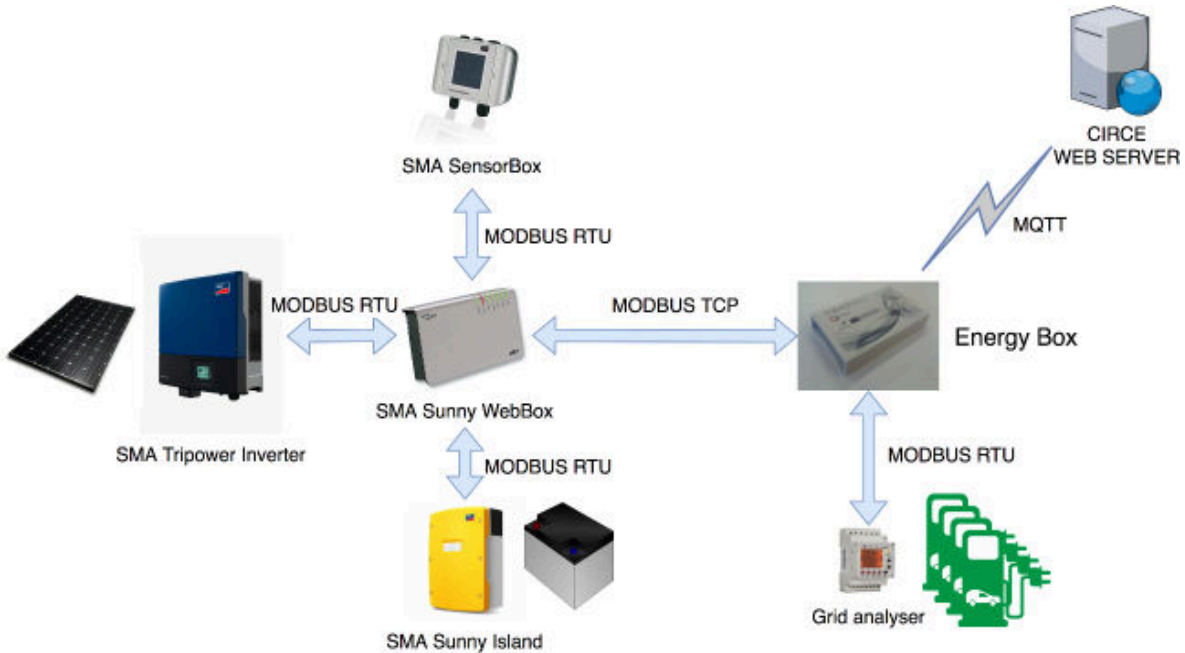
Two groups of hardware and software tools:

- **Local system**, to monitor the microgrid providing field measurements to the remote system and applying operation set points to battery converters, previously adapted to the real demo-site conditions
- **Remote system**, to calculate set points for the field devices that minimize the energy bill of the charging station





The Energy Box – CIRCE's IoT hardware solution

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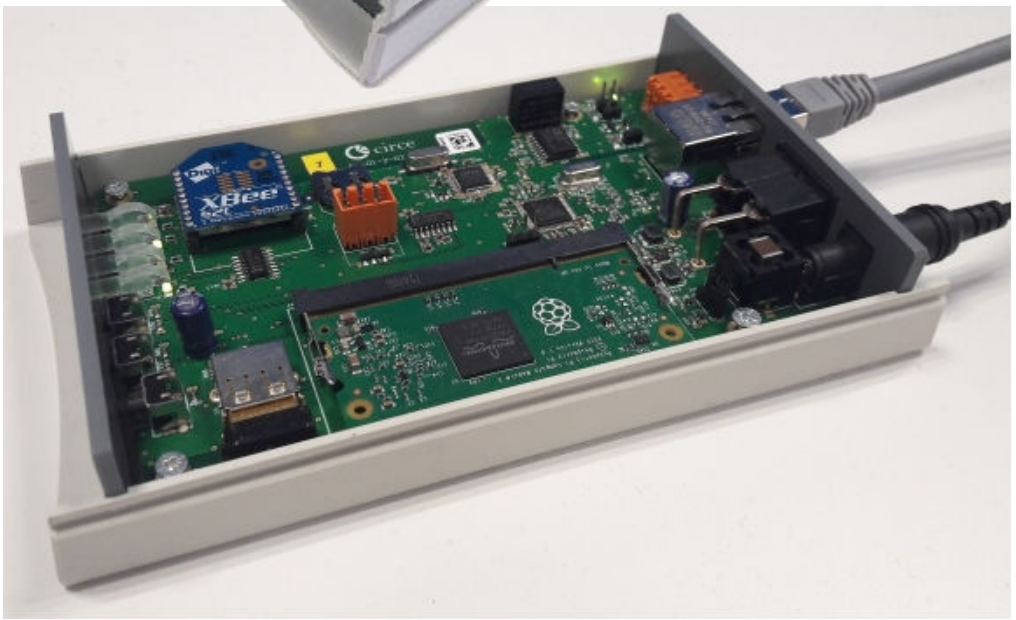
CIRCE's solution for µ-grid management

Multi-purpose concentrator for advanced grid control and Smart Grids

Main features:

- Versatile communication
  - Wifi, ZigBee, Ethernet, USB, serial communication
- Embedded computer for distributed control:
  - Capture and storage of information
  - Execution of algorithms



The Energy Box – CIRCE's IoT hardware solution

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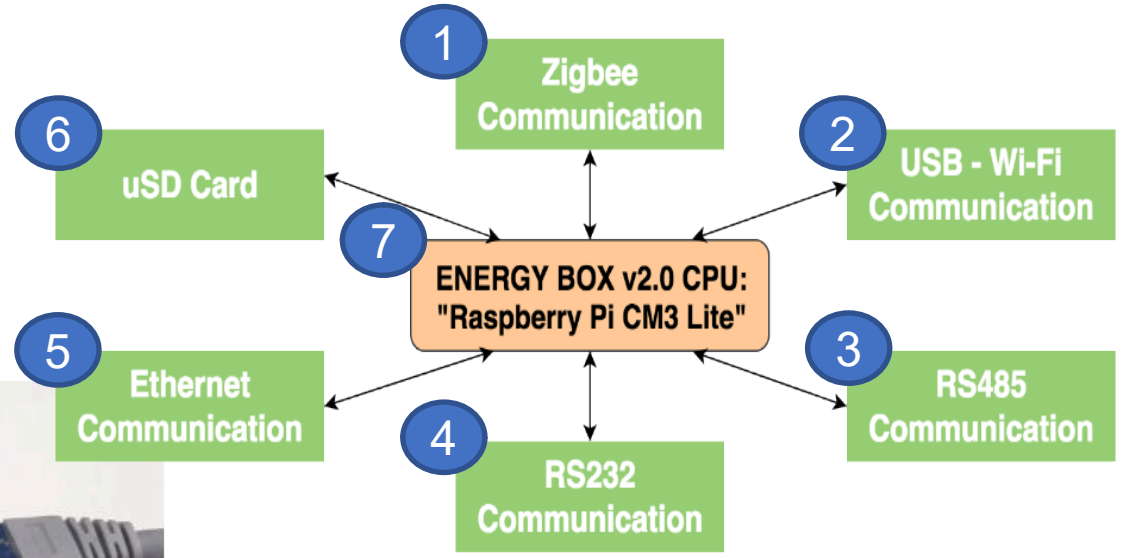
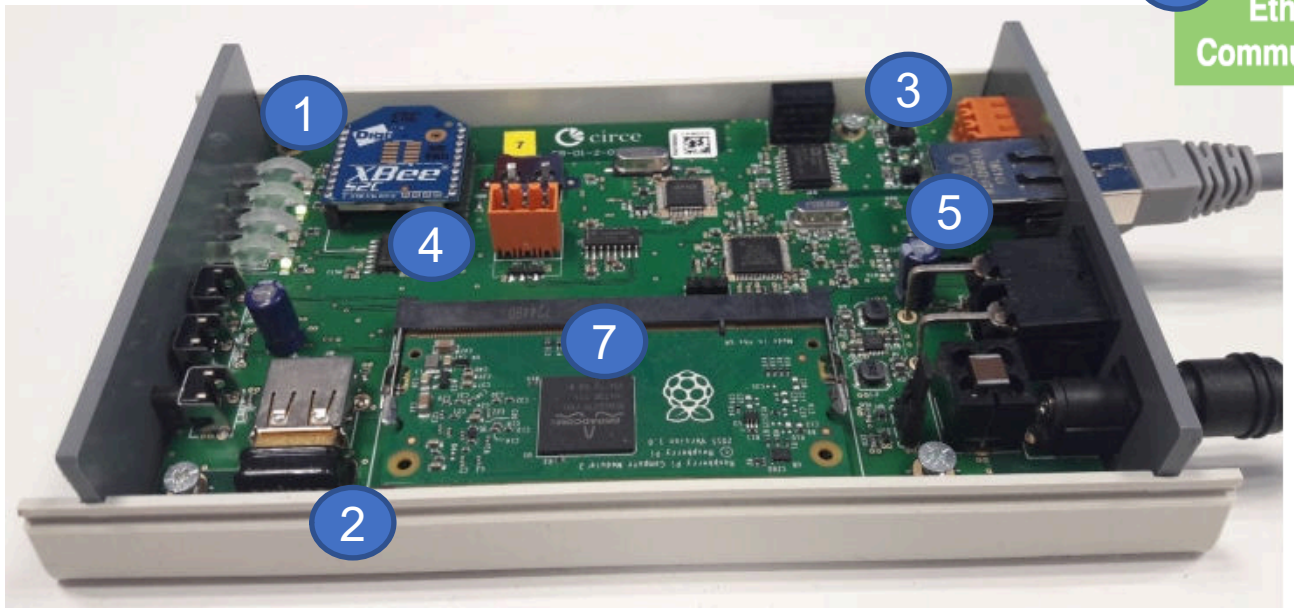
Hardware description:



Front layer



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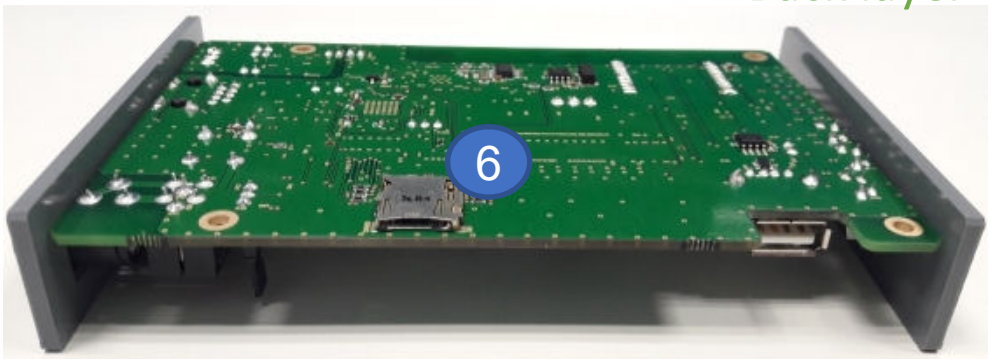

The Energy Box – CIRCE's IoT hardware solution

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Software description:

- Raspbian-Linux as operating system, given its known advantages regarding availability of device drivers and customizability
- As forecasts always have errors, the EB adapts the set points to the real state of the microgrid
  - These set-points adaptation algorithms are programmed in ADA

Remote System

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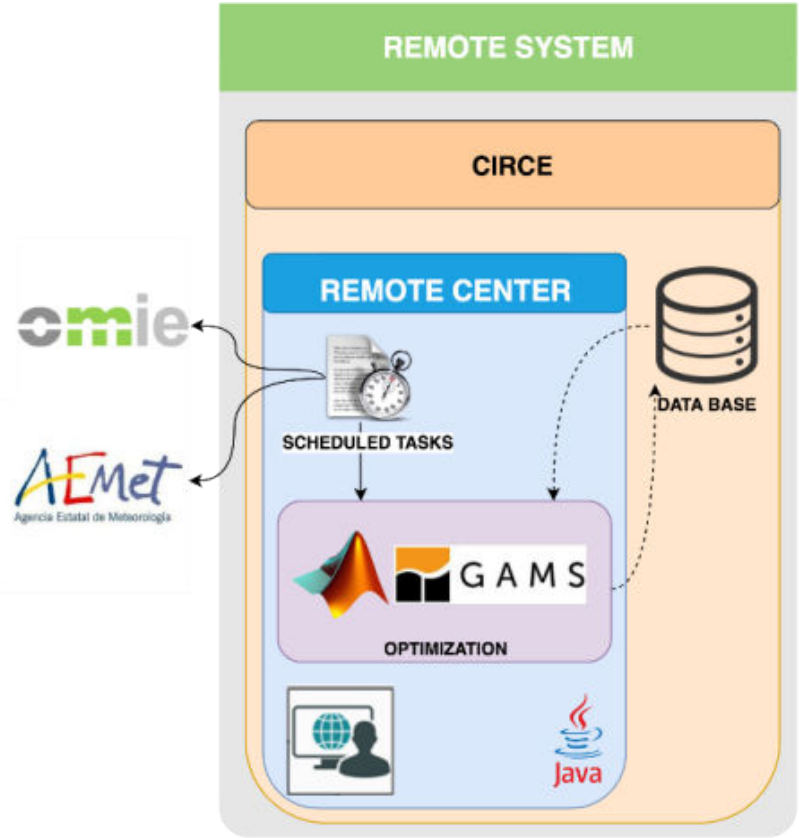
The remote system main tasks:

- Receive and store information gathered by field devices and sent by the Energy Box via MQTT
- Execute a programmed task to calculate 15-min average values from local measurements and to fill slots with missing data
- Forecast the state of some microgrid components
- Calculate optimized operational set points and send them to the Energy Box every 15 min
- Provide remote access to local SCADA



Remote System

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Optimization algorithm:

- Objective: minimize the customer bill
- Result: Consumption, PV generator and batteries storage system operation plan for the next 24 hours
- Implementation: using GAMS software + CPLEX solver
- Objective function:

$$f = C_{Pgrid} + C_{Egrid} - I_{Egrid} + C_{SS} + C_{PSS}$$

Where:

C_{Pgrid} , cost of grid access tolls (power price)

C_{Egrid}, cost of the energy purchased from the grid

I_{Egrid}, income from selling energy to the grid

C_{SS}, cost of using the battery

C_{PSS}, penalization for high battery power

Monitoring SCADA System

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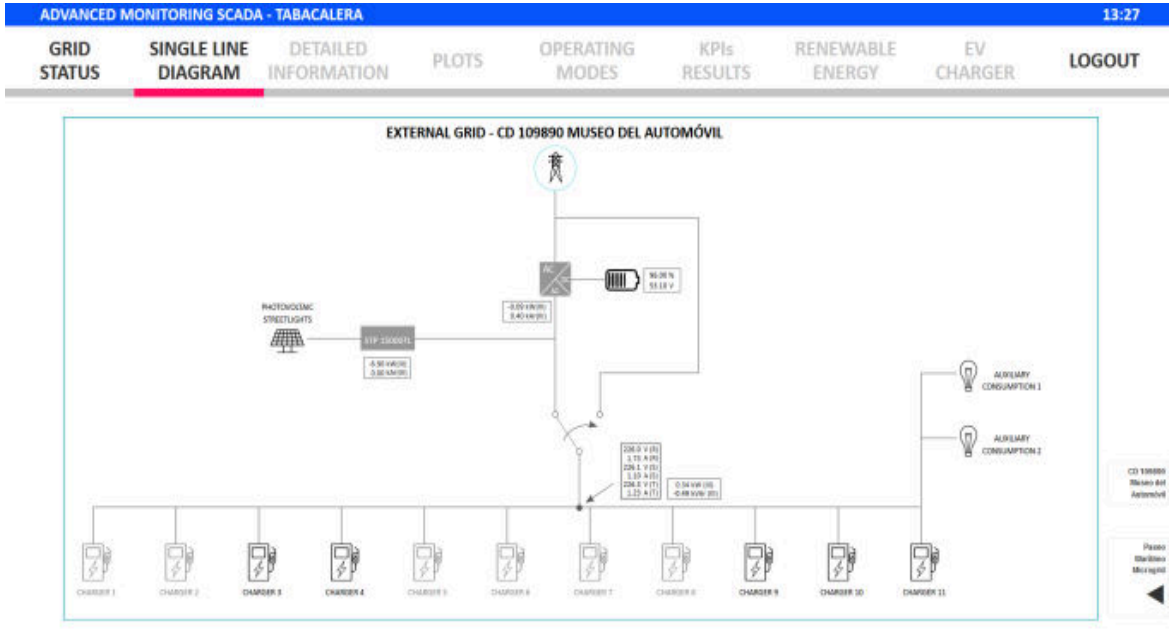
- The SCADA allows microgrid monitoring showing total energy balance and values of active and reactive power of the elements attached, battery SoC and voltage as well as weather data.
- The SCADA system is communicated with the EB software via REST-API providing a User Interface to the system.
- It uses the GNOGA framework in order to get modern web access in an Ada environment.



Conclusions

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- The solution developed is safe and robust:
  - More than 95% of the time the remote system provided operation set points for the storage system.
    - And when the remote system did not provide updated set points, the local system operated seamlessly with the last available plan (24 h / 15-min steps).
  - More than 96% of the 10-second measurements arrived and were stored in the database correctly
- Simulations carried out with real data from early October 2018 show that an optimized use of batteries can transform daily energy expenses into important income (selling excess energy during high-price hours).
- The proposed monitoring and control system transforms an EV charging station in a distribution grid support asset with an optimized operation and the possibility to offer flexibility services to grid operators, but also autonomous operation thanks to distributed control.

Performance monitoring and optimization of an electric vehicle charging station

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Scan me to learn more about FLEXICIENCY Project

Thank you, any question?