Energy storage projects for smart distribution grids

01/06/2018 Laura Pimpinella

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Agenda

- Introduction and Aim
- National and International Committees
- Classification of Energy Storage Systems
- EESS in MV/LV substation
- EESS in HV/MV substation
- Control Functions
- Conclusions and Future Works

Introduction and Aim

- The energy storage system represents a new technology enabling new use cases and roles for DSOs.
- An energy storage system basically is a network component able to inject and absorb power in a specific node of the network.
- This new technology poses new challenges in terms of regulation and evaluation of its profitability.

National and International Committees

IEC International Electrotechnical Commission TC 120 Electrical Energy Storage (EES) Systems

Established in 2013

In order to introduce EES Systems in electrical grids, users shall understand the EES Systems composed of numerous technologies, for example, battery cells, battery units, control system, interface, grid elements and their safety and environmental aspects.

WG1 - To define terms applicable to the electrical energy storage systems.

WG2 - To define Unit parameters and Testing methods to assure the system capability and performance of Electrical Energy Storage Systems (EESS)

WG3 - To give guidance for planning and installation of EES systems and to provide standards and other deliverables which can be used by power system planers, system integrators and commissioning staff.

WG4 - To deal with general environmental requirements, specific environmental requirements of EES systems

WG5 - To prepare normative documents on safety

National and International Committees

CEI CT120 – established in 2013

CEI is the national responsible for technical standardization (electrotechnics, electronics and telecommunications) through standards that are the reference for the presumption of conformity to the "rule of art" of electrical products, processes, systems (Law 186/68).

- Connection scheme updates for energy storage systems (CEI 0-16/0-21) tacking into account consideration on measurements coming from GSE
- CEI 0-16 and CEI 0-21 are adopted in AEEGSI deliberation

ITALIAN ELECTRICAL ENGINEERING AND ELECTRONIC INDUSTRY

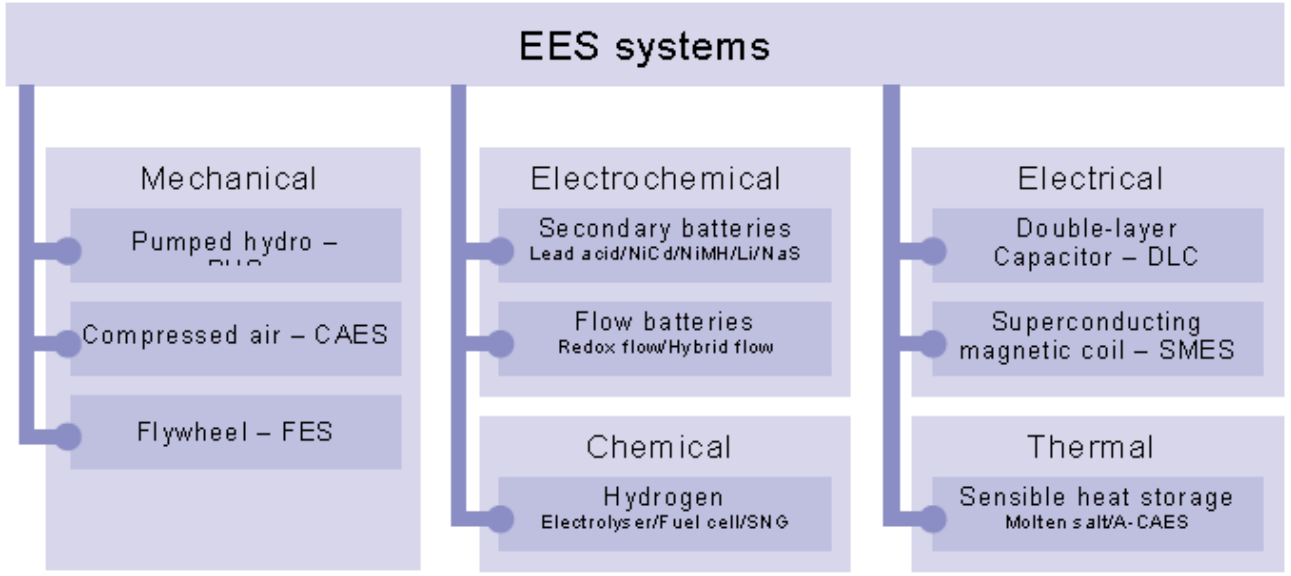
Position papers from 2012 explaining new and evolving scenarios:

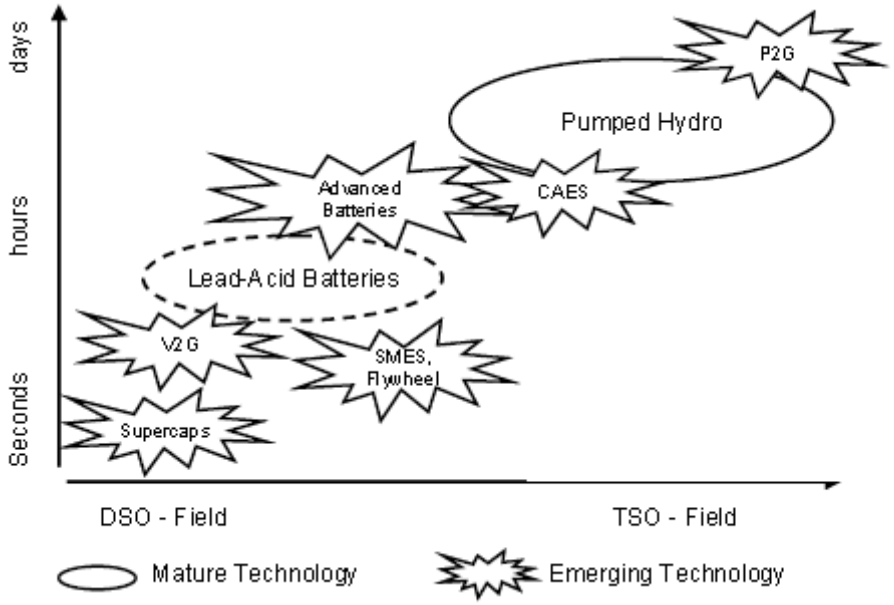
- benefits deriving from the possible installation of storage systems both in the networks of transmission that in those of distribution with the impacts on the components supply chain.

Classification of Energy Storage Systems

IEC TC120

A widely-used approach for classifying EES systems is the determination according to the form of energy used. EES systems are classified into mechanical, electrochemical, chemical, electrical and thermal energy storage systems.





Classification of Energy Storage Systems

IEC TC 120

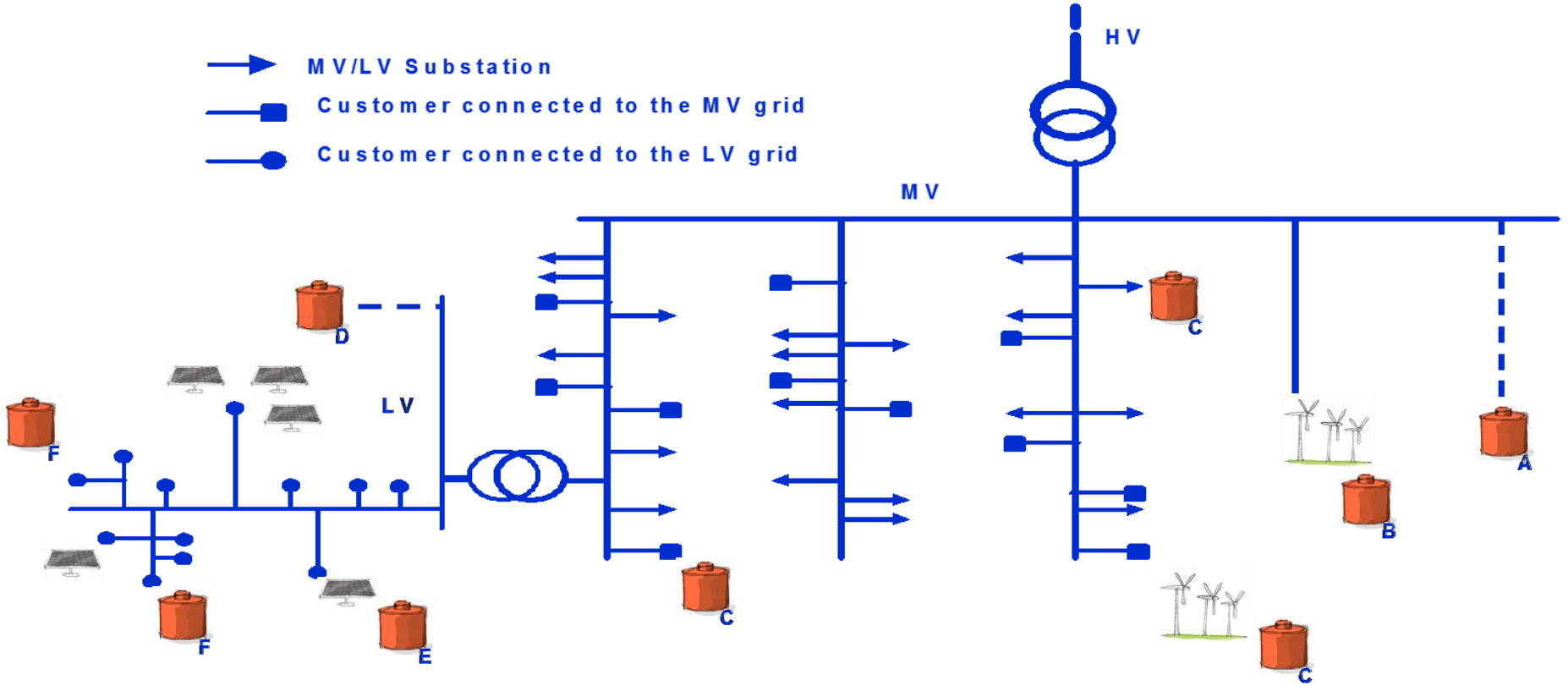
The application and use of an EES system differs according to its purpose and location. It can be categorized into three classes, and five representative applications:

Classifications	Class A (short duration)	Class B (long duration)	Class C (back-up)
Typical applications	Frequency regulation Fluctuation reduction Voltage regulation	Peak shaving/peak shifting	Back-up power

One EES system can be used in combination with applications of different classes based on Cost Benefits Analysis.

Classification of Energy Storage Systems

Placement



A	At a HV/MV substation
B	At a feeder of RES in the MV grid
C	At any point of an existing MV grid
D	At a MV/LV substation
E	At a *prosumer* facility connected to an LV grid
F	At any point of an existing LV grid

Source: "Decentralized Storage: Impact on future distribution grids" A Eurelectric paper

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EESS in MV/LV substation

EESS in the G4EU Project

ESS main characteristics

Battery technology: Li-ion

Max power: 1 MVA

Energy capacity: 1 MWh

Number of cycles: 5200

Efficiency: > 80%

G4EU Project

The Italian Demo Region of the European project G4EU is located in the Italian region Emilia Romagna. Enel, that lead this demo, installed a storage system (1 MVA – 1 MWh) in a MV/LV substation that can be connected to several feeders.

The goal is to study a new decentralized solution for voltage regulation and hosting capacity rising. In particular, thank to this particular installation, it is possible to “move” the storage in different feeders depending on the results of an **optimization** procedure (EESS optimal location).

EESS in HV/MV substations

EESS in the POI Project

Three EESS is used to reduce the variability of the power flow in the parts of the network with high penetration of RES, alleviating fast power flow variations in case of wind gusts or passage of clouds. **In particular, the EESS will be used to control energy exchange profiles between the HV/MV substations and the National Grid to make them more predictable (1h - 24h ahead)**.

EESS main characteristics

Battery technology: Li-ion

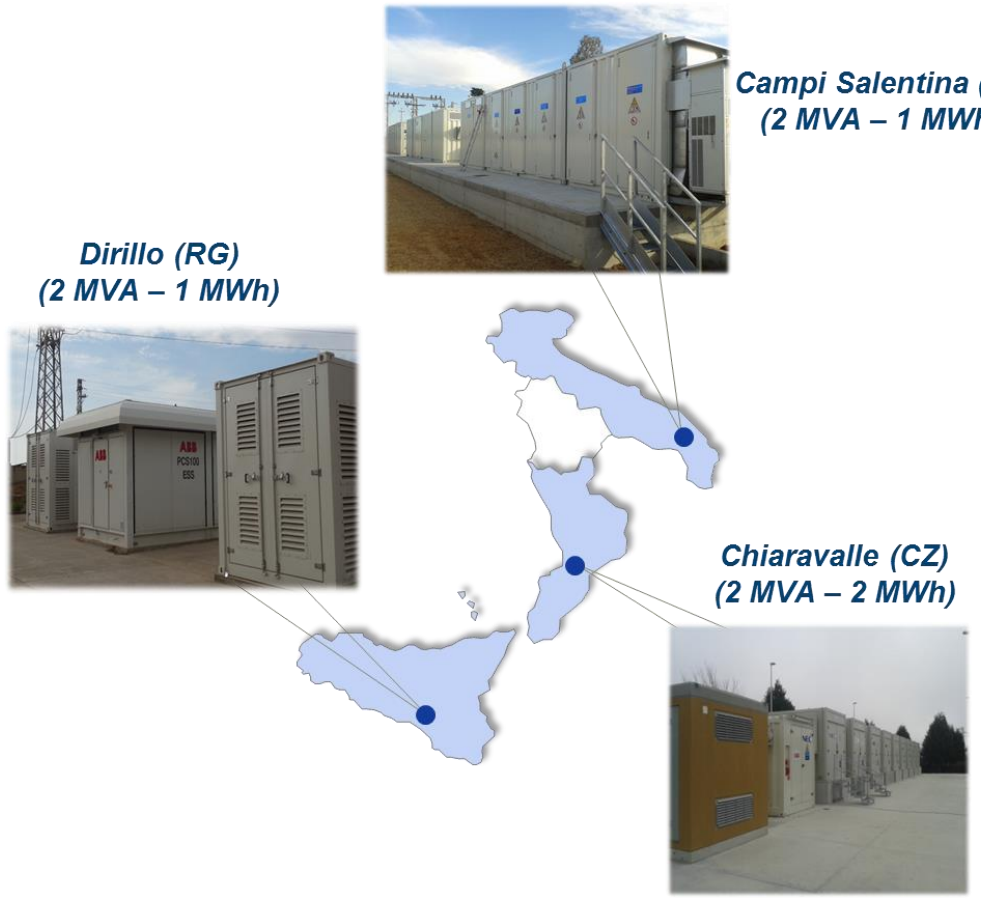
Max power: 2 MVA

Energy capacity: 1 MWh (2), 2 MWh (1)

Number of cycles: 2000 ÷ 4000

Efficiency: 85%

Max installation area: 200 m^2/MWh



EESS in HV/MV substations

EESS Chiaravalle (CZ) - CALABRIA

- **Placement:** MV BusbarChiaravalle (Calabria)
- **Installation type:** Containers (10 containers, 8 power converter systems, 136 battery racks, 3264 battery modules with 26112 Li-Ion cells)
- **Providers:** System integrator NEC with batteries NEC
- **Technology:** Li-Ion (Lithium metal oxide)
- **Nominal Power:** 2 MVA
- **Nominal Energy:** 2 MWh
- **Life:** 4.000 cycles – 10 years
- **Efficiency:** 81,36%
- **Aux consumption:** max 787,75 kWh day
- **Installation needed space:** 400 m^2

EESS in HV/MV substations

EESS Campi Salentina (LE) - PUGLIA

- **Placement:** MV Busbar CP Campi Salentina (Puglia)
- **Installation type:** Containers (3 containers, 8 power converter systems, 32 battery racks, 928 battery modules with 12992 Li-Ion cells)
- **Providers:** System integrator SAET with SAFT batteries
- **Technology:** Li-Ion (Lithium metal oxide)
- **Nominal Power:** 2 MVA
- **Nominal Energy:** 1 MWh
- **Life:** 2.000 cycles – 10 years
- **Efficiency:** 86,29%
- **Aux consumption:** max 356 kWh day
- **Installation needed space:** 200 m^2

EESS in HV/MV substations

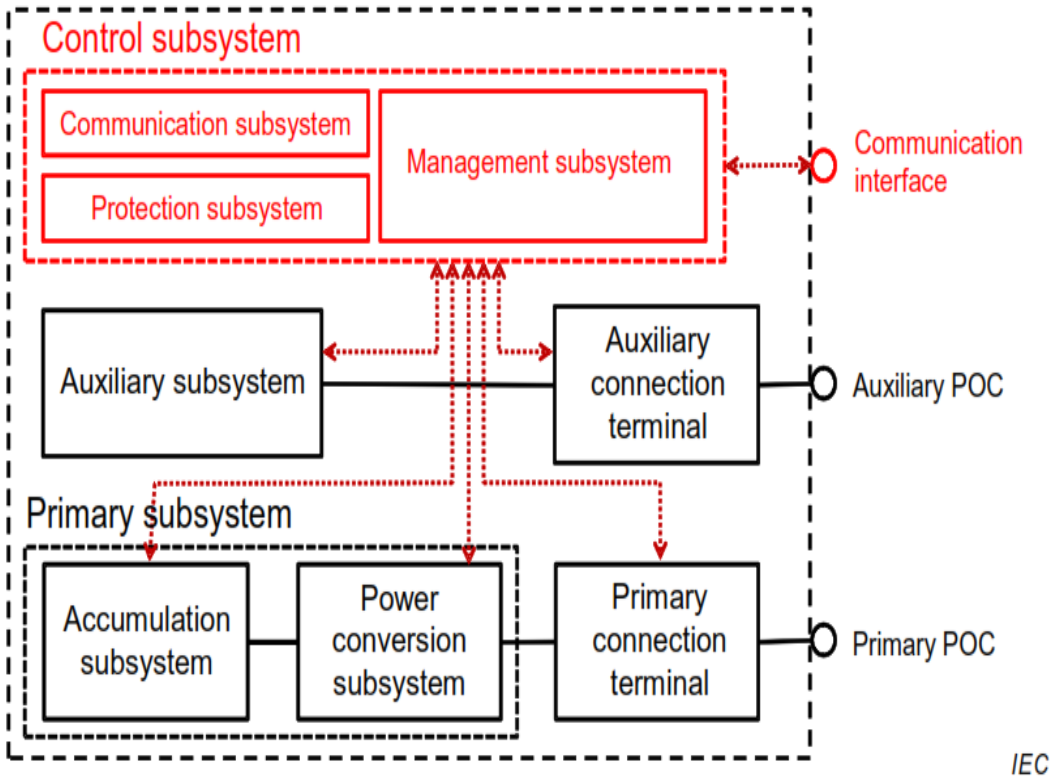
EESS Dirillo (CT) - SICILIA

- **Placement:** MV Busbar CP Dirillo (Sicilia)
- **Installation type:** Containers (4 containers, 5 power converter systems, 40 battery racks, 400 battery modules con 3600 Li-Ion cells)
- **Providers:** System integrator ABB with FiB batteries
- **Technology:** Li-Ion (Lithium Iron Phosphate)
- **Nominal Power:** 2 MVA
- **Nominal Energy:** 1 MWh
- **Life:** 3.000 cycles – 10 years
- **Efficiency:** 86,4%
- **Aux consumption:** max 580 kWh day
- **Installation needed space:** 240 m^2

EESS in HV/MV substations

Common Features

IEC 62933



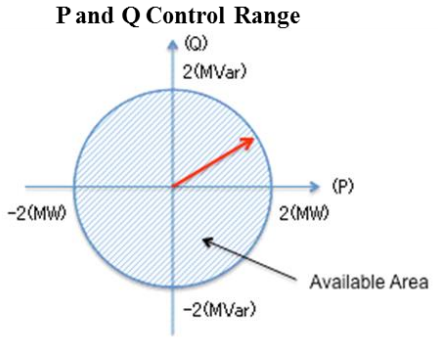
SITE INDIPENDENT

- **Control and monitoring chain**
- **MV Connection rules**

SITE DEPENDENT

- **Plant Layout**
- **Number of cycles, Efficiency …**
- **Internal protocols and communication choices**

Control Functions



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Ordinary Functions

- P/Q mode – The ESS is controlled by command from SCADA. It allows charging power to ESS during low demand periods and discharging power from ESS during peak demand periods..

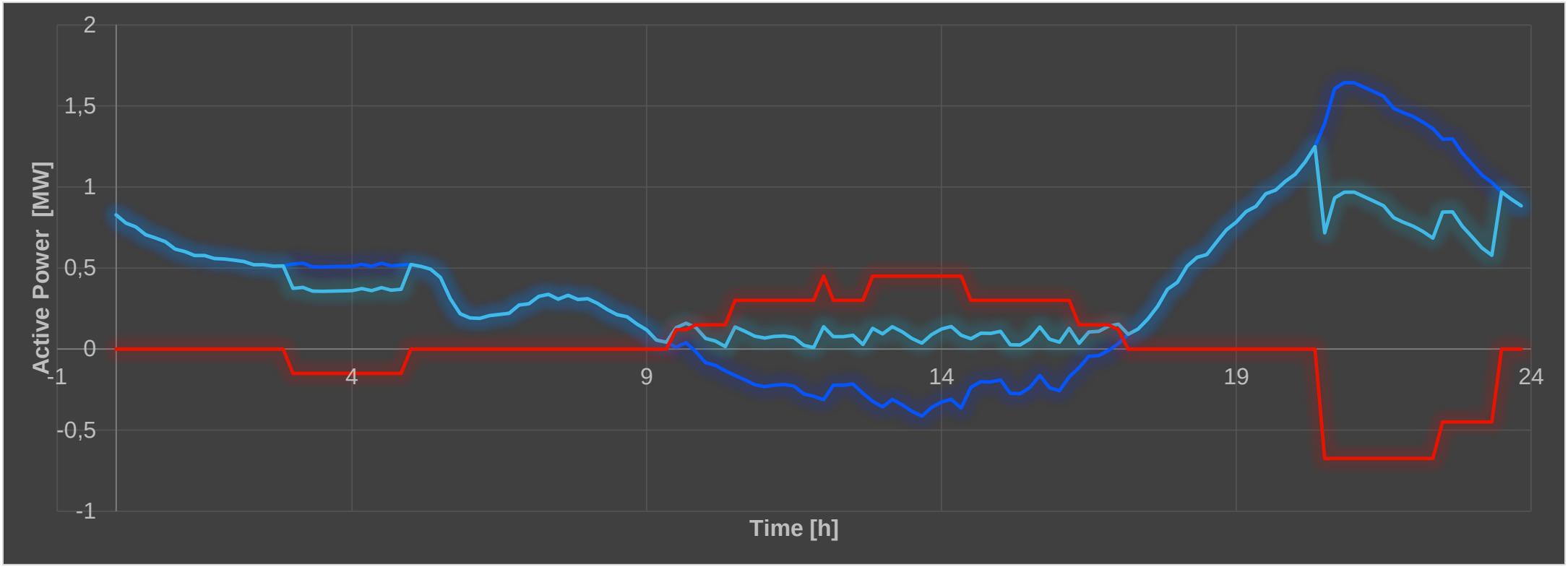
Autonomous Functions

- Imbalance compensation – Reduction of the imbalance between the phase voltages measured at point of connection;
- Harmonics compensation – THD Reduction of voltages measured at point of connection by means of harmonic currents.
- Voltage dips compensation – When a voltage dip occurs at point of connection, EESS detects it autonomously and discharges maximum active power;
- Frequency regulation – ESS can compensate for frequency deviations at point of connection in accordance with the following regulation rule: $P(f) = af + c$;
- Voltage regulation – ESS can compensate for voltage deviations at point of connection in accordance with the following regulation rule: $Q(V) = kV + n$.

It is possible to activate more than one function at the same time, respecting a map of priorities.

Control Functions

P/Q mode – how to mitigate the effect of RES



Exchanged Power at HV/MV Sub station level

Exchanged Power at HV/MV Sub station level with the effect of storage

Storage Active Power

Conclusions and Future Works

- Thesis in collaboration with Universities
- Students Site Visits
- Future works will be focused on simulations of the transient and steady-state behaviour of the ESS during Blackstart operation.

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Thank you.