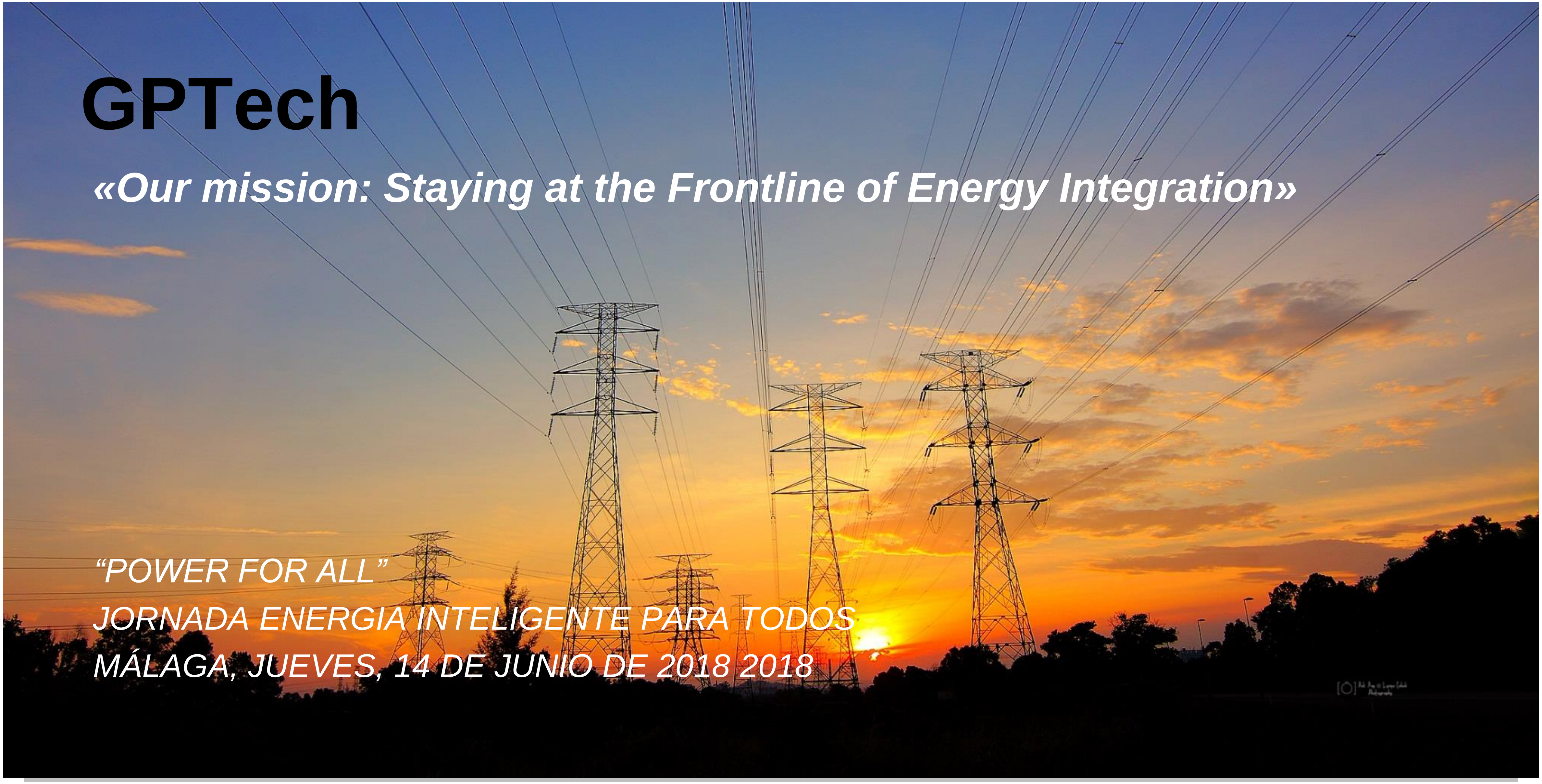
GPTech

«Our mission: Staying at the Frontline of Energy Integration»

“POWER FOR ALL”

JORNADA ENERGIA INTELIGENTE PARA TODOS

MÁLAGA, JUEVES, 14 DE JUNIO DE 2018 2018

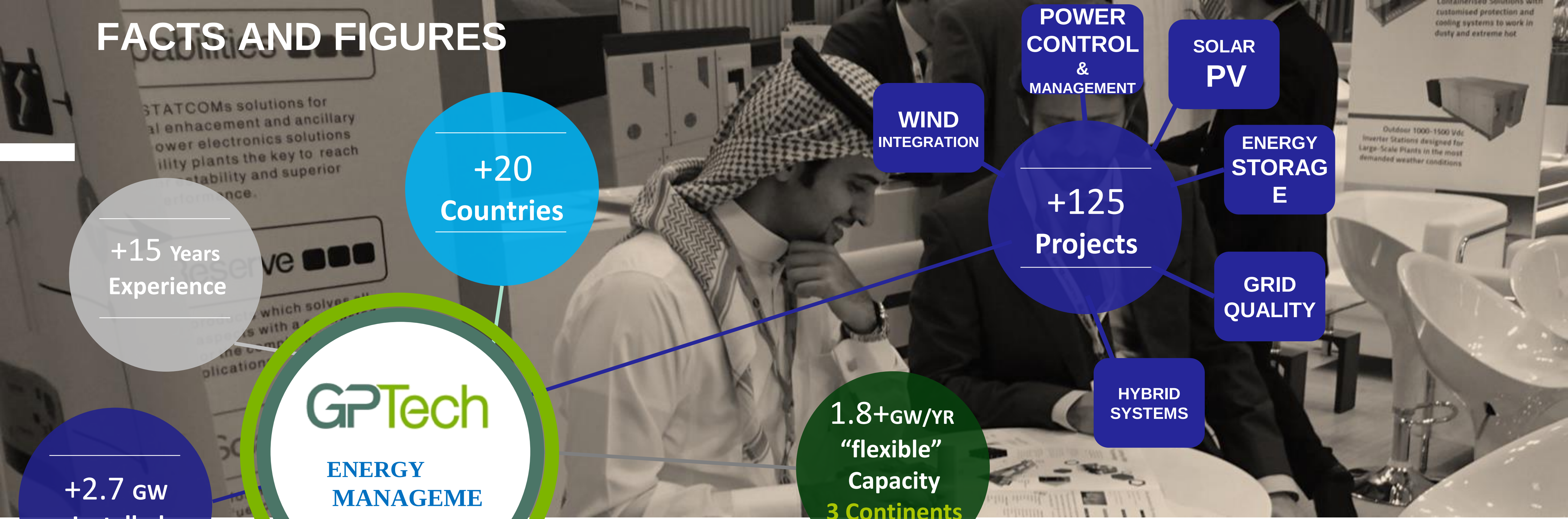


CORPORATE DNA

GPTech is a Designer, Manufacturer and System Integrator of Advanced Power Electronics and Energy Management Solutions for Distributed Energy Generation/Storage and Grid Management.

Key Brand Attributes:World-Class Team, Know-How, Versatility and Effectiveness under Challenging Grids environments.

FACTS AND FIGURES



+15 Years Experience

+20 Countries

+2.7 GW Installed

+125 Projects

WIND INTEGRATION

POWER CONTROL & MANAGEMENT

SOLAR PV

ENERGY STORAGE

GRID QUALITY

HYBRID SYSTEMS

1.8+GW/YR “flexible” Capacity
3 Continents

GPTech
ENERGY MANAGEMENT SOLUTIONS

PRODUCTS
TECHNOLOGY

O&M

Grid Code Compliance

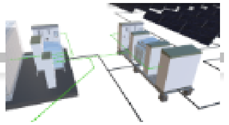
Performance Improvement

Power Quality

Mw-scale Power Converters & Statcoms

Integrated Mv Conversion Stations

Power Plant Control Sw & Hw



FACTS AND FIGURES: MARKET FOOTPRINT

A Robust Track Record → Pioneers entering new markets

NORTH AMERICA (MW)

USA	368	80	50
Mexico	135	10	

CENTRAL–SOUTH AMERICA (MW)

Guatemala	80	
Honduras	35	
El Salvador	10	
Panama	10	4
Brazil	1.1	90
Chile	268	16
Peru	80	
Argentina	35	139
Ecuador	2	
Aruba	5	

CENTRAL AFRICA (MW)

Nigeria	100	200
Mozambique	30	

SOUTHERN AFRICA (MW)

South Africa	37.8	300
Swazilandia	0.1	

EUROPE (MW)

Spain	1481	630
Italy	45	
Portugal	40	5
France	1	10
Germany	20	
UK	13	
Rumania	99	

MENA (MW)

Jordan	55	130
Egypt	150	

ASIA (MW)

India	50
Taiwan	3.3
Malaysia	150
Iran	250
Vietnam	2

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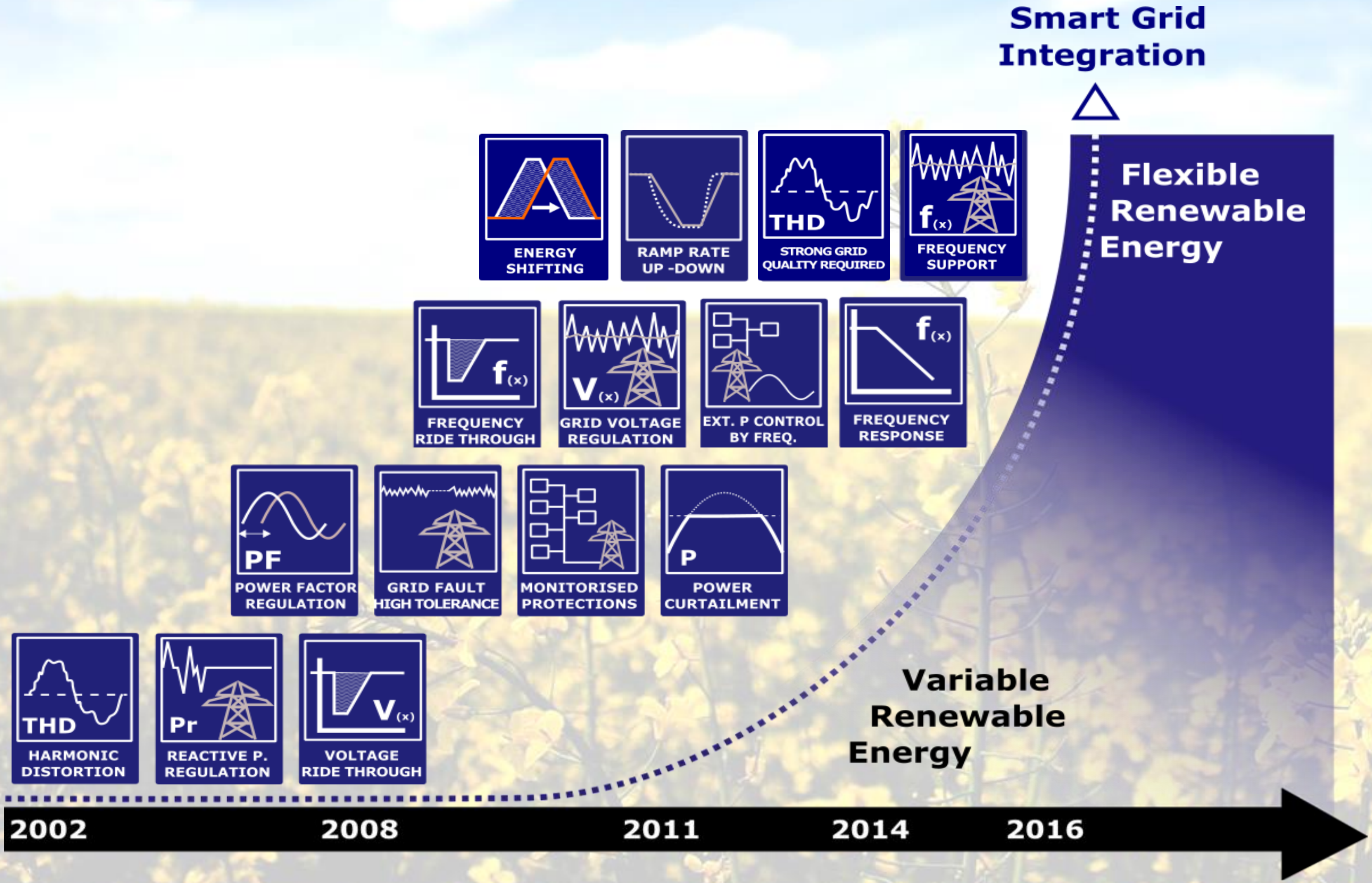
VALUE PROPOSITION: FOCUSED R&D

Incremental Interconection Complexity : "There, where the value is born…"

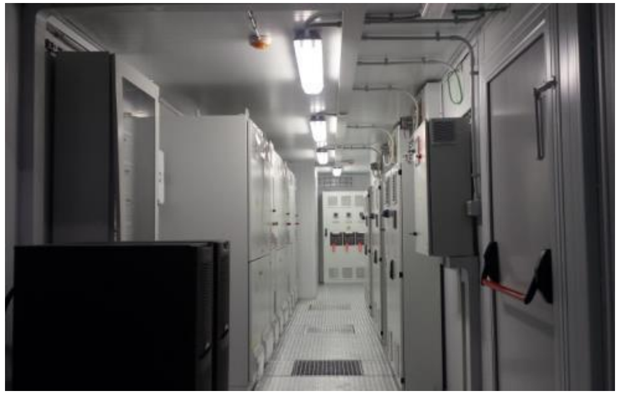


Grid Codes Evolution show IPPs the path towards "Value" (and "Risk")

- **Tolerate (and improve!) Grid Stability**
- **Use the distributed power (and intelligence!) to ensure better Grid Quality**

A Robust Track Record → Highly Complex Projects In The Key Markets








Funded by the
European Commission
Grant No 645963

SENSIBLE - Storage Enabled Sustainable Energy for Buildings and Communities

June 14th, 2018

- SENSIBLE will demonstrate the cost-optimized, coordinated use of different forms of energy (such as electricity and gas) in the operation of heating, cooling and CHP devices, micro-generation and local renewables – in conjunction with the small-scale storage technologies.
- The project SENSIBLE will integrate electro-chemical, electro-mechanical and thermal storage technologies into power and energy networks as well as homes and buildings. The benefits of storage integration will be demonstrated with three demonstrators in Portugal, UK and Germany.
- An important aspect of the project is about how to connect the local storage capacity with the energy markets in a way that results in sustainable business models for small scale storage deployment, especially in buildings and communities.

SENSIBLE – Évora demonstrator
Objectives and developments

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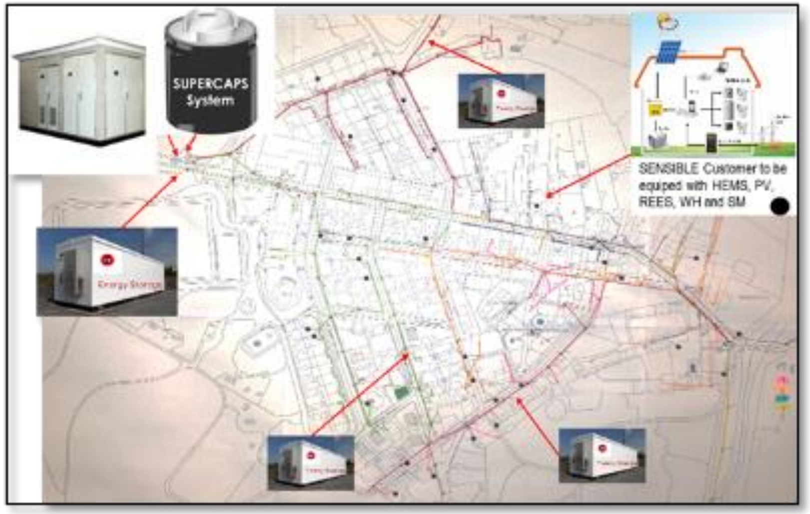
Grant No 645963

Main focus of the Évora Demonstrator is to define, develop and demonstrate:

- New energy management solutions applied to **grid operation optimization**
- Development of **new energy services to clients/end users**
- Test and validate every developments in **full real scenario in real grids and real customers,** after proper laboratory validation

Therefore we have developed:

- **Advanced storage devices**, **protection and automation** for grid operation in extreme scenarios
- Integration off home DER by development of **advanced home energy management solutions (HEMS)**:
- Advanced **forecast tools** (consumption, generation)
- High level **grid management tools** (OPF)
- High level **market tools** (flexibility management)
- Equipmment is installed and in operation



*Supported EDP in engineering services in Évora

Valverde is a beautiful and peaceful place, 13 km east from Évora where the population has been strongly engaged with SENSIBLE

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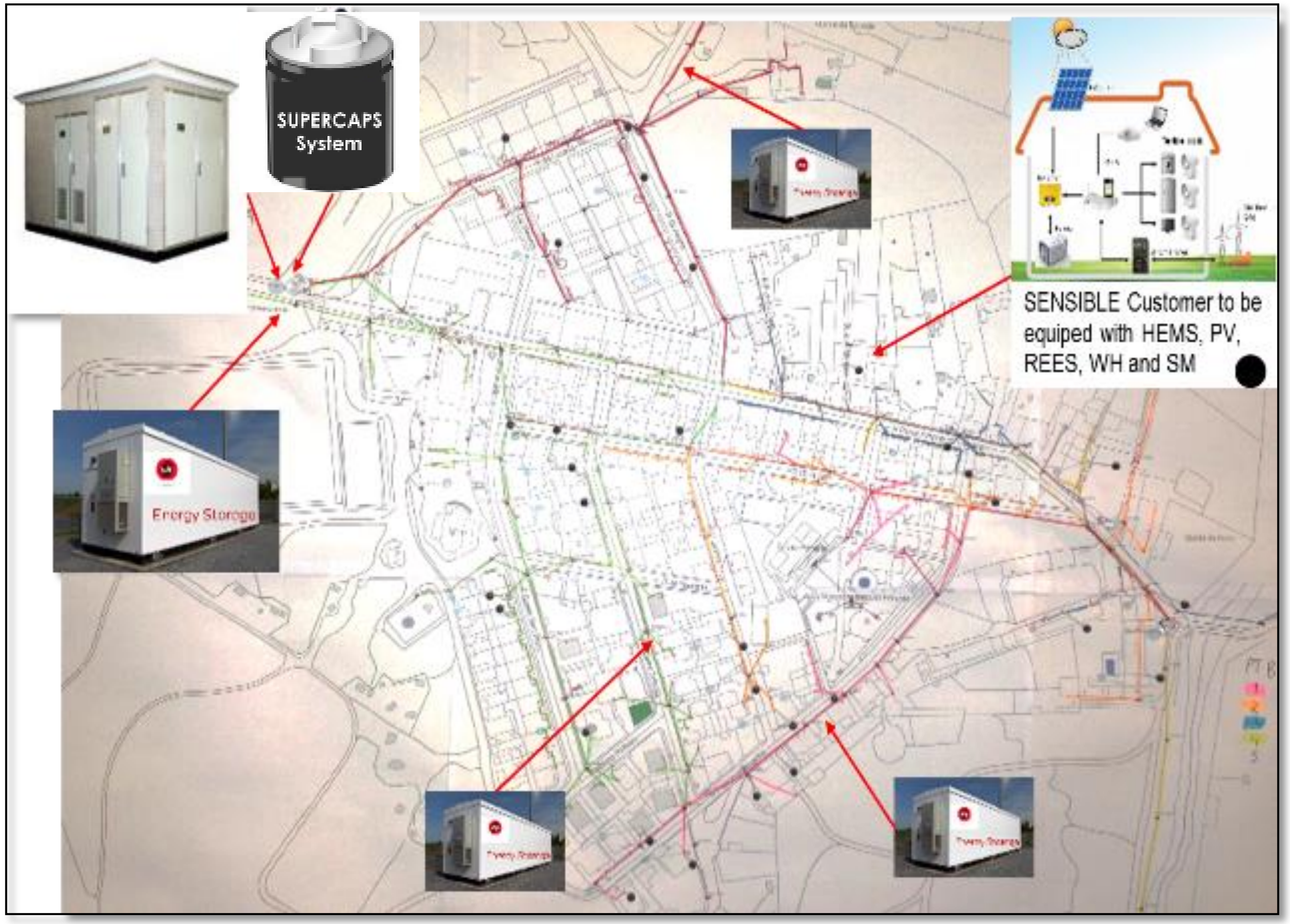
Valverde Village



Electrical grid - *layout*

Several assets were installed in Valverde, both in grid side and residential side, in order to enable Évora demonstrator

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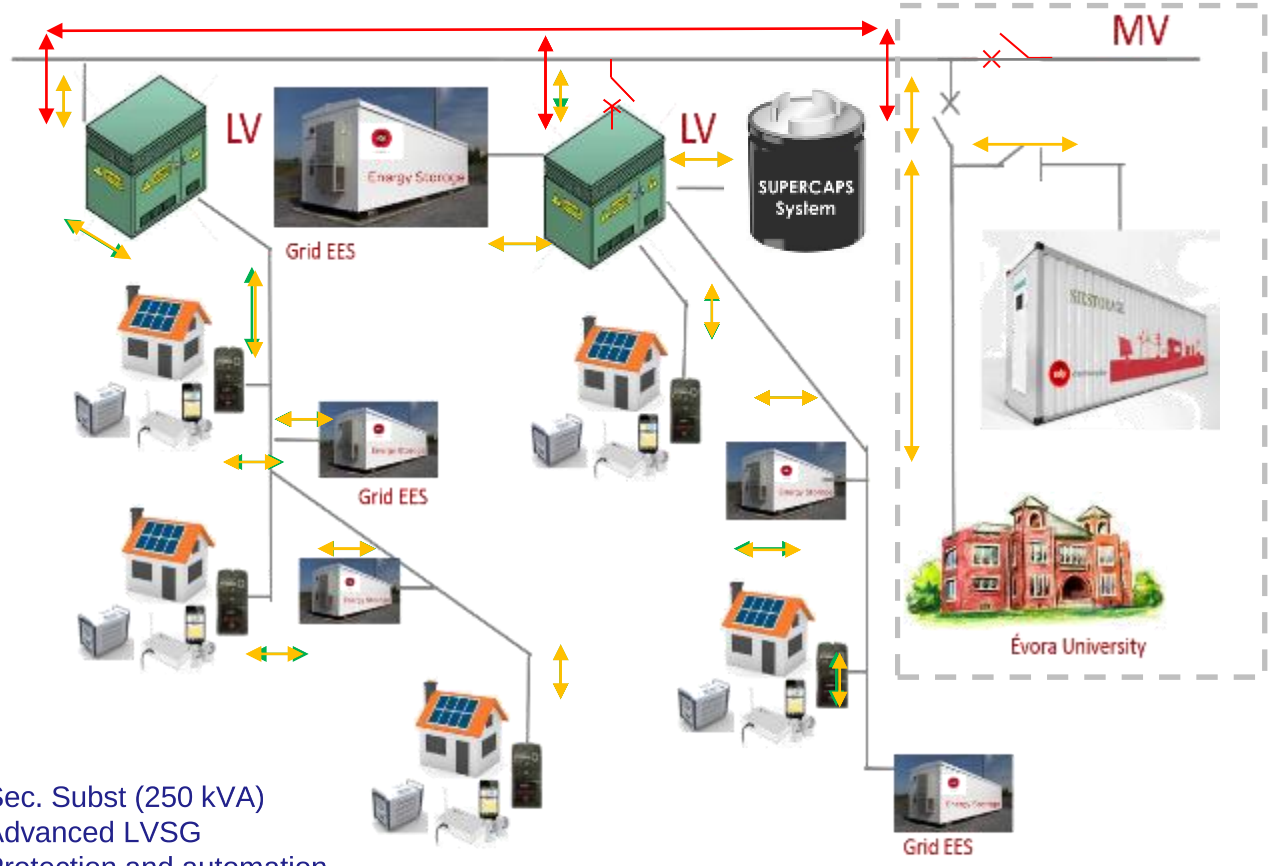
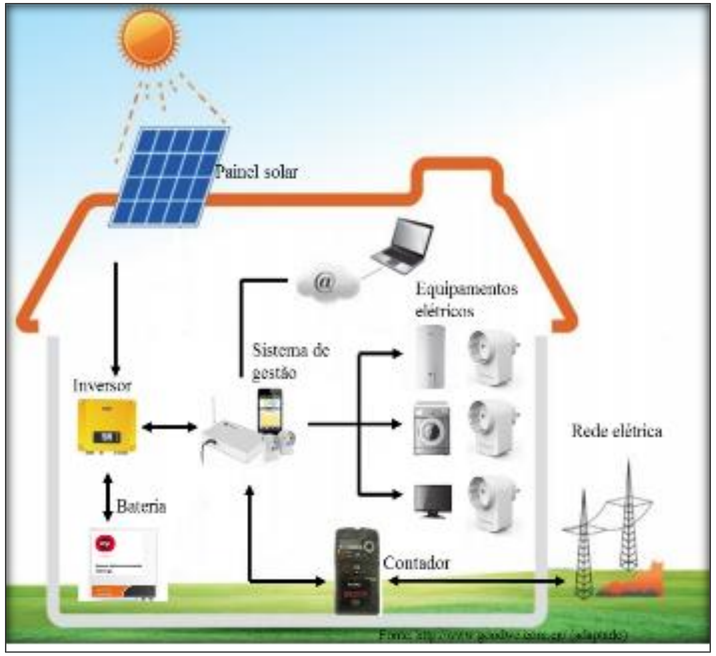
Grid scope



2 Sec. Subst (250 kVA)
1 Advanced LVSG
1 Protection and automation
1 MV Client (870 kVA)
1 MV ESS - 480 kW/360 kWh
1 MV recloser

4 LV ESS – 50/2x30/10 kW total of 160 kWh
1 supercaps system: 125 kW/0,9 kWh
240 LV customers (InovGrid, EDP-D)

Residential scope



HEMS | 25 units
Residential batteries – 3.3 kW/ | 15 units
PV system – 1,5 kWp| 25 units
Electrical water heaters- 2kW | 15 units
Smart plugs – 2kW | 2 units each client
Residential battery prototype - 10kW/20kWh | 1 unit

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Use cases

Optimizing energy storage operation in MV grid: Normal operation versus emergency operation

How should DSO optimize storage management?

Additional extension to LV+MV coordination

If there is flexibility both at LV and MV level, how can it be optimized for grid operation purposes?

Optimizing energy storage operation in LV grid in normal operation

How to optimize storage operation in LV grids?

Smooth islanding transition and main grid synchronization

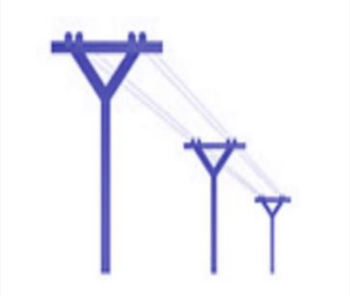
How to island LV grids in a safe, reliable and smart way?

Energy management in emergency operation regiment

When in islanding, how can the energy be managed in order to last energy supply?

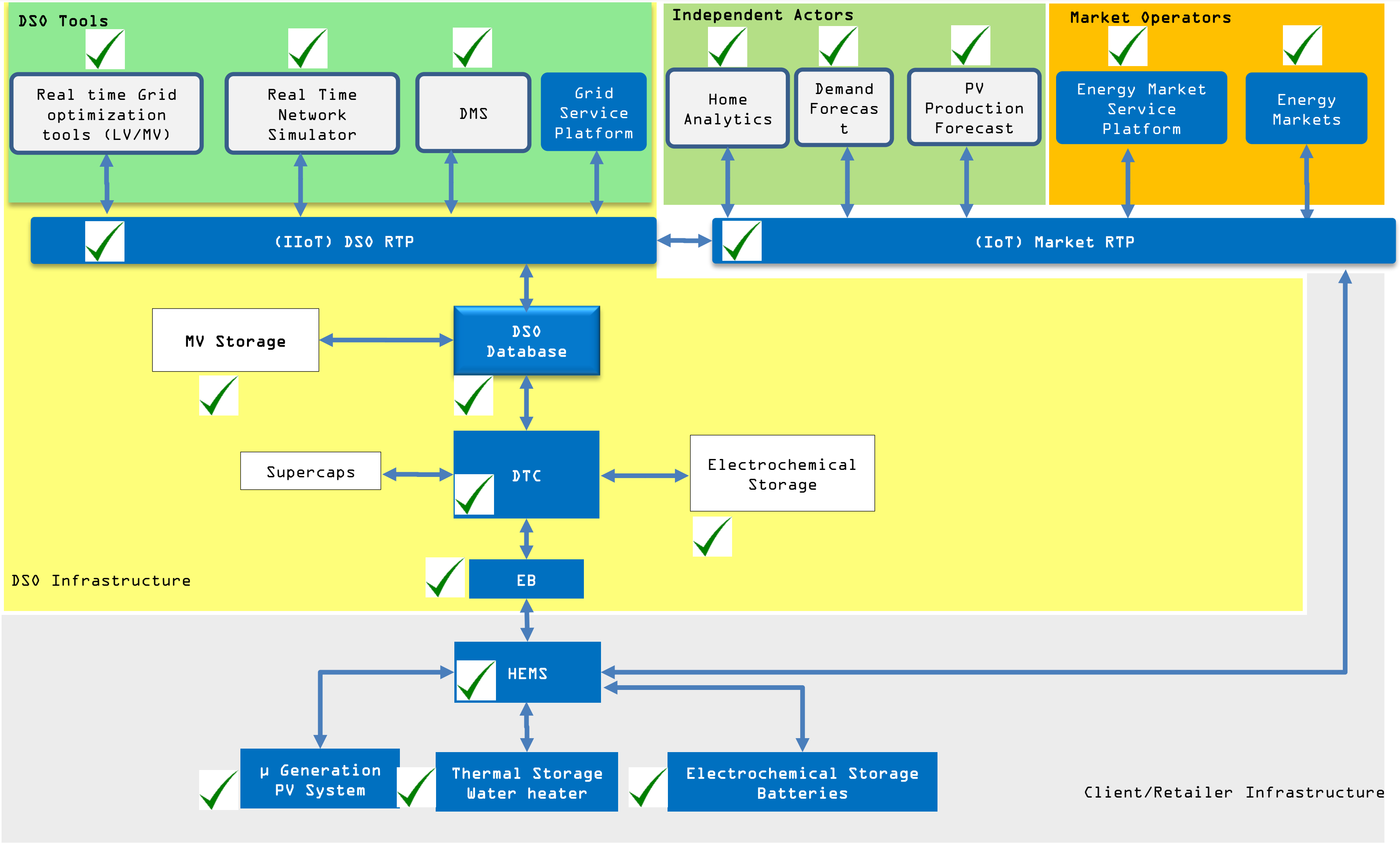
Framework

Grid operation



SENSIBLE – Évora Demonstrator Laboratory Validation

Equipment testing: Results and conclusions



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Main focus of the Laboratory Validation is to:

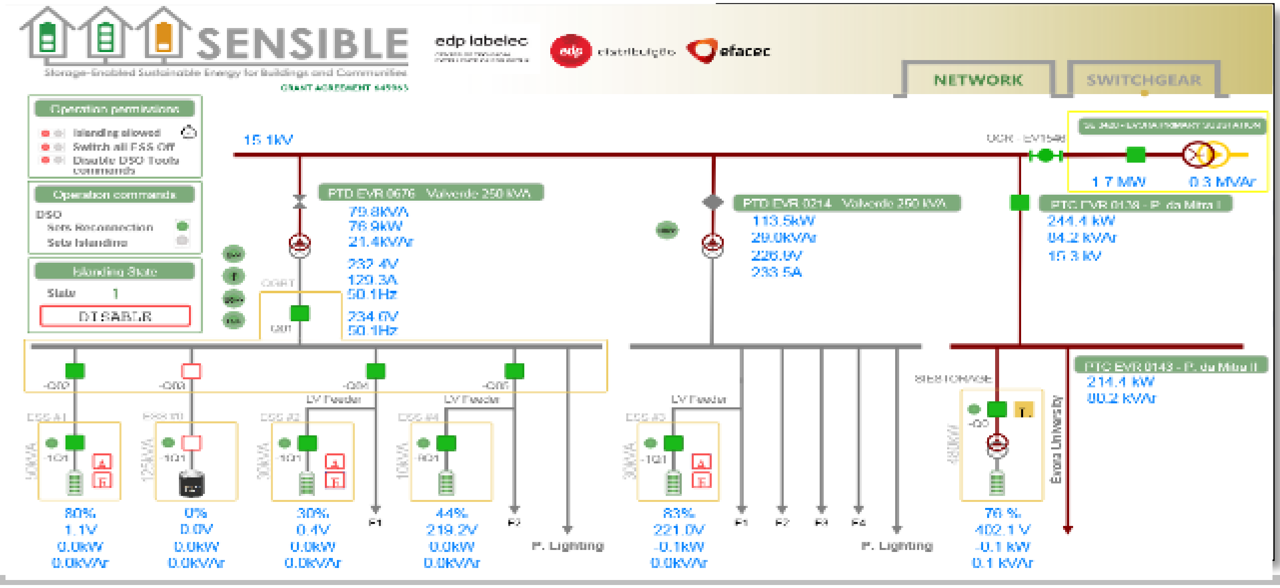
- **Describe the test procedures** for the equipment/software that was **installed** on the **Évora LV Grid**;
- Perform all the developments in the ESS and Grid infrastructure in order to ensure that all the safety conditions of equipment, grid and people;
- **Test the equipment/software developed by the partners**, responsible for the overall management of the grid functionalities demonstration;
- **Ensure** that all the **project and grid requirements** defined during the specification phase **are met.**

Therefore we have developed and performed:

- Creation of a **tests protocol based** on **IEC TC120** and **EDP Distribuição Guidelines**;
- **Implementation** of a **similar LV Grid** similar to Valverde LV Grid in **EDP Labelec facilities**;
- Evaluate the **behavior** of the several grid **ESS** under **fault conditions**;
- **Integration** between the low level **management system** and the **field equipment**;
- **Integration** between the low level **management system** and the **middleware platform**;
- Emulate as far as possible Évora demonstrator real environment conditions and constraints.

Grid Validation was performed in StorageLab based on testing protocols designed

- 4 Battery storage systems were fully tested according to the developed protocols.
- Short circuit tests performed in order to evaluate storage behaviour under fault conditions.
- LVSG, HMI, protection, control and automation also included in testing protocols.



SENSIBLE – Évora Demonstrator

GPTech: Battery Power Converter

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- Bidirectional 3-phase power converter
- Unbalanced loads control capability
- Grid-forming functionality
- FRT
- Low switching losses
- Galvanic isolation
- Control droop in order to control parallel generators (Islading Manager)
- Transition between normal/islanding mode
- Comm. interface with the Islanding Circuit Breaker

SENSIBLE – Évora Demonstrator

GPTech: Battery Power Converter in demonstrators

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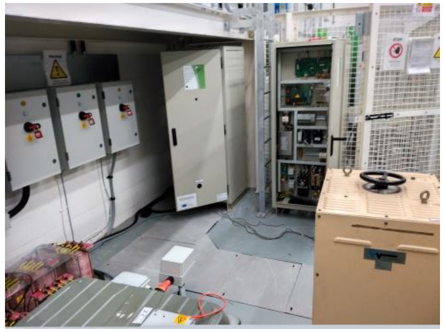

SENSIBLE – Évora Demonstrator Results

Some interesting results from islanding tests – Transitions and steady state

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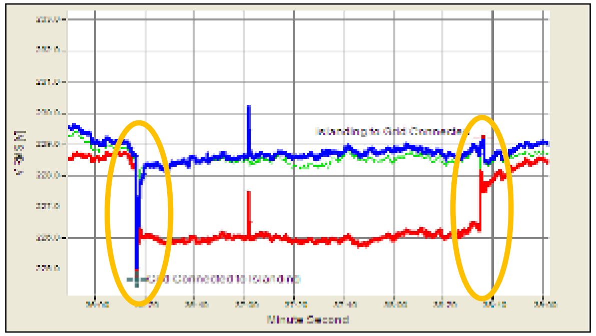
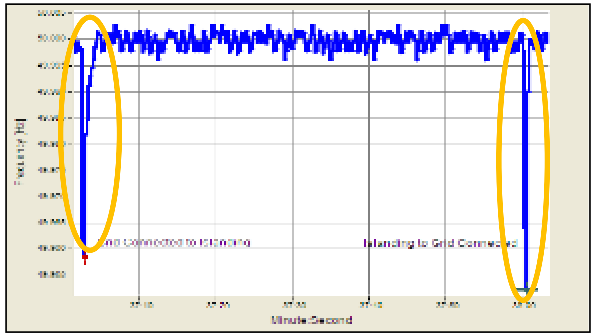
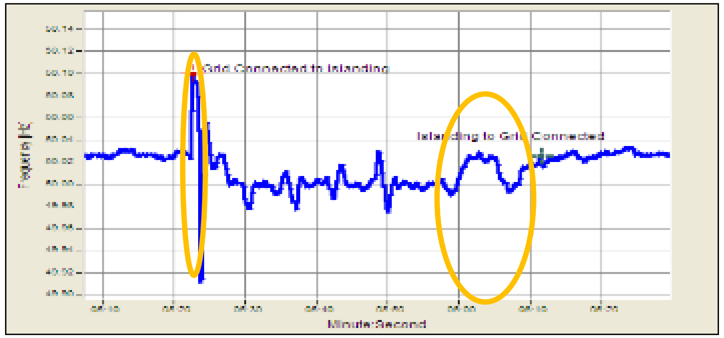
- Several islanding tests were were performed to ESS1, ESS2, ESS3, ESS4 under different scenarios as different loads, and different time periods
  - Initial results lead to the necessity of changes to the equipment as the supply of voltage measure upstream ICB to ESS1 and wire the ICB state (open/closed) to ESS1;
  - Islanding tests were used to finish and test the DTC state machine.

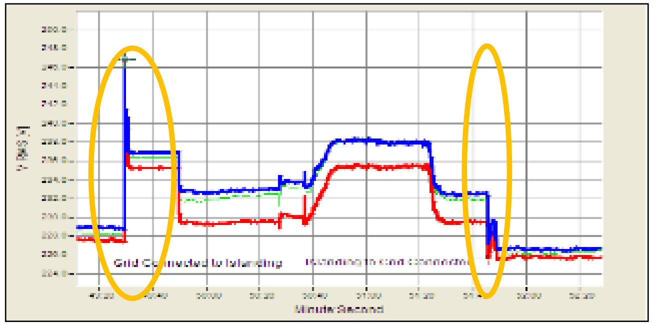


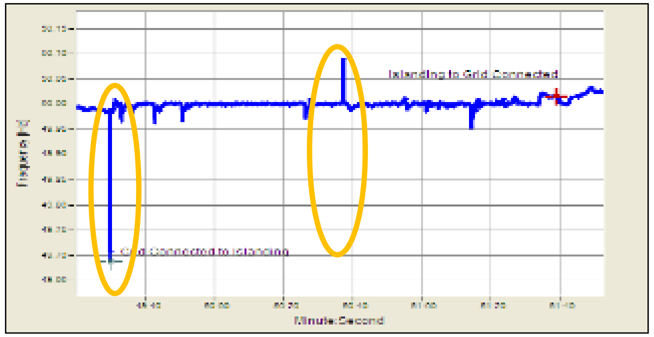


No load



Active load (~60kW)





Reactive load (~60kVar)

SENSIBLE – Évora Demonstrator Results

Some interesting results from islanding tests – Fault real simulation

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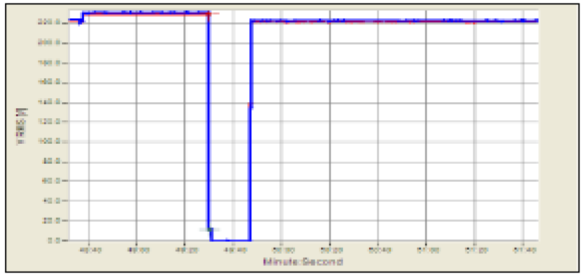
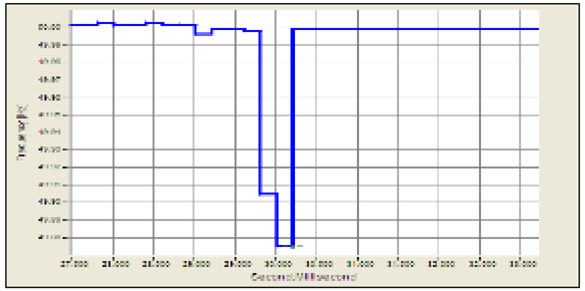
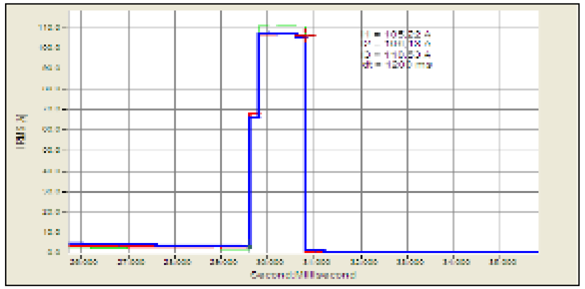
- **Several short-circuit tests were performed to ESS1, ESS2, ESS3 under different scenarios**
  - Different load - No load, active load and reactive load.
  - Different faults – Single-phase, Phase-to-Phase, Three-Phase, 2Ph-ground …
  - Different periods

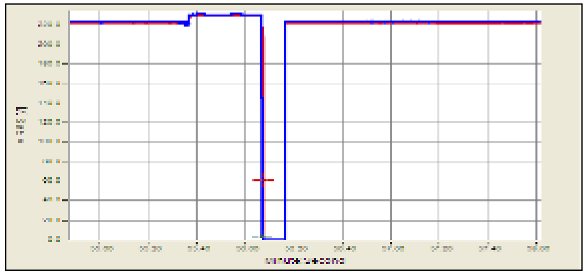
3Ph–Ground (Z ~ 0,156 Ω)

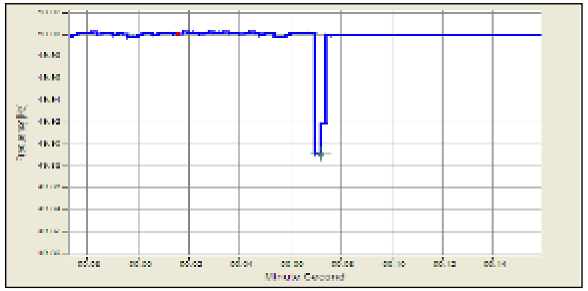


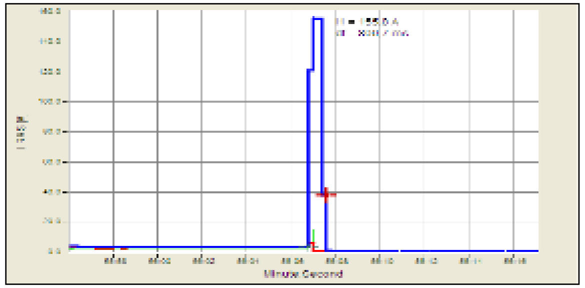




Phase-ground (Z~0Ω)







SENSIBLE – Nottingham demonstrator
Aims and Objectives

- Main Aims
  - Demonstrate the socio-economic benefits of storage technologies
  - Reduce energy costs –individual and community based
  - Gather convincing data to change policy

- Microgrid energy market
  - Examine the feasibility of creating of a local energy market
  - Control of the energy flow according to market constraints as well as technical in order to minimise energy costs
  - Increase self consumption

- Microgrid PV Management
  - Test PV penetration limit
  - Increase PV by stabilising local grid with energy storage units

- Enabling an independent energy community
  - Economic benefit in using community energy stores
  - Create a ‘movement’ of energy between community members
  - Show increased benefit from a reduced number of larger stores
  - Network Usage improvements – community becomes a more ‘attractive’ energy user

SENSIBLE – Nottingham demonstrator Architecture

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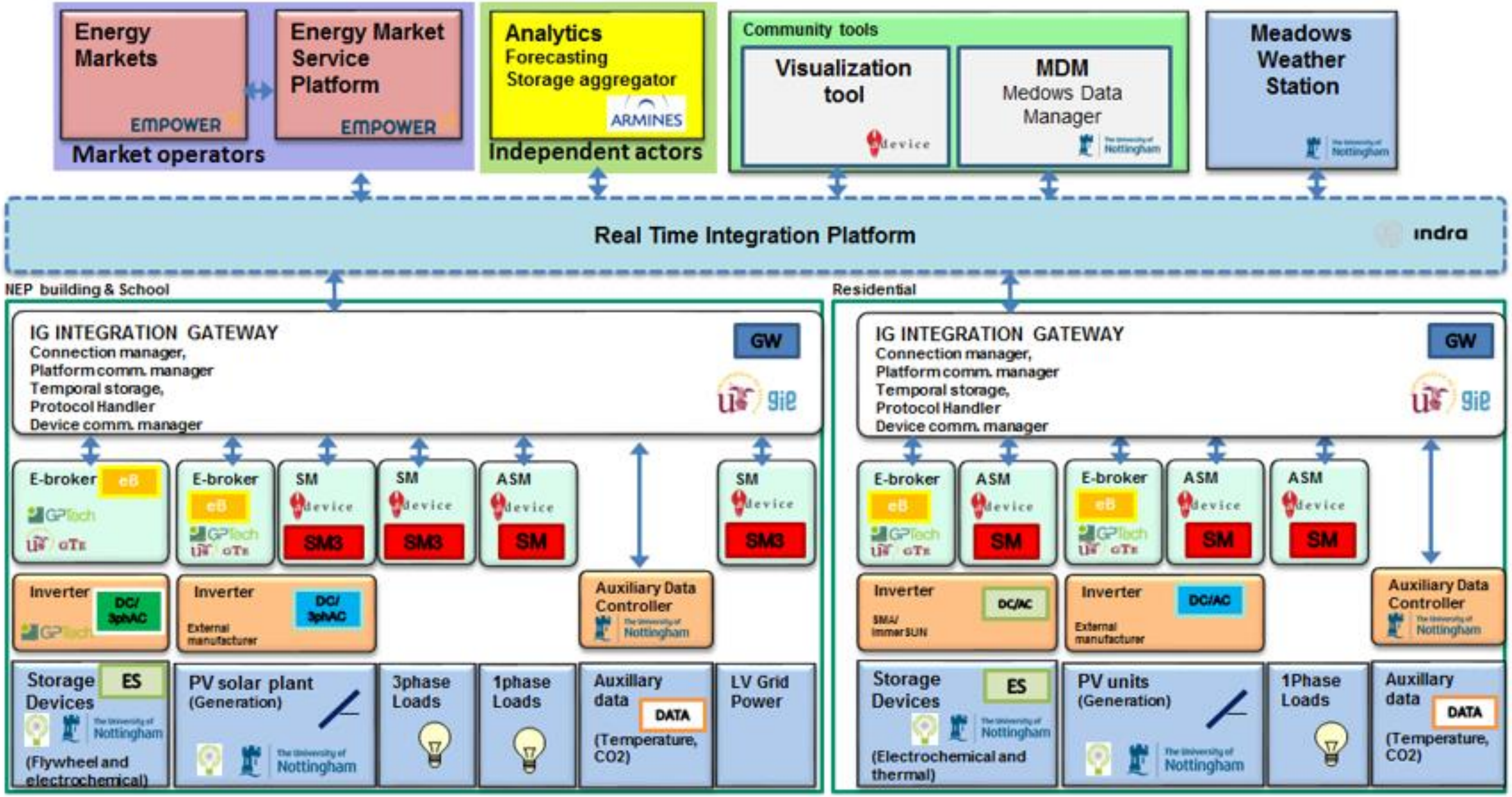
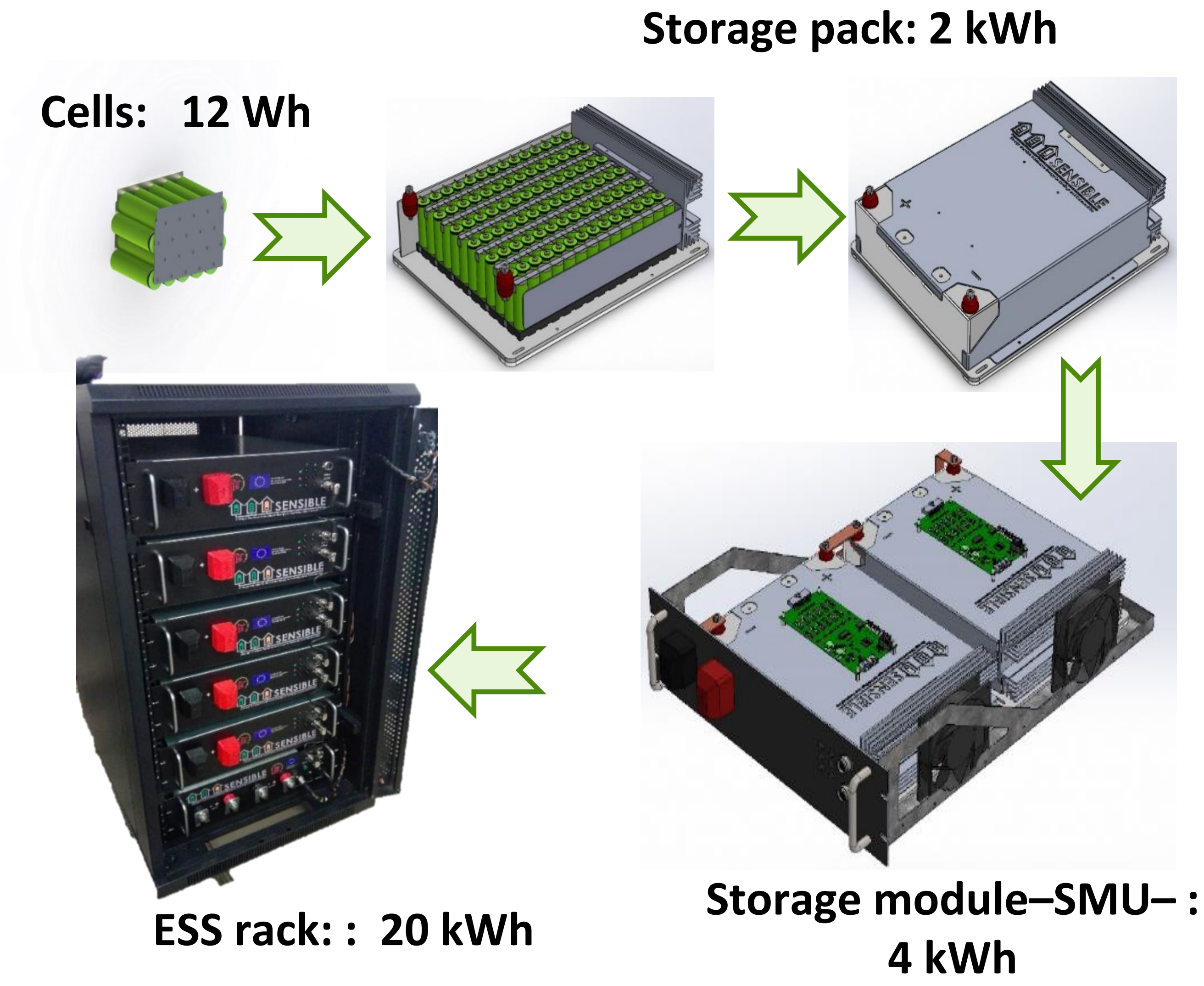


SENSIBLE – Nottingham demonstrator Energy Storage System

- BMS development and test in a set of batteries
- Design of assembly and integration of battery system
- Several designs were studied to assemble and integrate an energy storage system with 20kWh of energy



SENSIBLE – Nottingham demonstrator eBroker

Funded by the European Commission Grant No 645963

- **The eBroker algorithm allows to identify and adapt in every period the best operation and services to be offered by the ESS:**
- **Full exploitation of all the Energy Storage Services.**
- **This advantages allow to implement:**
  - Multiple services regardless the application
  - ESS lifetime management
  - Integration of different types of ESS
- **Which means:**
  - ESS life cycle extension
  - More services implemented by the same ESS
  - Aggregated state of charge management of ESS increasing the total available power and energy

Category 1 — Electric Supply
1. Electric Energy Time-shift
2. Electric Supply Capacity

Category 2 — Ancillary Services
3. Load Following
4. Area Regulation
5. Electric Supply Reserve Capacity
6. Voltage Support

Category 3 — Grid System
7. Transmission Support
8. Transmission Congestion Relief
9. Transmission & Distribution (T&D) Upgrade Deferral
10. Substation On-site Power

Category 4 — End User/Utility Customer
11. Time-of-use (TOU) Energy Cost Management
12. Demand Charge Management
13. Electric Service Reliability
14. Electric Service Power Quality

Category 5 — Renewables Integration
15. Renewables Energy Time-shift
16. Renewables Capacity Firming
17. Wind Generation Grid Integration

SENSIBLE – Nottingham demonstrator eBroker

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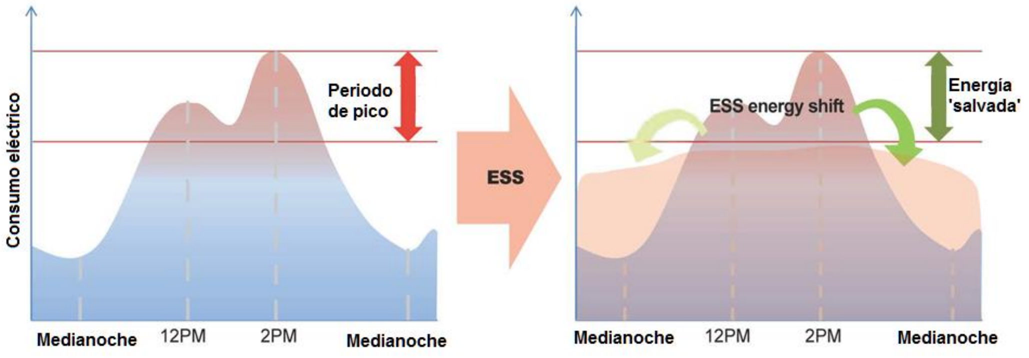
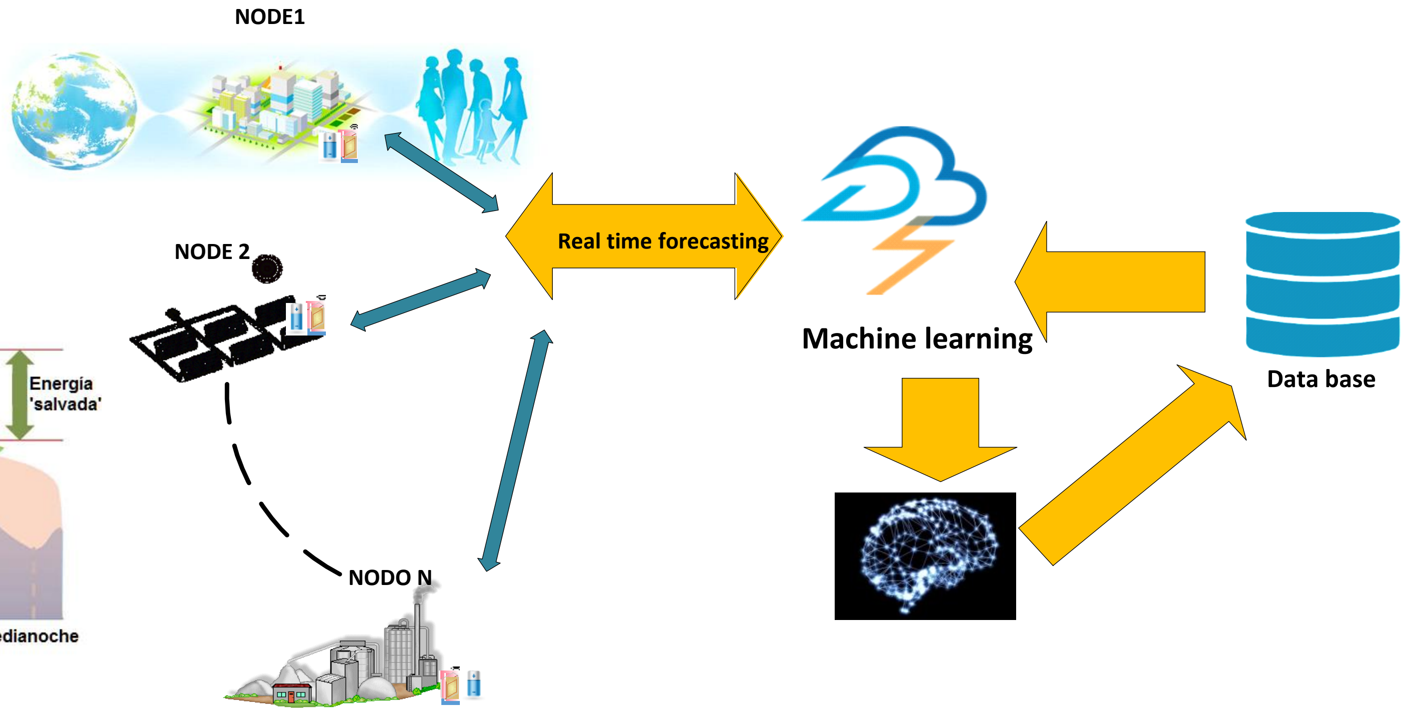
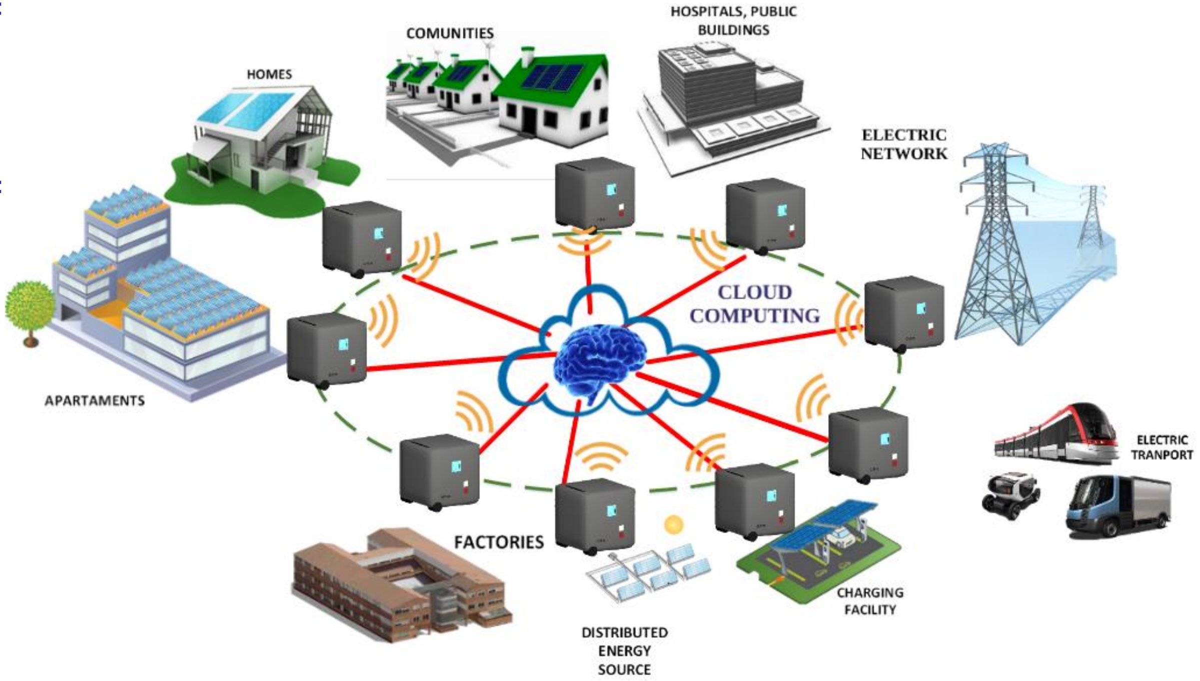
- **Energy broker (E-broker)** algorithm for distributed resources and energy storage technologies: E-broker is a Smart management system based on cloud computing and focus on renewable generation and prosumer efficient integration. This patented method provide competitive advantages such as increment on the total storage capacity, increase of the life expectancy of ESS and optimal financial profitability by means of:





- Programming the demand curve through control by price system
- Algorithm for the electrical network and/or microgrid stability, protecting them from any contingency
- Behind the meter intelligent management system of the overall consumption to optimize the economic profitability, total capacity and the ESS life span
- Customized installation based on a deep evaluation of user habits and location providing local, automatic and adapted control system with important economic impacts
- By means of demand prediction, an energy storage aggregation management is implemented, providing ancillary services to the operator and extra power reserve.
- Energy demand prediction processes for the TSO to be applied in distributed generation systems



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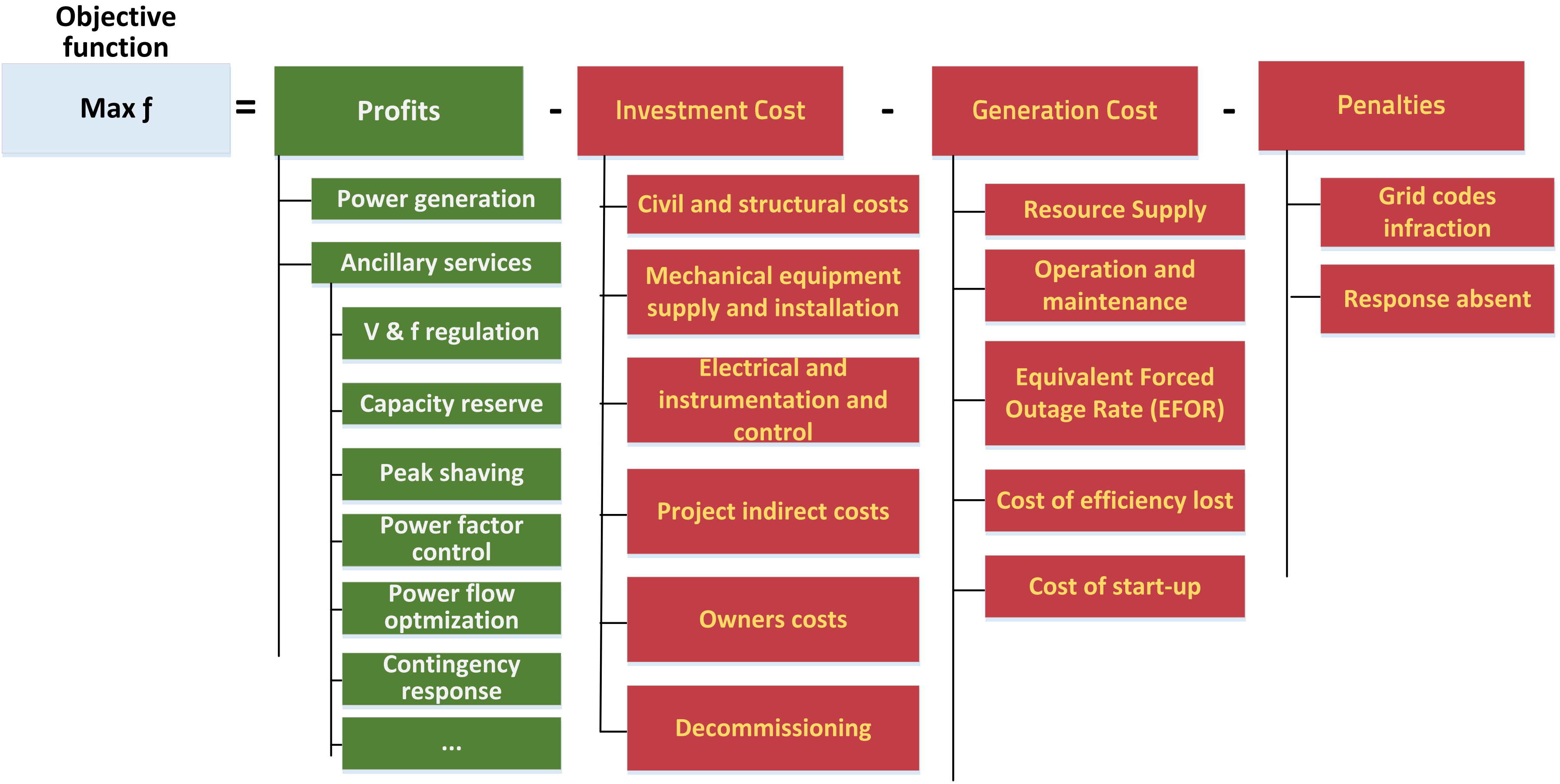
- **Single objective function for the optimization process which is adaptive to all the possible scenarios from power plant generators to Distributed resources management systems**



Thank you!

Salvador Rodríguez (srodriguez@greenpower.es)