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Grant No 645963

**Energising Communities:** Nottingham's Energy Revolution

# **SENSIBLE Project** – Technical innovations

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October 18th, 2018

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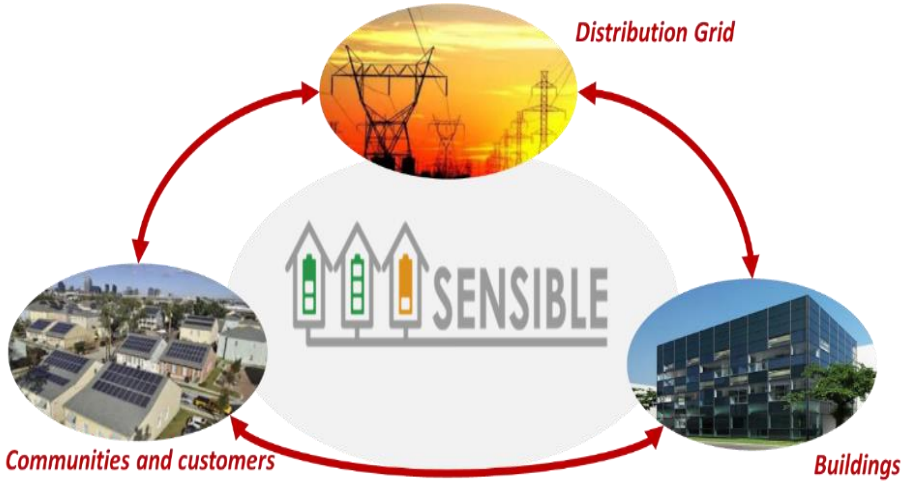
# SENSIBLE

Overview and highlights

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## Scope

- **Demonstration of energy storage and management** in buildings, communities and distribution grids in **real operation scenarios**




## Objectives

- **Demonstrate applications of distributed energy storage** and energy management aiming to **increase RES penetration**.
- **Find technical, legal and regulatory barriers** blocking storage applications
- **Develop business cases** able to support the large scale deployment of distributed small scale storage

## Demonstrators

- **Évora:** Focused in **distribution grids** and **new energy services** to customers
- **Nottingham:** Focused on **communities**/ESCO energy management
- **Nuremberg:** Focused in **buildings** energy management

## Budget and timeline

- 15,6 M€
- January 2015 - December 2018

## Partners

- Siemens AG
- ARMINES
- EDP Labelec
- Empower
- GPTech
- INDRA
- K&S
- INESC TEC
- Mozes
- Univ. of Nuremberg
- Univ. of Nottinhgam
- Univ. of Seville
- Siemens S.A.



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# Real environment and lab Demonstrators

## Storage and energy management in buildings, communities and networks

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## Nottingham - UK



### Scope:

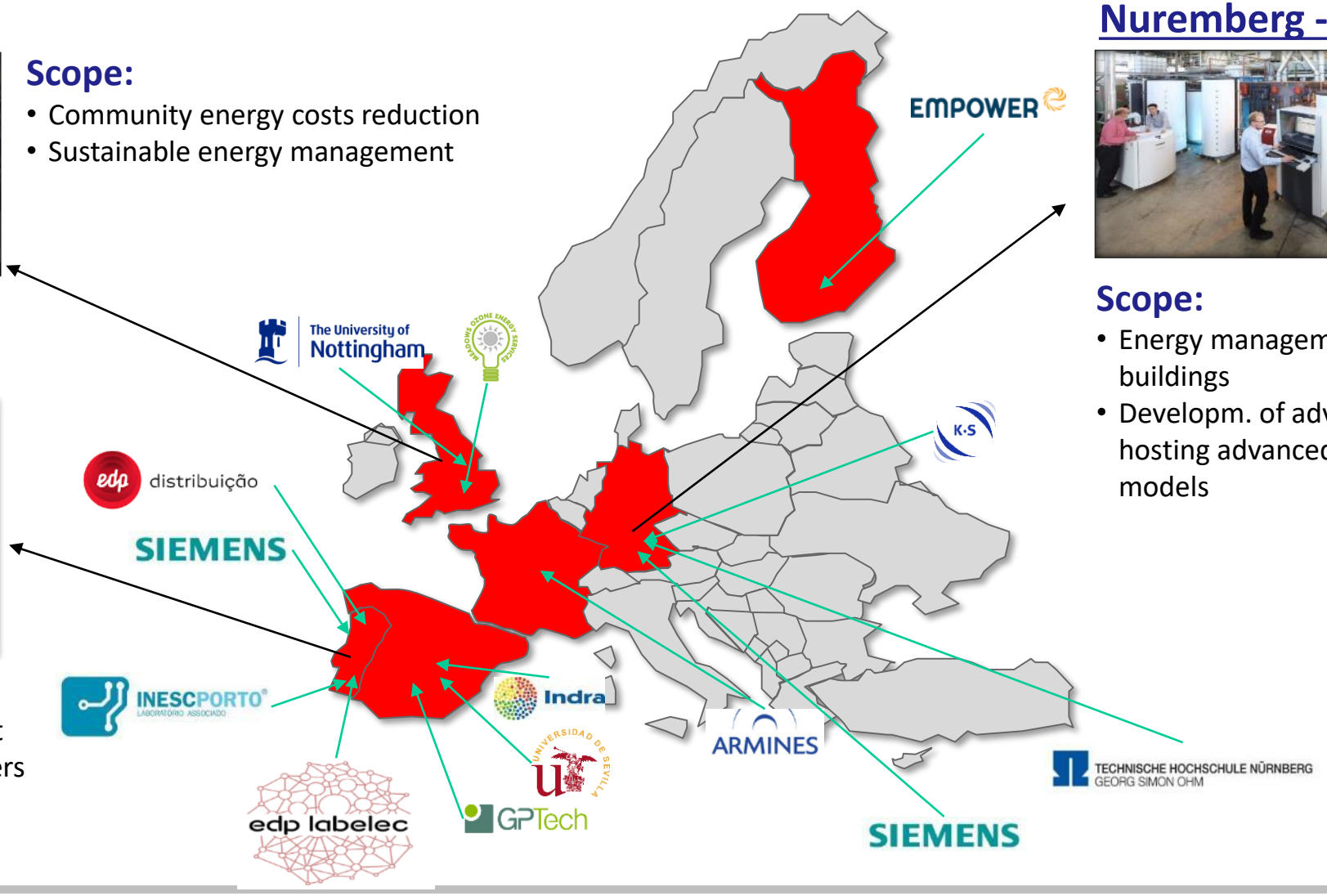
- Community energy costs reduction
- Sustainable energy management

## Évora - PT



### Scope:

- MV/LV optimal grid management
- New energy services for customers




## Nuremberg - GR



### Scope:

- Energy management in buildings
- Developm. of advanced BEMS hosting advanced thermod. models

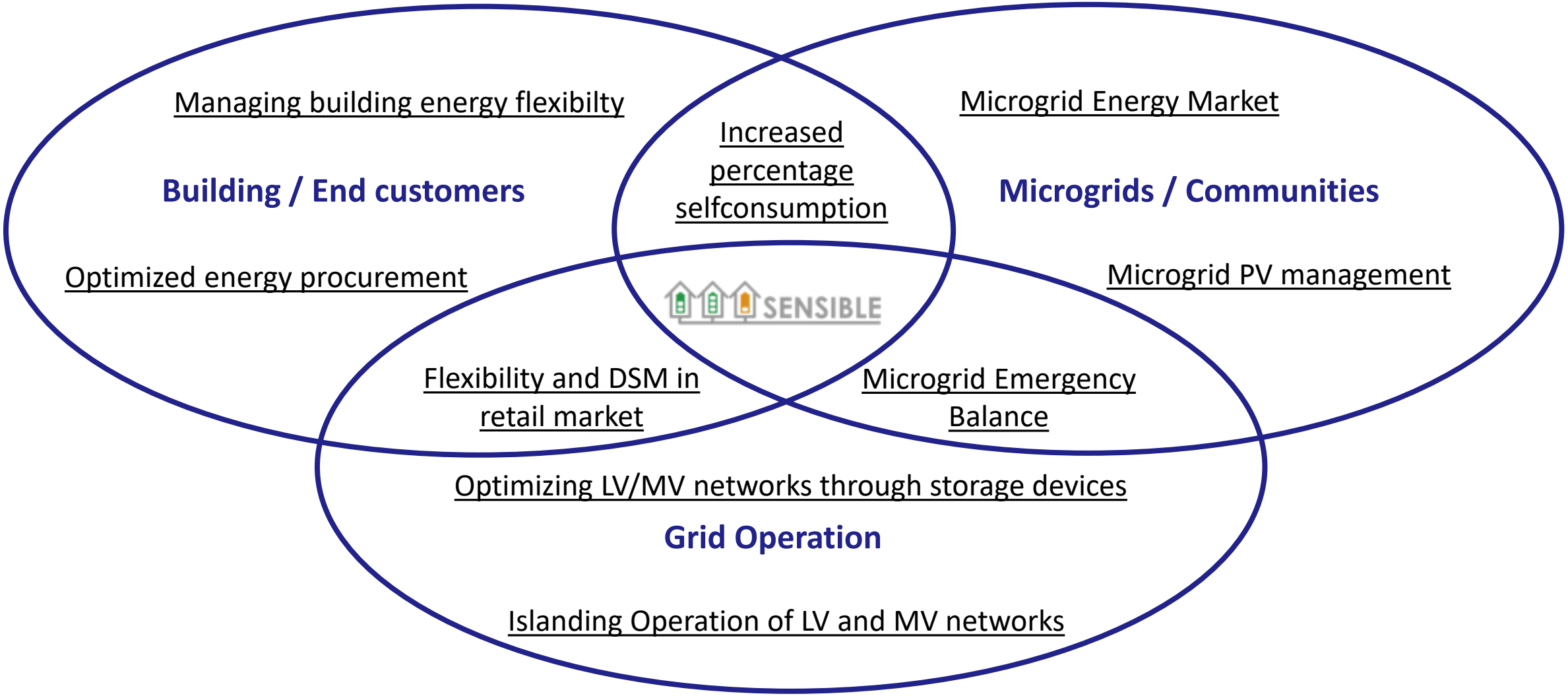


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# Objectives by domain

The 3 demonstrators have a common scope with complementary approach

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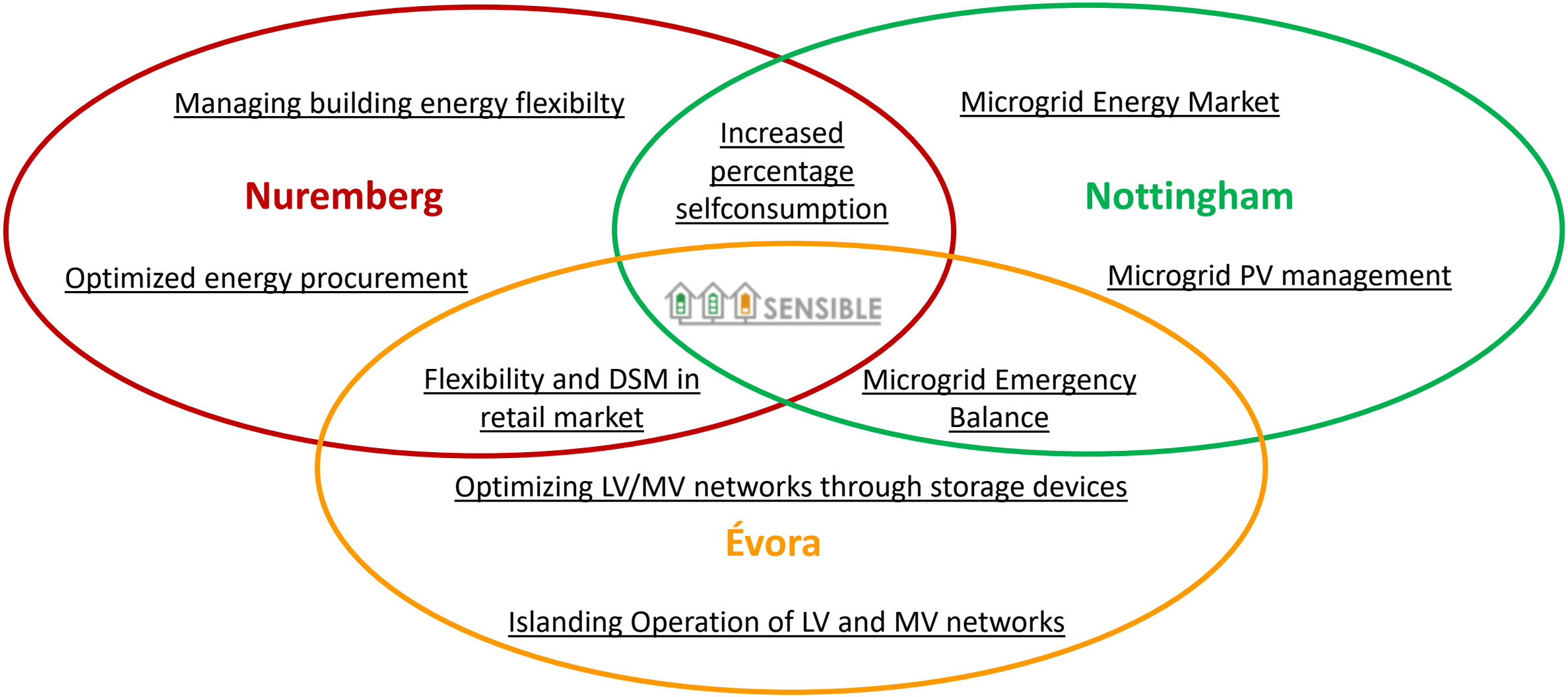



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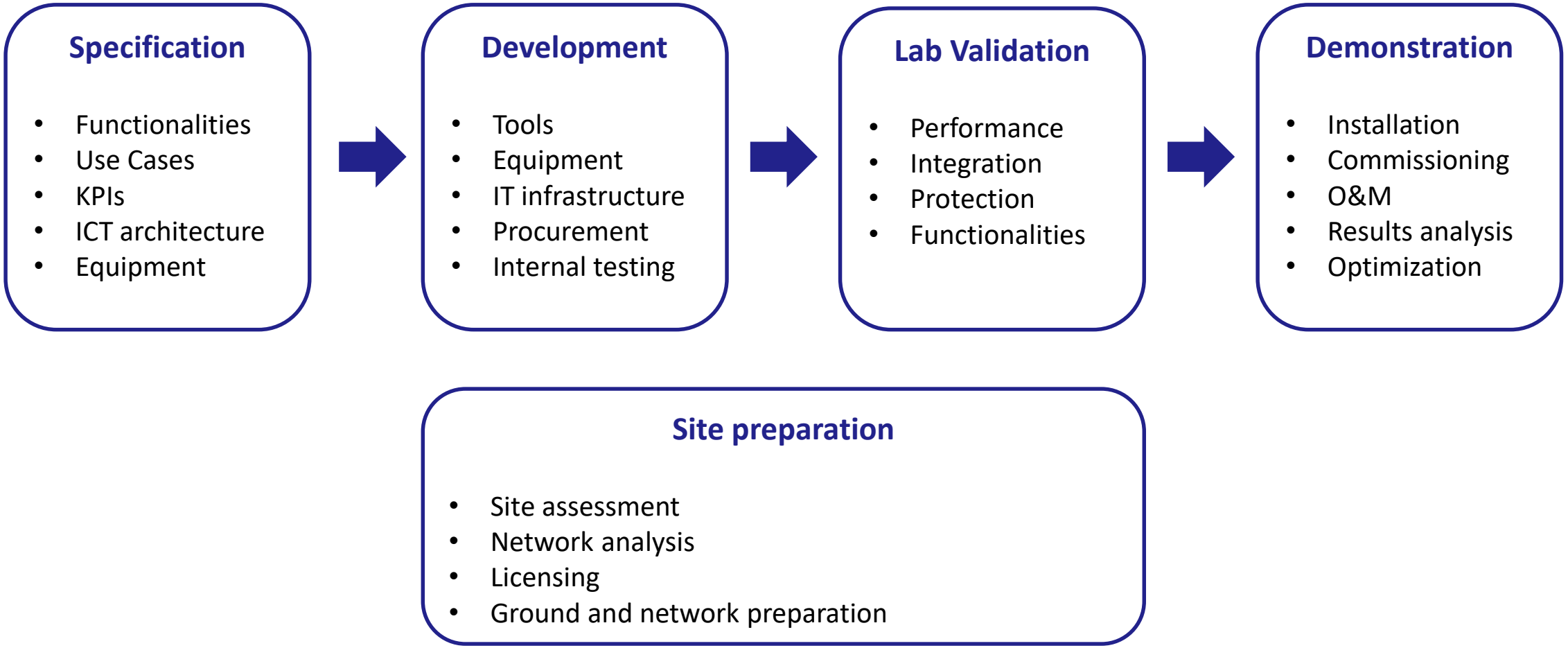



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# Work plan

SENSIBLE followed the typical workflow of na implementation project

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# Évora demonstrator infrastructure

Two seperate but complementary infrastructures. A grid infrastructure…

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## Grid infrastructure

- 2 Sec. Subst (250 kVA)
  - 1 Advanced LVSG
- 4 LV ESS – 50 /2x30 /10 kW
  - Total of 160 kWh
- 246 Smart Meters (GPRS)

- 1 MV Client (870 kVA)
- 1 MV ESS - 480 kW/360 kWh
- 1 MV Circuit Breaker












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# Évora demonstrator infrastructure

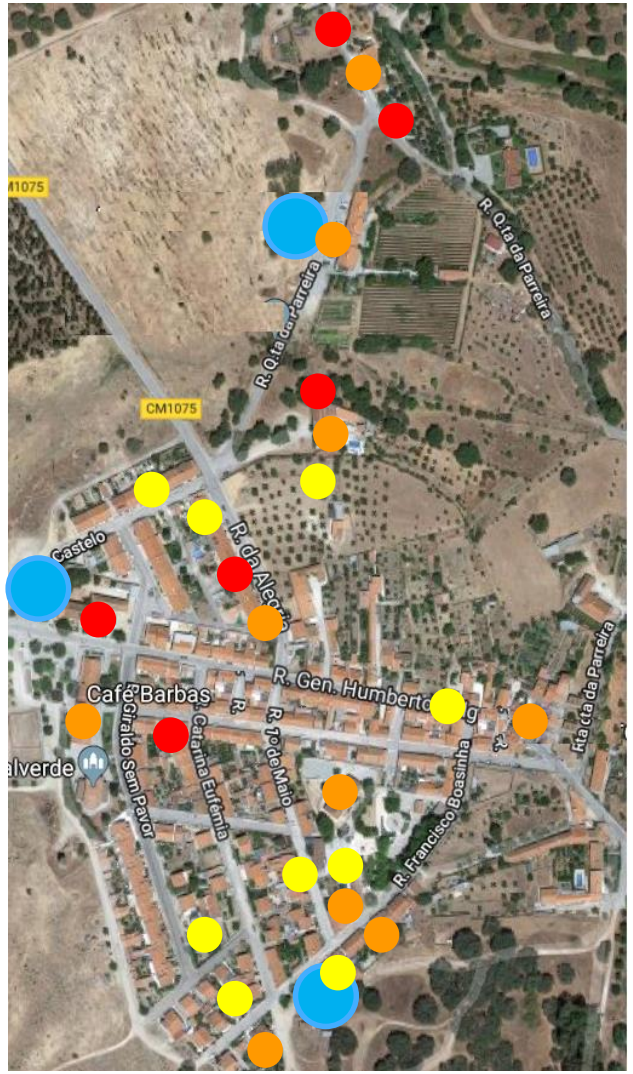
…and a Residential infrastructure.

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**25 Residential clients of which:**

- 25 with PV (1,5kWp)
- 9 with Water Heaters
- 10 with batteries (3 kW/ 3 kWh)
- 6 with battery and Water Heater
- 25 with HEMS












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# Nottingham demonstrator infrastructure

## Demonstration scenario focused on Meadows community

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### Domestic installations – 27 houses:

- 11 x SMA SB Storage 2.5 + Tesla Powerwall 1
- 4 x SMA Sunny Island (3.0/6.0) + LG Chem Resu 6.5
- 6 x ImmerSuns
- 6 x Monitoring only

### Community installations – 3 sites:

- School / Library – Tesla Powerwall 2 with 5kW inverter
- Creative Energy Homes – 30kVA 4-wire inverter with 34 kWh battery

### SENSIBLE solution

- Equipment: 31x Integration Gateways, 37x Smart Meters, 17x eBrokers, 6x Auxiliary Data Collectors and 1x Weather Station






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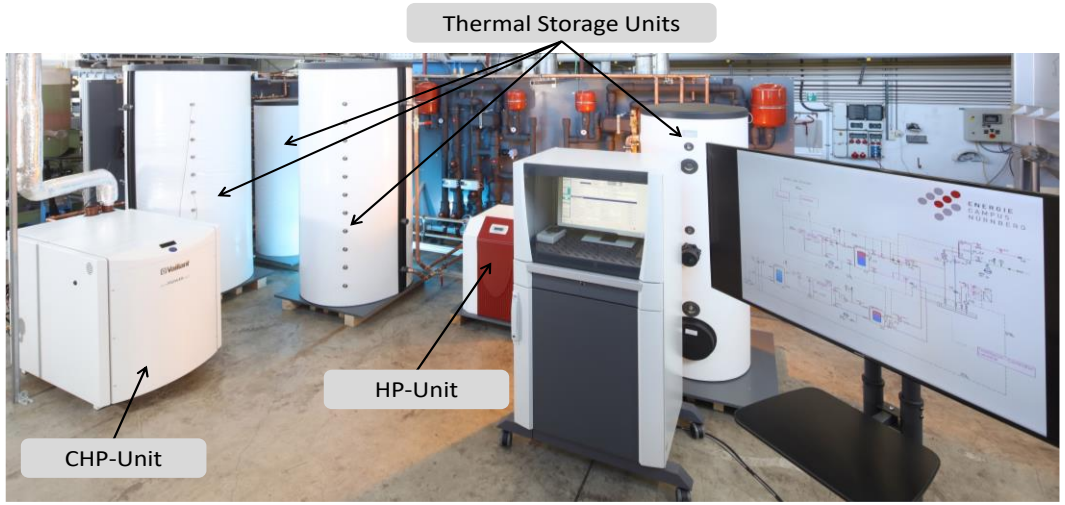
# Nuremberg demonstrator infrastructure

## Demonstration scenario based on laboratory Hardware-in-the-Loop test bed

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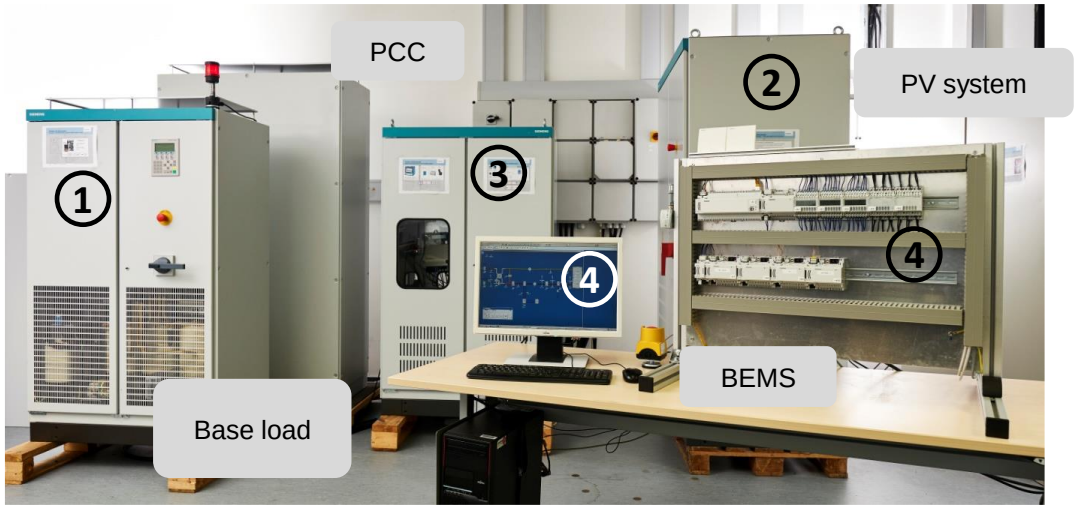
### Generator-Systems Lab in Nuremberg

- Geothermal heat pump (10.5kW)
- Combined heat and power unit (4.5kW el. & 12.5kW ther.)
- Thermal storage devices (with resistive heaters)
- Building Thermal Load Emulation System (40kW)




### BEMS Lab in Erlangen

- Base load Emulator (80kW)
- PV Emulator (40kW)
- Li-Ion Battery (31kWh)
- Building Energy Management System





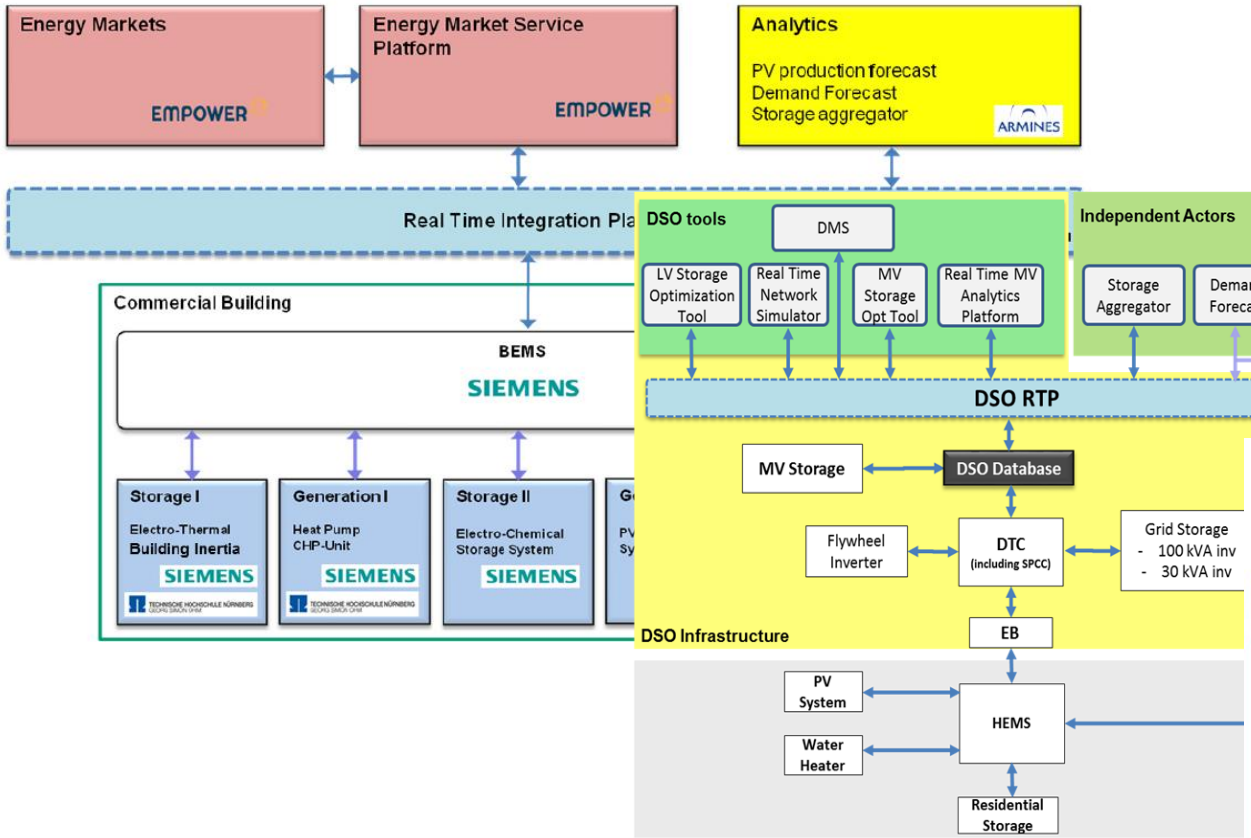

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# ICT architectures

## Digitalization as key role to enable the provision of energy services

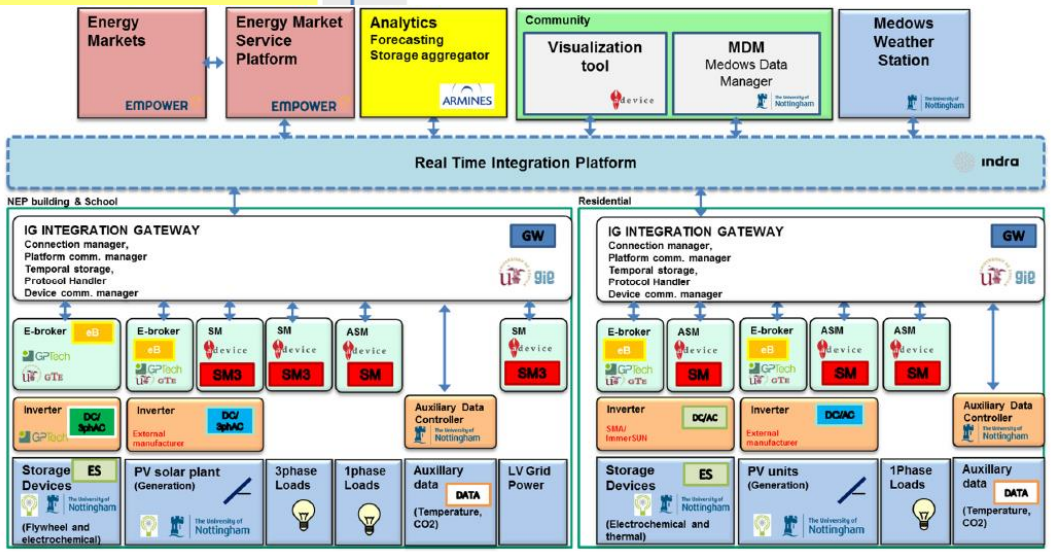
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## Nuremberg




## Évora

## Nottingham






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# Laboratory validation

Laboratory Validation in EDP Labelec facilities had a key role in Évora demo

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## Grid Validation was performed in StorageLab based on testing protocols designed by EDP Labelec (Lisbon)

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



## Residential validation took place in EDP Labelec SmartLab (Lisbon)

- Full residential infrastructure was tested
- Equipment tested in limit situations, including response during voltage sags and blackouts in the grid
- High level engineering markets tools integration were also addressed



## Validation of Grid management tools at INESC TEC laboratory (Porto)

- Prototype validation
- High level algorithms performance



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# Laboratory validation

## All the involved partners participated actively in laboratory activities

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# Évora demonstrator implementation

## Residential installations concluded in July 2017 and grid in November 2017

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# Nottingham demonstrator implementation

Focus enabling community with Distributed Energy Storage systems

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## Home Battery Systems






## Communications



## Thermal Storage Controller



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# Nuremberg demonstrator implementation

## Virtual Building divided into two laboratories

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# Main Technical Achievements

SENSIBLE was considered a H2020 Flagship project by the European Commission

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## Évora

- Definition of a scalable and replicable monitoring anf control architecture to be used by DSO and Retailer/ESCO to manage DER (PV and different storage technologies)
- Operation of LV and MV networks in islanded mode through the coordinated use of grid ESS (LV and MV) and end customers flexibility
- Implementation of a end customer flexibility agregation framework able to provide support to Retailer/ESCO to optimize results in energy markets as well as to DSO to optimize network operation

## Nottingham

- Increased self-consumption of over 12.7 MWh using batteries and immersion heaters
- Reduced participants' energy bills through self-consumption and shifting energy to lower price periods
- Improved the low-voltage network operation in the Meadows and increased PV penetration

## Nuremberg

- Seamless integration of energy production and storage components with the ICT infrastructure including forecasting services and energy market services platform
- Development of a Building Energy Management System (BEMS) that's able to control multi-modal energy components within the building
- Demonstration of the so-called smart buildings' interactions with external smart grid systems like virtual power plants, DSOs and the energy markets



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# Main Technical Challenges

The technical complexity and ambition brought several challenges. Some…

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## Évora

- Lack of standardization for the testing, installation and operation of Energy Storage Systems in the LV networks
- Integration of high-level (forecast, management, monitoring, etc) tools provided by 6 partners, IT infrastructure provided by 2 entities and equipment provided by 6 entities
- Provision and reliability of (almost) real time metering to enable network and market services, always complying with GDPR

## Nottingham

- Technical integration of 6 equipment types – packaging (for house), communication protocols, approvals
- Integration of different software tools developed during the project – eg prediction, markets, control, security and communications (VPN)
- Development of central server database and control system
- DNO flexibility – approval process and battery storage classification

## Nuremberg

- Implementing the basic automation (with safety functions) together with ICT architecture
- Integration of systems from different manufacturers (special software gateways needed to be programmed)
- Synchronization of electrical and thermal components of the testbench



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# Preliminary Conclusion

SENSIBLE demos are ongoing but we can take some conclusions already

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## Buildings / End consumers

- Energy Management System at the building level is essential while considering local energy production and storage in order to increase energy efficiency and also grid stability

- Management of customers energy consumption flexibility is difficult. Different storage technologies provide different benefits but also imply different control complexity.

- Making building devices and its operation flexible could prove to be vital for decarbonized future energy systems

## Grid operation

- Distributed LV and MV Energy Storage systems can be a powerfull asset for the DSO to optimize the network operation (in connected or islanded operation)

- Effective and efficient Smart Grid infrastructure is crucial to enable reliable monitoring of the grid and provide exploitable data to forecast and management tools.

- With increasing penetration of distributed generation and storage in distribution networks, new protection paradigms must be thought and tested

## Microgrids / Communities

- Islanding operation at LV and MV level can be achieved through independent or coordinated control of MV and LV ESS, and also with the support of DER enabled end customers.

- Need to work with communities to develop user acceptance of technologies (aesthetics, security, safety, understanding of system behaviour for maximum benefit)

- Potential to increase penetration of PV

- Ambitious projects like SENSIBLE must start at full speed since day 1, with proper definition on demonstration scope
- H2020 projects have become such highly complex and ambitious that the full commitment of the Consortium is a must.



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# Thank you!

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