Gareth Bissell

ENEL - GLOBAL INFRASTRUCTURE AND NETWORKS

Smart Grid evolution and the LivinGrid microgrid demonstration project

e-distribuzione

e-distribuzione S.p.A.
Italian infrastructure and networks

31.6 M
Customers

667.000
Producers

27 GW Distributed Generation

>16.000
Plants

1.145.000
Km of conductors

442.000
Secondary substations

2.195
Primary substations

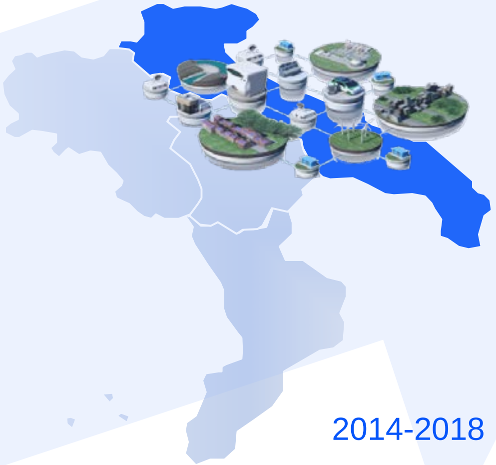
223 TWh
Distributed energy

Evolution from passive to active distribution networks

From **large scale demonstration to regional deployment** of innovative solutions to facilitate:

- Integration of renewables and DRES
- Supporting customer engagement
- Providing EV charging infrastructure

PROGETTO
Puglia Active Network



- 170 M€
- 102 Primary substation
- Entire region (2.4M customers)

2014-2018

Isernia project

2011-2014

- 10 M€
- 1 Primary substation
- 8000 customers

e-distribuzione

Isernia Project
Scenario

- Integration of Renewables (excl. storage)

  Problem to be addressed: Power Quality (Voltage limits)

- Storage
- Active Demand
- Electric Vehicles

Budget: 7 M€

Autorità per l'energia elettrica il gas e il sistema idrico

Delibera AEEG ARG/elt 39/10

- **HV/MV Primary Substation: Carpinone (1,4 % of annual reverse energy flow);**
  - **5 MV lines (198,445 km);**
  - **LV generation 1,300 kW**
  - **11 active customers involved in the project;**
    - **5 Hydro (8,967 kW);**
    - **1 biogas (650 kW);**
    - **5 PV (3,448 kW);**
  - **157 CS with 8000 LV customers (18.540 kW);**
  - **25 MV customers (12.970 kW);**
- **Li – Ion storage (1 MVA – 500 kWh) integrated to a PV plant (50 KWp) – already installed;**
- **5 Electric Vehicles and 5 Recharging Infrastructures**
- **Up to 8,000 LV customers will be equipped with the Smart Info – installation already started.**

Isernia Project
BaU vs Smart Grid solution

1

New Lines

New lines will double current DG hosting capacity, i.e. 28 MVA.

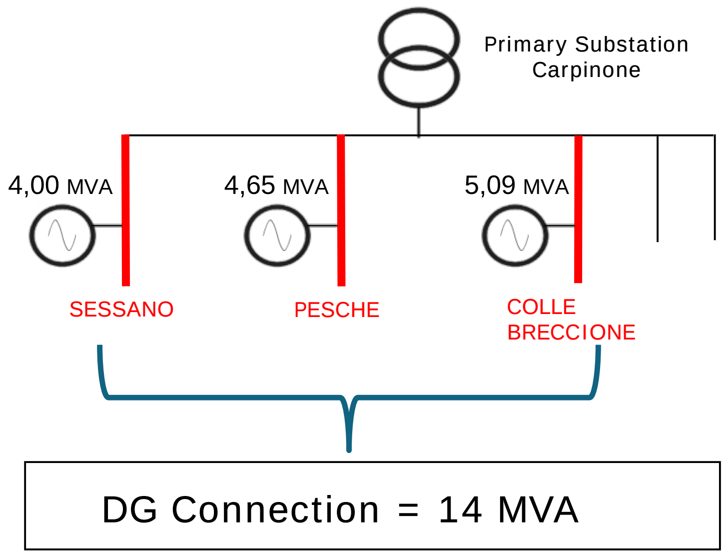
[Assuming Transformer power rating is within limits]

VS

2

Smart Grid Technologies ✓

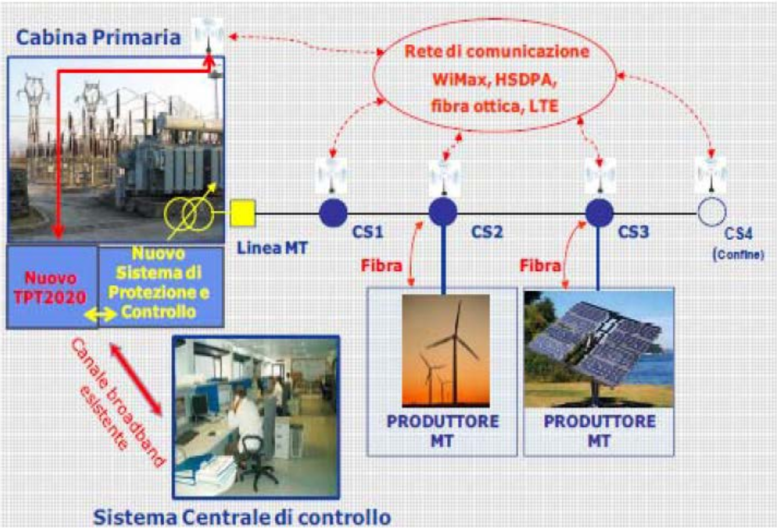
Smart Grid technologies allow hosting capacity of existing lines



WHY?

1. Along the lines, there is **both DG & Distributed Load**, therefore Hosting Capacity thermal limit along different lines is not reached
2. Most DG is PV, where peak production overlaps with peak consumption → implies **little reverse power flow** to transformer & lower current on busbar.

Isernia Project
Smart Grid solution



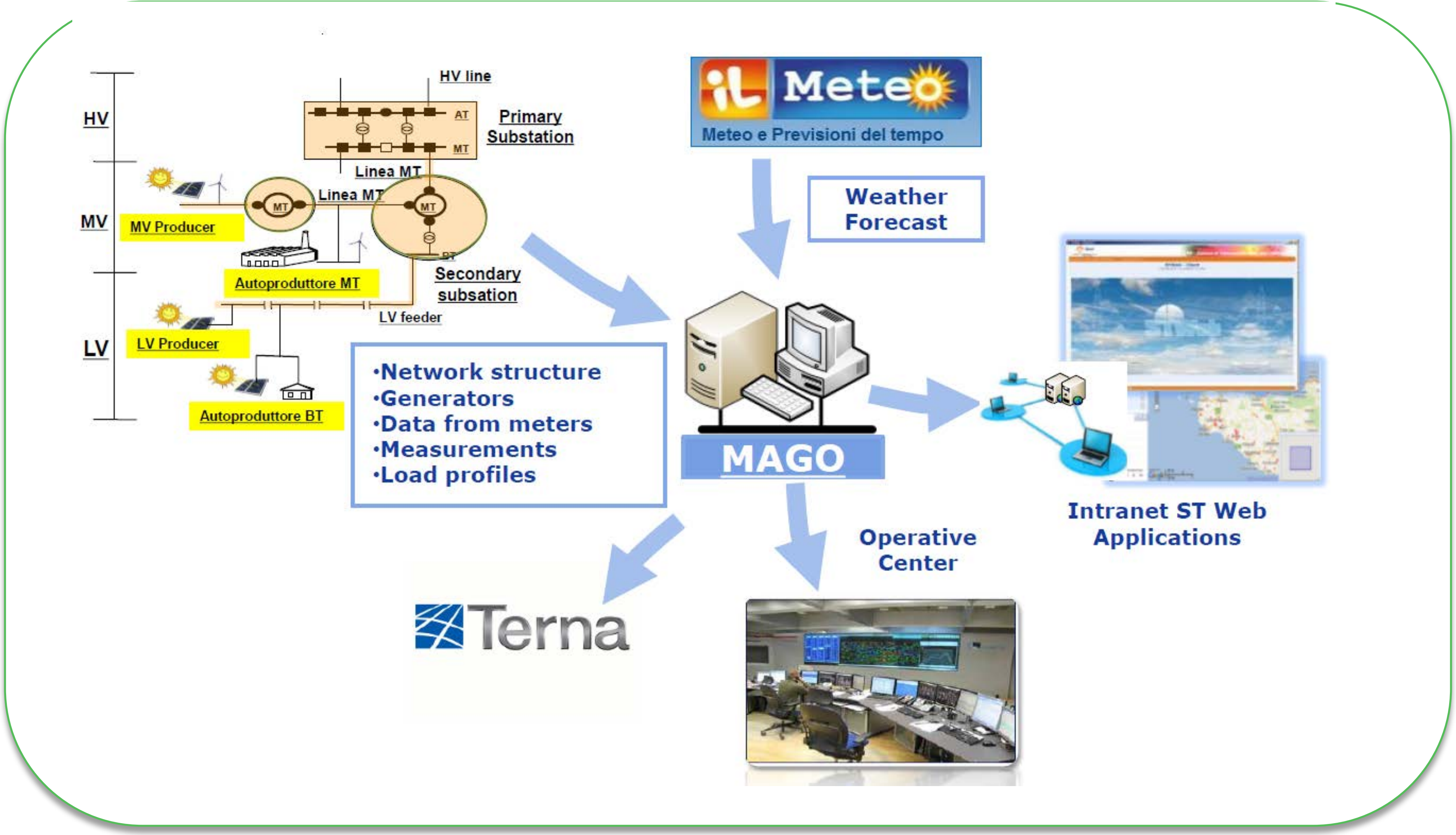
Control system: Distribution Management System (DMS) at the control centre

Functionality: Voltage profile is maintained by the sending set points to control the reactive power injected by the Distributed Generation (PV connected to MV network)

Communications: LTE/Fibre
IEC 61850

Isernia Project

Measurement collection, DG production forecasting and data transmission towards TSO systems



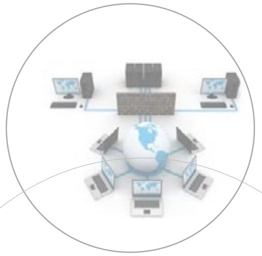
Puglia Active Network Project

E-distribution project with a total budget of **€ 170 million** and € 85 million funding by the European Union through the Call for Proposals NER300. The PAN project will provides innovative solutions for services for the first time in an entire Region

- Puglia is the region with the largest energy production from New Renewable Non-Programmable Sources
- Adapting infrastructures to accommodate high power generation from Distributed Generation
- Enhanced network management to ensure quality and security of supply

Puglia Active Network Project
Objectives

Enabling customers to participate in new markets



ability to interact real-time with active customers and involved steps

Energy efficiency

Enabling new energy efficiency services

PROGETTO
Puglia Active Network

Quality and security of supply

Monitoring voltage profile to ensure operation in accordance to EN50160

Renewable integration

- *19.3 TWh of RES managed by the network in 5 years*
- *Increased Hosting Capacity*

Increase network flexibility

integration of charging stations for electric vehicles

Smart Grid functionality

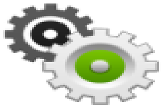
Enhanced management of an active network across an entire region

PROGETTO
Puglia Active Network

Advanced automation

Monitoring and Controlling Distributed Generation

Monitoring and monitoring the tension of the medium voltage lines



Predictive maintenance on primary substation MV switches

Electric vehicle charging infrastructures

LivinGrid Project

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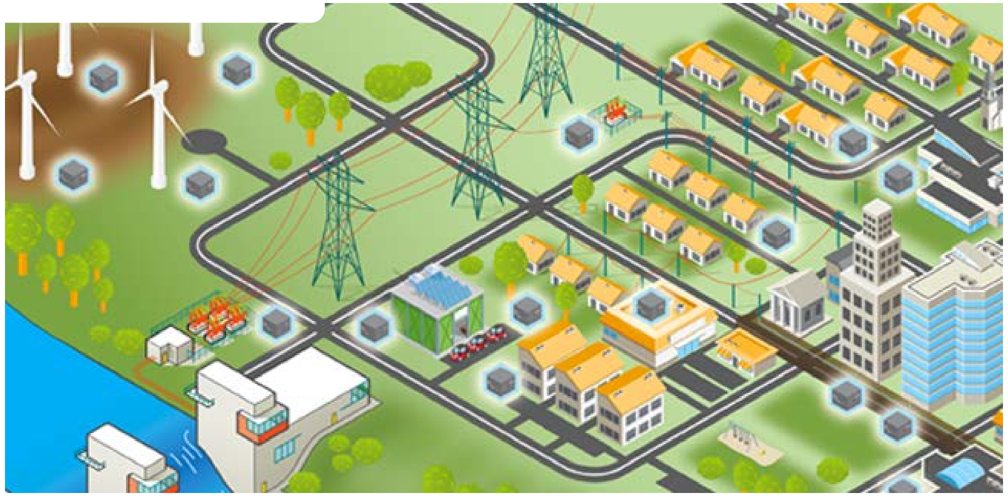
Objectives

- Demonstration / pilot that could represent technologically scalable model solutions for greater DRES integration
- Integration of storage systems of different technologies
- Demonstrate microgrid concept
- Create a technologically "scalable" model with the aim to improve the observability and controllability of DER and the additional services (TSO and DSO)
- Create a model in which the explicit question DSO TSO DSO leaving the decision as to which loads or production source distributed intervene



Partners (Core Group)

- ENEA
- e-distribution
- Terna
- RSE
- CNR
- EnSiEL

ENEA
Agenzia nazionale per le nuove tecnologie, l'energia e lo sviluppo economico sostenibile

Terna

National Research Council of Italy

RSE Ricerca Sistema Energetico

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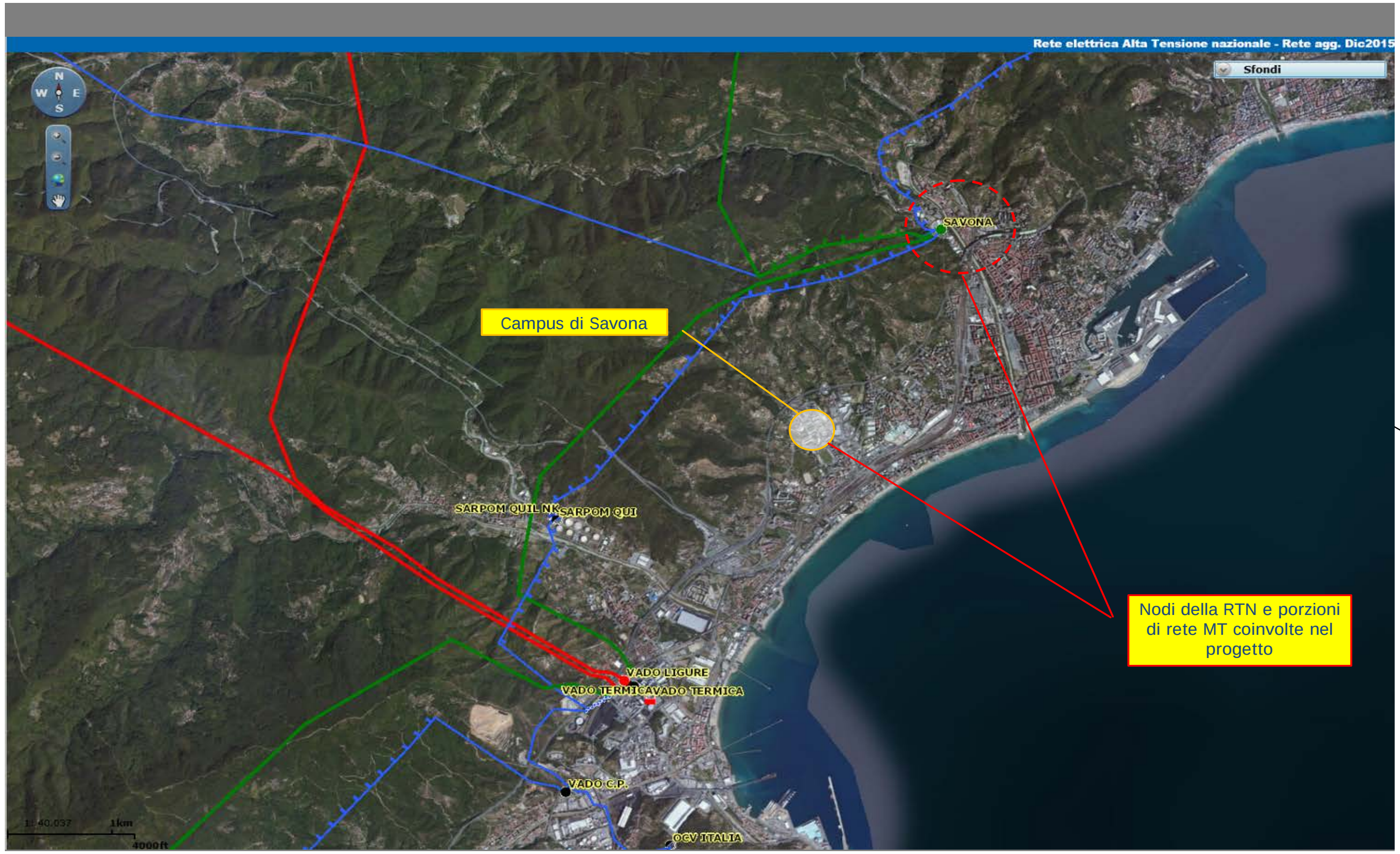
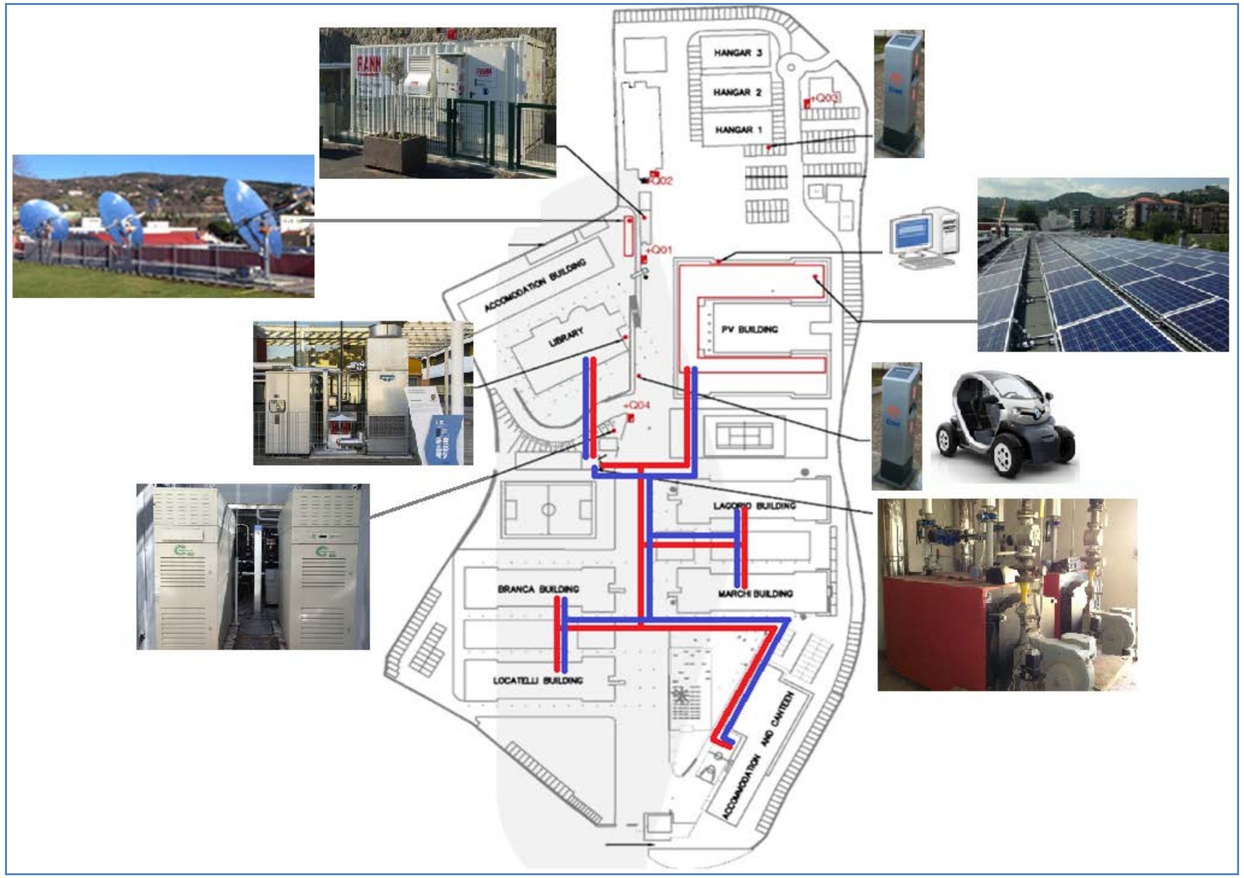
ensiel
ENERGIA E SISTEMI ELETTRICI

LivinGrid project
Savona University Campus



Savona Campus
Smart Polygeneration Microgrid (SPM)

- Smart microgrid with a ring configuration (600m long)
- Electrical loads and the generation units of the SPM are connected to the aforesaid switchboards and operated by the Energy Management System
- Installed power plants:
  - o 3 cogeneration gas microturbines (450kW each)
  - o 2 photovoltaic roof top fields (80 kW and 15 kW of peak power each)
  - o 3 Concentrating Solar Systems (rated electrical power of 1 kW and a rated thermal power of 3 kW)
  - o 1 Na-NiCl2 electrical storage system (141 kWh)
  - o 1 lithium-ions electrical storage system (25 kWh)
  - o 1 water/lithium bromide absorption chiller (rated thermal power input of 105 kW, rated cooling power of 70 kW)
  - o 2 charging stations for electric vehicles



SPM Layout The heat distribution network (red and blue pipelines) and the location of the SPM power plants

The Savona Campus Single-line diagram

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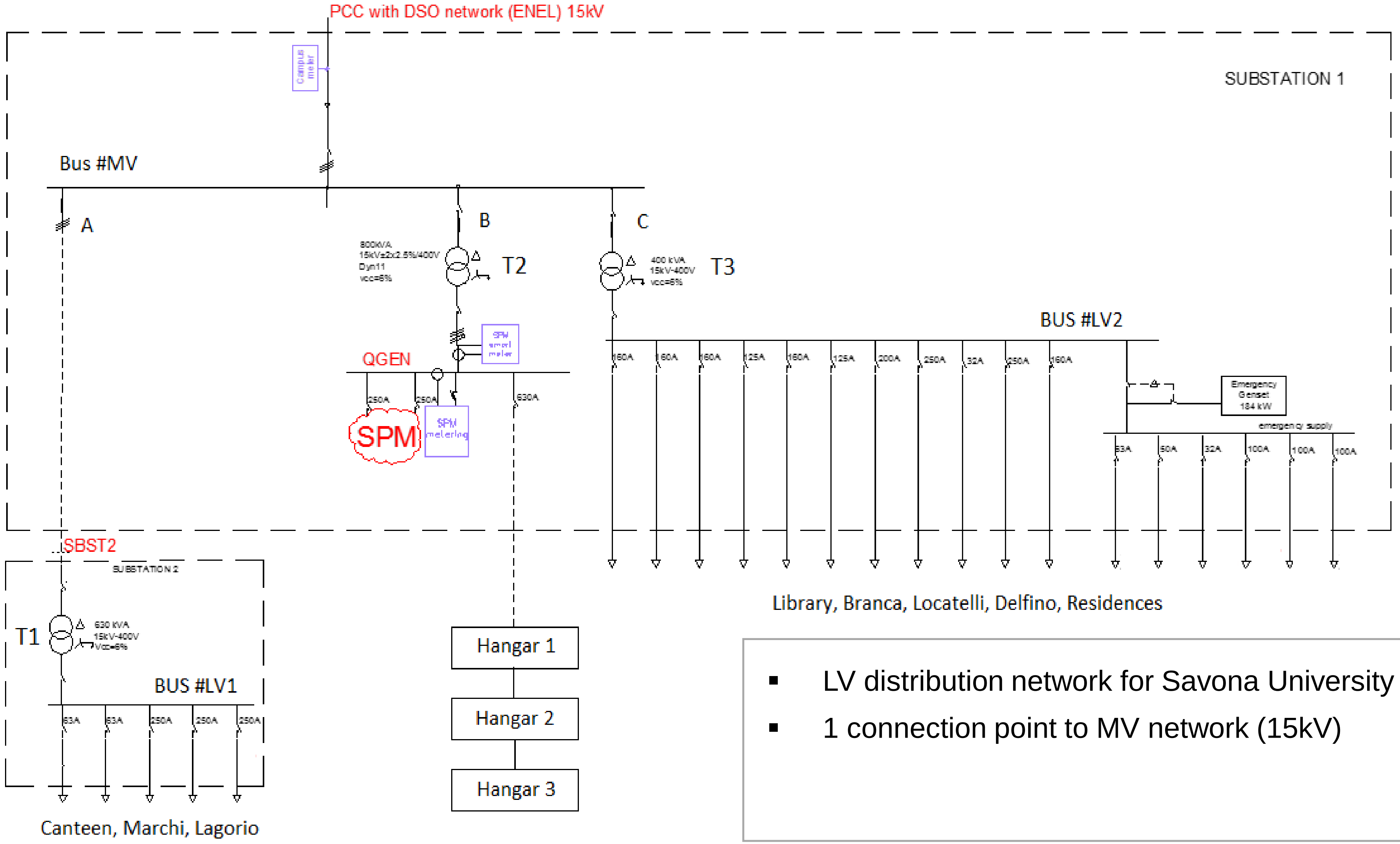
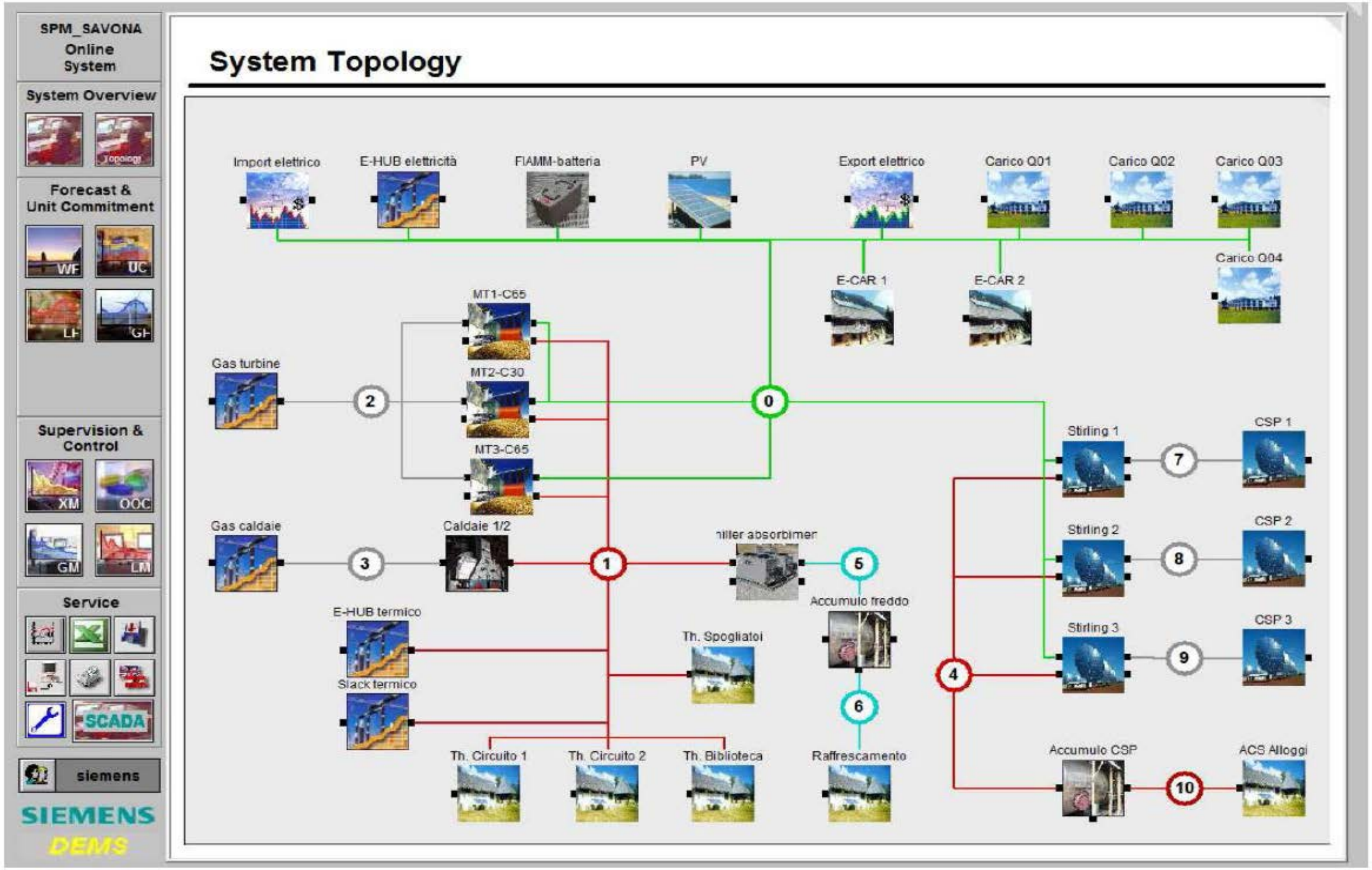


- LV distribution network for Savona University campus
- 1 connection point to MV network (15kV)

Energy Management System

- Communication network for interconnection of decision and control points
- Intelligent algorithms for the control, protection systems and operation of the electrical network
- All these communications employ the IEC 61850 protocol
- The optimization algorithm is based on a time horizon of 24 hours, and a time interval of 15 minutes
- Temporary operation of areas of the network in an "intentional island" state to be investigated
- Islanded operation is envisaged under conditions that would be beneficial for both the needs of the transmission and distribution network
- Shifting on real load and implementation of new facilities



The main user interface of the SPM’s Energy Management System

LivinGrid project
Expected benefits

- **Observability and controllability of the system**
  - ✓ Implementation of more accurate and fast measurement functions and optimization of the applied active generation power supply control and regulation, and the distributed load.
- **TSO-DSO integration**
  - ✓ Innovative model for load curtailment, that in emergency conditions, allows the detachment of the NTG controlled by the network portions distributor and their temporary management in island intentional, not impairing the continuity and quality of service to end-customers connected to that network.
- **Optimization of distributed generation**
  - ✓ Study of models for the optimized management of loads and sources of generation, thanks to the use of storage systems connected to the LV distribution network
- **Evaluation of the impact of the proposed solutions on environmental and regulatory aspects**
  - ✓ Analysis of innovative dispatching models of renewable sources and the flexibility on the network

Main Outcomes

1. Verification that **advanced monitoring and control** system on electrical distribution network has **attainable benefits** for **increasing hosting capacity** of renewable generation sources.

2. Demonstrated **reduced costs** as the scale of the deployment is increased

3. Further potential for **increased flexibility** that **can be facilitated**

4. Installations of **more efficient charging station** including fast recharge and better distribution, allowing an increased output

5. Realisation of **improved customer engagement** resulting from Smart Info deployment

6. Generators **connection time** may be **reduced** through use of Smart Grid technologies

7. Service levels to customer can be **continuously improved** (possible network problems can be anticipated)

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Lessons learned

Unexpected component costs:

- Telecommunication (LTE, Optical fibre, Routers, and switches)
- IRE interface

Difficulties and time consuming activities:

- To involve producer and to equip their plants
- To involve people in Enel smart info trial
- To involve the main European producers of inverters
- To obtain permission for PV power plant

Barriers

1. Existing **regulatory framework does not facilitate utilisation of flexible Distributed Generation**. A mechanism to enable the utilization of this flexibility is the next essential step to unlock the full potential of Active Network Management.

2. Exiting **regulation is CAPEX based**: Incentive is to use network reinforcements. As Smart Grid solutions show potential to provide more promising solutions, OPEX must also be considered. A TOTEX based regulation would be a driver towards smart grid solutions

3. High **cost of the IRE interface** (equipment necessary to allow communication between DSO system and DER plant

4. Increased cost and risk to investment with **insufficient standardisation** (Invertors for example)

Needs for future R&I activities

1. Provision of **grid services** and **TSO-DSO-Customer** interface (Reference: SmartNet, H2020 2018 LC-SC3-ES-5-2018-2020 call)

2. A new approach for design and operation of distribution networks will need a new approach to **network planning / grid codes**

3. Inherent **diversity of electrical power system**: Will a one-fits-all solution will provide the greatest overall benefits?