

University of Genoa - Italy
Savona University Campus

The Smart Polygeneration Microgrid at the Savona University Campus

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Gap (France) - September 16, 2014

The Savona University Campus

- 50,000 m² of extension
- 1,700 students
- Different courses offered by the **Polytechnic School of Engineering**, the **Medicine School** and the **Social Sciences School**
- Presence of **laboratories**, **research centres** and **SMEs**
- Regional Research and Innovation **Cluster for Sustainable Energy** (aggregating 44 companies, including SMEs and research institutions)
- **International Centre on Environmental Monitoring (CIMA)**
- Library, housing, cafeteria, study halls, sports facilities, other services for students



ENERGIA 2020 Project - University of Genoa (2010-2016)

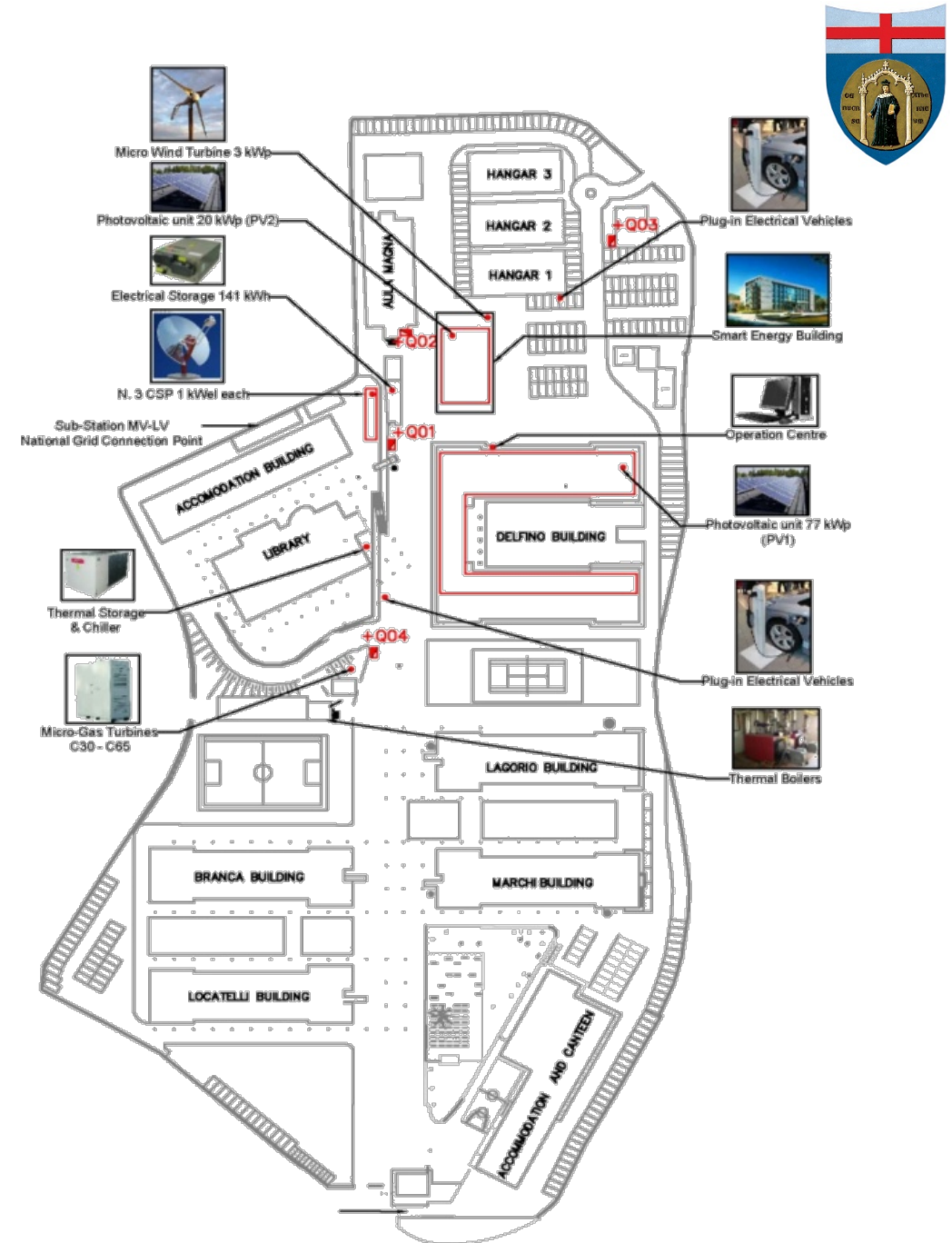
The project "Energy 2020" of the University of Genoa, that has been developed at the Savona Campus thanks to a full public funding, is an important R&D project related to the concept of Sustainable Energy (renewable energy, primary energy saving and reduction of CO₂ emissions).



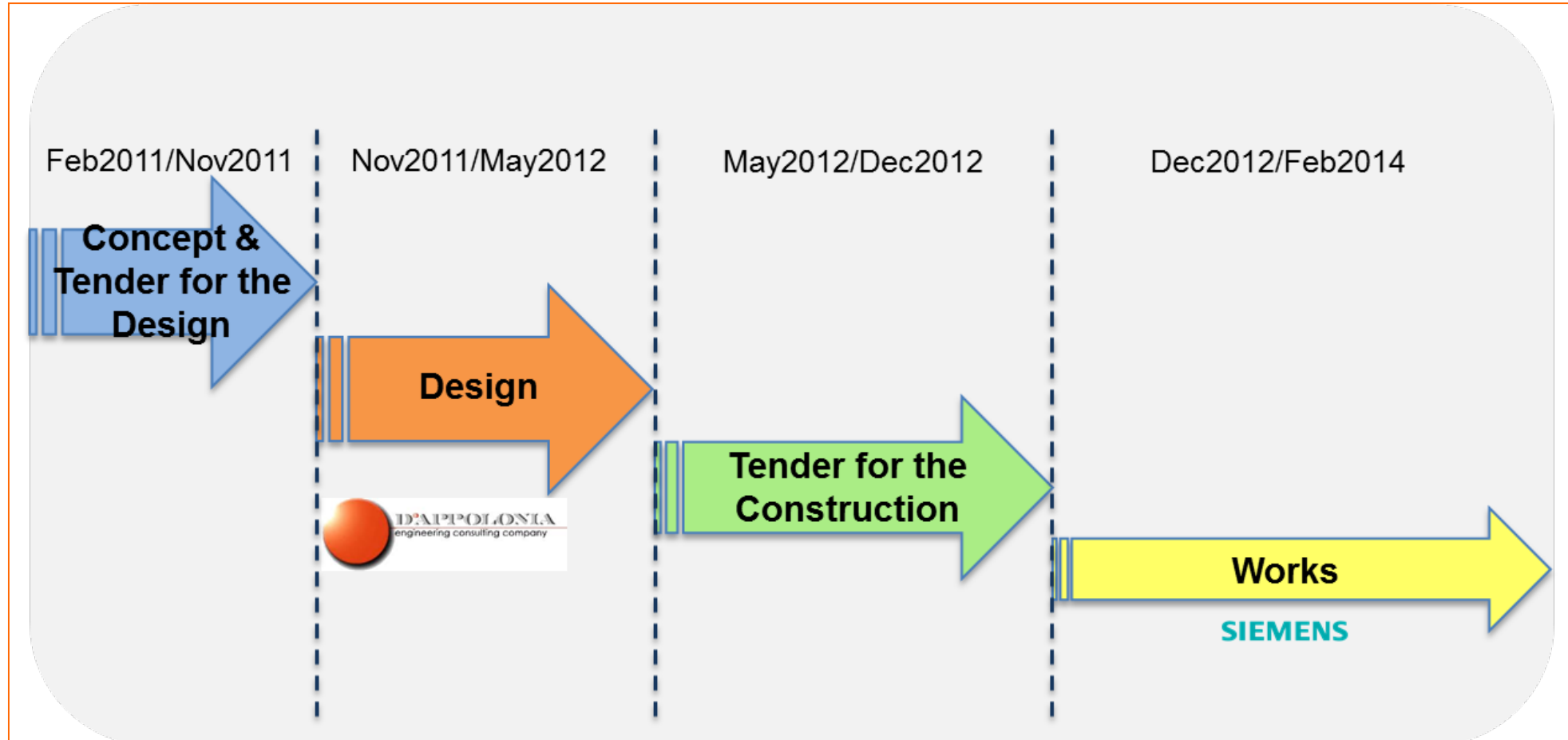
The Smart Polygeneration Microgrid (SPM)

Funded by the Italian Ministry for Education, University and Research, the SPM is a 3-phase low voltage “intelligent” distribution system running inside the Savona University Campus and connecting:

- 3 CCHP Gas Turbines (Capstone C30 and C65 models, 160 kW_e, 284 kW_{th}) fed by natural gas;
- 1 Photovoltaic Plant (80 kW_p);
- 3 CSP (Concentrating Solar Power systems) equipped with Stirling engines (1 kW_e and 3 kW_{th} each);
- 1 absorption chiller (H₂O/LiBr) with a storage tank;
- 1 electric storage: Na-NiCl₂ batteries (100 kWh)
- 2 PEV (Plug-in Electric Vehicle) charging stations.



The Smart Polygeneration Microgrid (SPM)



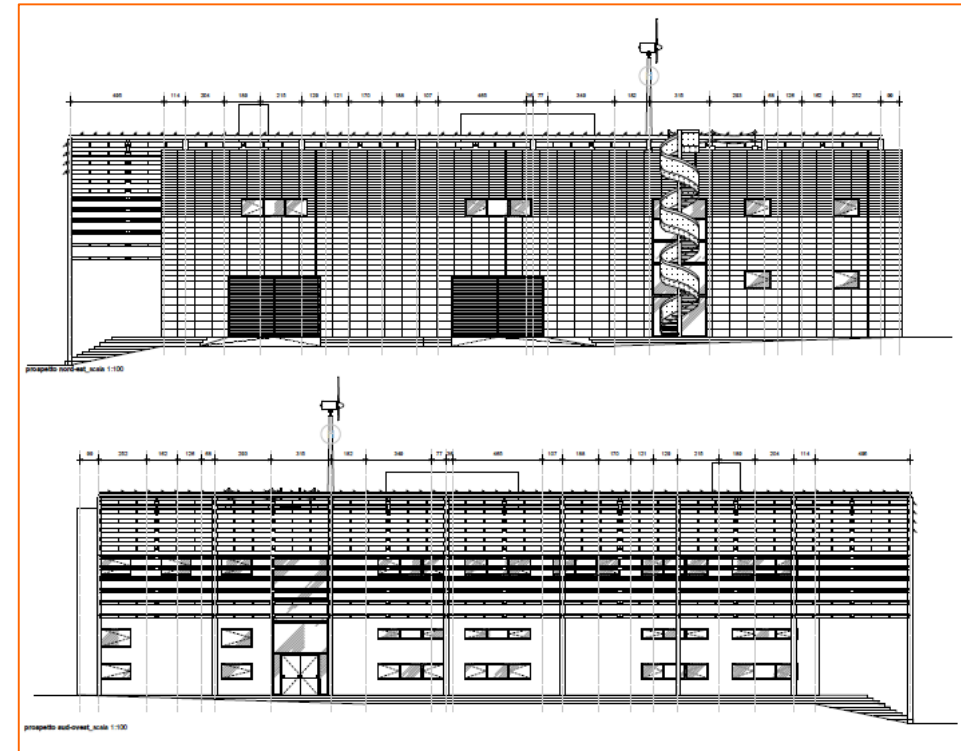
SPM Project development



The Smart Energy Building (SEB) Project

SEB is a special project in the energy efficiency sector funded by the Italian Ministry for the Environment, Land and Sea. SEB is an environmentally sustainable building connected to the SPM, as an “energy prosumer”, and equipped by renewable power plants and characterized by energy efficiency measures:

- geothermal heat pump
- photovoltaic plant on the roof (20 kW_p)
- micro wind turbine (horizontal axis, 3 kW)
- high performance thermal insulation materials for building applications
- ventilated facades

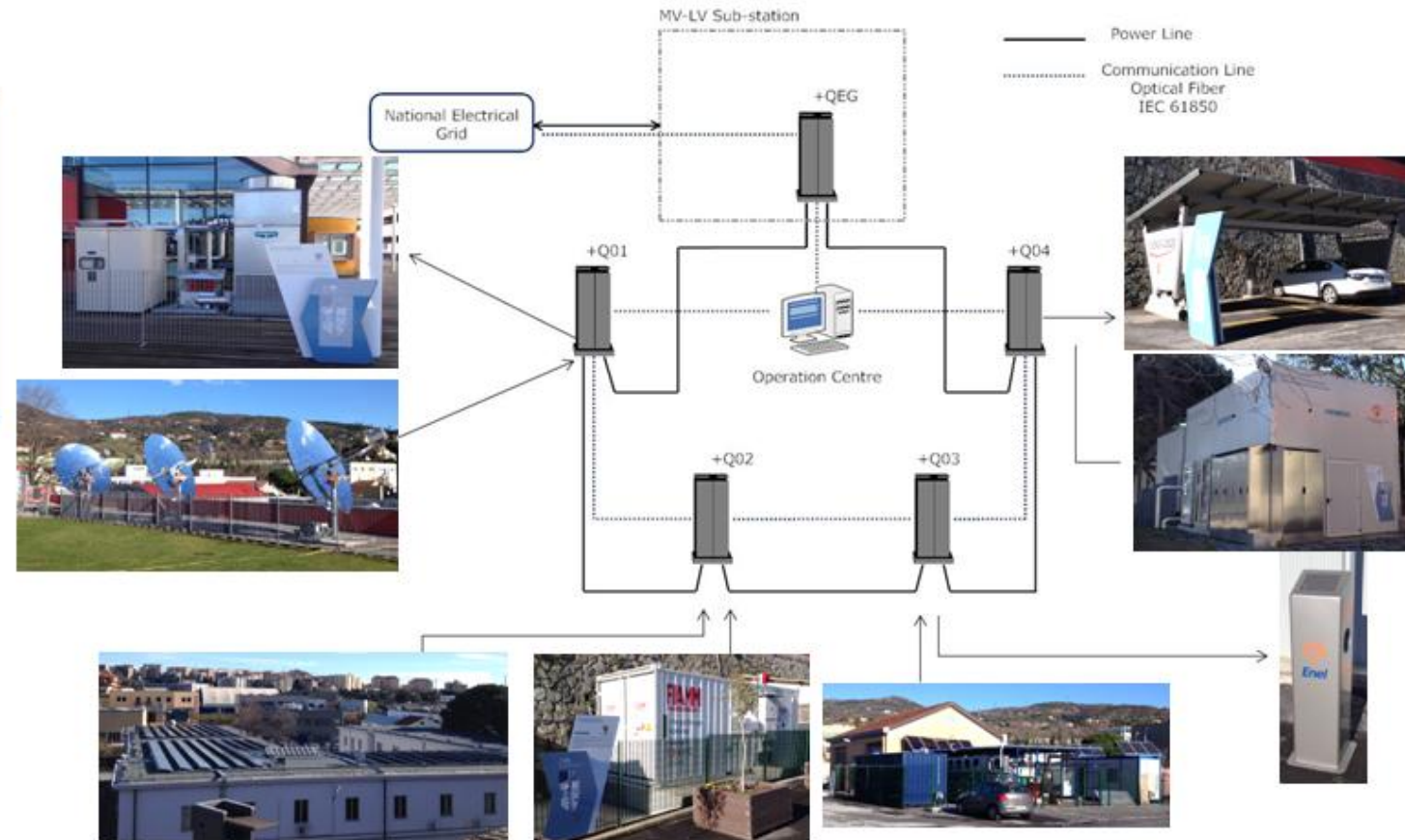


The Smart Polygeneration Microgrid (SPM)

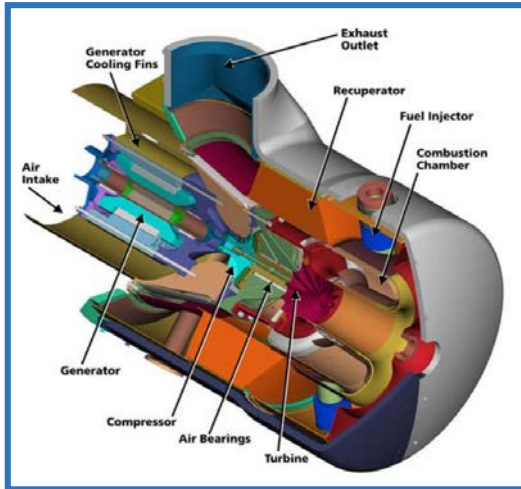
Definition of “microgrid” proposed by the US Dept. of Energy (DOE):

“A group of interconnected loads and distributed energy resources (DER) with clearly defined electrical boundaries that acts as a single controllable entity with respect to the grid and can connect and disconnect from the grid to operate in both grid connected or island-mode.”

**Smart
Polygeneration
Microgrid (SPM):
technologies
and
configuration**

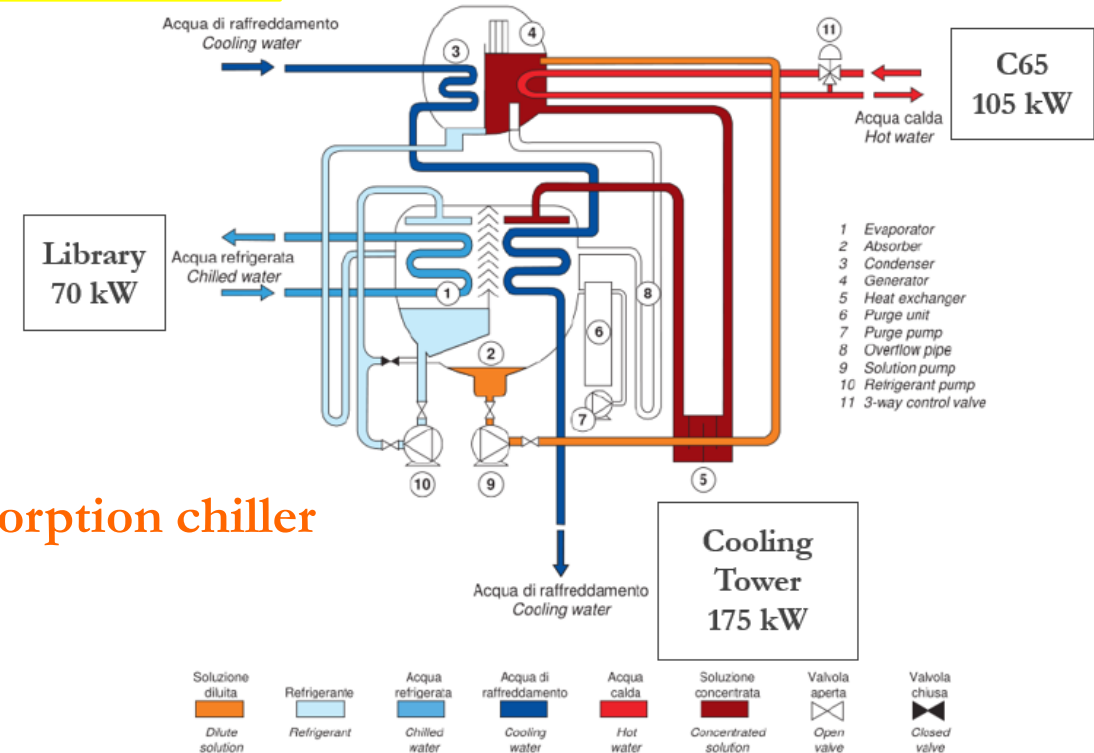


The Smart Polygeneration Microgrid (SPM) - the CCHP technologies



The C65 gas turbine

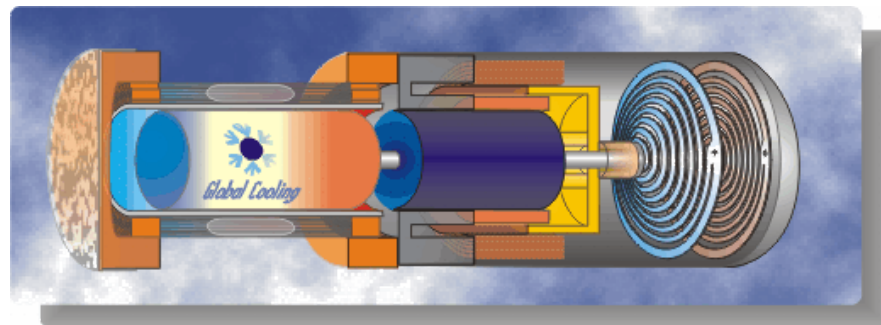
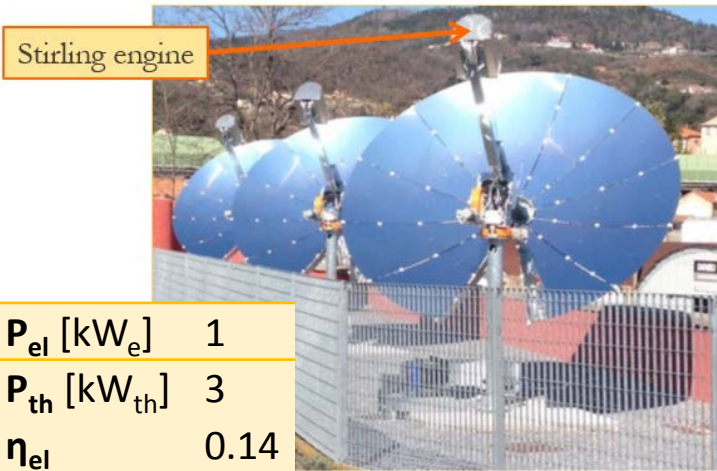
P_{el} [kW _e]	65
P_{th} [kW _{th}]	112
η_{el}	0.29
η_{th}	0.50
n [rpm]	96000



The absorption chiller

The Smart Polygeneration Microgrid (SPM) - the solar technologies, the batteries and the e-mobility

The CSP plants



The photovoltaic plant

336 modules
240 W each
 $\eta_{el} = 0,145$



E-mobility

(Renault Twizy and Fluence ZE)

The electrical storage

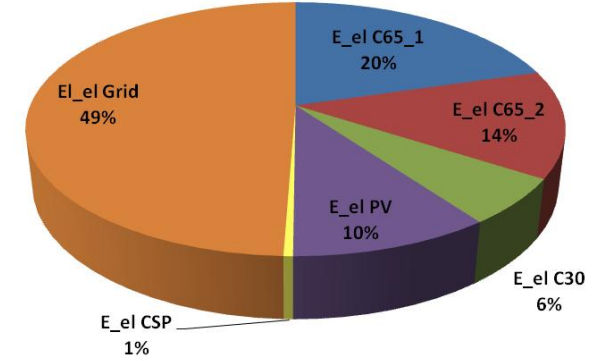
6 batteries
23.5 kWh each
420-700 V



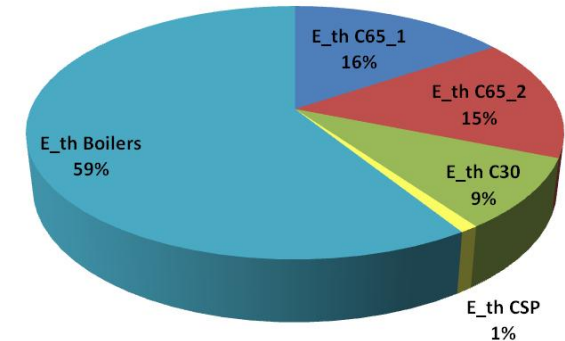
Main goals:

- to build an R&D facility test-bed for both renewable and fossil fuel power plants
- to promote joint scientific programs among the University of Genoa, other Universities, industrial companies and distribution network operators
- ✓ **Day-ahead production scheduling of dispatchable sources and storage, exploiting renewables forecast and optimization techniques**
- ✓ **Real time optimal control of production and storage systems**
- to optimize thermal & electrical energy consumptions, **minimizing the CO₂ emissions, annual operating costs and primary energy use of the Savona University Campus**
- **To export the approach to wider areas such as new residential or industrial districts**

Savona Campus Electric consumptions



Savona Campus Thermal consumptions



Energy Bill (without SPM): 300 k€ / year



Energy Bill (with SPM): 250 k€/year



Reduction of the energy bill: -50.000 €/year
Reduction of CO₂ emissions: -120 tons/year

Energy Management System of the SPM

The SPM *Energy Management System* uses:

- costs and revenues functions;
- forecast of electric and thermal energy demands;
- operative constraints (equipment ratings, maximum power ramp, etc.);
- forecast of the renewable units production by resorting to weather services and historical records

to compute a **scheduling for dispatchable sources including storage**, which **minimizes the daily energy costs**.

The optimization process has a time-horizon of 1 day, subdivided in 15 (or 30 or 60) minutes time-intervals. The optimization method is based on *linear programming*.

INPUT

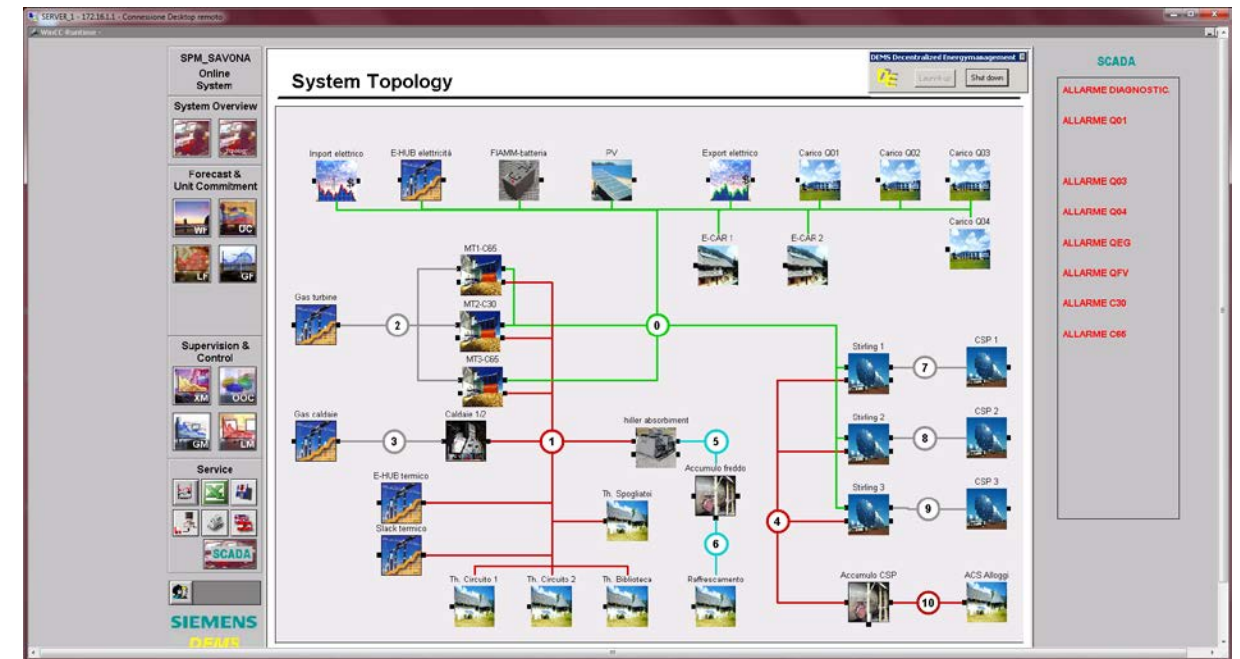
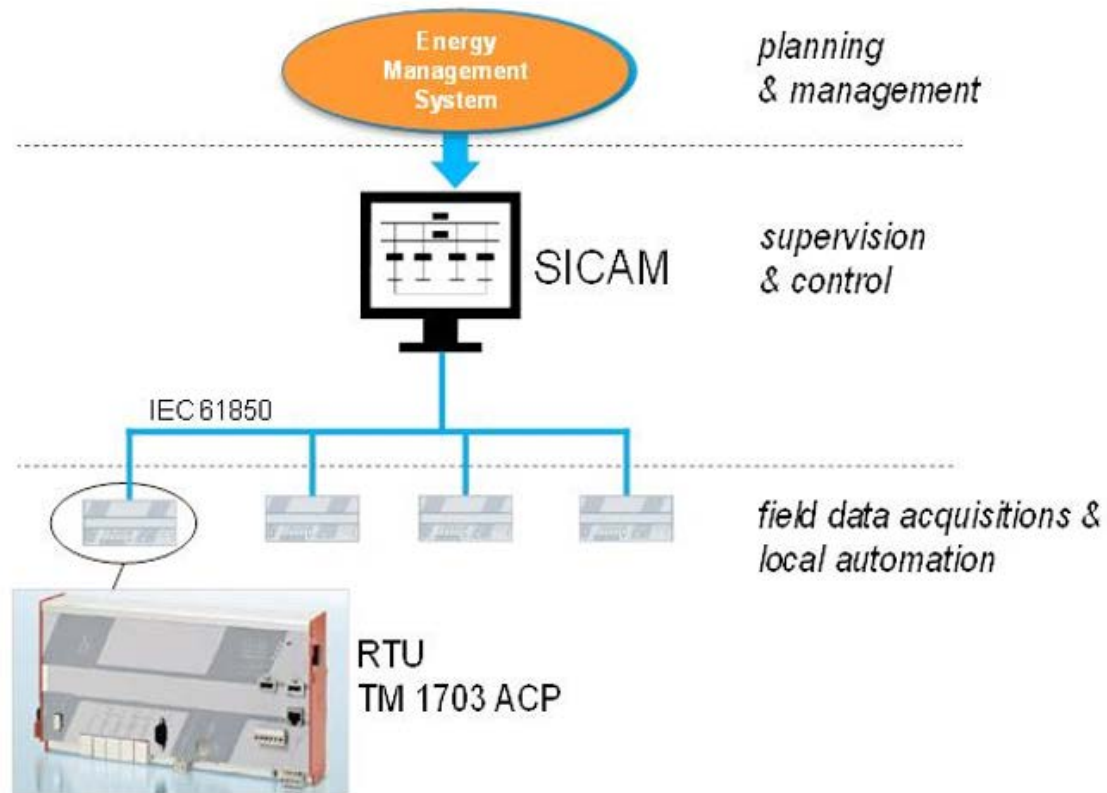
Generation forecasting
Electric and thermal load forecasting



OUTPUT

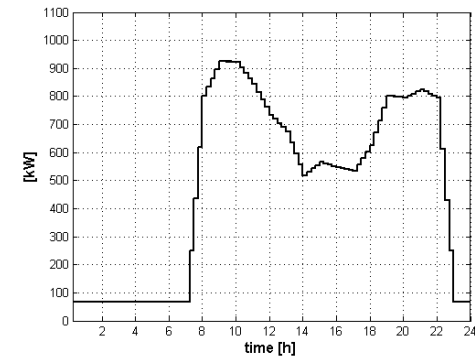
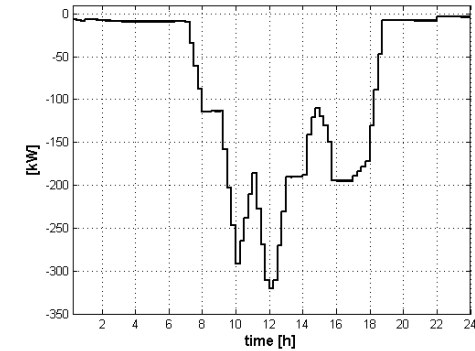
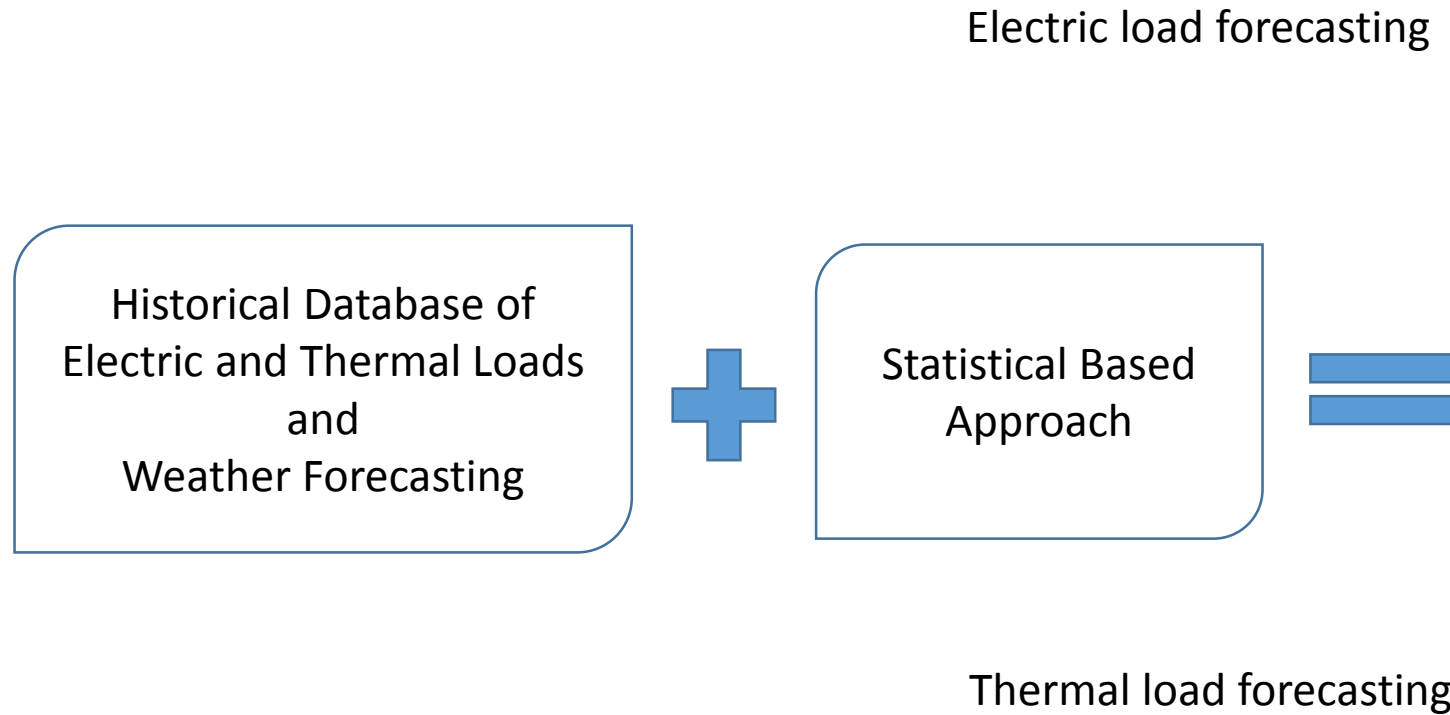
Power profile of each unit

The Smart Polygeneration Microgrid (SPM) - automation, control and planning system

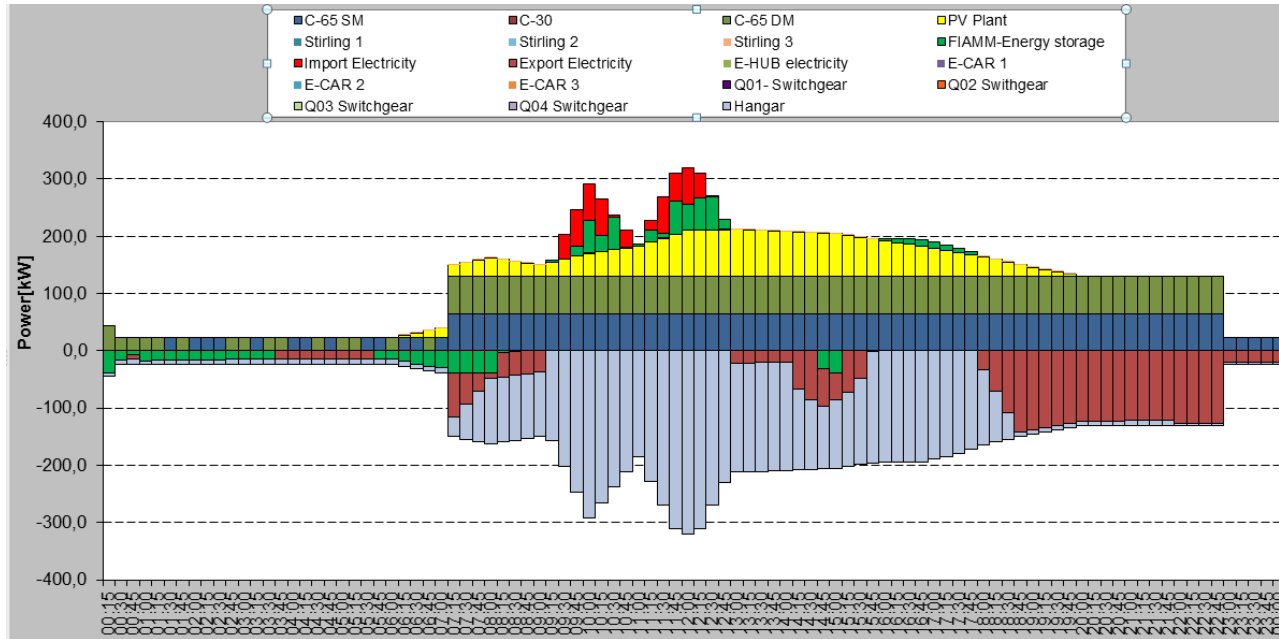


Main screen of the Energy Management System

Energy Management System of the SPM – forecasted data

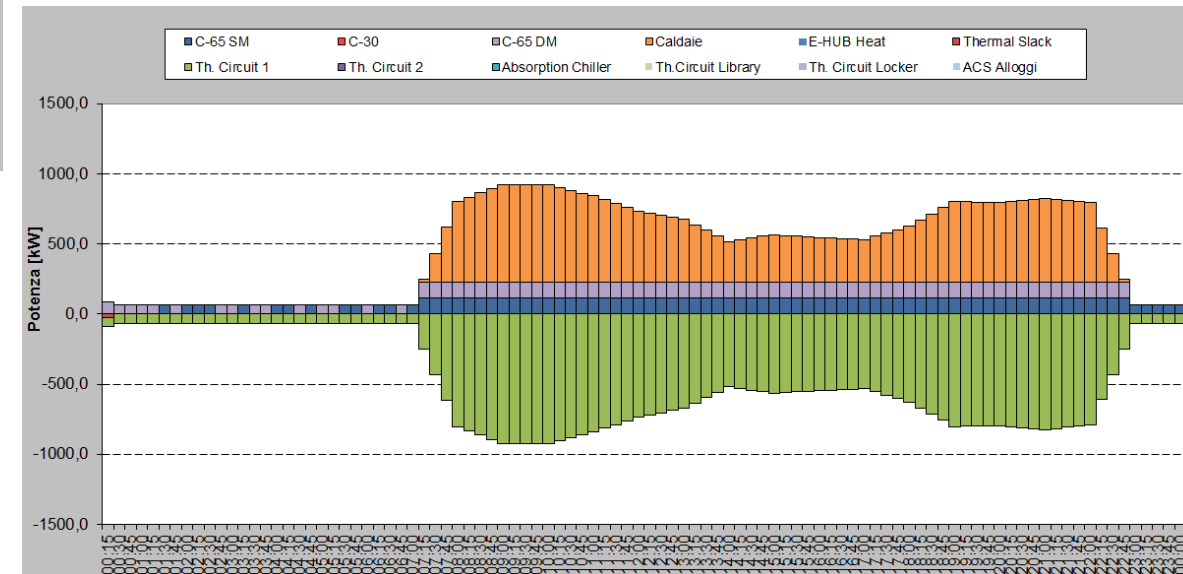


Energy Management System of the SPM – output



Scheduling of distributed energy sources to meet the Campus electricity demand on June 21, 2014

Scheduling of gas microturbines and boilers to meet the Campus thermal demand on February 1, 2014



THANK YOU FOR THE ATTENTION!

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