UNIVERSITÀ DEGLI STUDI
DI GENOVA

Savona Campus

Living Lab

Savona Campus at a glance

Savona Campus is a Research and Teaching facility of the University of Genoa

Courses:

- B.Sc. Industrial and Management Engineering
- B.Sc. Sport Science and Health
- B.Sc. Nursing
- B.Sc. Communication Sciences
- M.Sc. Energy Engineering
- M.Sc. Management Engineering
- M.Sc. Digital Humanities – Communication and New Media
- M.Sc. Engineering for Natural Risk Management
- Master on Rehabilitation of Musculoskeletal Disorders

More than 100 Professors & Researchers

2021 students

60.000 sqm

1 library

1 Canteen

2 student accomodation buildings

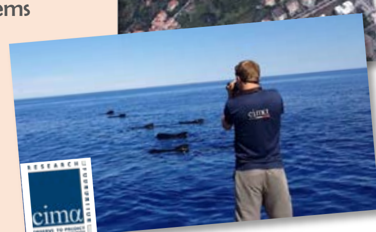
Sport Facilities

1 Cafè

Research:

- Research & Innovation Cluster on Sustainable Energy (www.es.sv.it):
  - Power systems engineering & control
  - Renewables & storage systems
  - Planning, design and management of smart energy systems
  - Distributed Generation modelling and simulation
- International Environmental Research Centre (www.cimafoundation.org):
  - National Centre for Civil Protection
  - Disaster Risk Reduction
  - Biodiversity

15 SMEs



Savona Campus: growth to Sustainability

- **1930 - 1990**: The area hosted a **military compound** of the Italian Army
- **1992**: Urban regeneration process to host **University of Genoa** facilities

- **2007**: **CIMA Research Foundation**
- **2011**: UNIGE project **Energia 2020**
- **2011**: Italian Research & Innovation Cluster on **Sustainable Energy**
- **2014**: Unveiling **Smart Polygeneration Microgrid**

- **2016**: Entry into **ISCN**
- **2017**: Entry into **UI Greenmetric**
- **2017**: Beginning of **Living Lab Microgrid** UNIGE- Enel
- **2017**: Project **Energy Efficiency Measures**

- **2017**: Unveiling **Smart Energy Building**

- **2018**: Outdoor **Fitness Trail**

Energia 2020 Project

ENERGIA 2020

"Energia 2020" is an innovative project started in 2011 concerning with the Smart City & Sustainable Energy topics. It has been conceived, designed and developed by the University of Genoa with the final goal to make Savona Campus a Living Lab of the City of the Future

Energia 2020 is based on 4 main actions:

Total Value: 10.7 M€

- ✓ **Smart Polygeneration Microgrid (SPM)** — "Intelligent" & Sustainable Microgrid feeding the electrical and the thermal loads of the Campus
- ✓ **Smart Energy Building (SEB)** — "Intelligent" & Active ZEB interacting in real-time with the SPM Energy Management System
- ✓ **Energy Efficiency Measures (EEM)** — Reduction of the Campus consumptions and the energy dispersions at the building level
- TO BE DONE **Smart City Demo Campus (SCDC)** — The Campus as a "test-bed" of state-of-the-art technologies for the City of the Future (the Campus as an independent "Energy Island" with high confort level for its population)

Smart Polygeneration Microgrid

- Funded by: Italian Ministry of Education, University and Research
- Value of the project: 2,4 M€
- Status: in operation since February 2014

- EEGI Label on March 2015 (www.gridplus.eu/node/172)
- Italian award on environmental innovation on April 2015 (www.premioinnovazione.legambiente.org)

EEGI
EUROPEAN ELECTRICITY GRID INITIATIVE
- SUPPORT -

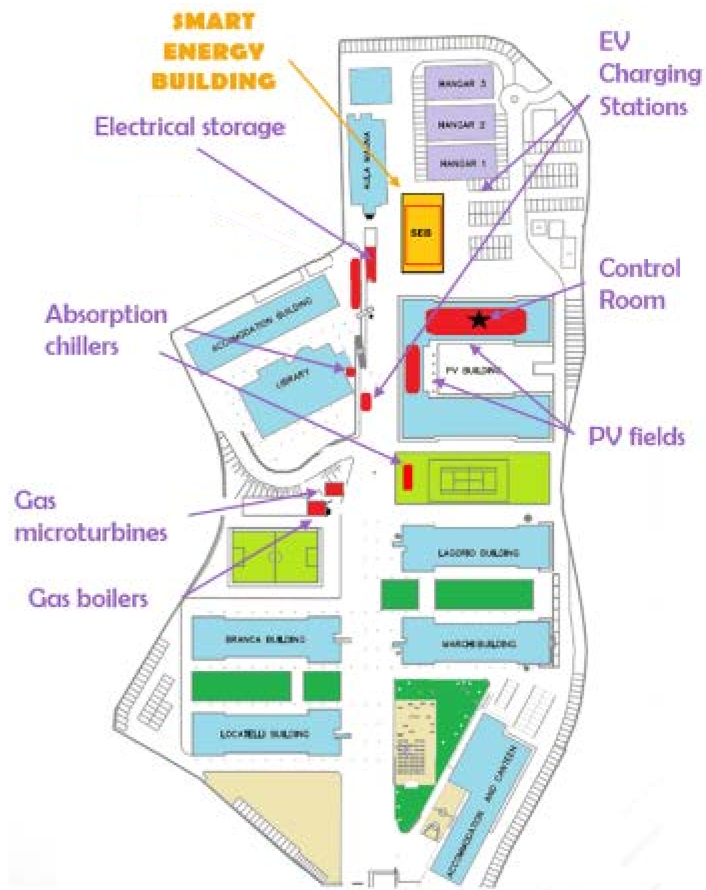
INNOVAZIONE AMICA DELL'AMBIENTE
LEGAMBIENTE

SPM components

3-phase low voltage (400 V line-to-line) “intelligent” distribution system coupled with a thermal network, composed by:

- 2 micro-cogeneration gas turbine (µGT) fed by natural gas (130 kW_{el} and 240 kW_{th});
- 2 photovoltaic fields (PV) (95 kW_p) ;
- 2 absorption chillers (AC) (200 kW) employed to refrigerate two buildings during the summer;
- 1 electrical storage systems (ES) ($Na\text{-}NiCl_2$, 140 kWh).
- 2 standard electrical vehicle (EV) charging stations;
- 2 V2G charging stations;
- 2 gas boilers (B) (450 kW_{th} each);

SPM layout


SMART ENERGY BUILDING
Electrical storage
EV Charging Stations
Control Room
Absorption chillers
PV fields
Gas microturbines
Gas boilers
SEB


SEB

SPM 3-level planning & control system

Energy Management System (EMS)

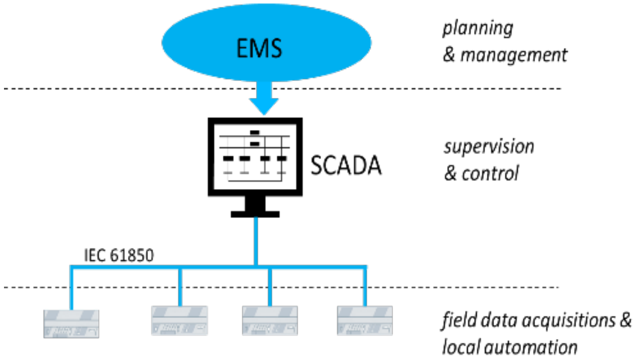
Optimization algorithm (time horizon: 24 hours, time interval: 15 min) – Objectives: reduction of daily operational costs & CO_2 emissions

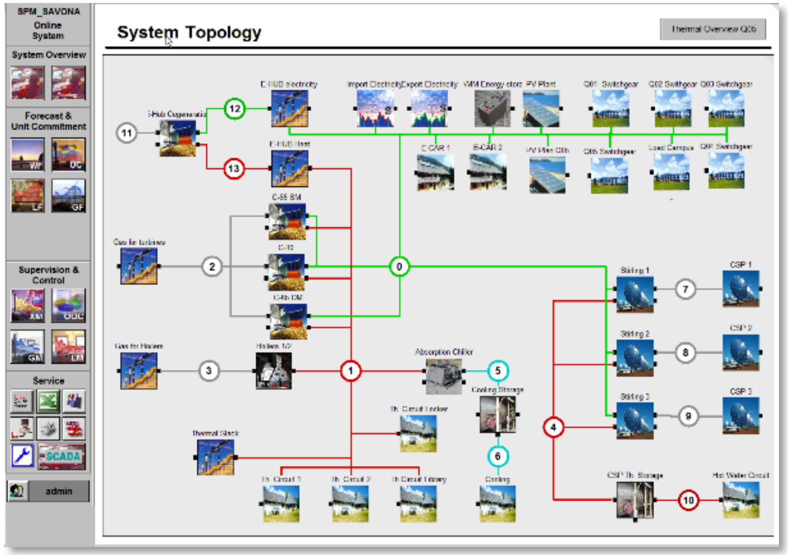
Inputs:

- Cost functions
- Technical and environmental constraints (related to the performance of power plants)
- Savona Campus electrical and thermal load forecast
- Estimation of power production from renewable sources based on weather forecast and historical data

Outputs:

- Optimal scheduling of the production of fossil fuel power plants (microturbines and boilers) and electrical storage systems
- Such scheduling minimizes daily operational costs and emissions





Smart Energy Building

- Funded by: 90% Italian Ministry for the Environment and the Protection of Land and Sea, 10% UNIGE
- Value of the project: 3 M€
- Status: in operation since February 2017
- Main technical peculiarity: Smart Building interacting with a Smart Microgrid as a Prosumer
- Surface: 1000 m^2

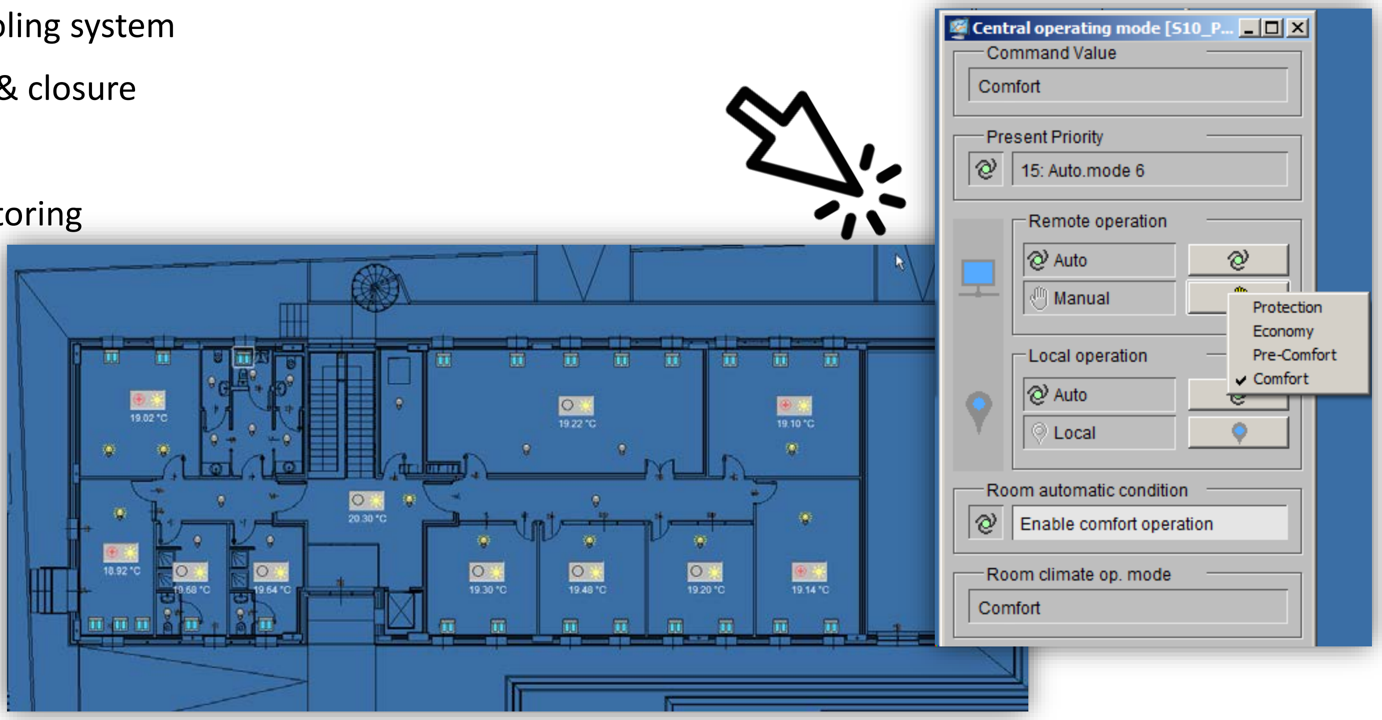
Energy Efficiency Class A4

A complex regulation system controls the air conditioning and lights of SEB

SEB – Buildig Management System

Building Management System (BMS)

- Room automation system & Indoor temperature control (3 different comfort levels: comfort, pre-comfort, economy)
- Real-time monitoring of electrical, thermal and environmental performaces
- Regulation of heating/cooling system
- Windows blinds opening & closure
- Light intensity regulation
- Presence sensing & monitoring



Motivation for SPM and SEB

Motivation for microgrid:

- CO_2 reduction
- Daily operational costs reduction
- Test bed for technologies & Algorithms (to increase probability of success of projects presented for fundraising at EU level)

Key design principles:

- Sustainability
- Technology diversity

Technical Objectives

- use of IEC61850 protocol (standard for substation automation, power networks protection, control and supervision, now proposed for DERs control and supervision also)
- installation of different kinds of sources (PV, CHP, CSP,…) and storage
- “open” system for research purposes (easily interfaced with other software/systems and easy to upgrade/modify – requirement partially met…)

Barriers

At planning level:

- technical: limited historical information about the thermal and electrical demands (e.g.: thermal and electrical consumptions logs, time behavior of consumptions, etc.)
- financial: to match grant financial scheme with the timeline for equipment procurement, tender and construction (the grant was subdivided in 5 yearly contributions, UNIGE anticipated some founds)

At administrative level:

- complex tender and complex project for UNIGE administrative staff
- generation set (different kinds of generators connected to the same PCC) did not fit the "standard" cases considered by the DSO in its regulatory framework; storage devices not normed at the time

During implementation:

- hybrid electrical-thermal system (different type of controllers, different SCADAs, different protocols: IEC61850, Modbus, BACnet, etc.)
- LV equipment not compliant with IEC 61850: RTUs used as Modbus-IEC61850 gateways

Results Costs vs. Revenues

Installation costs:

- total cost of the SPM project: 2.4 M€

Operative costs:

- natural gas: 40k€/year
- CHP maintenance: 5k€/8000h per CHP, about 4000 h of operation per CHP, 2 CHPs → 5k€/y
- chillers maintenance : 2 days/year, 600 € per day, 2 chillers → 2.4 k€/y
- PV maintenance (panel cleaning, twice a year) → 1k€/year
- SCADA maintenance (1 technician, 2 days/year) → 1.2k€/y
- storage maintenance: 1k€/year

TOTAL 50.6 k€/year

“Direct” Revenues:

- net electric energy: between 250 kWh and 300 kWh (of which 100 kWh PV) → 50k€/y avoided costs
- net thermal energy: 500 kWh - → 45k€/y avoided costs

TOTAL 95 k€/year

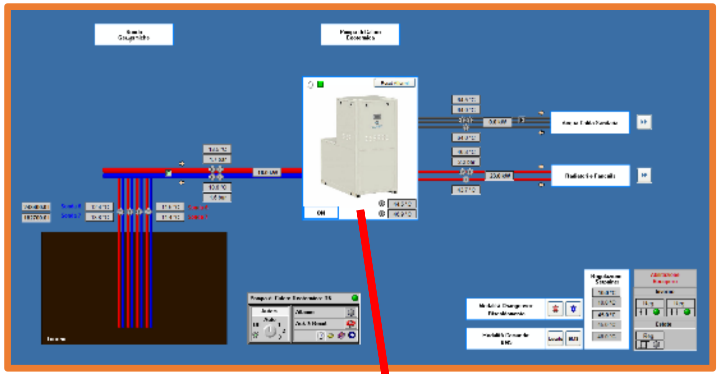
“Indirect” Revenues:

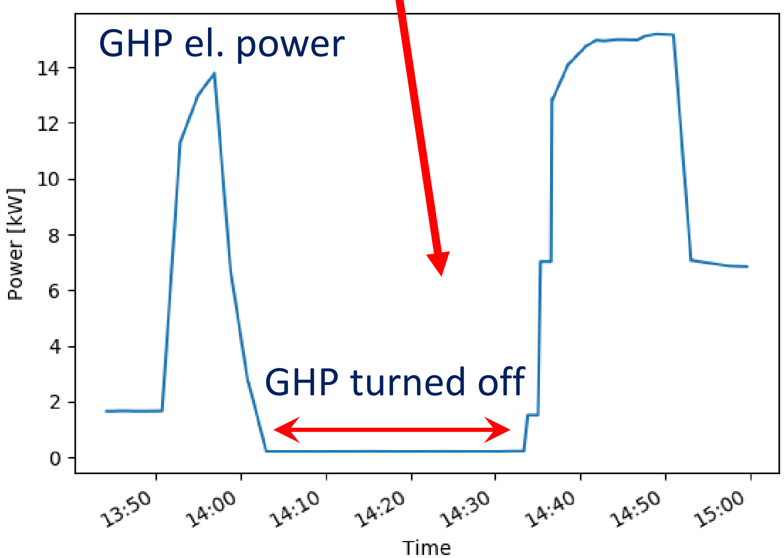
- founding from cooperation with industries, EU and national projects, etc… (Campus as test-bed)

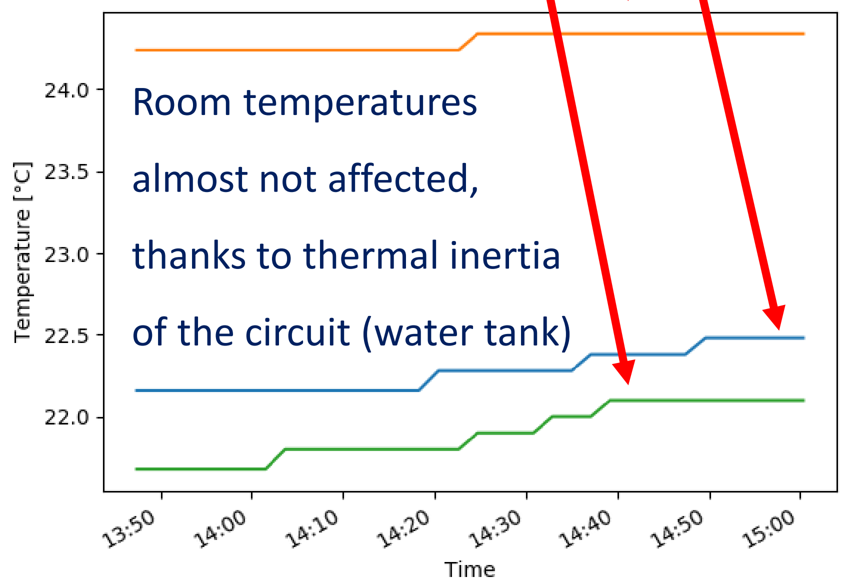
Needs for further development

- monitoring and supervision of all the buildings of the Campus
- increase of the local generation (installation of additional PV fields and CHPs) – goal: to satisfy all the electrical and thermal demans
- capability to work in islanding mode (not just for test purposes – solution for protection coordination needed)

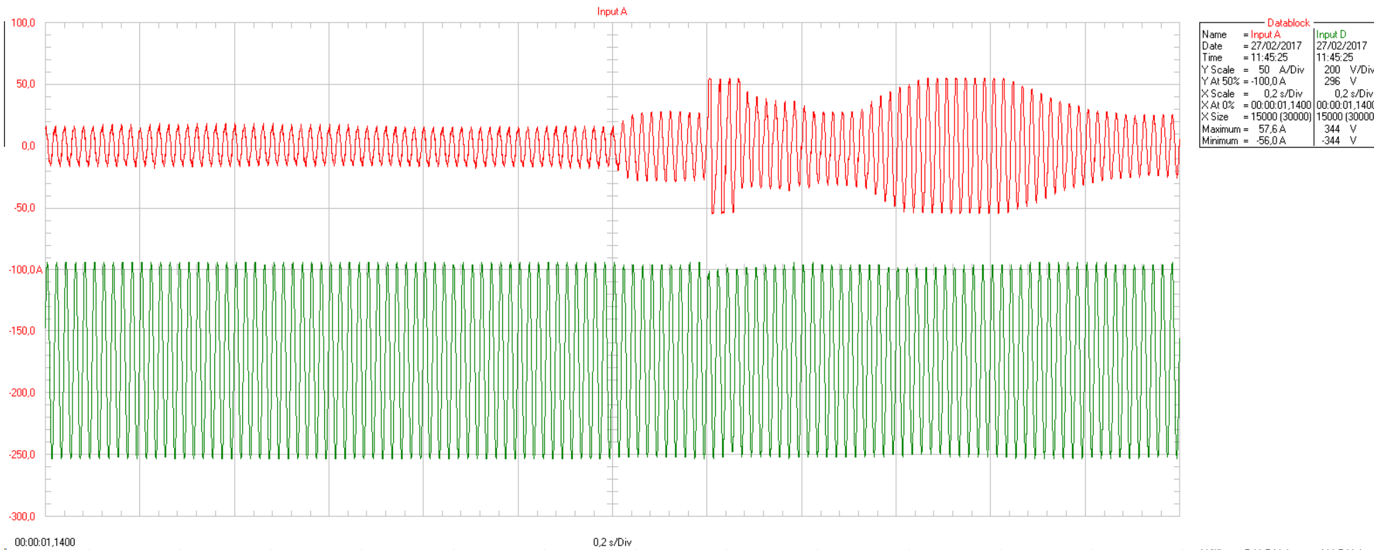
Examples of tests: SEB GHP for Demand Response

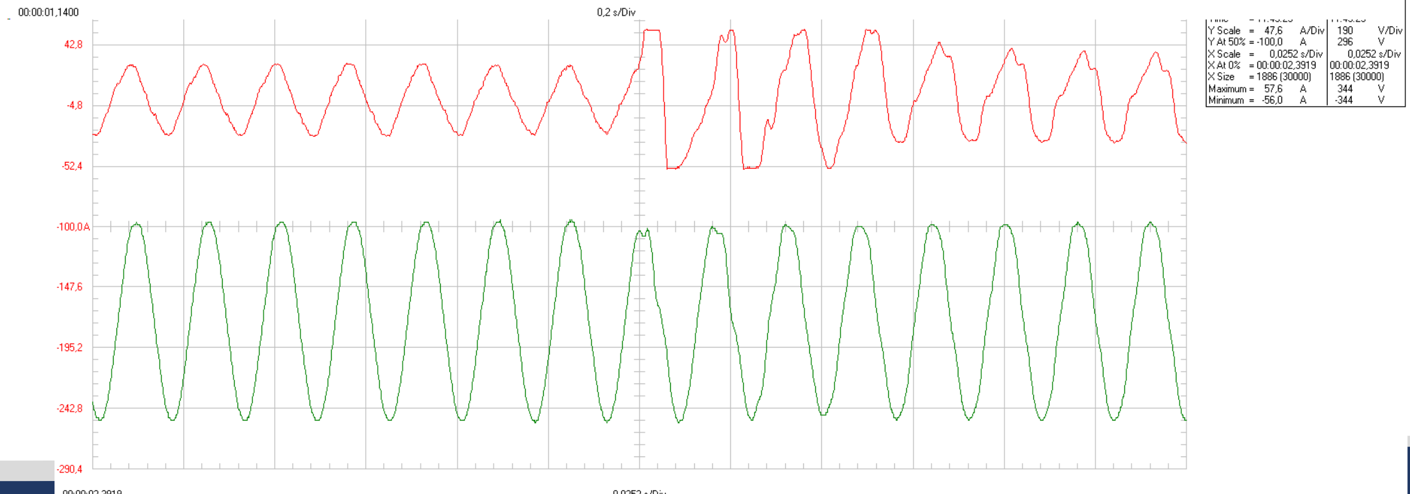






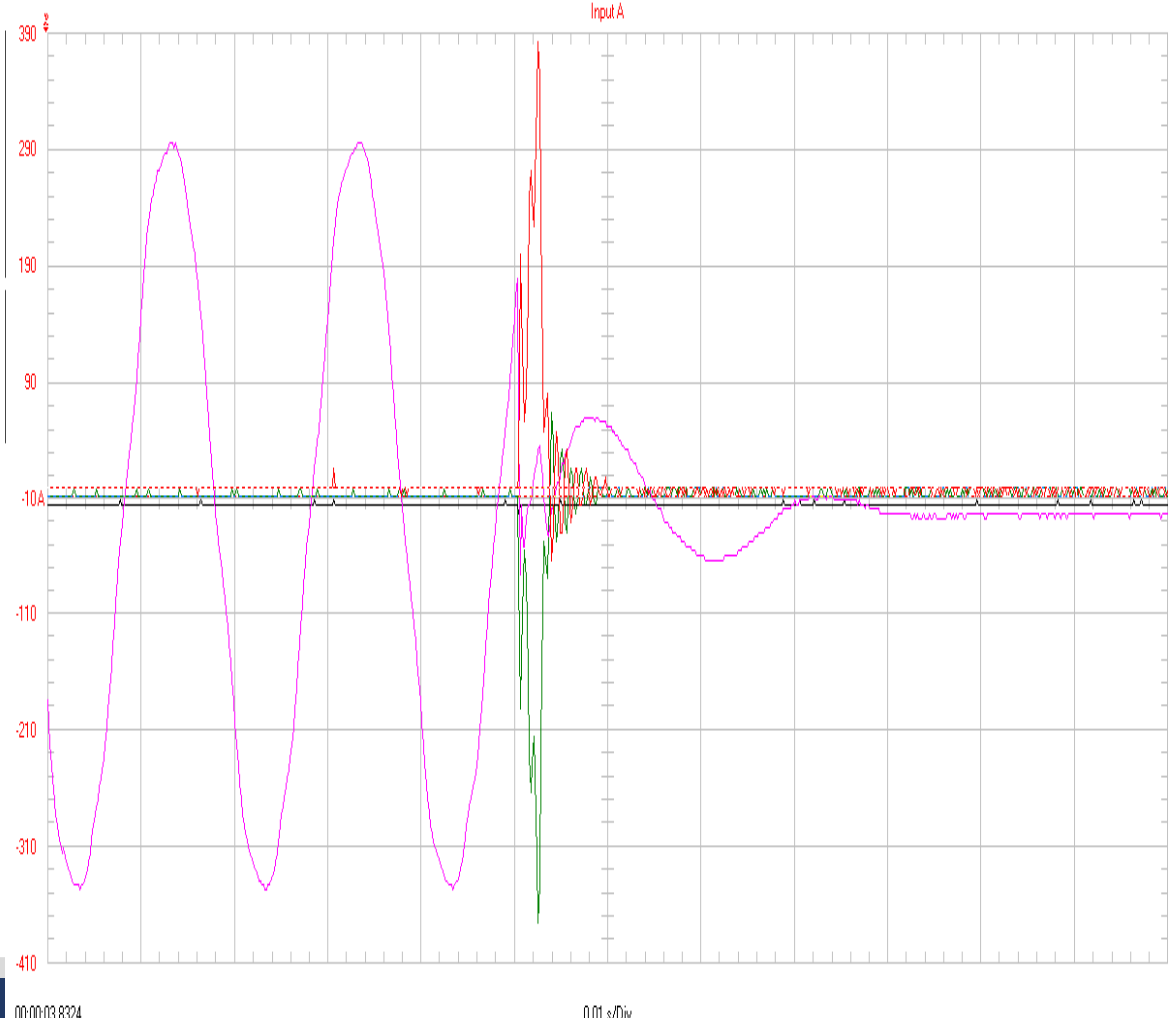
Examples of tests: Storage+PV+load from on grid to off-grid





Current and voltage of one phase of the storage system

Examples of tests: short circuit in islanding mode



Datablock

Name	= Input A	Input B	Input C	Input D
Date	= 31/03/2017	31/03/2017	31/03/2017	31/03/2017
Time	= 09:19:19	09:19:19	09:19:19	09:19:19
Y Scale	= 100 A/Div	100 A/Div	200 A/Div	100 V/Div
Y At 50%	= -10 A	-10 A	4 A	14 V
X Scale	= 0,01 s/Div	0,01 s/Div	0,01 s/Div	0,01 s/Div
X At 0%	= 00:00:03,8324	00:00:03,8324	00:00:03,8324	00:00:03,8324
X Size	= 750 (30000)	750 (30000)	750 (30000)	750 (30000)
Maximum	= 416 A	184 A	144 A	328 V
Minimum	= -344 A	-408 A	-192 A	-332 V

Cursor Values

X1: 00:00:00,0120 (09:19:19,0120)
X2: 00:00:00,0360 (09:19:19,0360)
dX: 00:00:00,0240
Y1: 0 A
Y2: -8 A
dY: -8 A

One phase voltage and three currents at fault location

Book "Microgrid Design and Operation: Toward Smart Energy in Cities"

Editor: Artech House
ISBN: 9781630811501
Authors: Federico Delfino, Renato Procopio, Mansueto Rossi, Massimo Brignone, Michela Robba, Stefano Bracco

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- Islanded Microgrids
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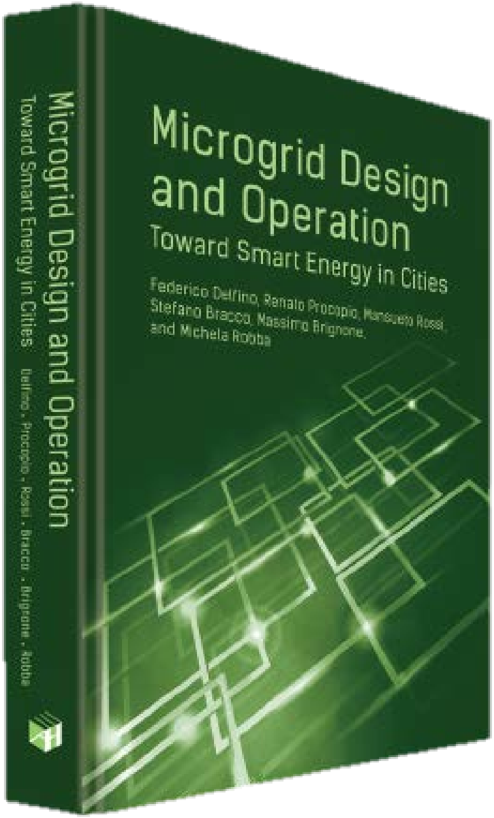
- From Microgrids to Smart Cities



Thanks for your attention

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