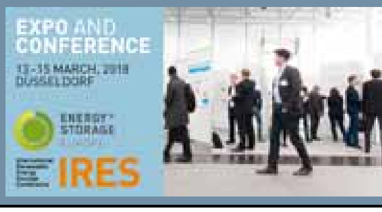
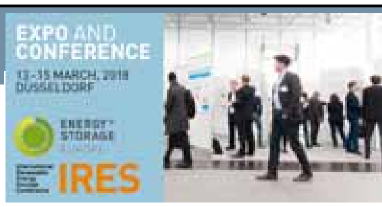
San Severino Marche Smart Grid Pilot within H2020 InteGRIDy project

D. Falabretti, M. Moncecchi, F. Bovera, M. Mirbagheri, M. Delfanti, M. Fiori, **M. Merlo**
Energy Department
Electric Power Systems research group
Politecnico di Milano
marco.merlo@polimi.it



Agenda



- inTEGRIDy project overview
- ASSEM Pilot overview
- Smart Functionalities
- Pilot’s figure
- Conclusion


inteGRIDy project overview
DR
Demand Response (DR) including energy efficiency, demand shifting and shaving. Energy Management with valuable active end-user engagement.
SG
Smartening the distribution Grid. RES and Distributed Energy Resources (DERs) integration within VPP aggregators.
ES
Energy storage. Direct electricity storage in batteries or conversion to other forms of energy (chemical, hydrogen, etc.)
EV
EV integration. Smart, bidirectional EV energy exchange, smart charging and fleet management.
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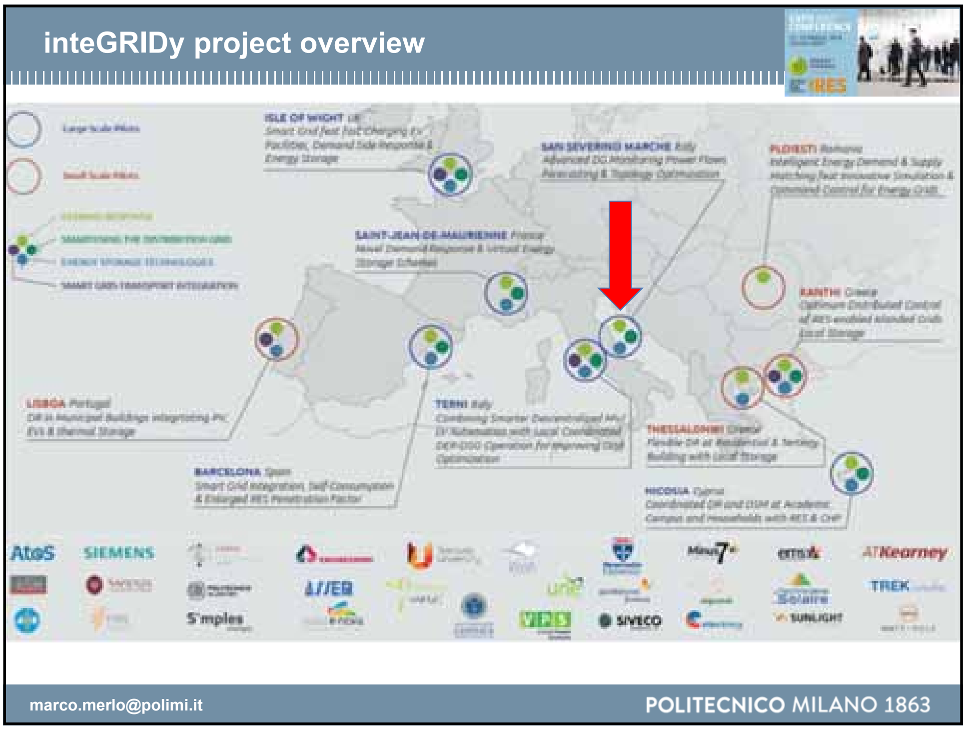
inteGRIDy project overview
ISLE OF WIGHT
SAN SEVERINO MARCHE
PLOIESTI
SAINT-JEAN-DE-MAURIENNE
XANTHI
LISBOA
TERNI
THESSALONIKI
BARCELONA
NICOSIA
AtoS
SIEMENS
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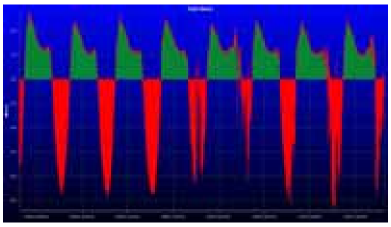
ASSEM Pilot overview

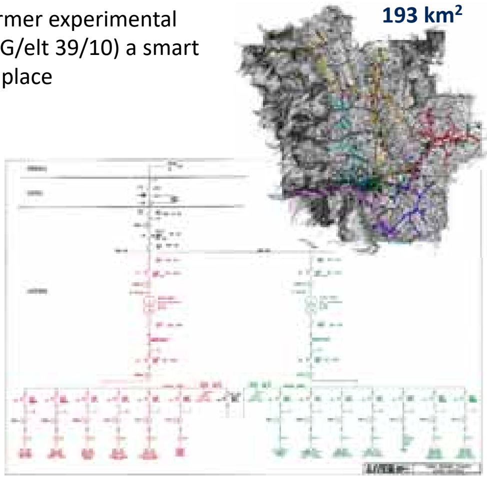
HV/MV substation Colotto: thanks to a former experimental project (founded by the Italian resolution ARG/elt 39/10) a smart grid architecture is already in place

Power exchanges measured at the HV/MV interface



green = standard (passive) operation
red = Reverse Power Flow condition

PV generation: 25.5 MW
Hydro generation: 1.7 MW

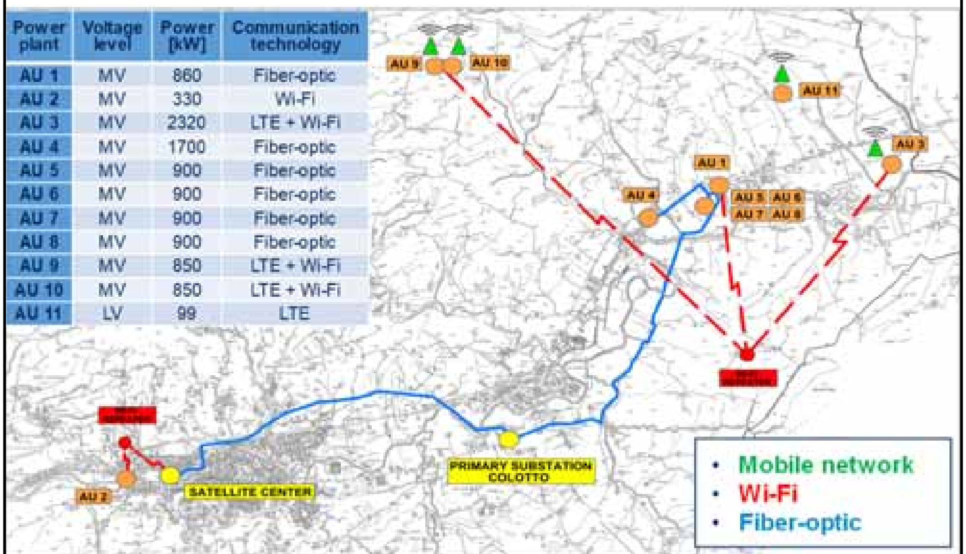


MV lines length
Red busbar :104 km
Green busbar: 76 km

ASSEM Pilot overview

The area is provided with several TLC links

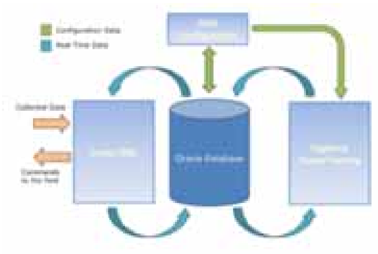
Power plant	Voltage level	Power [kW]	Communication technology
AU 1	MV	860	Fiber-optic
AU 2	MV	330	Wi-Fi
AU 3	MV	2320	LTE + Wi-Fi
AU 4	MV	1700	Fiber-optic
AU 5	MV	900	Fiber-optic
AU 6	MV	900	Fiber-optic
AU 7	MV	900	Fiber-optic
AU 8	MV	900	Fiber-optic
AU 9	MV	850	LTE + Wi-Fi
AU 10	MV	850	LTE + Wi-Fi
AU 11	LV	99	LTE



Smart Functionalities

Smart Grid functionalities already in place:

- Measurements are collected on the grid and on Active Users PCC by a distributed monitoring system, communicating in real-time with the SCADA/DMS in the ASSEM control center.
- All data is saved in an Oracle database with a time resolution of 1 minute.
- Power flow calculations are performed to evaluate the behavior of the distribution network in a given instant and to identify suitable control actions (DG active/reactive injections; OLTC position) in order to improve the grid's operation.



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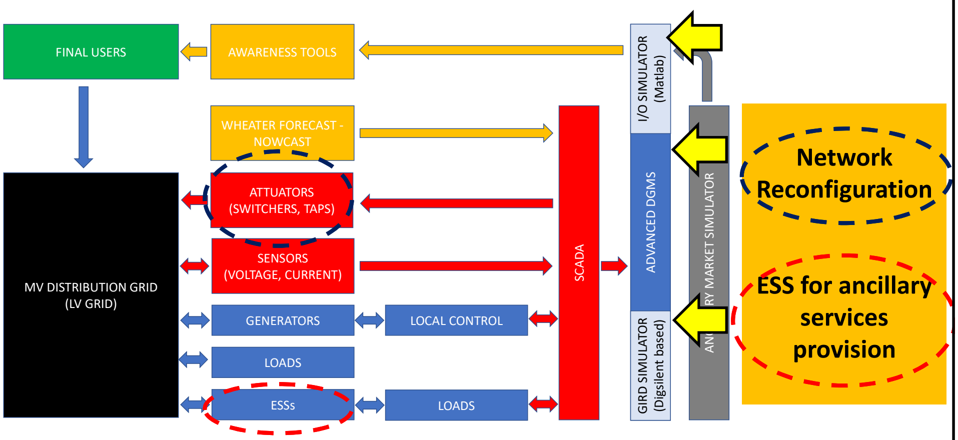
Smart Functionalities

NEW Smart Grid functionalities investigated



The Distribution Grid Management System is in charge to elaborate all the measures coming from the grid, to perform the state estimation, to solve the MV grid optimization problem, etc.

The Grid Simulator is in charge to manage an electrical model of the distribution grid, to solve the Power Flow problem and to validate solutions calculated by the DGMS.

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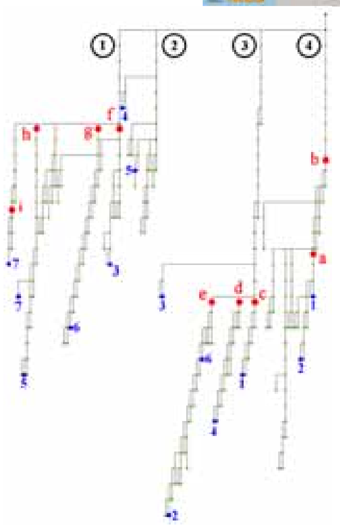
New Smart Functionalities: Network Reconfiguration

EXHAUSTIVE RESEARCH

- ER has been adopted as a benchmark, both for the optimization process and for the computational effort evaluation
- The grid under analysis depicts 16 reconfiguration point over 287 buses
- A preliminary analysis is performed in order to identify the subset of «feasible» configuration
  - all the busses have to be feeded
  - no mesh allowed
- A whole year is simulated adopting hourly samples
- The grid topology is optimized once a week



Sectionalizing switches → red dots
tie-switches → blue

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New Smart Functionalities: Network Reconfiguration

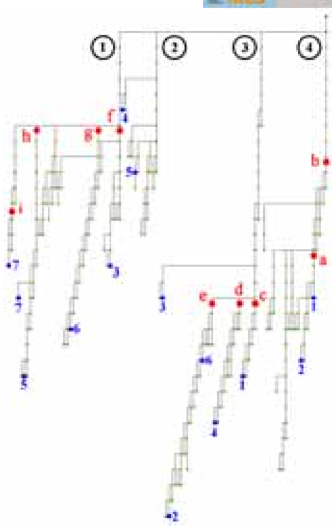
GENETIC ALGORITHM

- The goal of the procedure is the minimization of the energy losses on the feeders

$$Min\ f_h = \sum_{i=h+1}^{i=h+T} E_{loss}(X,i)$$

$\boldsymbol{h}$ is the hour of the year for which the optimization tool is run;
$\boldsymbol{E_{loss}(X,i)}$ is the total amount of energy losses, evaluated through power flow computations, function of the configuration *X* and hour of the year *i* considered;
$\boldsymbol{T}$ is the time horizon (in hours) on which the losses forecasting and network optimization is performed (e.g. for a weekly optimization, *T = 168*).

Population Size = 350 // Max Generations = 5 // Max Stall Generations = 3 // Crossover Fraction = 0.5 //Elite Count = 2



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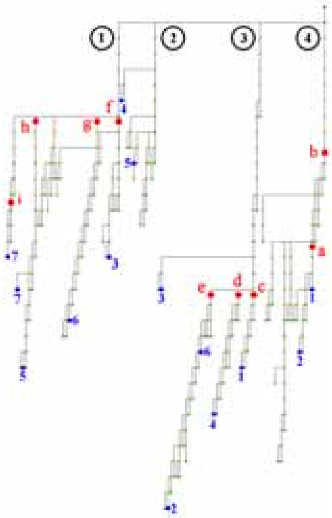
New Smart Functionalities: Network Reconfiguration

MONTE CARLO ALGORITHM

- Every feasible configuration (no loops or electric islands) the number of maneuvers required for the grid rearrangement is determined
- for the i-th configuration, the corresponding weight is computed as:

$$w_i = \frac{SW_{max}}{SW_{ib}}$$

SWib is the number of switching maneuvers to move from the base case configuration to the *i-th* one;
SWmax is the maximum number of switching maneuvers required to move from the base case to all other possible configurations.



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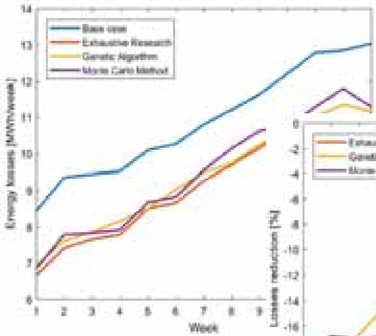
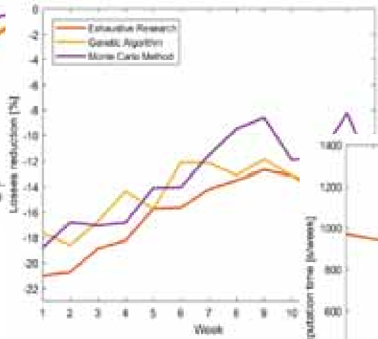
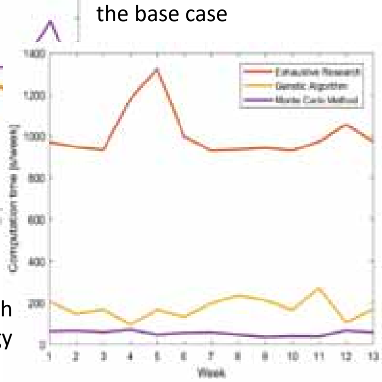
Pilot's Figure



Weekly energy losses estimated on the MV network



Reduction of weekly energy losses with the optimization strategies developed w.r.t. the base case



Computation time required to run weekly each optimization strategy

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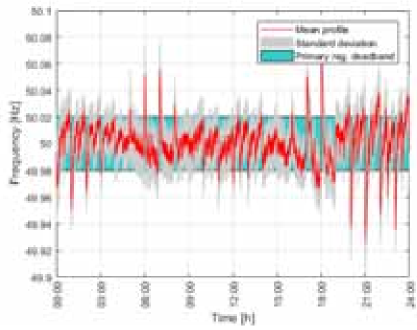
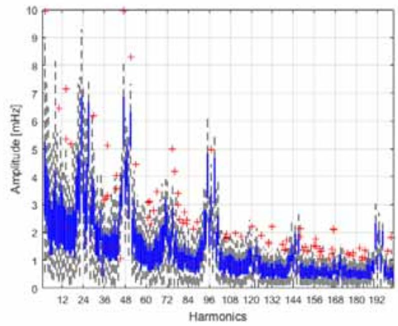
New Smart Functionalities: ESS 4 ancillary services

Preliminary tests performed in the IoT (Internet of Things) lab of POLIMI

- Samples of the electric frequency
- FFT of the electric frequency

→ Identification of a «sound» frequency profile





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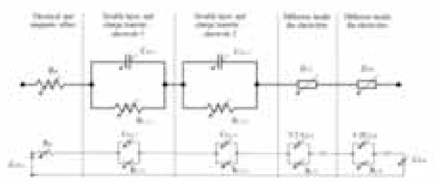
New Smart Functionalities: ESS 4 ancillary services

Preliminary tests performed in the POLIMI's lab

- ESS modelling



→ measurements carried out within the framework of the collaboration between Politecnico di Milano (DoE) and CSEM-PV Center (Swiss Center for Electronics and Microtechnology).
The experimental tests refer to LNCO cell (Li-ion) of Boston Power (model SWING5300)

ESS simulations detailed w.r.t. different control logics

- Behind the meter services: self-consumption (users coupled with PV generators)
- Front of the meter services: two ancillary services have been considered together: Frequency Containment Reserve (FCR, also known as Primary Reserve) and Frequency Restoration Reserve (FRR, also known as Secondary Reserve)

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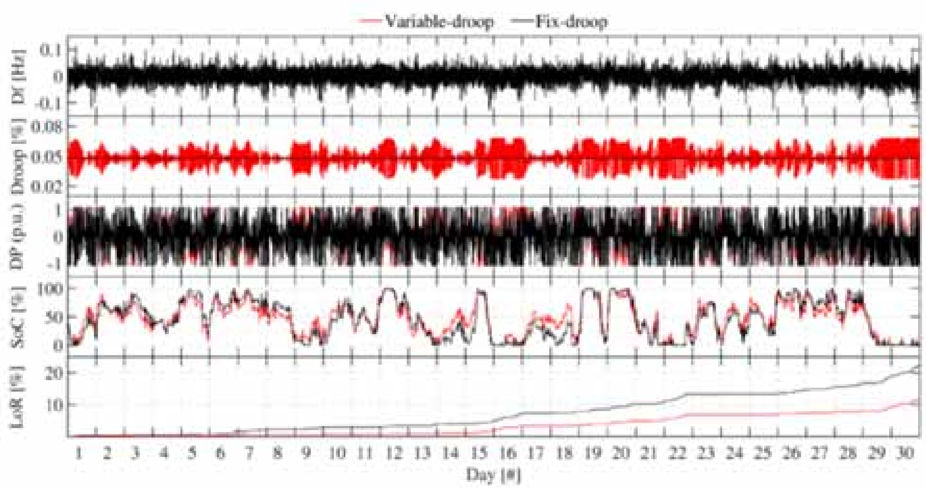
New Smart Functionalities: ESS 4 ancillary services

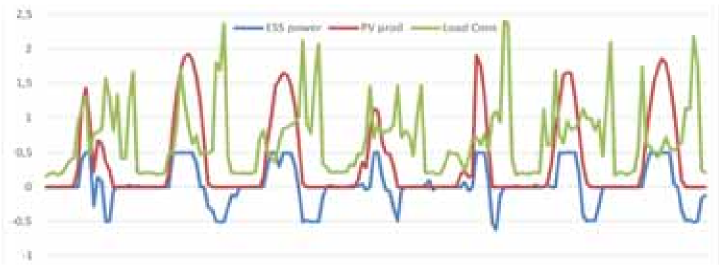
BESS for FCR provision:



New Smart Functionalities: ESS 4 ancillary services

Simulated power flows [kW] at the ESS PCC

ESS coupled with a PV power plant over a 7 days time window (self-consumption logic)



ESS coupled with a PV power plant over a 7 days time window (multi service logic)

New Smart Functionalities: ESS 4 ancillary services

Tests refer to a “standard” house sited north of Italy.

Energy tariff has been assumed equal to 0.18 €/kWh while injected energy is remunerated at 0.06 €/kWh.

Coupling the load with a 3 kW PV generator, 61% of the energy results self-consumed, with a saving of 285 €/year.

Deploying a 1kW–3 kWh BESS self consumption grow up to 86% (402 €/year savings)

Then a ESS multi-service regulation has been simulated (10% of the nominal power has been dedicated to FCR and 40% to FRR).

Self-consumption results marginally affected: it decreased to 83%, i.e. savings for 388 €/year (i.e. loss induced by multiservice regulation are limited to 14 €).

FCR and FRR regulation drive revenues stream equal to:

15 €/year for capacity premium payment + 13 €/year for energy remuneration

→ multiservice regulation could be economically viable

marco.merlo@polimi.it

Conclusions

Network Reconfiguration:

- Several optimization techniques have been coded and compared: Exhaustive Research, Genetic Algorithm and Monte Carlo algorithm.
- Numerical results pointed out good performances improvement achievable thanks to the procedure developed (losses minimization results solid, up to 20% with respect to the base case scenario).
- GA and Monte Carlo techniques proved to be effective in managing the optimization problem limiting its computational effort.

ESS for ancillary services provision:

- ESSs have been designed in order to maximize the users’ self-consumption and, in an experimental perspective, to provide ancillary services to the main grid.
- Users’ self-consumption, primary frequency regulation and secondary frequency regulation have been simulated as joint services.
- ESSs multi-service regulation could be economically viable

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