SmartNet

Smart TSO-DSO interaction schemes, market architectures and ICT Solutions for the integration of ancillary services from demand side management and distributed generation

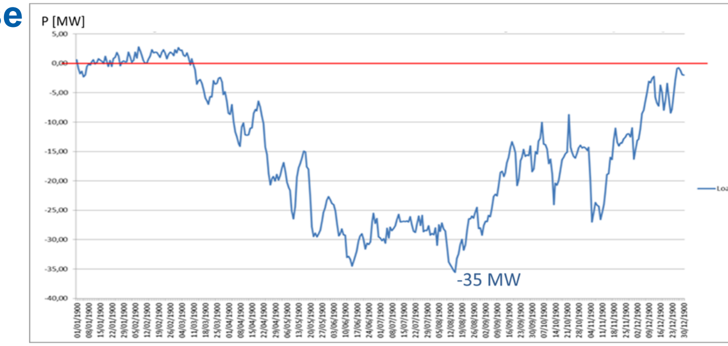
External Workshop | October 24th-26th , 2018
Florence School of Regulation

WP5 – Italian pilot project

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 691405

Italian Pilot Project - Implementation in field

Experimentation in an area characterized by frequent **reverse flow** and **renewable** generating modules of **different sizes** connected to **all voltage levels**:

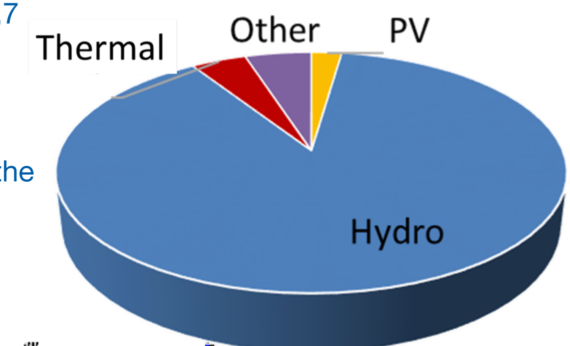


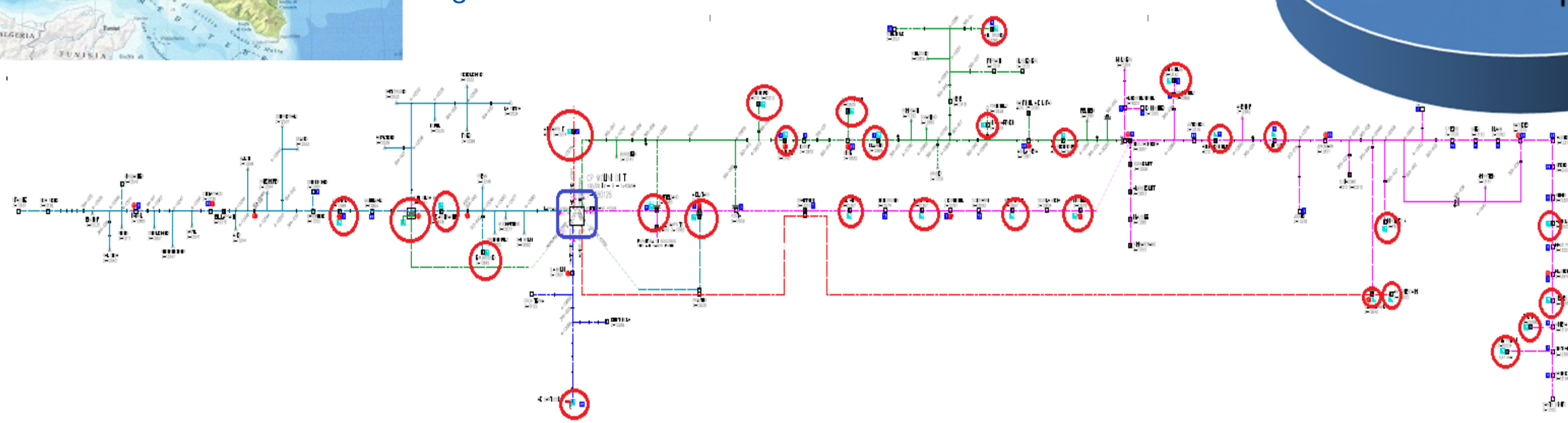
Primary Substation of Molini di Tures: 2 HV hydraulic generators (20MW)

MT Generation: 33 generators with 43,5 MW of power (41,7 MW hydro, 1,5 MW thermal, 0,2 MW PV).

Others 0,85 MW of generation in LV (0,73 MW PV).

Also there are 9,6 MW of generation waiting to connect to the grid.





Goals of Italian Pilot A

The Italian pilot project aims to implement new features for an innovative experimentation in field

Power-frequency regulation (aFRR)
development of an architecture and implementation in field of a system for the power-frequency regulation by generators connected to MV grid

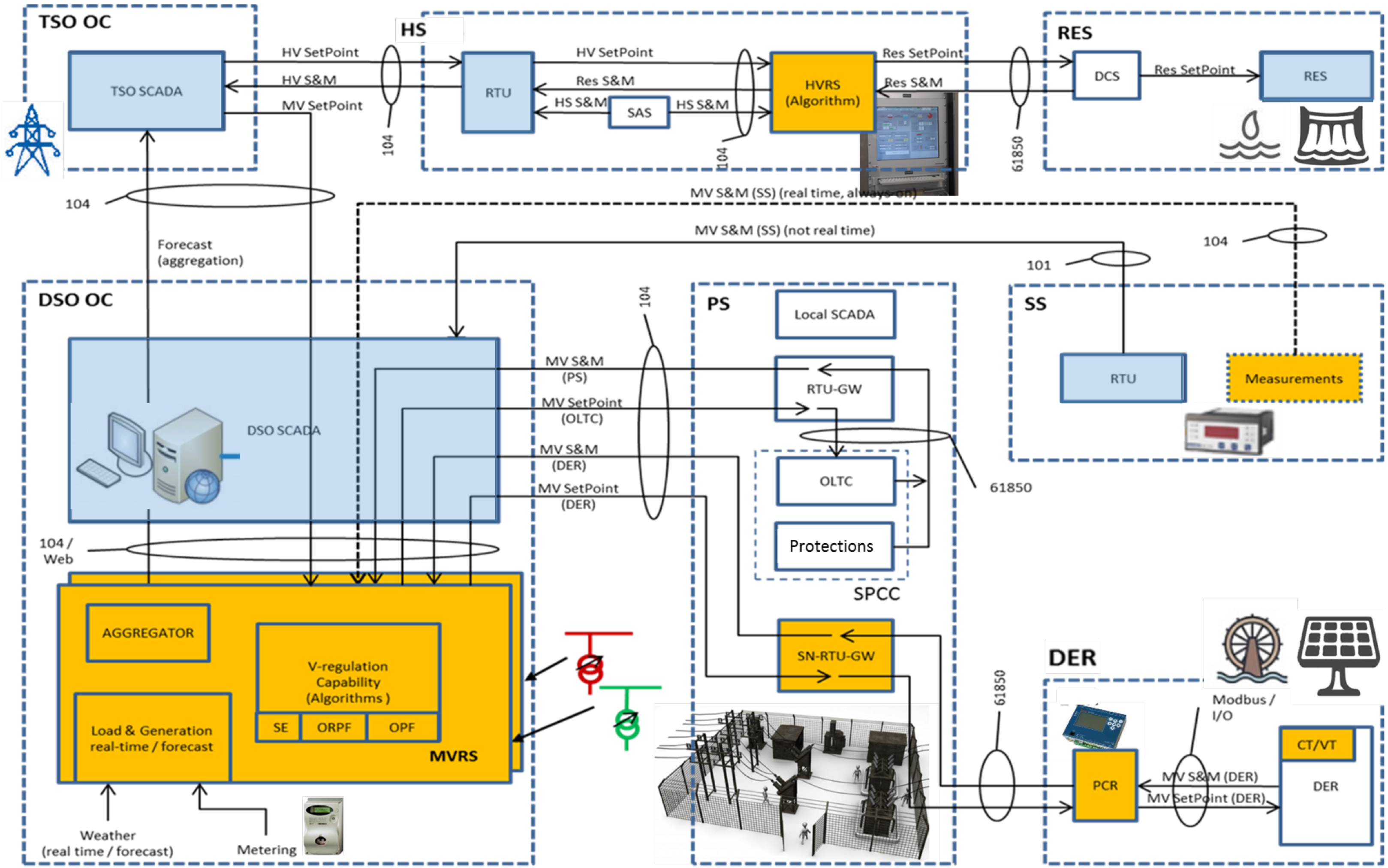
Voltage regulation
development of an architecture and implementation in field of a system for the hierarchical voltage regulation by generators connected to subtransmission HV grid and small plants at MV levels

Aggregation of information
in real time at the interconnection point between TSO-DSO (HV/MV transformer).

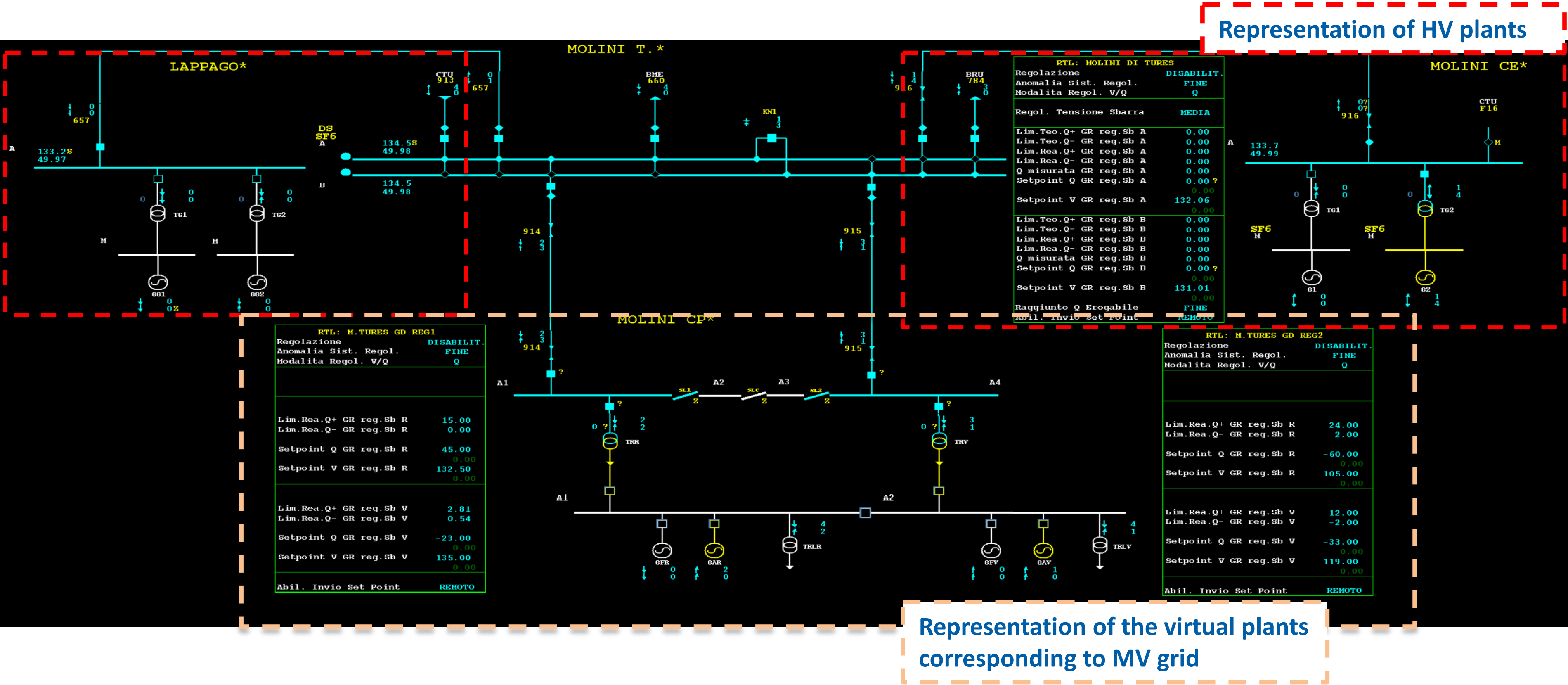
The functionalities described above are implemented in two systems:

- HVRS (High Voltage Regulation System) in Terna's substation
- MVRS (Medium Voltage Regulation System) in Edyna's Control Center

System architecture



Interface of TSO Control System



PCR (Plant Central Regulator)

Devices installed in field in order to:

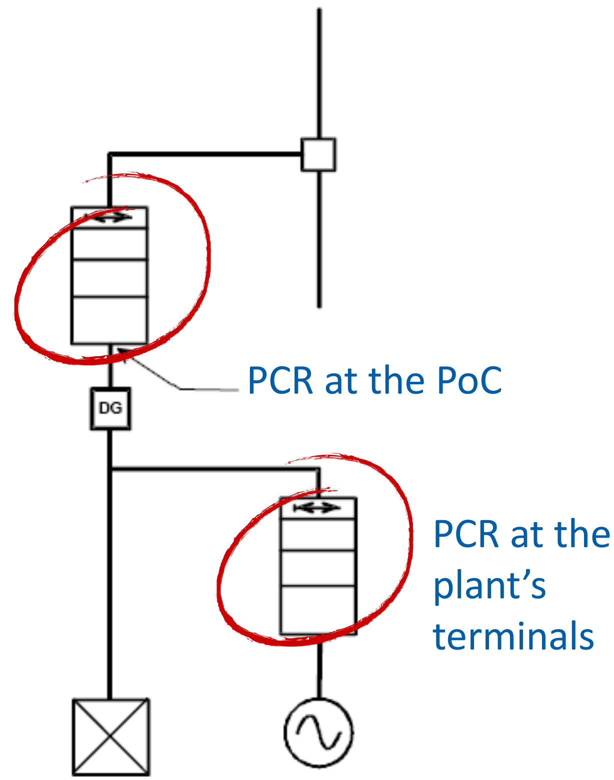
- Monitor interconnection points
- Monitor and control plants involved in the voltage regulation and in the frequency/power regulation

16 monitored plants (7,5MW)

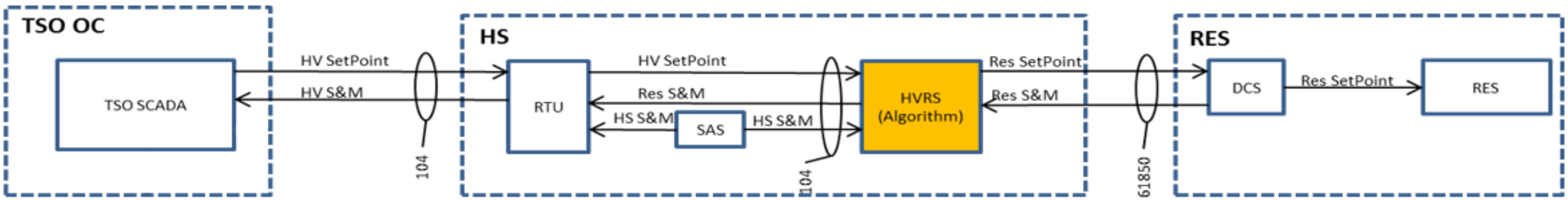
5 subtended DSO monitored (16,7MW)

7 monitored and controllable plants (21,7MW)

28 PCR



HVRS - Voltage Regulation process



TSO send to HVRS at Primary Substation

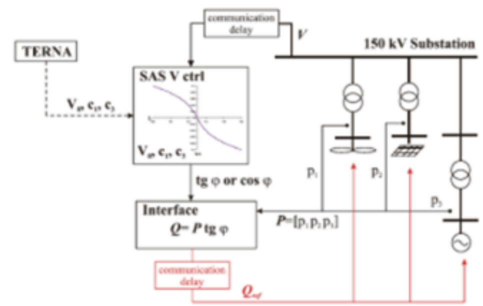
Q → Q setpoint

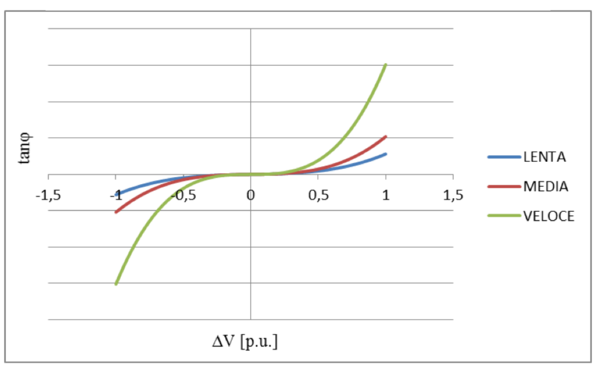
or

V → V setpoint → HVRS converts the V setpoint in Q setpoint

HVRS splits the Q requirement among the groups

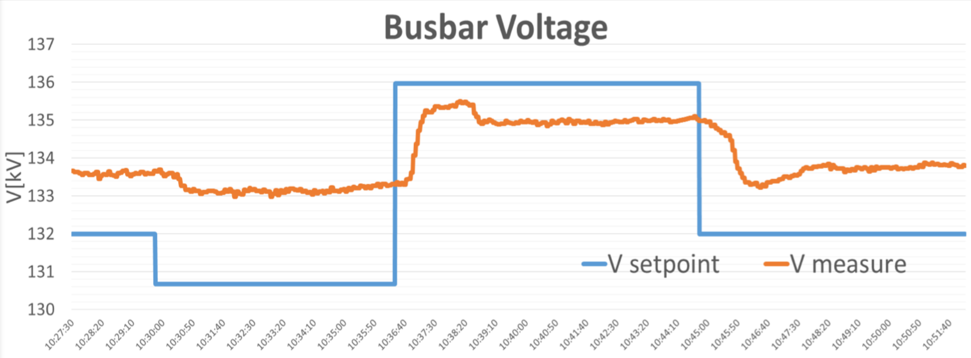
Q command to group DCS

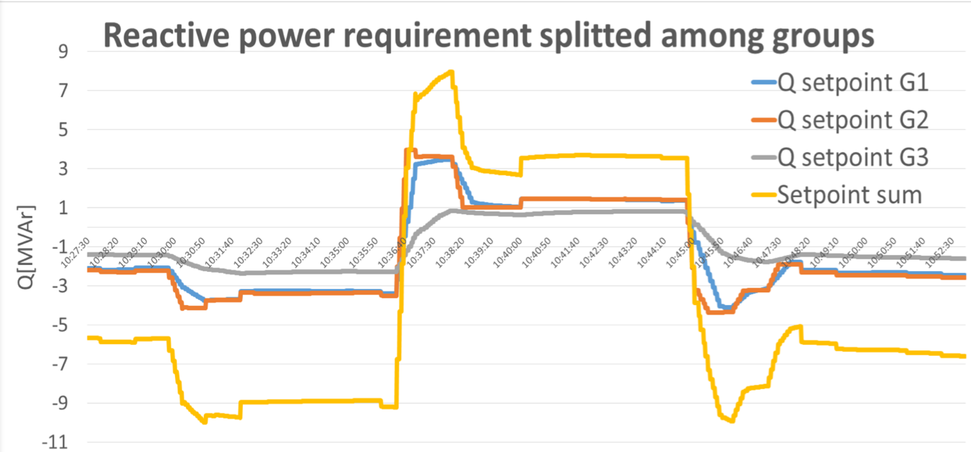




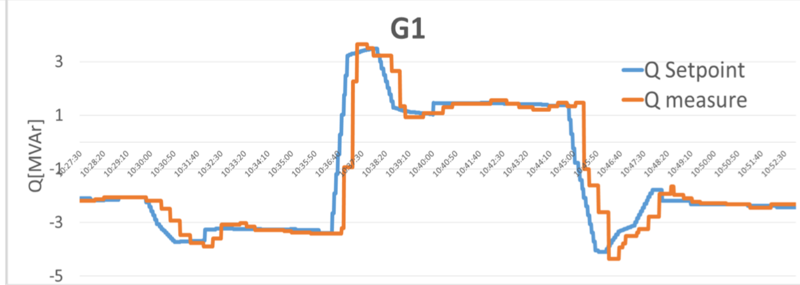
HVRS - Voltage Regulation tests

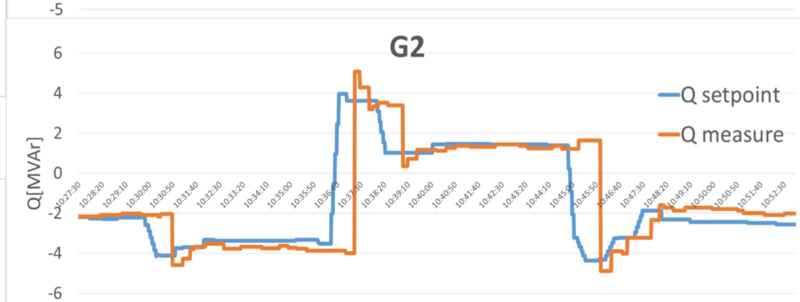
HV Busbar setpoint and measures

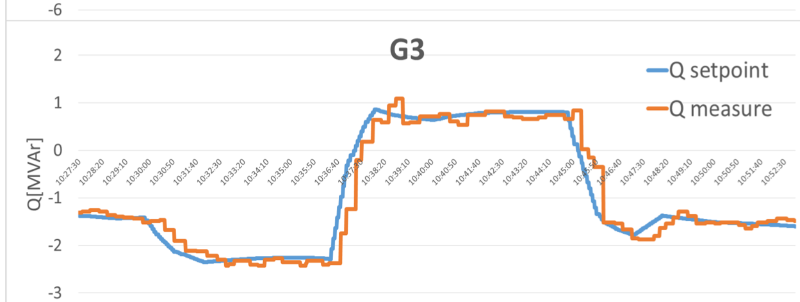




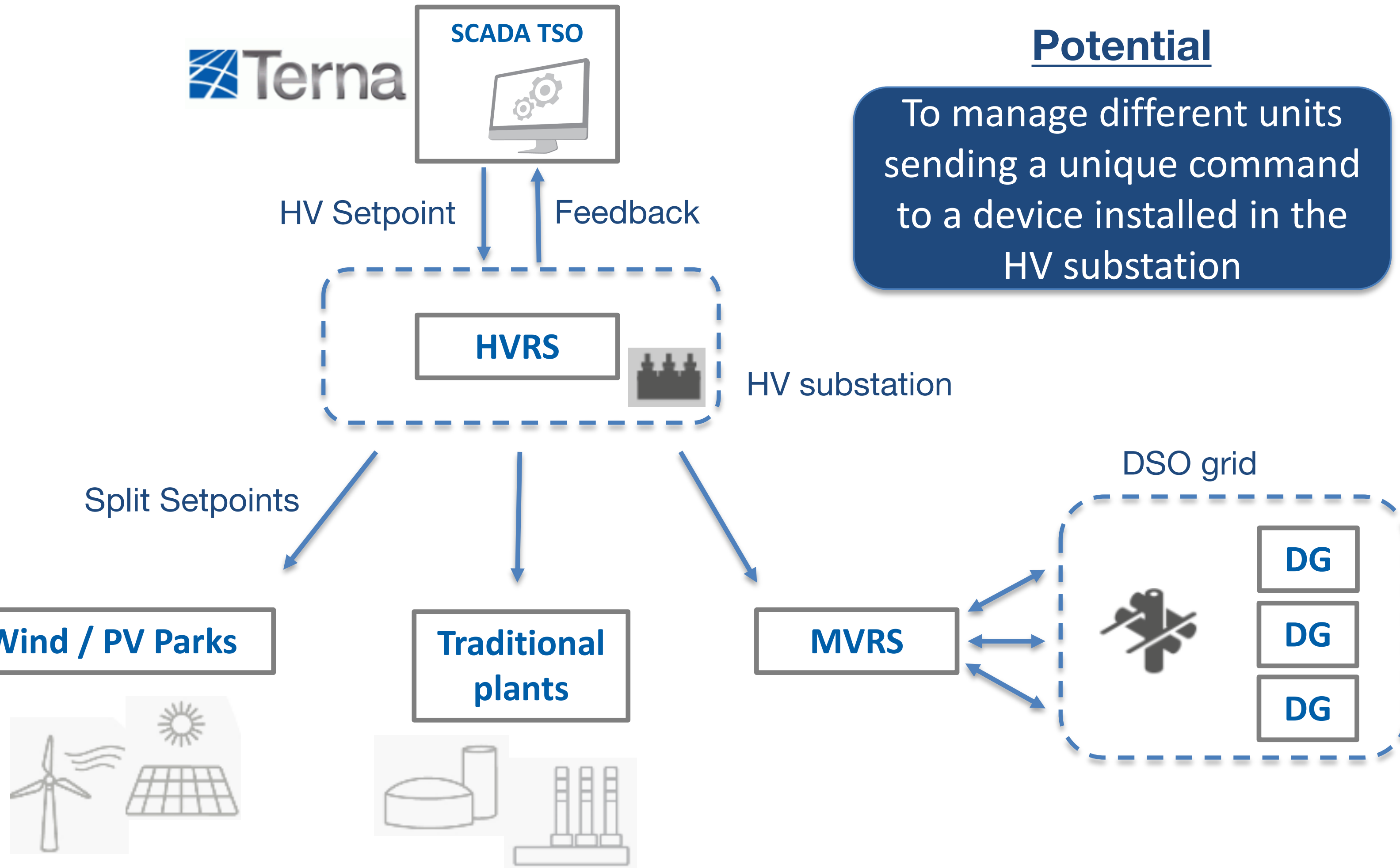
Plants performance







HVRS – Possible exploitation



Potential

To manage different units sending a unique command to a device installed in the HV substation

MVRS functionalities

Observability and aggregation of data of distribution grid

Aggregation of information in real time at the interconnection point TSO-DSO (HV/MV transformer) differentiated by load and energy sources. Aggregations are composed by measures and estimations.

Acquisition of measurements (active and reactive power) through PCRs

Estimation of unmonitored plants data through Sentinel Measurements (weather data, neighboring plants, historical profiles…)

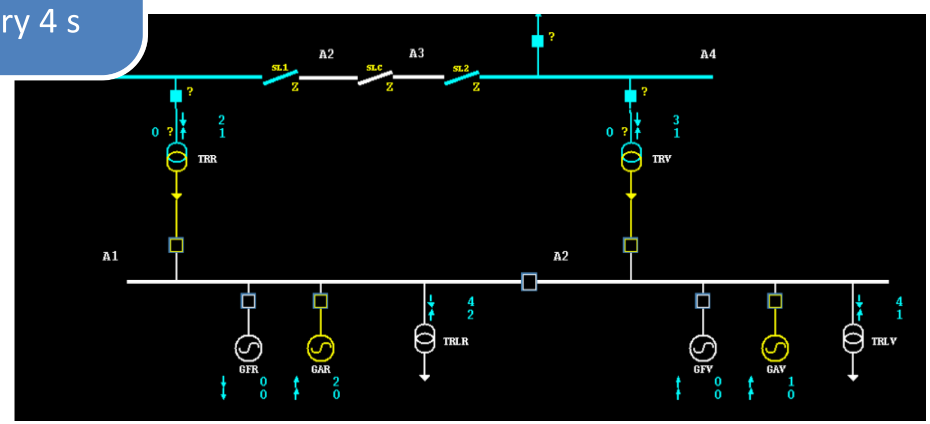
Aggregation of active and reactive power data differentiated by energy source

Every 20 s

Data transmission to TSO control room

Every 4 s

Functionality in operation:
P and Q values of the aggregations are automatically updated every 20s and sent every 4s

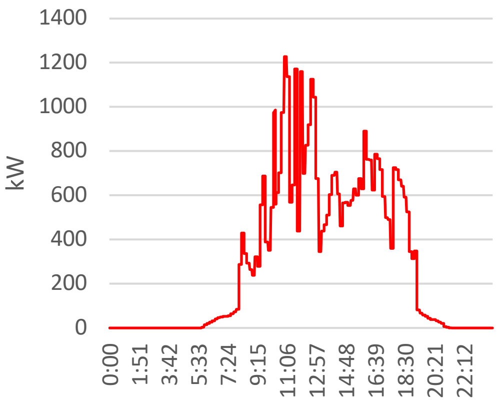


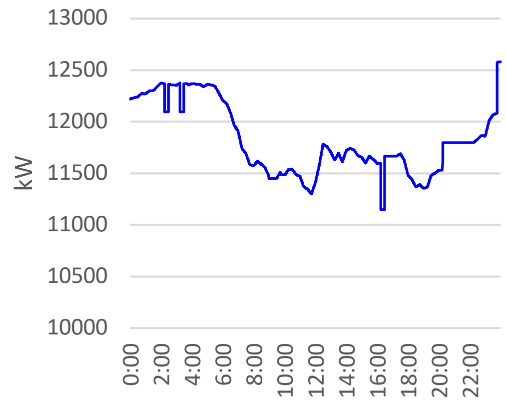
Interface of TSO Control System

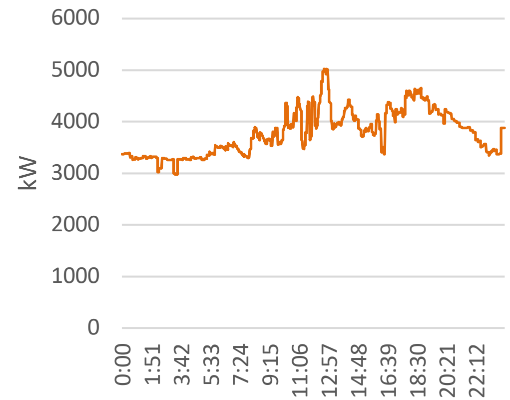
MVRS - Observability results

Solar Generation | Other Generation | Load

17th June 2018







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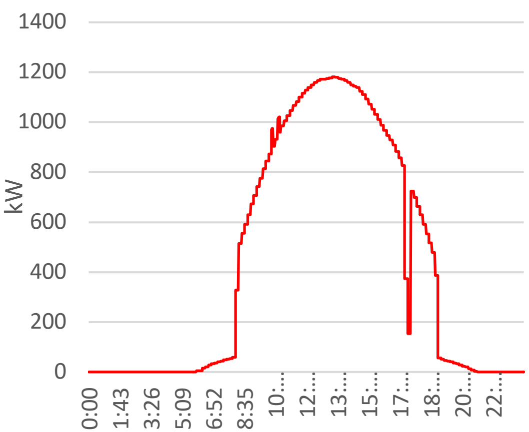
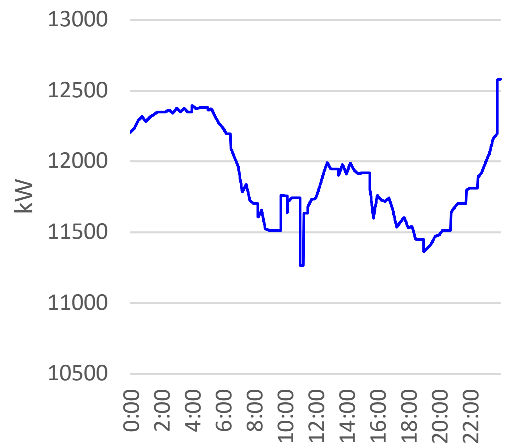
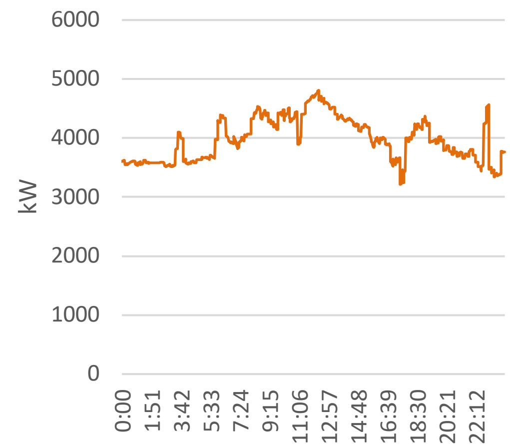




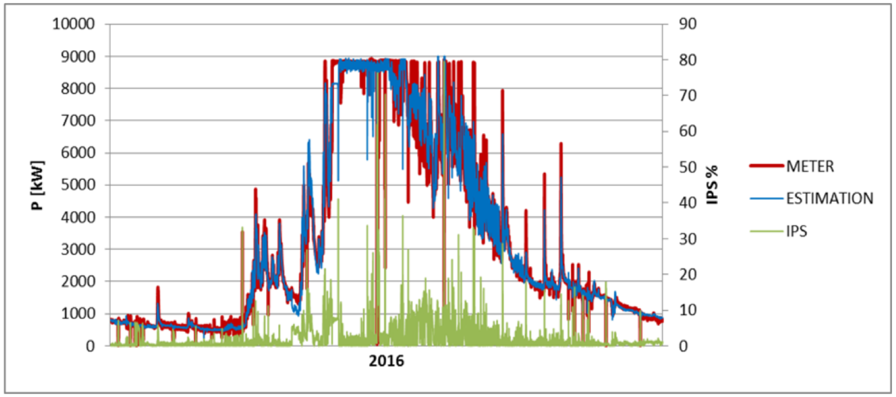


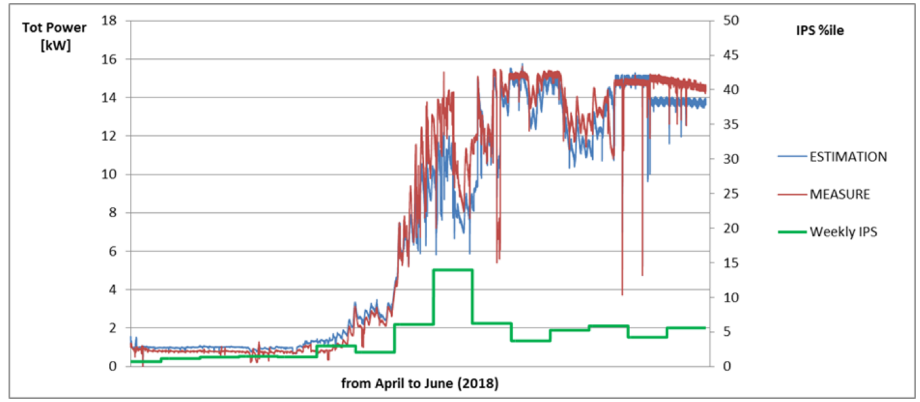
MVRS - Estimation results

Estimation Accuracy Index (IPS)

To evaluate the accuracy of the estimation algorithm

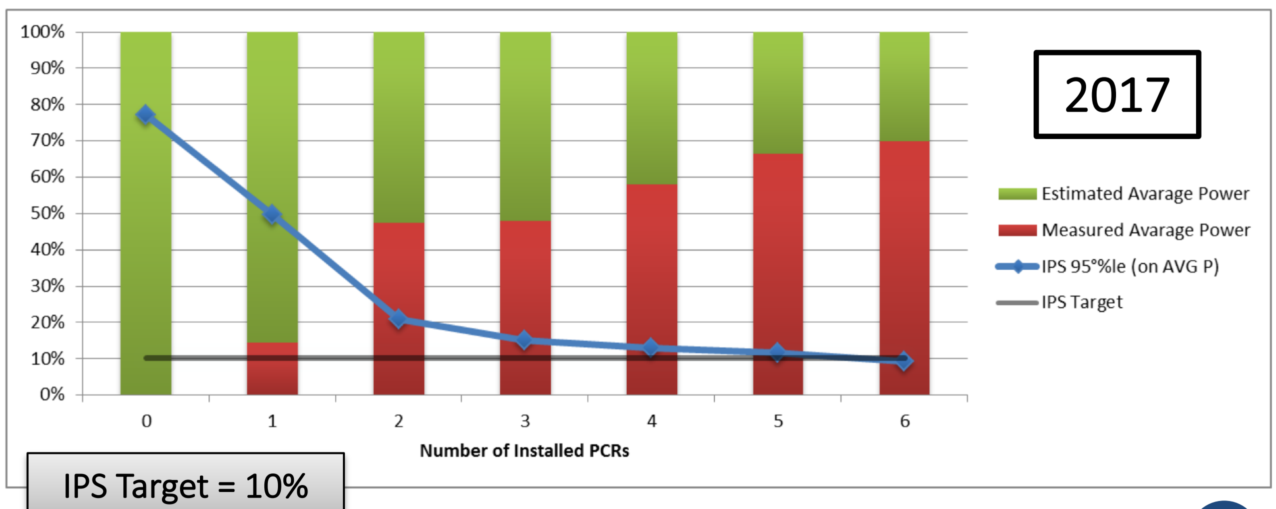
$$IPS_{aggr} = \frac{ASS\left(\sum_j E_{metering\_15'_j} - \frac{\sum_{ij} P_{ij} \cdot T_i|_{15'}}{3600}\right)}{\sum_j E_{\_nom\_15'_j}} \cdot 100$$





Ex-post analysis of the number of measures necessary to have an adequate accuracy of the estimation.

Measured Avarege Power	IPS 95°%le (on AVG P)
0%	77,1
14%	49,7
47%	20,9
48%	15,2
58%	13
66%	11,8
70%	9,17



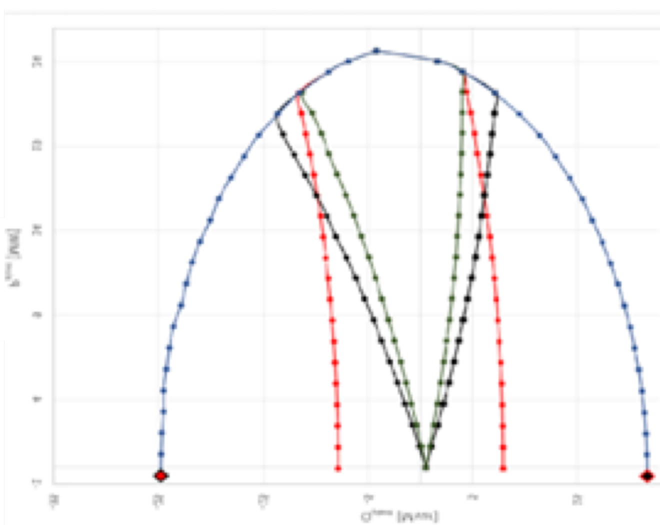
MVRS functionalities

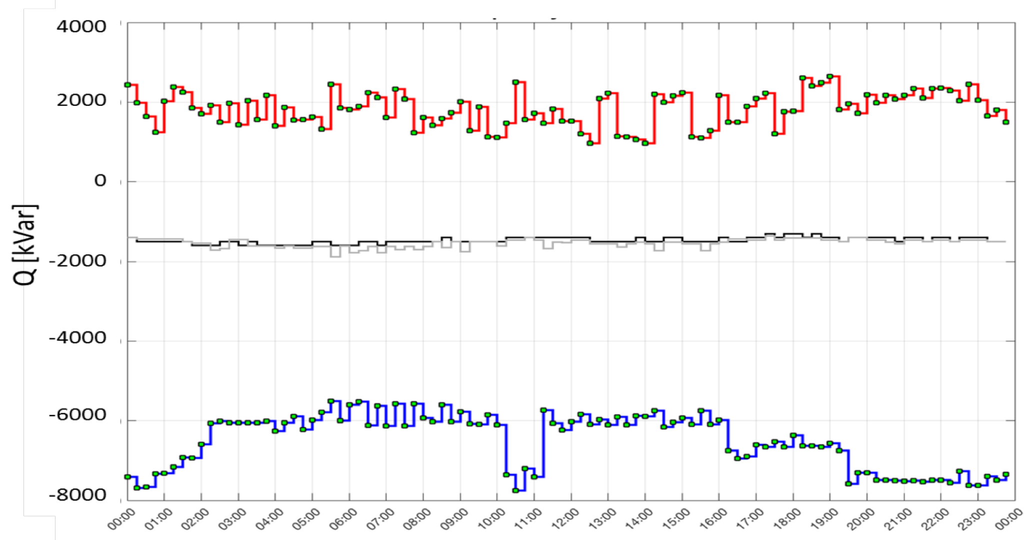
Virtual capability calculation

Virtual capability: it represents the **operational limits** in terms of P and Q, updated also considering **the operation point in real time** at the interconnection point. The calculation of virtual capabilities is carried out by the DSO, because the limitation consider also **information about the topology** of the distribution network.

Active power limits define the availability of the virtual plant for the **f/P regulation**

Reactive power limits define the availability of the virtual plant for the **voltage regulation**

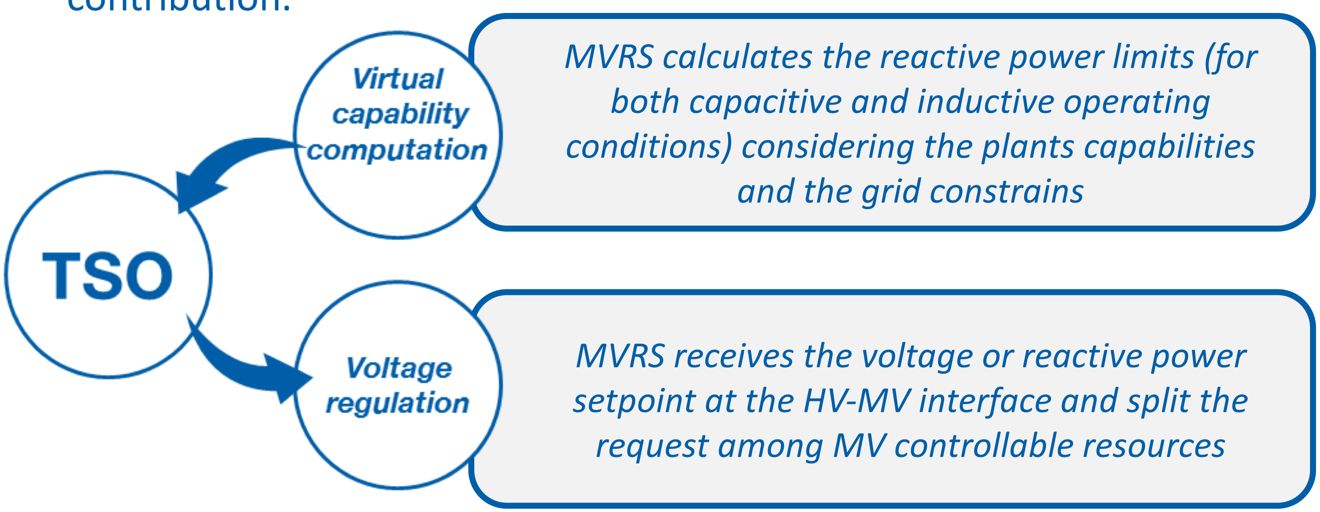




MVRS functionalities

Voltage regulation

- MVRS provides **the reactive power availability of the virtual plant** at the interconnection with TSO, taking into account the single generators capabilities and the DSO grid constrains.
- TSO can provide a **voltage** or a **reactive power setpoint** fitting with available capability considering the DG as a virtual plant
- MVRS receives a unique setpoint and splits the command among the DG taking into account the distribution grid constrains
- The plant receives the command through PCR (Plant Central Regulator) and provides its contribution.



Topical in the Network Codes:

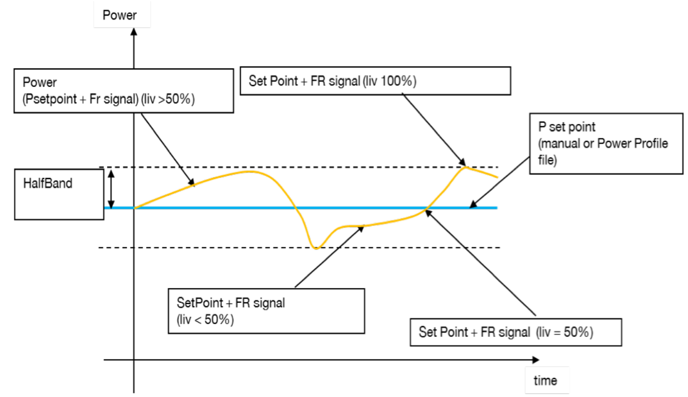
- **Art. 15 DCC**
- **Art. 29.5 SO GL**

MVRS functionalities

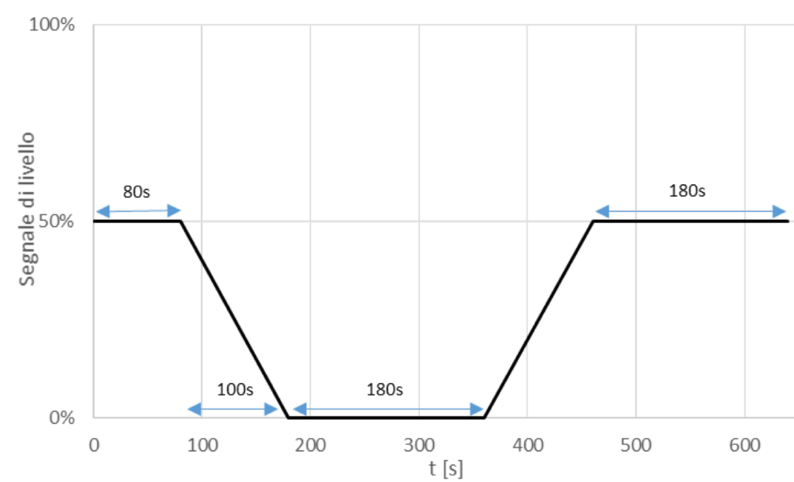
P/f regulation

- MVRS calculates the program and the half band available for the active power modulation at the interconnection point considering all the controllable DG and sends the values **of the virtual plant** to the TSO
- National regulator sends automatically an active power level signal every 8 s that is a percentage of the band
- MVRS receives the level and splits the command among the DG involved in the regulation

Ad hoc test with volunteer hydroelectric plants' owner connected at MV grid

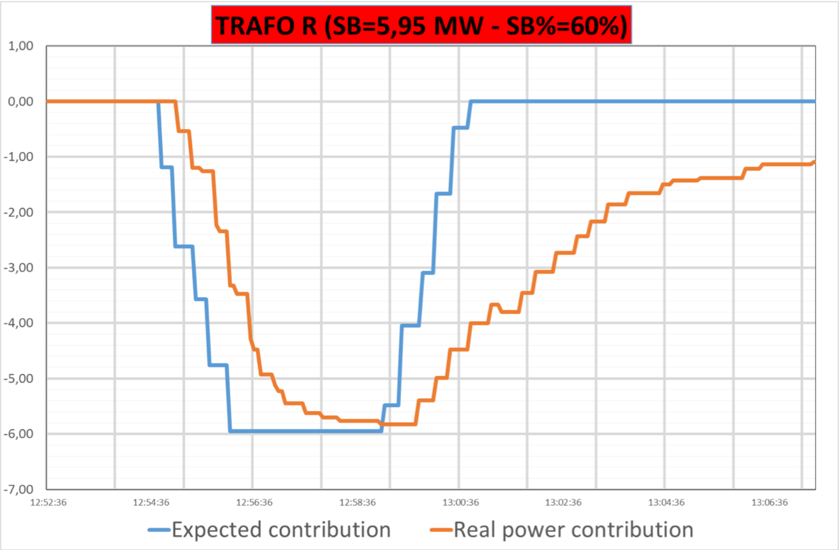


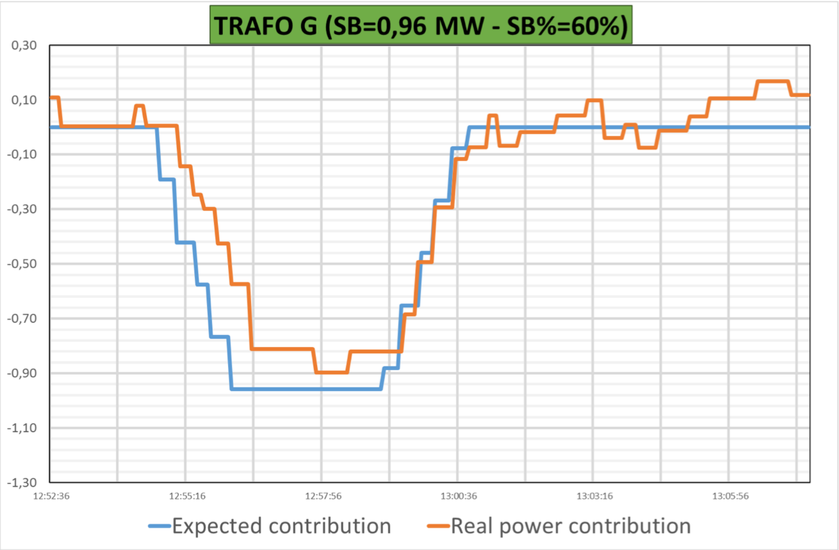
Ramp level signal profile for the downward service tests

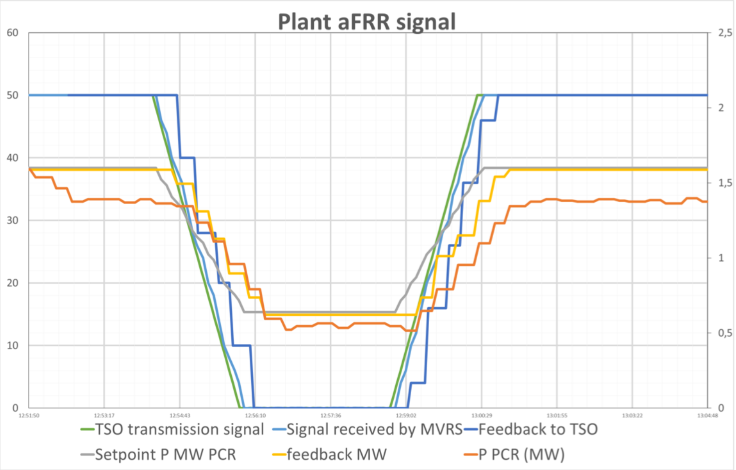


MVRS - aFRR test

Example where the TSO has required ramps of 6,91 MW through 3 MV plants







Two test sessions:

- 07/06/2018
- 12/09/2018

Conclusions

- HVRS and MVRS have been successfully developed and installed in field, demonstrating the feasibility of all the functionalities foreseen by the pilot project.
- The calculation by MVRS of active and reactive power limits lead to know the available DG contribution in both voltage and frequency regulation taking into account DSO grid's constrains.
- The experimentation of the ancillary services by DG sources shows promising results but it also highlights the need for improvement and especially for a continuous and extended period of operation. In order to obtain the compliance with the requirements for these services, it is necessary to deepen the characteristics and the performance of each stage within the regulation chain (TSO, DSO, devices, telecommunications infrastructure, generator performance, protocol standardization, data exchange, availability, reliability and quality of the service, etc.)
- With the implemented observability algorithm it has been possible to check how many measurements are necessary to achieve the required accuracy (IPS 10%); it is evident the dependence on type of source (PV vs Hydro). The first results highlighted that for hydro power plants at least 60% of installed power has to be measured.

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Thank you for your kind attention!

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