Visibility & Control of distributed resources

SEERC TAC Workshop
"TSO & DSO Interaction in operation and planning"
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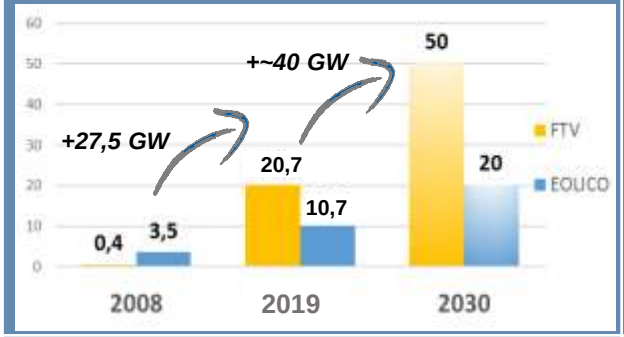
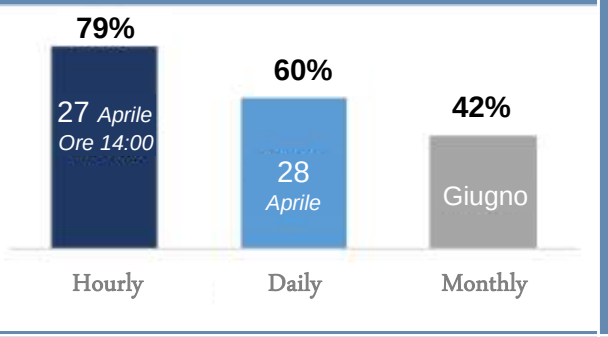
Italian Electricity System at a glance

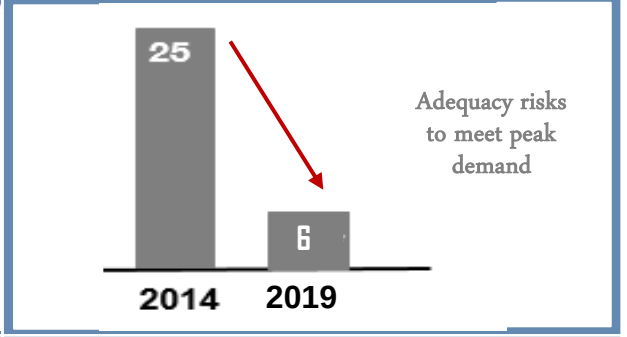
Installed wind and PV capacity (GW)



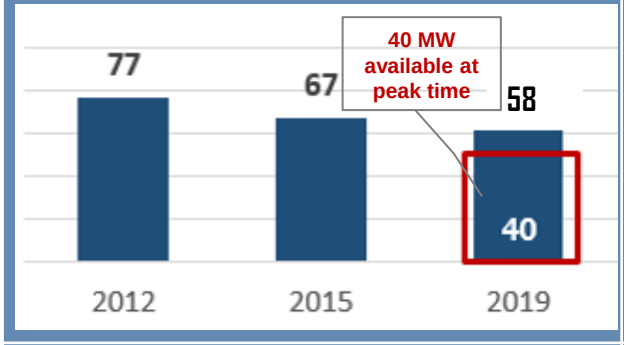
Share of demand covered by RES[1,3] (%)



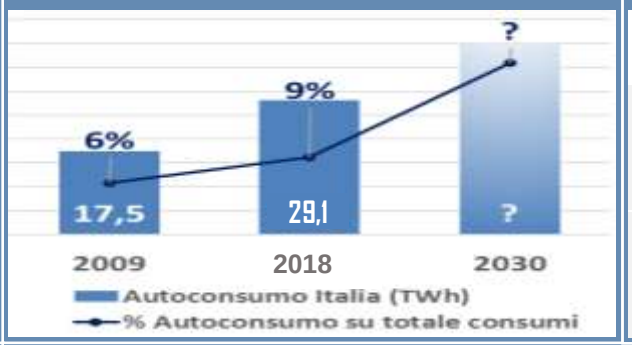
Minimum yearly reserve margin[2,3] (GW)



Phase out thermal capacity (GW)



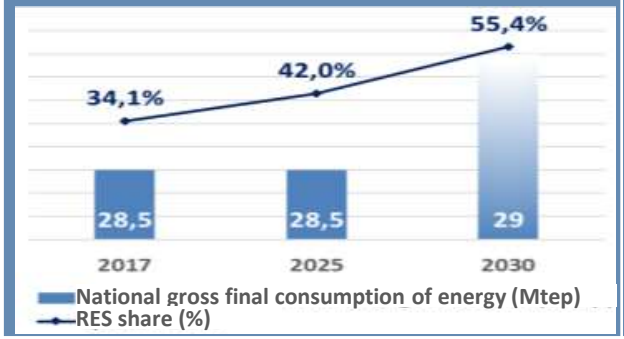
Self-consumption (TWh)



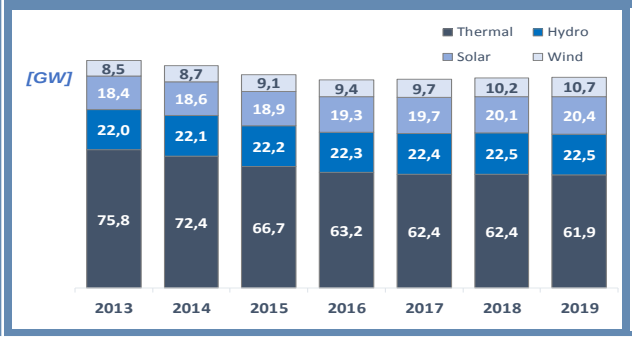
Target NECP

	Obiettivi 2020		Obiettivi 2030	
	UE	ITALIA	UE	ITALIA (PNEC)
Share of energy from RES in gross final consumption of energy in 2030	20%	17%	32%	30%
di energia				
2030 target for non-ETS GHG emissions under ESR compared to 2005	-10%	-13%	-30%	-33%

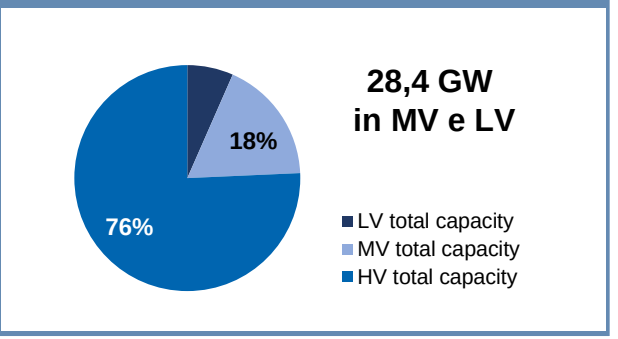
RES in the electricity sector (%)



Installed capacity (GW)



Installed capacity by voltage level (%)



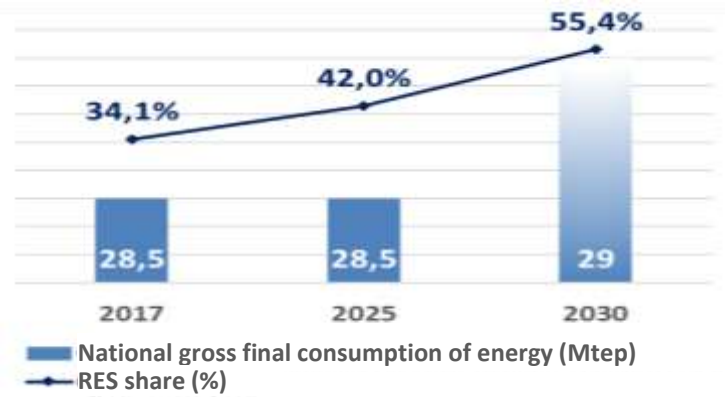
1) Including hydroelectric
2) Difference between the available production capacity and consumption (including the reserve) at the time of maximum load
3) Provisional data 2019

Decarbonization

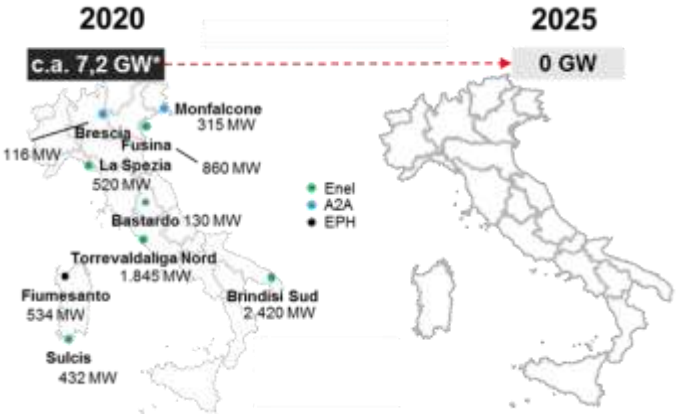
National Energy and Climate Plan (NECP): Italy by 2030

Main target of NECP

Growing RES share

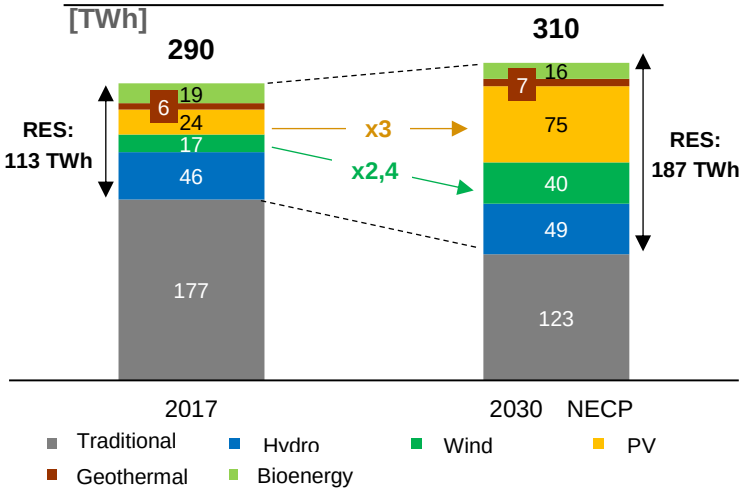


Coal phase-out by 2025

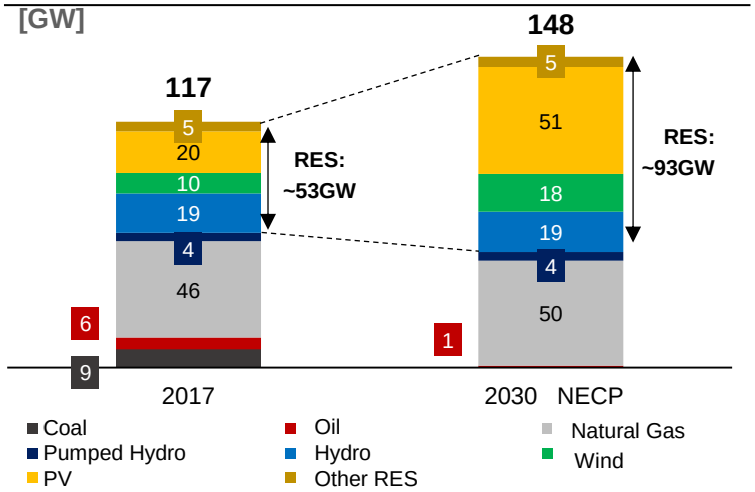


2030 Scenario

Electricity production



Installed capacity



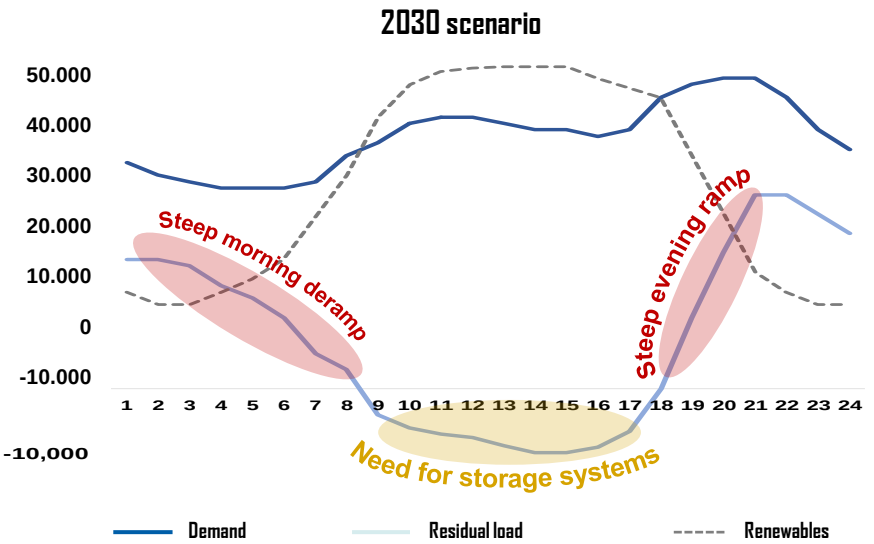
The NECP targets a complete coal phase-out by 2025 and a significant push towards RES

The rise of Renewable sources: challenges

OPERATIONAL ISSUES

1. Steep **RAMPS** for instance when the sun sets and the contribution from PV falls
2. Reduced **FREQUENCY REGULATION** to automatically balance supply and demand
3. **GRID CONGESTIONS** as wind-solar production is concentrated most of all in the Centre-South area
4. Poor reactive power for **VOLTAGE CONTROL** coming from DG connected to the distribution
5. **ADEQUACY** risks: lack of reserve margin to meet load at peak time
6. **OVERGENERATION** when net load is negative or where wind parks raise local congestions
7. Reduced **INERTIA** when less generators with rotating mass is in operation

RESIDUAL LOAD GROWING ISSUE



The increasing penetration of renewables in the generation mix, combined with the simultaneous decommissioning of conventional carbon-fired power plants is putting system operations at stress

The rise of Renewable sources: solutions

GRID EXPANSION

- To strengthen connections between **internal market zones** and **cross-border exchanges** with neighboring countries;
- **Synchronous condensers** for voltage regulation, inertia and short circuit level

MARKET DESIGN

- **Power Purchase Agreement and tenders** to finance **RES** investments
- **Capacity market** to give long-term price signals to 'peakers' unit
- **Aggregation** of demand, RES and storage to access Ancillary Services Market

STORAGE

- Additional **6 GW of storage** capacity by 2030 to meet **security**, **adequacy** and **flexibility*** needs

DIGITALIZATION

- **Data-exchange** between TSO-DSOs to allow **GD observability** and controllability
- ICT infrastructure to capture **distributed flexibilities**

Focus in the following

* **Ramp up/ down** at the sunrise/ sunset, **downward regulation** to accommodate the excess of non-dispatchable generation

Structure of the current Italian production mix

Already today in Italy 25% of installed generation capacity is "DER"

Share[1], per **number** and **rated power**[2], of all the power plants distributed over the Italian national territory, sorted by **primary energy source** and **kV level**:

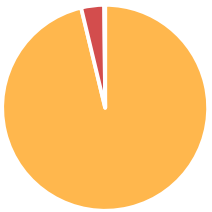
Source	LV		MV		HV / EHV		Total	
	Num [x1000]	P_{inst} [GW]	Num [x1000]	P_{inst} [GW]	Num [x1000]	P_{inst} [GW]	Num [x1000]	P_{inst} [GW]
PV	799.4	7.3	22.6	11.7	0.1	1.1	822.2	20.1
Hydro	1.3	0.1	2.6	3.3	0.4	23.2	4.3	26.7
Wind	4.7	0.2	0.6	1	0.3	9.1	5.7	10.3
Thermal	1.7	0.1	4.0	4.7	0.3	54.1	6.1	58.9
Other	0.02	0.001	0.02	0.002	0.03	1.0	0.1	1.0
Total	807.3	7.7	29.9	20.7	1.3	88.5	838.4	116.9

LV/MV Perimeter

HV/HHV Perimeter

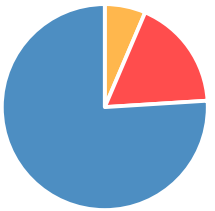
TOT: 837 k plants | 28.4 GW

Plant number distribution:



- Qty of LV plants **(96,3% of the Total)**
- Qty of MV plants **(3,6% of the Total)**
- Qty of HV/HHV plants **(0,1% of the Total)**

Plant power distribution:



- LV total power **(6,6% of the Total)**
- MV total power **(17,7% of the Total)**
- HV/HHV total power **(75,7% of the Total)**

In Italy almost 1/4 of installed capacity is connected to the MV-LV distribution grid (≈28 GW). Real-time telemetries from such DG are not acquired by Terna (for the time being).

[1] Source: GAUDÌ, extraction performed in January 2019.

[2] For the thermal source, the input power of the Production Units was considered (net of the part reserved for primary regulation), while for all the other sources the nominal active power of the plants was considered.

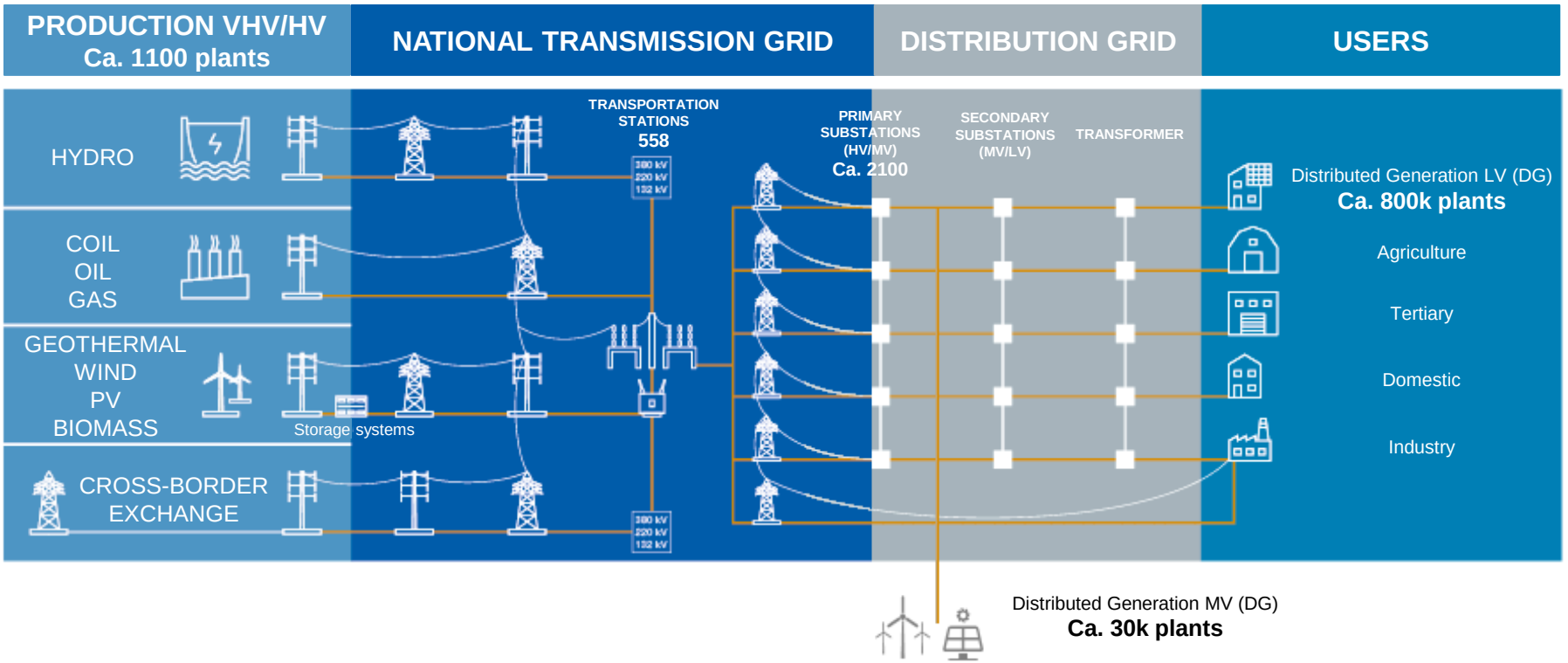
Controllability of grid connected DERs

Direct observability and controllability of DER is fundamental for a safe operation

The word «observability» refers to the ability **to know in real time the main electrical data of the power system**, in order **to manage it correctly and safely**.

100% monitored by Terna in real time [1]

0% monitored by Terna in real time [2]



The significant growth of RES connected to MV/LV, and the increasingly "active" role played by prosumers in the provision of flexibility, make the observability of distributed resources of key importance for the TSO to manage properly the power system.

[1] As defined by the IEC 60870 and 61850 standards, data acquisition takes place every 4 s via SCCT (Control and Conduction System).
[2] Terna reads 3 times a day, for the purposes of forecasting, only the measurements of a subset of MT plants (ca. 200).

Observability of grid connected DERs

Areas of application

In the new energy context **the observability of the DG** becomes crucial for the secure management of the Electric System.

Most notably, the following **applications** will benefit from information of resources connected to the distribution networks:

Real-Time applications

- **Grid calculation (static and dynamic regime)**
  - Estimation of system inertia in real time
  - Early detection of dynamic instabilities and decision making support
- **Power flows optimization**
  - With the inclusion of DG data within the tools (eg OPF - Optimal Power Flow), improves the computing of the DG enabled to Ancillary services market and the monitoring of its performance.
- **Defense Plan**
  - Increased flexibility and effectiveness of the Defense Plan strategies
- **Real-time operations**
  - Optimizatimal activation of aFRR-automatic frequency restoration reserve in real time, with consequent cost saving
  - Fine tuning of wind energy curtailment to maintain system security

Forecast applications

- **Demand & RES forecast:**
  - Higher reliability in forecast data and nowcasting, with consequent advantages for network security and economy of operation
- **Reserves dimensioning :**
  - Lower dimensioning of the reserve quantities to be purchased (e.g. replacement reserve - RR)

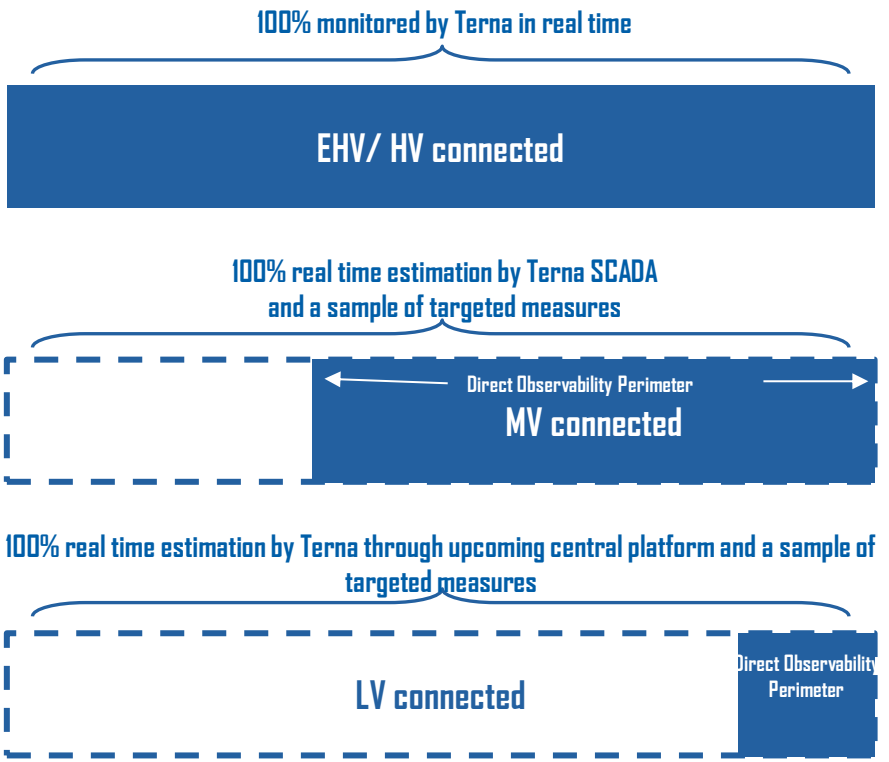
Ex-Post applications

- **System Analysis**
- **Turn Historical Data Into Predictions**
- **Grid development, reporting**

DERs observability positively impacts on multiple applications for system operations

Proposed model of observability and data exchange with DSO and SGU

- Terna's implementation model is based on a **statistical-probabilistic approach** characterized by:
  - An **estimation "engine" developed and centrally managed by Terna**, the only solution able to guarantee full visibility and awareness of the potential and the limits to the reliability of the algorithm itself
  - **Real-time acquisition of a suitable set of "sample" measures** selected on the basis of their statistical relevance
  - The acquisition of other information necessary for the development, operation and evolutionary maintenance of the algorithm (**real time and forecast weather data**, **technical plant data**, **historical measurements**)
- The sample subset of DG consists of:



Proposed model of observability and data exchange with DSO and SGU

The model will be based on a combination of probabilistic techniques and algorithms with near real-time estimation and adaptative algorithms (i.e. with "machine learning" features) which must be provided with a set of input data. In particular, **input data** can be classified into four main categories:

Tele-measures
Tele-signals

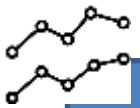
- Direct and precise measurements of electrical parameters and real-time status signals from a selected subset of DG

Meteorological data

- Weather forecasts are key parameter for forecasting/estimating generation from solar PV

Grid Master Data

- The model will be provided with the master data of the distributed generation plants already available to Terna (GAUDI' platform)

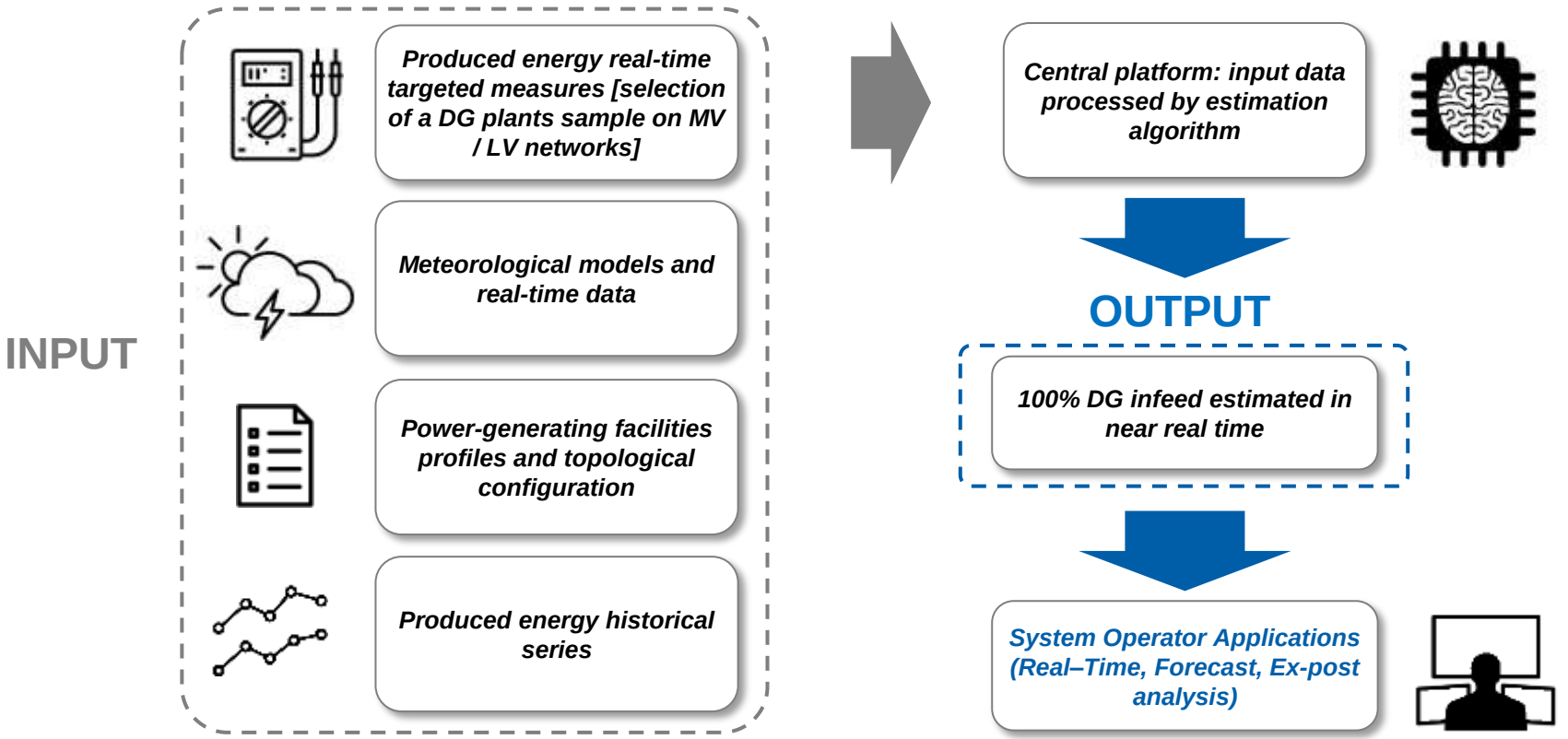


Historical data

- Electric data such as the energy produced by plants connected to LV and MV and the exchange of active and reactive power flowing to the HV grid
- Time series are used for the continuous running of estimation models and for the identification of statistical correlations between input data and target outputs

Observability of grid connected DERs - Model

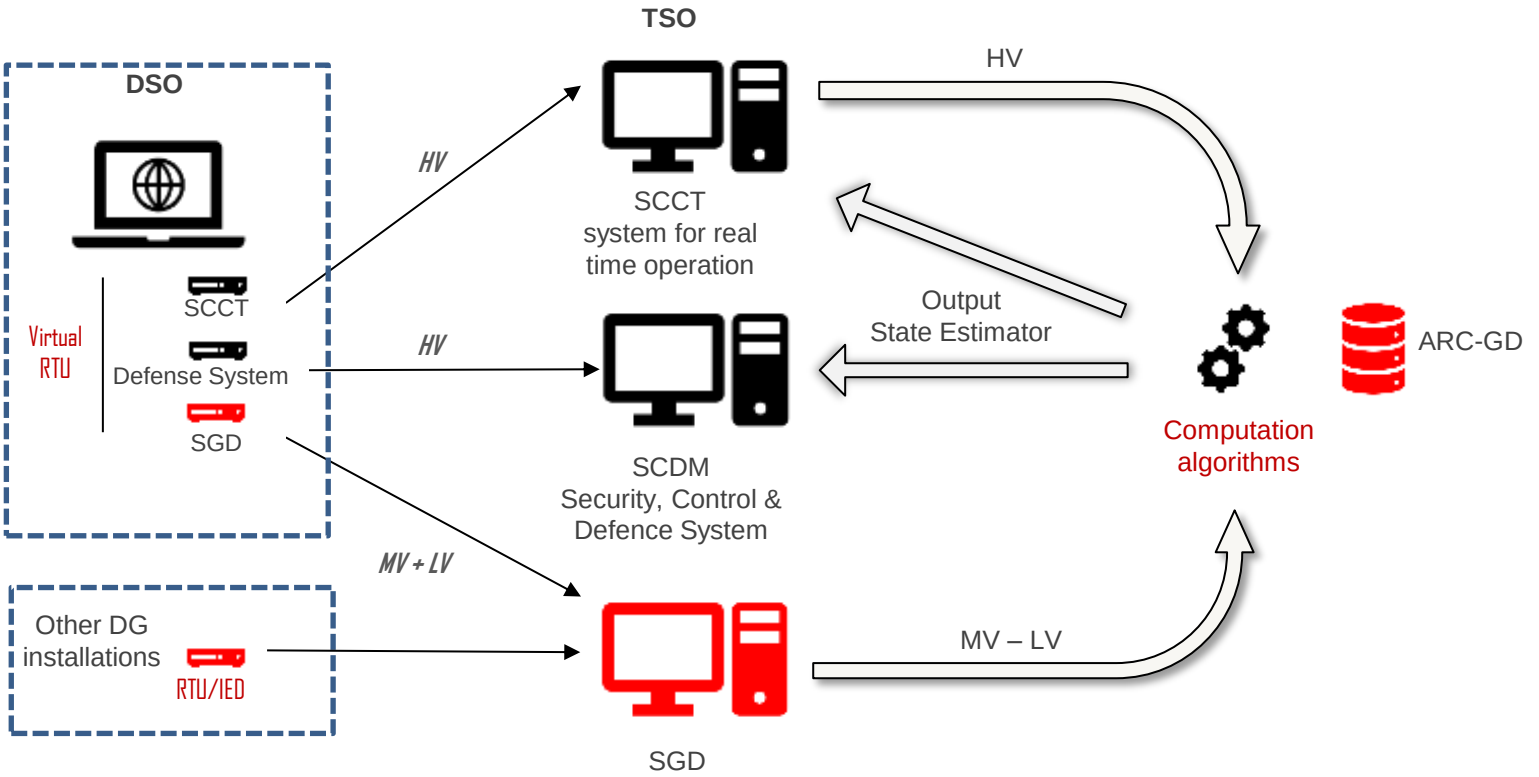
Conceptual framework



The total energy produced by renewable sources is estimated by metering a representative subset of plants

Observability of DERs - Architecture

Data collection and transmission model



- Terna's SCADA system dedicated to DG data to ensuring high level of flexibility and scalability for future applications
- Each DSO's concentrator is provided with a virtual RTU[1] dedicated to the data flow towards Terna's DG SCADA

(1) Today, each gateway is equipped with 2 virtual RTUs: one dedicated to the SCADA, one dedicated to the Defense Systems

Observability of grid connected DERs - Model

Minimum requirements – Key Parameters

REAL-TIME OPERATIONS, POWER FLOWS OPTIMIZATIONS, GRID CALCULATIONS (MINIMUM REQUIREMENTS)

DEFENSE SYSTEMS (BEST OPTION)

1 Electrical metrics of interest

Active and Reactive Power Production

2 Aggregation level

Aggregation for Primary Substation distribution
Split type (PV, Wind, Hydro, Thermo, Other)

3 Accuracy level

Over 90%[4]

→ **Accuracy level**

Higher levels of accuracy: > 95% (target 98%)

4 Run frequency for calculation

15 min

→ **Run frequency for calculation**

<5 min (target 1 min)

5 Systems Recovery Time

RTO[2]: 6 hh ; RPO[3]: 45 min

→ **Systems Recovery Time**

RTO[2]: 5 min; RPO[3]: 5 min

Tightening constraints compared to «minimum requirements» allows for advanced applications

[1] Evaluated on 98° percentile | [2] RTO: Recovery Time Objective
[3] RPO: Recovery Point Objective | [4] Measured on larger aggregation perimeters

BACK-UP

Key enablers of the energy transition

1 Transmission grid development

- **Strengthening** of North-South **backbone** and **grid reinforcements** in the South of Italy and the Islands
- **Foreign interconnections** - **Reinforcement** and **meshing of national transmission grid**
- **Investments** in **voltage regulation and to increase the inertia** of the electricity system

2 Long-term price signals

- **Capacity Market** to deliver long-term price signal to encourage investments in new efficient and flexible generation
- **Power Purchase Agreements (PPAs)** long-term power purchase contracts for RES
- Long-term **contracts through competitive procurement** for storage capacity

3 Market evolution

- **Participation of new flexible resources in ancillary services market,** i.e. demand, distributed generation, non-programmable renewable energy sources and storage, including electric vehicle-to grid
- **Evolution of the structure of the ancillary services market** to cope with new needs (voltage regulation, inertia,…)

4 Innovation and digitalisation

- **Digitalisation of the Transmission Grid** (Assets and processes) and of its control systems (data management)
- **Full IoT, Energy Systems e Advanced Materials**
- **Sector Coupling**

Markets evolution

Opening the Italian Ancillary Services Market to new resources

Pilot Projects currently under way

From traditional resources… **… to a market with an higher degree of complexity**

- **Relevant qualified units** (P>10MVA)

ca. 250 Generation Units

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ca. 250 Generation Units

- **Demand Response**
- **Distributed Generation**
- **Non-qualified RES**
- **Storage** (including **EVs**)

Potentially more than 800k generation units and ca. 40 million consumptions units

What is our strategy?:

- **Increase the amount of resources** able and available to provide grid services
- **Diversify the portfolio of resources** eligible for participation in ancillary services markets
- Enable the participation of **new market players from outside the sector**