CONTEXT AND PROSPECTIVES TO RES INTEGRATION IN THE ITALIAN TRANSMISSION SYSTEM

Corrado Gadaleta
Giuseppe Bonavita
Power System Planning and Permitting
Interconnections, System Efficiency and Sustainability

Terna
Driving Energy

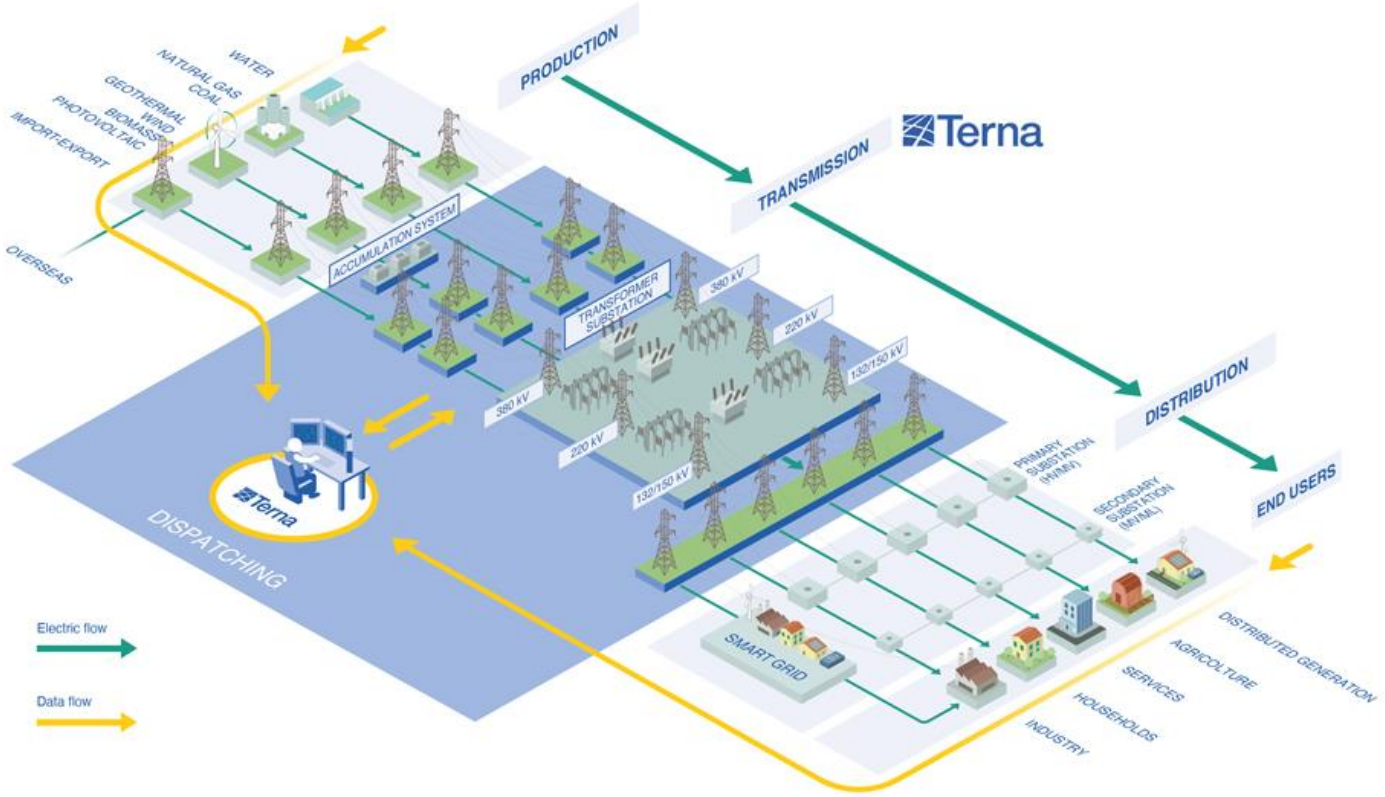
10th CIGRE SEERC Technical Advisory Committee (TAC)
Cavtat (Croatia) May 27-28, 2024

Italian Transmission Network Operator

Terna's role

WHO IS TERNA?

- Responsible for the **planning, development and maintenance** of the national transmission grid (RTN) and for the management of the electricity flows.
- It operates under a **monopoly regime** according to the rules of the Regulatory Authority for Energy, Networks and the Environment (ARERA) and the guidelines of the Ministry of the Environment and Energy Security (MATE).
- **First independent operator** in Europe for km of lines managed.
- Owner of **99,7%** of **transmission grid.**



ELECTRICAL DEMAND

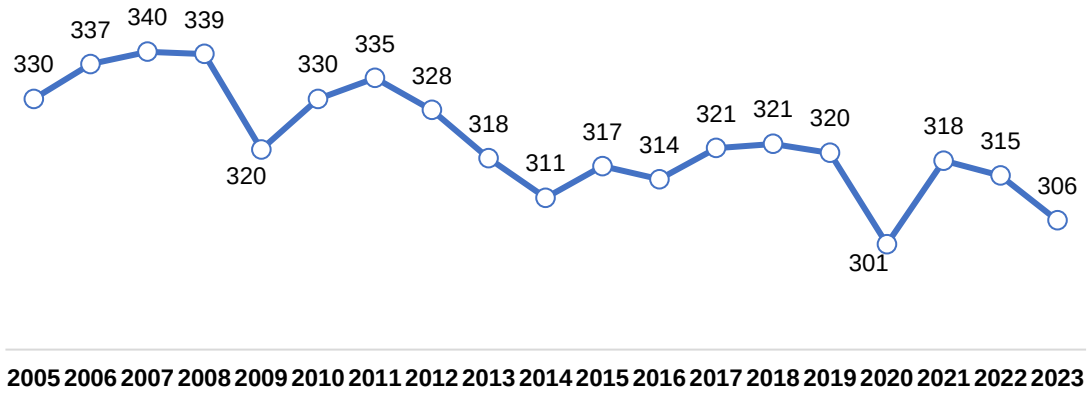
- **340** TWh highest annual demand (2007)
- **60,5** GW historical peak load (2015)
- **37%** of electrical load covered by RES (2023)

THE GRID

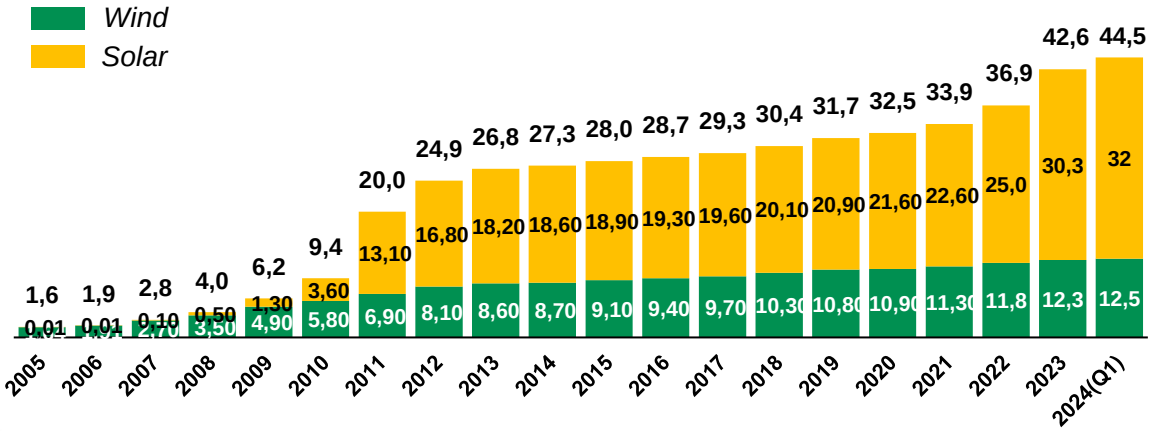
km of lines	Interconnection	Substations	Transformers
> 74,000	30	897	769

Electricity Demand and Renewables Share

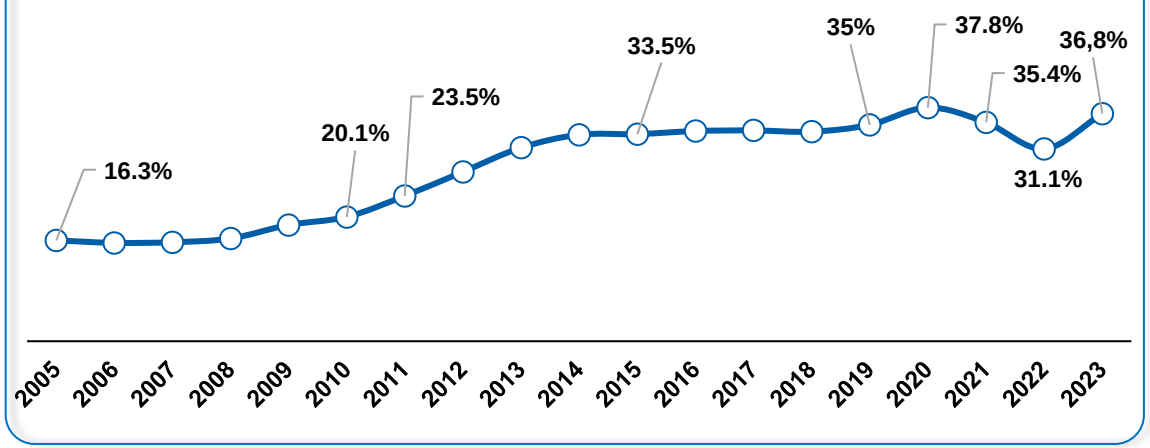
Electricity Demand (TWh)



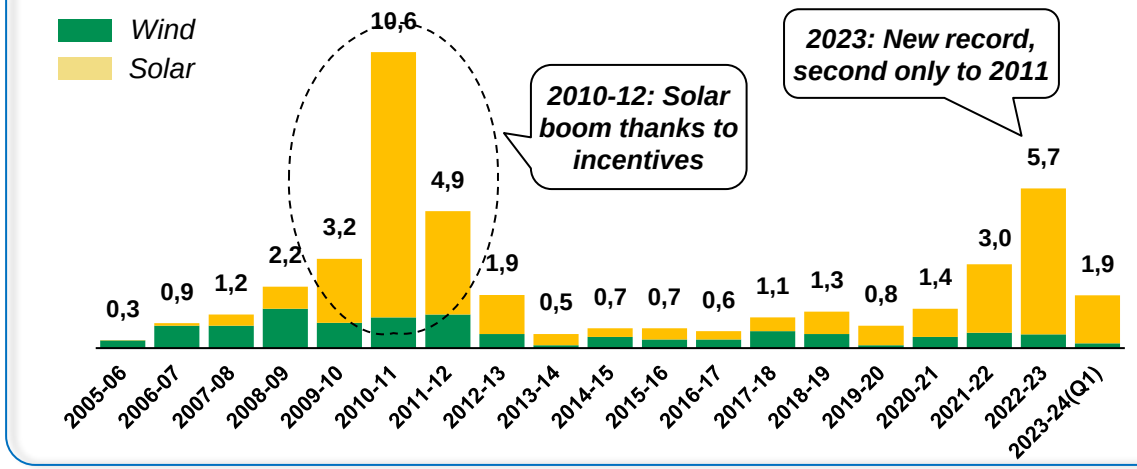
Total installed capacity of wind & solar* (GW)



RES-E share** (%)



Annual installation of wind & solar (GW)



The 2022-23 growth of installed RES represents a new record, second only to 2011

(*) Source: Terna. 2021 data is provisional and potentially subject to updates
(**) Source: Eurostat, Transparency Terna for 2021 (preliminary)

Overgeneration during «low consumption» days

Real case of «spring Sunday» - 7th of April 2024

REAL-TIME RECORDED DATA

> **Renewable production** amounted to **74%**[1] of electricity daily demand

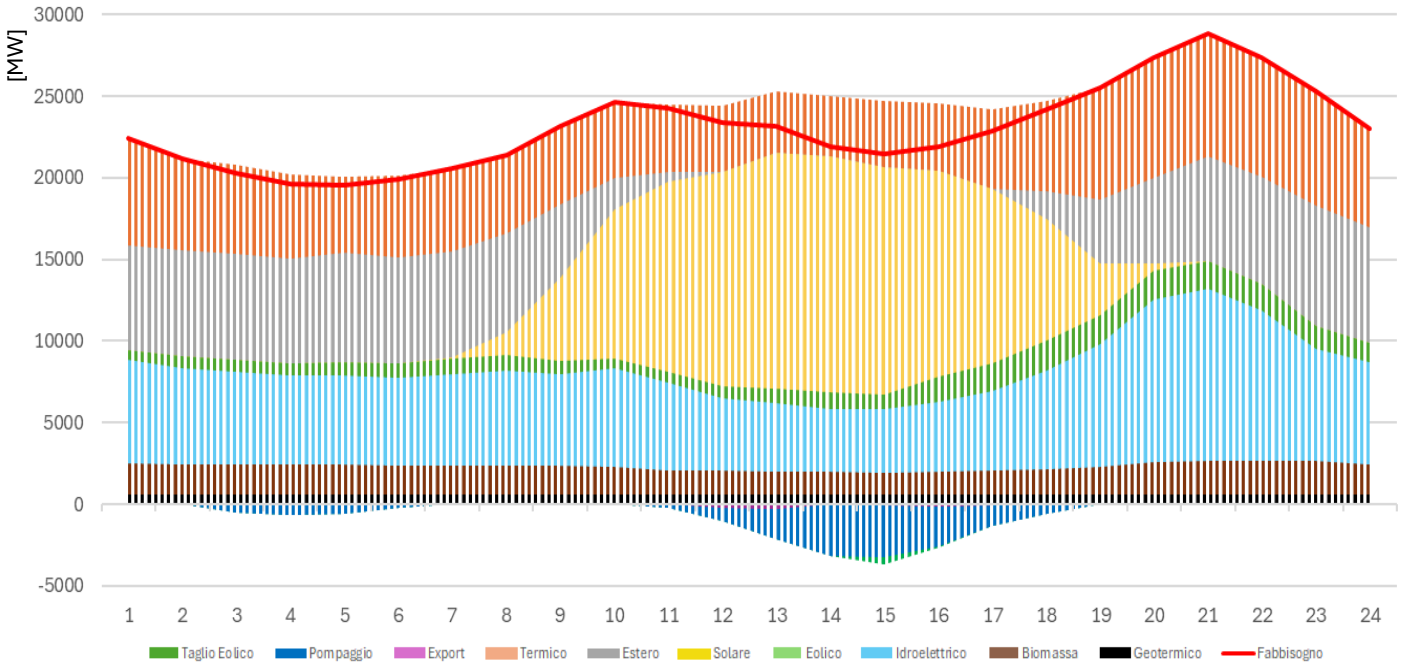
> **Peak RES share** at 1 PM reached **97%**[1] of electricity demand (despite the low contribution from wind power)

> **PV infeed of 14.5 GW**[1] was recorded, a record level never reached before (value net of self-consumption)

> Use of **13.6 GWh of flexibility pumped storage plants** to maintain margins of reliability and minimize overgeneration

> The wind's generation has been very low

ENERGY BALANCE DURING 'LOW CONSUMPTION' PERIODS



1. Preliminary data

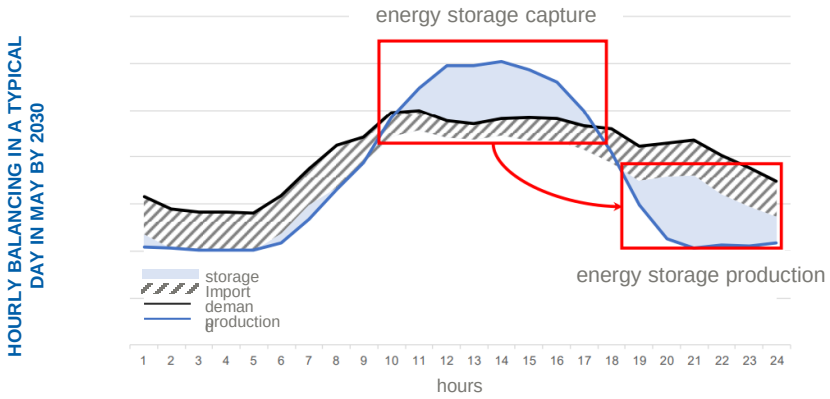
Energy Storage 2030 Scenario

Storage grid services

HIGHLIGHTS

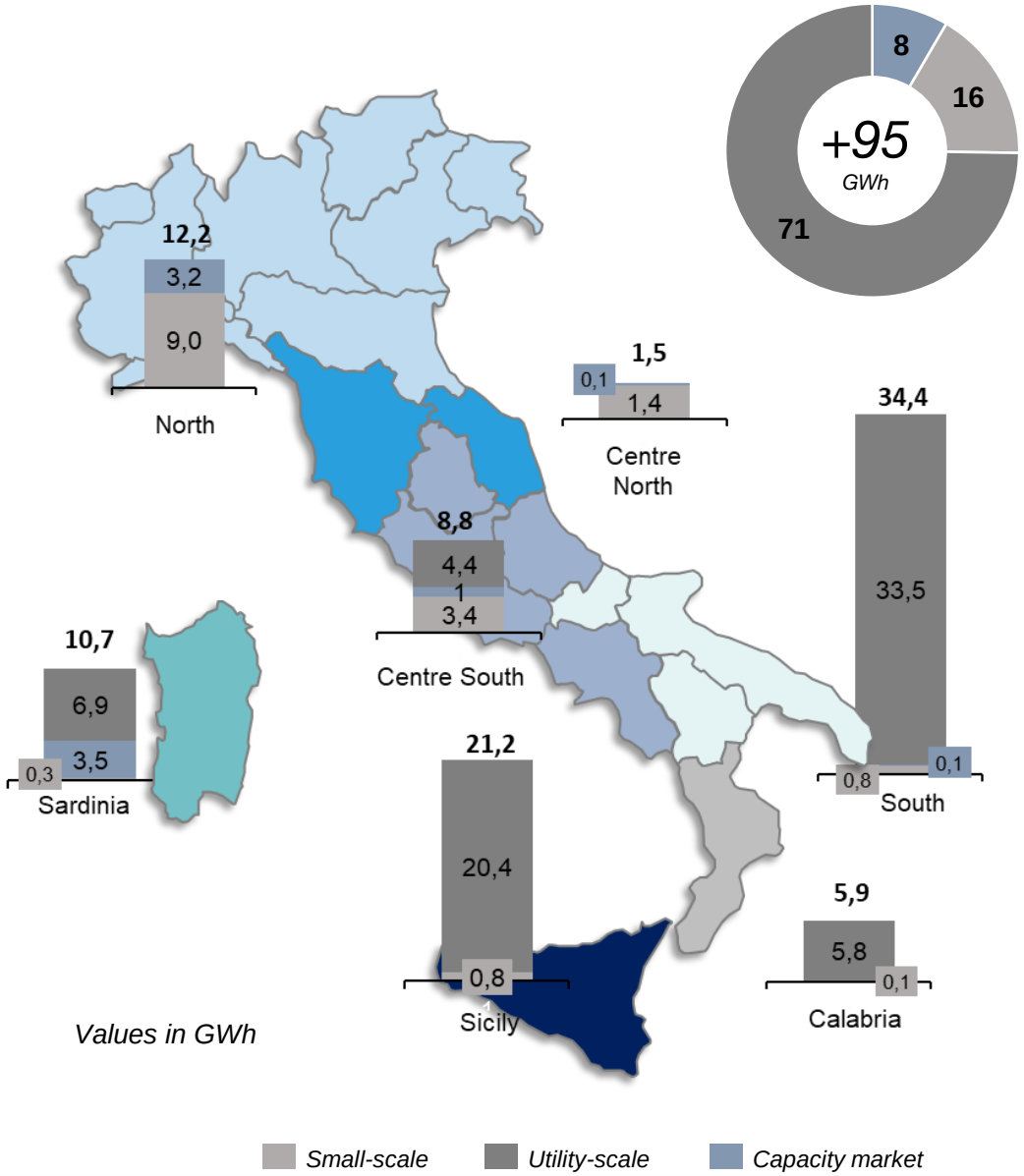
Storage capacity installation will significantly **reduce RES overgeneration** during the hours when RES production is greater than electricity demand.

Energy storage will be fundamental **to shift energy in time and space.** In addition to «energy shifting» service, **storage will provide** multiple services necessary to ensure both the **balance between demand and production** and the **quality and security of energy supply.**



Coordinated planning of grid, RES and storage is needed to minimize overall system costs.

Optimal location and storage sizing depend on the evolution of RES installed capacity and grid infrastructure. RES integration leads to higher storage demand, and, at the same time, it is enabled by additional storage capacity installation.

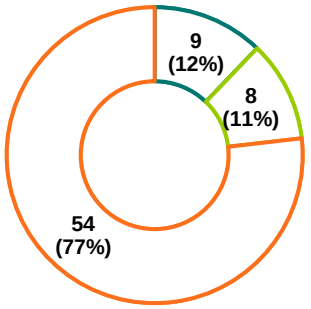


Connection requests for RES

SOLAR AND WIND CONNECTION APPLICATIONS

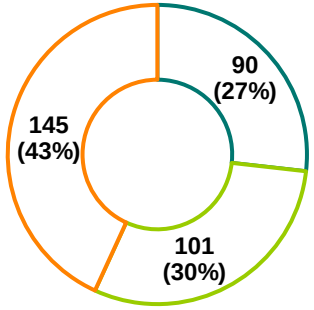
The **connection applications** to the national electricity transmission grid differs significantly from the «Fit-for-55» reference scenario in terms of **volume**, **distribution** and **technology mix**.

The effective realization of these projects may require additional network reinforcements.



+70 GW

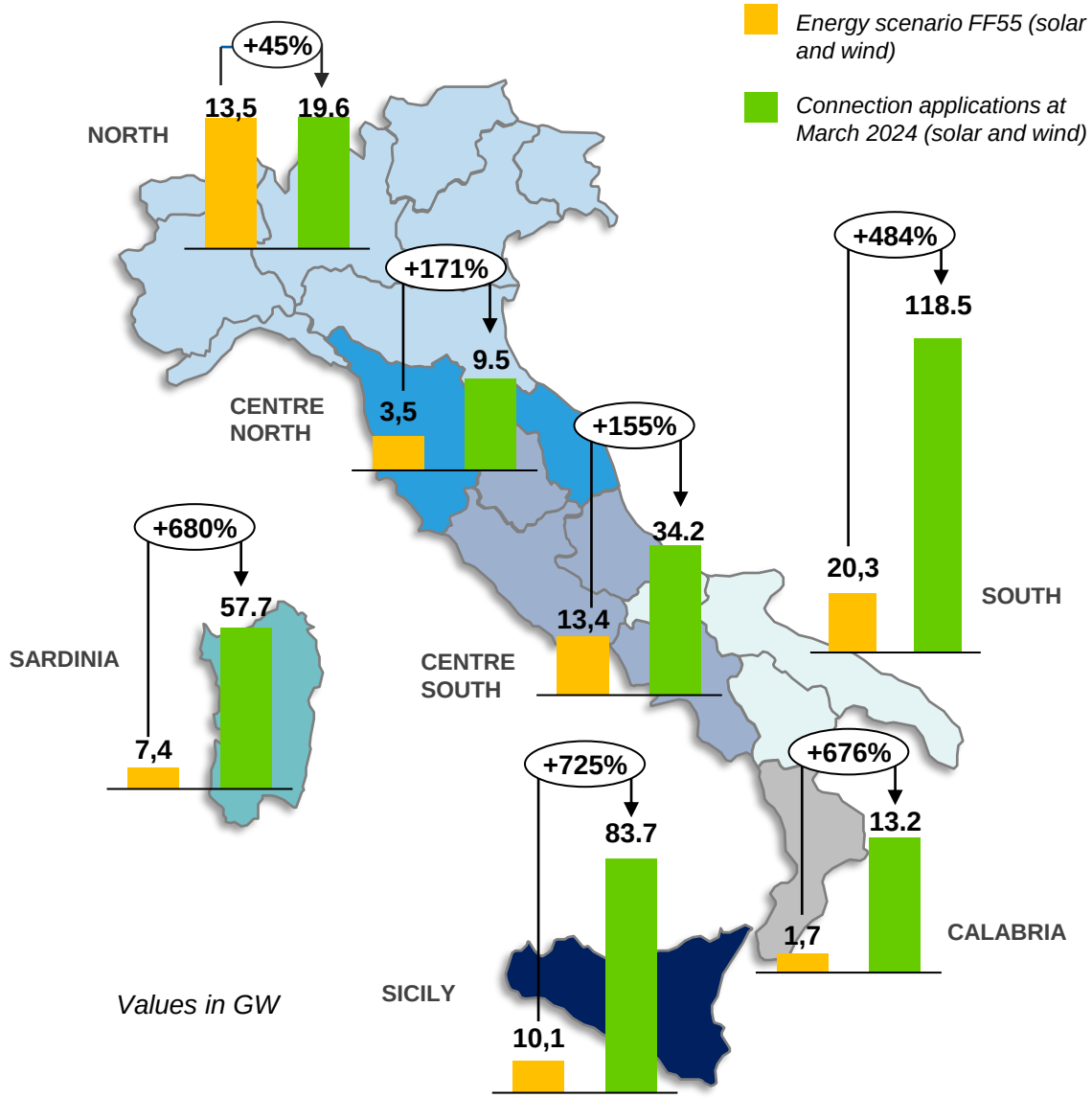
RES capacity increase «Fit-for-55» 2030



+336 GW

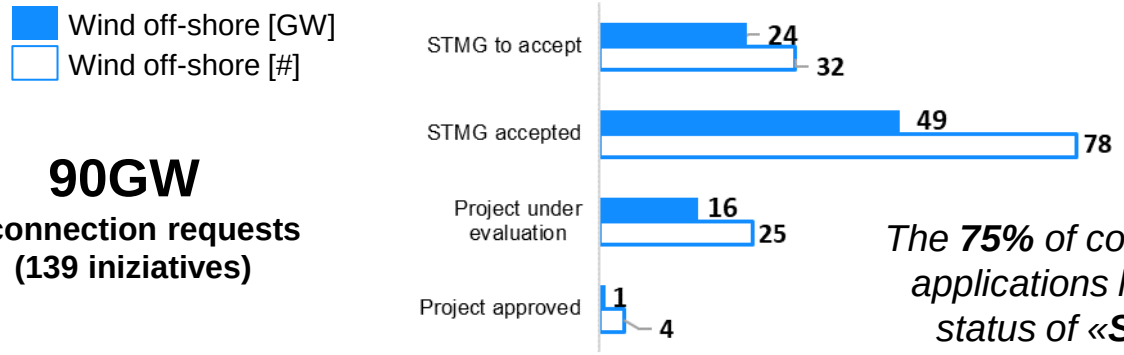
Connection applications (March 2024)

Off-shore wind | On-shore wind | Solar



Connection requests for off-shore Wind

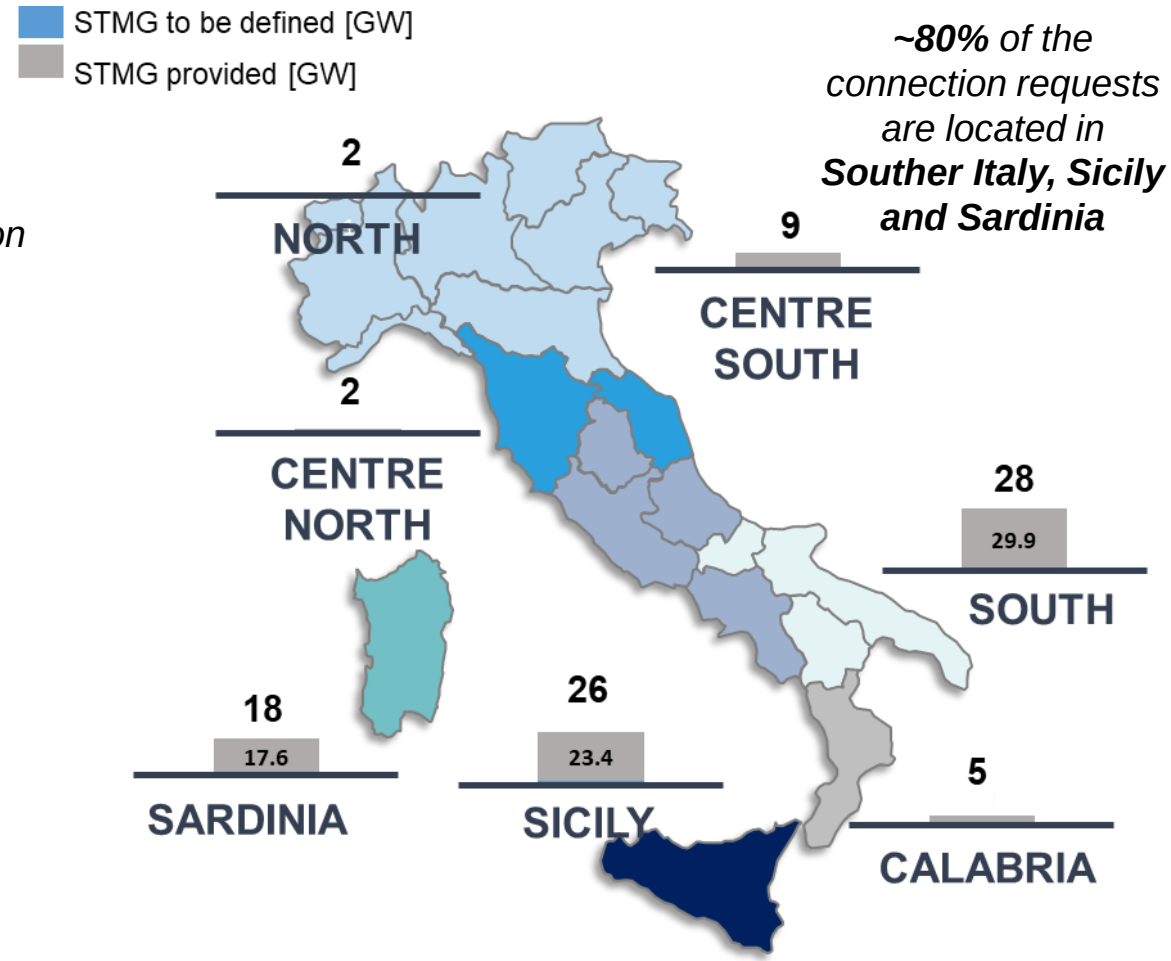
Connection applications clustered by state of progress



90GW
of connection requests (139 iniziatives)

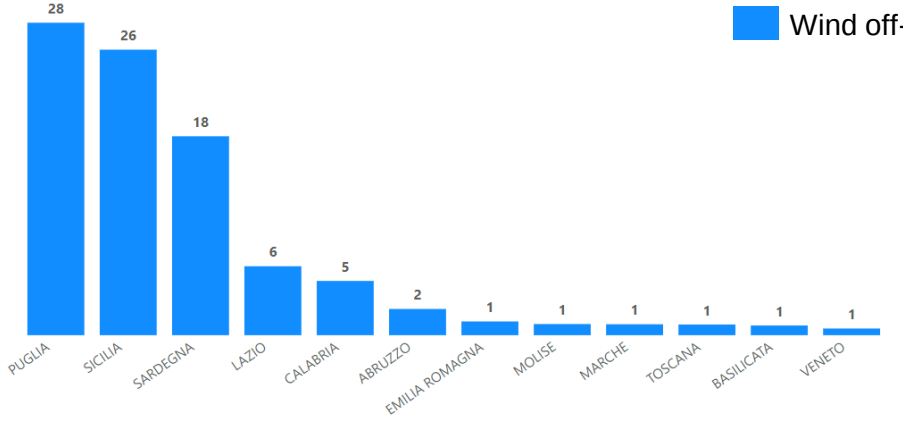
*The **75%** of connection applications has the status of «**STMG accepted**»*

Connection applications distribution: bidding zones detail [GW]



~80%** of the connection requests are located in **Souther Italy, Sicily and Sardinia

Connection applications distribution: regional detail [GW]



Connection requests for wind off-shore

WIND OFF-SHORE CONNETION REQUESTS

Wind off-shore connection requests are more than 90 GW

Most of the connection requests (more than 80%) **are concentrated in the southern Italian regions** where the potential for offshore wind, both in terms of geographical suitability and producibility, is higher. The regions with more requests are, in order, Puglia, Sicily and Sardinia.

The floating substation solution for RES offshore collectors is more suitable for the bathymetry of the **Mediterranean Sea**, which is characterized by **depths of several hundred meters** just a few km away from the coastline

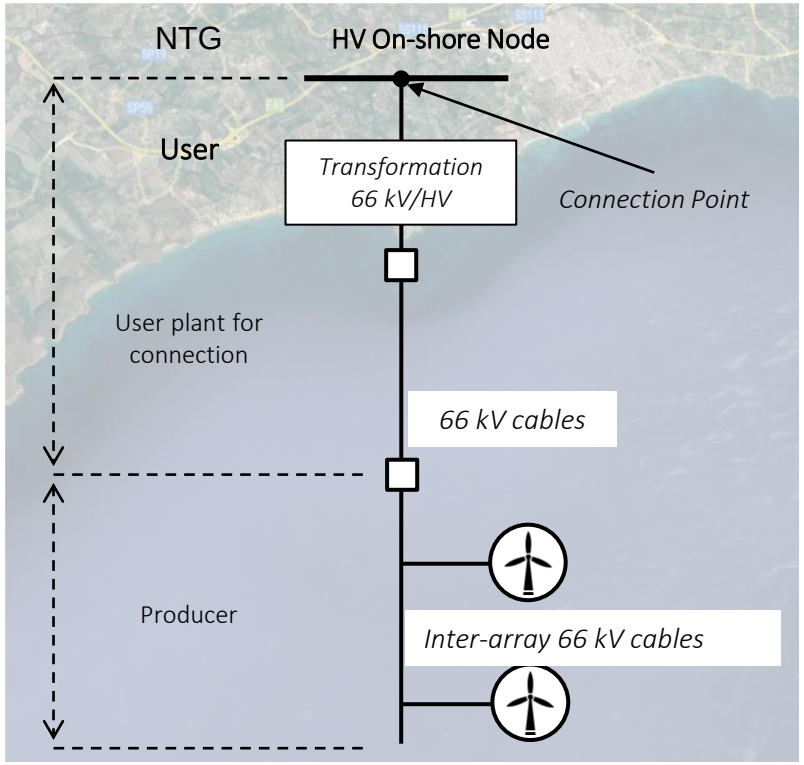
Raising issues for AC/DC converter stations

ITALY - OFFSHORE WIND FARM PROJECTS MAP

Connection solution (scheme) for wind off-shore

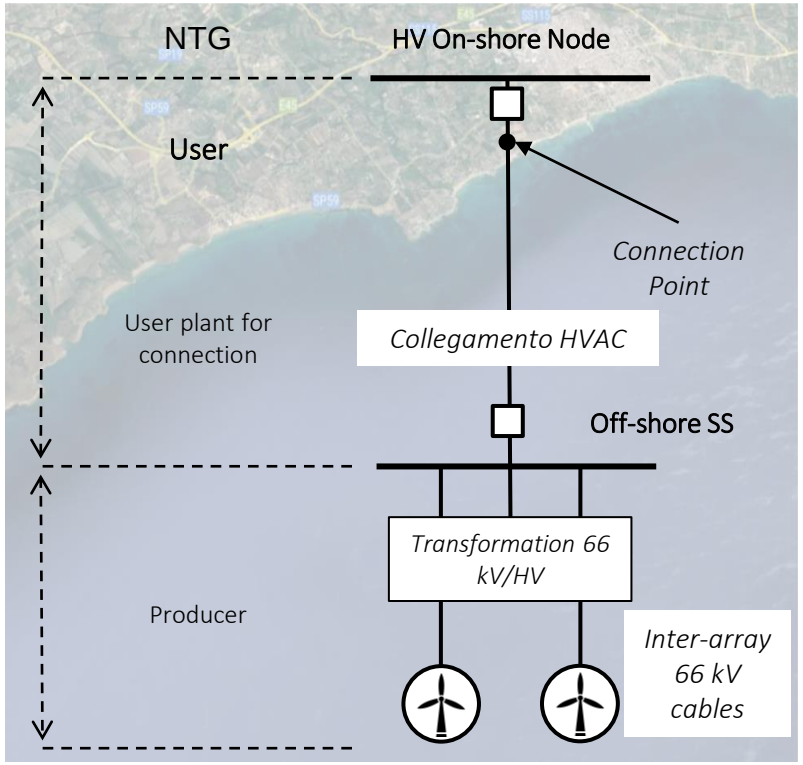
OPTION 1

- Application for distances **up to approx. 40-60 km** from new/existing NTG node
- Scheme with **direct 66 kV connection** of the windfarm (6-7 turbines of 14-17 MW) to an on-shore HV node



OPTION 2

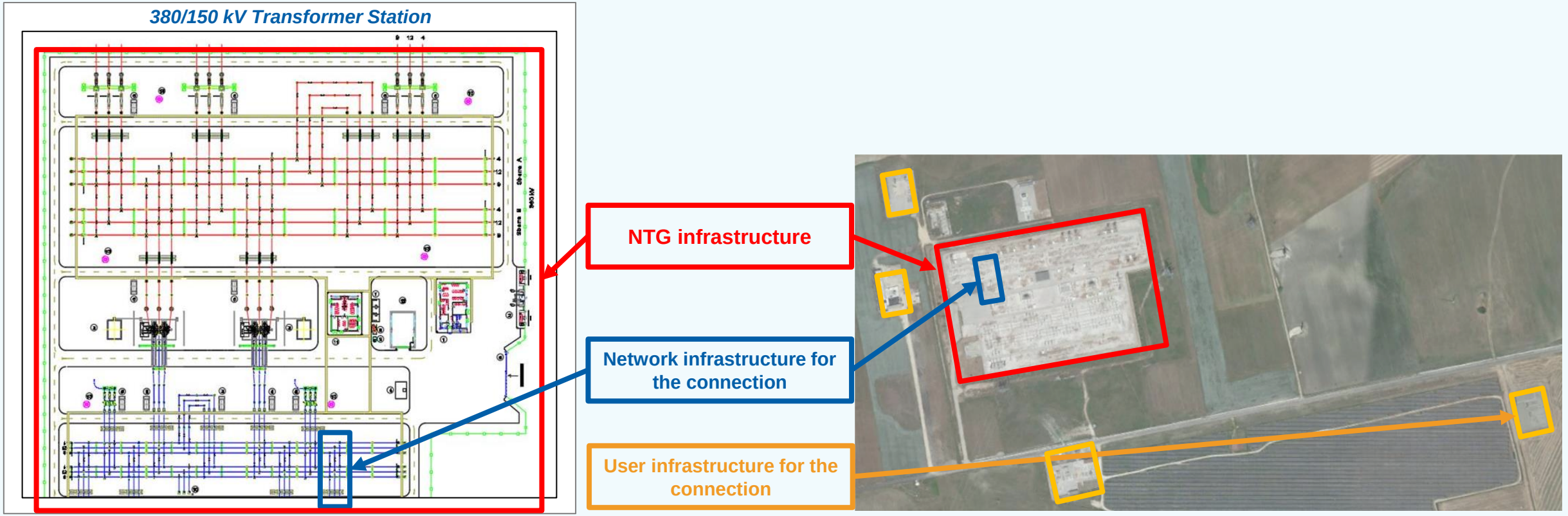
- Application for distances **over 40-60 km** from new/existing NTG node
- Scheme with **HVAC connection (up to 120 km) or HVDC connection (over 120 km)** of a SS to an on-shore HV node



Connection solution (scheme) for RES on-shore

In the former regulation framework, Terna provided connection solutions for RES on-shore initiatives collecting **380/150 kV transformer stations** or on **150 kV switching stations** where:

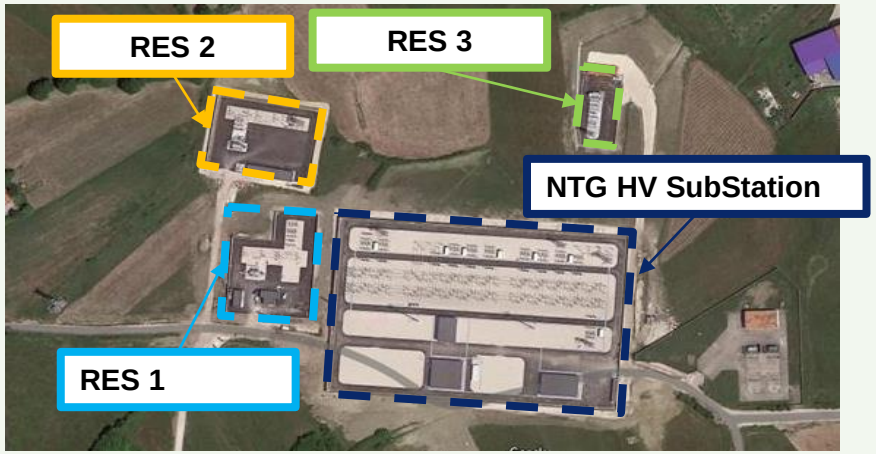
- ✓ The **collecting stations** is under the National Transmission Grid perimeter;
- ✓ The **150 kV bay** represents the **network infrastructure** for the connection, under the TSO responsibility, payed by the RES producers based on the **power injection**;
- ✓ The **150/36 kV substation** represents the **user infrastructure** for the connection, located near to the NTG station and under the producers responsibility.



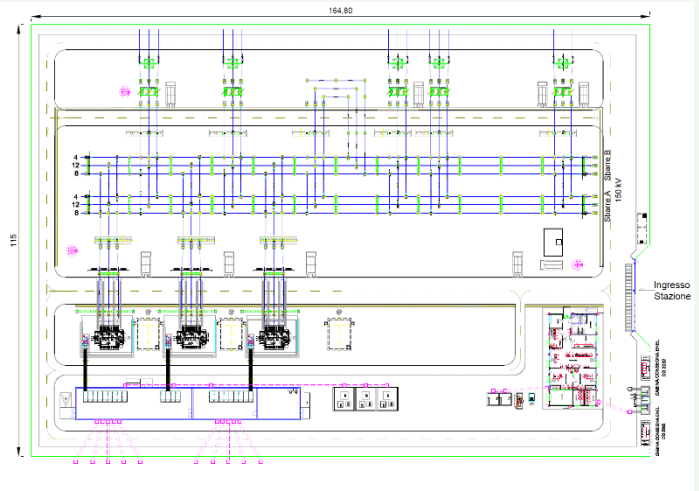
Connection solution (new 36 kV scheme) for RES on-shore

National Network Code provided for the standard to connect **power plants smaller than 200-250 MW** (maximum capacity of the substation bay) to the 132/150 kV. The nominal power of the initiatives resulted strongly undersized as compared to the capacity of the bay.
In order to **optimize the use of the grid infrastructures** and avoid the oversizing of the substation, the new standard voltage level **for RES power plants with rated power up to 100 MW has been introduced.**

AS-IS



TO-BE



Advantages:

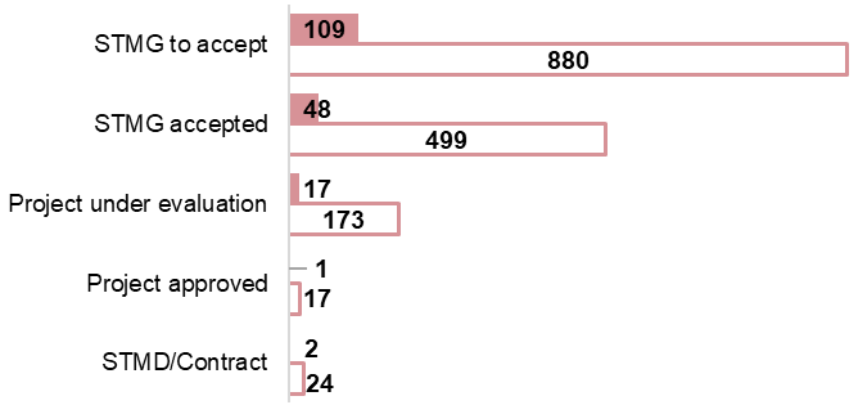
- design **more consistent with the nominal power of the initiatives**;
- reduction of the administrative timelines;
- **simplified and standardized connection layout**, thanks to the installation of one 36/132-150 kV transformer shared among multiple initiatives and managed by the TSO;
- **reduced land occupation**, avoiding the user's substation where the step-up transformer is installed;
- lower local opposition and simplified permitting process;
- **improved management of the RES power plants** during the connection process and the operational phases;
- **cheaper solution and infrastructures rationalization**, resulting in cost optimization for the system.

Connection requests for Battery Energy Storage System (BESS)

Connection applications clustered by state of progress

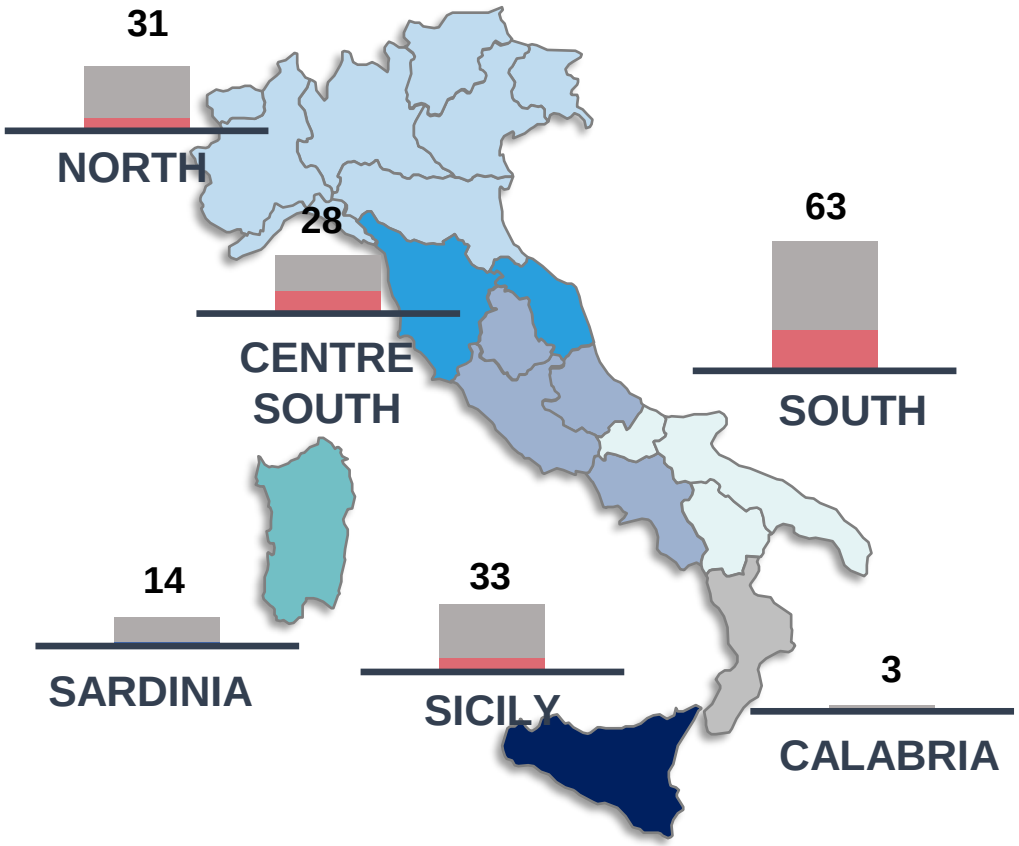
BESS [GW]
BESS [#]

177GW
of connection requests
(1593 iniziatives)



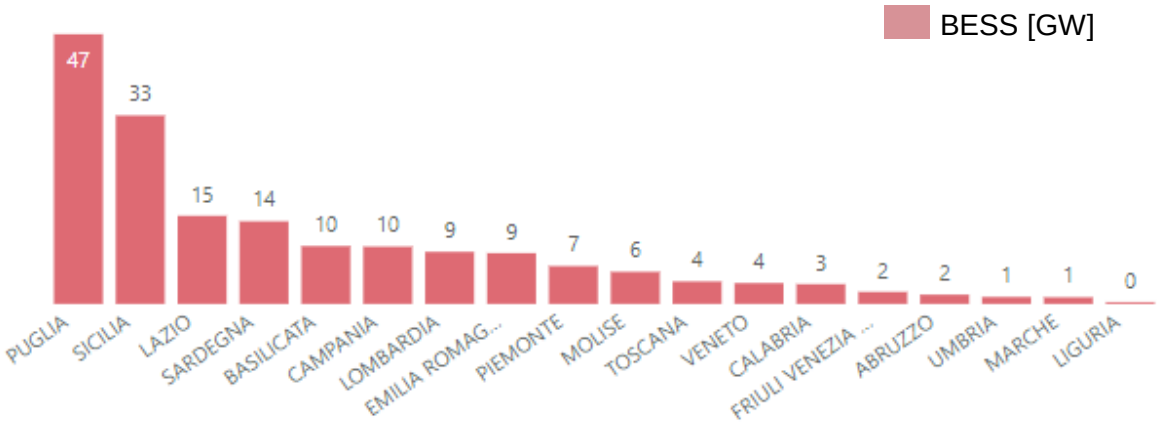
Connection applications distribution: bidding zones detail [GW]

STMG to be defined [GW]
STMG provided [GW]



Connection applications distribution: regional detail [GW]

BESS [GW]



Grid Planning: Italian Grid Development Plan

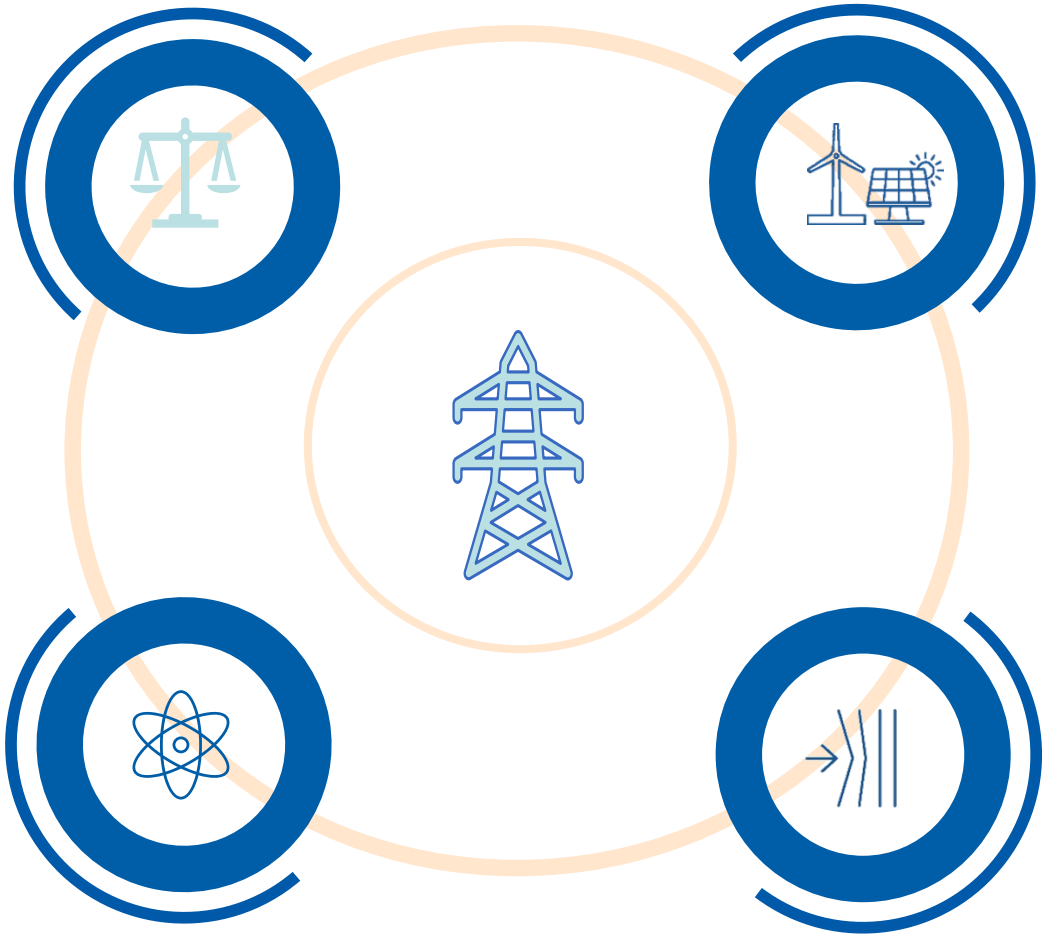
Guidelines

Increase exchange capacity between bidding zones

Increasing transfer capacity btw each market section, moving more and more power generated by renewables in Southern Italy to the load centers of Northern Italy, through the development of innovative infrastructures

Infrastructural synergies

Enhancement of synergies with already planned projects, exploit corridors of existing assets and reuse disused sites, minimize the impact of infrastructure on the territory



RES integration

+70 GW of **new renewable capacity by 2030**, to achieve at least 65% share of the RES in gross electricity consumption and -55% of CO2 emissions

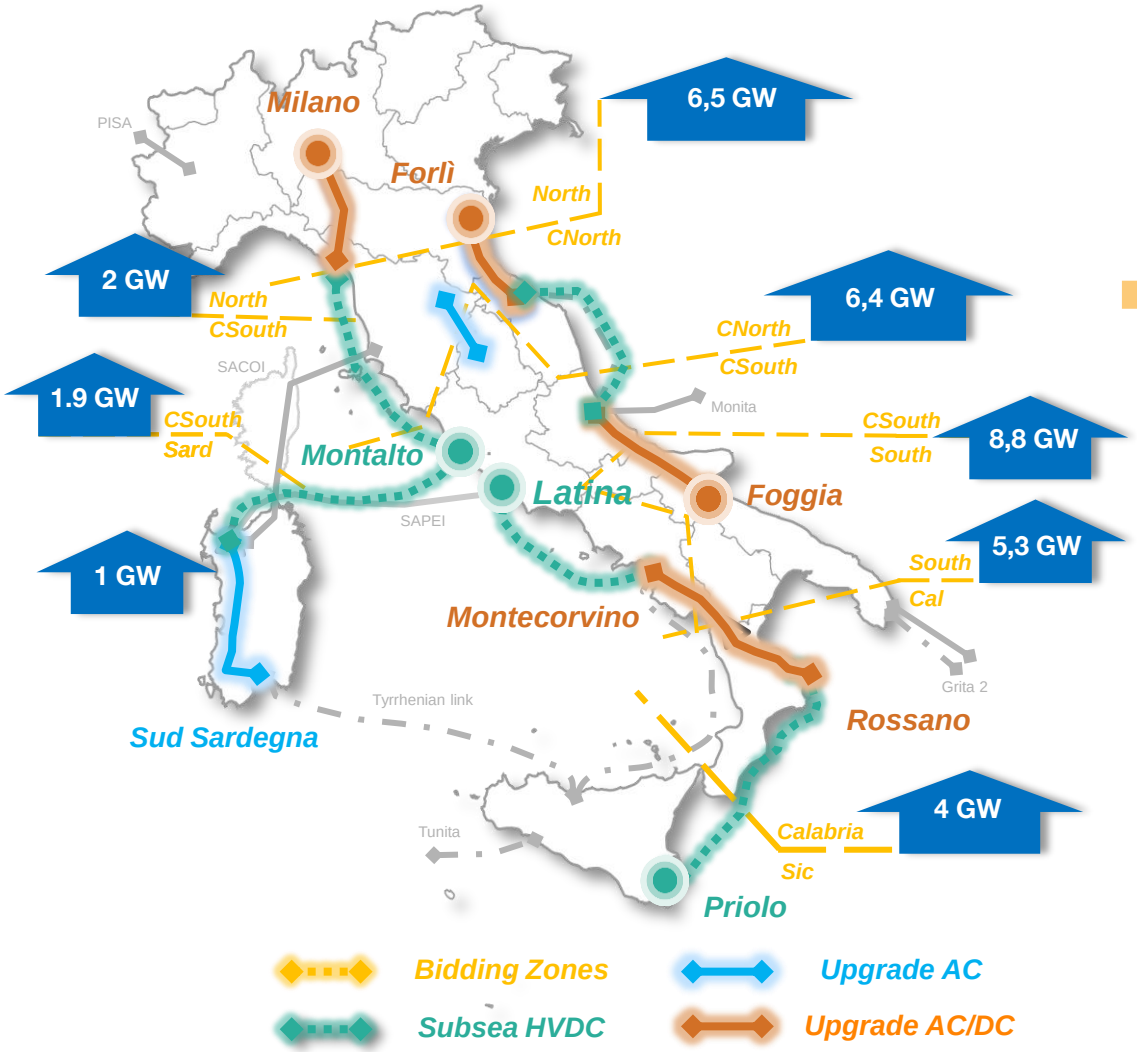
Enhancement of system strenght and resilience

Increase of system strength in the grid thanks to the planned projects

Grid Planning: Italian Grid Development Plan

Key features of the new Hypergrid project

Total NTC including HG *Corridors*



Double transfer capacity over bidding zones up to **+30 GW**

Improving investments efficiency with a per unit cost of **0.7 Bln€/GW** (Hypergrid investment/new capacity grid)

Over 400 km of AC power lines upgrade **with new infrastructure technology**

More than 2500 km of **new DC overhead lines and cables**

New AC/DC converter station in **VSC technology** up to **13 GW**

Support the grid with key needs (Power System Strength, flexibility, etc.)

Grid Planning: Italian Grid Development Plan

Grid Planning with HVDC vs. Conventional AC Technologies

HVDC

- **HVDC** offers unique advantages and a **broader set** of **capabilities than AC lines** (higher transfer capacity, electromagnetic fields reduction, better power flows directionality)
- Allow to more easily **integrate RES**, with savings in investment costs (new development needs, even on other grids and regarding connection infrastructures), allowing better transmission capacity and efficiency
- AC transmission lines can be converted into DC lines and can be integrated in existing infrastructures
- Will allow to pursue higher RES integration, allowing a **wider vision** (of the grid and technological), even for other DC sources

HVAC

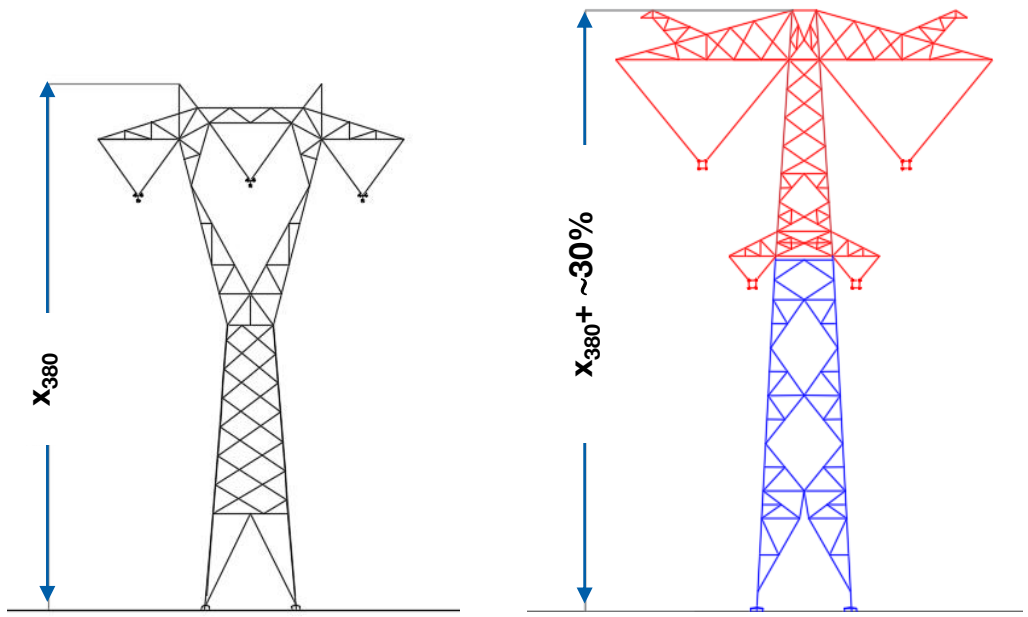
- More difficulties to control the voltage for final users
- Require a security of supply with accurate voltage and frequency control (reactive compensation, f/P control, FACTS)
- The decentralization of the generation enlightened the issues related to the AC grids (more reactive power, minor short circuit power…)
- The power flows controllability is more difficult

DC grids will allow a better transport capacity, modularity and scalability compared to AC grids, allowing the optimization of investments and of commissioning time. DC grid will allow to better integrate DC sources (electrolysers, batteries, EV chargers…)

TRANSMISSION IN DIRECT CURRENT (DC)

The reconstruction and refurbishment of existing AC backbones will be implemented through the review of pylons technologies making then able to DC transmission.

Example of new Pylons DC at 500 kV



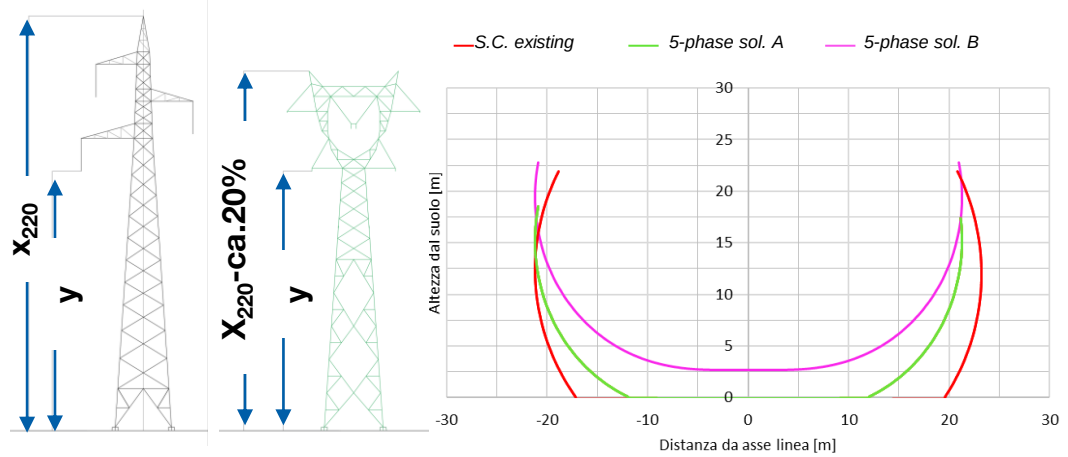
TRANSMISSION IN ALTERNATE CURRENT (AC) AT A FREQUENCY OF 50 HZ

The reconstruction and retrofit of existing AC backbones will be implemented adopting technologies that will be able to limit EMF.

The 5-phase 230 kV (splitting phase) guarantees an increase in transmissible power of approx. **+250%** maintaining the same *EMF Safety Distance* of a single circuit support.

The reconstruction of the power line also allows its electrical parameters to be modified, thus giving an advantage in terms of transmission of active power over long distances and improving static stability.

Example of 5-phase Pylons 230 kV



Thank you for your attention!