The need for flexibility in a climate neutral electric system

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Power sectors in transformation

Impacts on electricity system operation

The progressive increase of (variable) renewables will have **substantial impacts on the electricity system** and will lead to a series of operational challenges, already visible today, to be faced:

Cluster	Impacts on Electricity System management
Technical characteristics of RES	Reduction of **system inertia**
	Reduction of resources providing **voltage and frequency regulation**
	Reduction of **short-circuit power**
Variability of RES	Decrease of **adequacy margin**
	Growing **over-generation** periods during noon hours
	Increasing steepness of **residual load evening ramp**
Location of RES	Increasing **grid congestions** due to geographical distance between RES supply and consumption centres
	Growing **system operation challenges**, due to growth of Distributed Generation

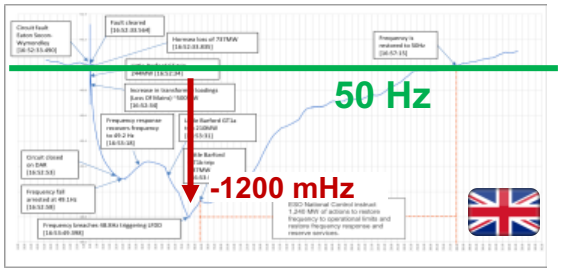
A full integration of renewables into the electricity system can only be achieved by implementing a set of essential, coordinated and coherent actions

Power sectors in transformation

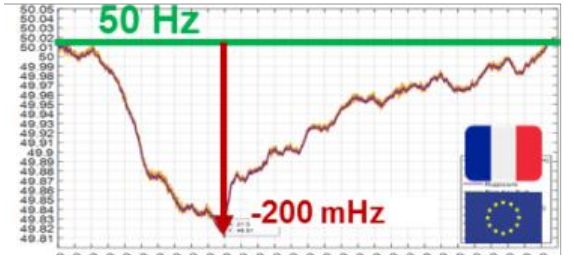
Recent frequency events (2019)

European frequency – 12.06.2019

UK Frequency – 09.08.2019



FR frequency – 07.10.2019



	June 12, 2019	August 9, 2019	October 7, 2019
CAUSE	• **Incorrect forecast** of renewable production in Germany • Deficit of ≈ 6.500 MW in real time	• **Generation loss after lightning** • Deficit of ≈ 2.000 MW in real time	• Loss of a **900-MW nuclear reactor** in northern France • Deficit of ≈ 3.500 MW in real time
EFFECT	• Frequency reached **49.90 Hz** • For 20 minutes, there was a risk of widespread **power failure** on the entire European territory	• Frequency reached **48.80 Hz** • For almost 60 minutes, 1.1 million users have been automatically disconnected (hospitals included)	• Frequency reached **49.80 Hz** • Interruptible load disconnection in France for ca. 1.400 MW • 1,000 MW injection by Terna into the European network

Evidence of progressive fragility of the network is significant and visible throughout Europe. The integration of new RES capacity in a context of progressive reduction of large generation units requires strategic measures in terms of grid development, storage and flexibility resources

Key enablers for energy transition

1 Transmission grid development

- **Strengthening** of North-South **backbone** and **grid reinforcements**
- **Foreign interconnections**
- **Investments** in **voltage regulation and to increase the inertia** of the electricity system
- **Interventions to strengthen grid resilience**

2 Long-term price signals

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

3 Market evolution

FOCUS

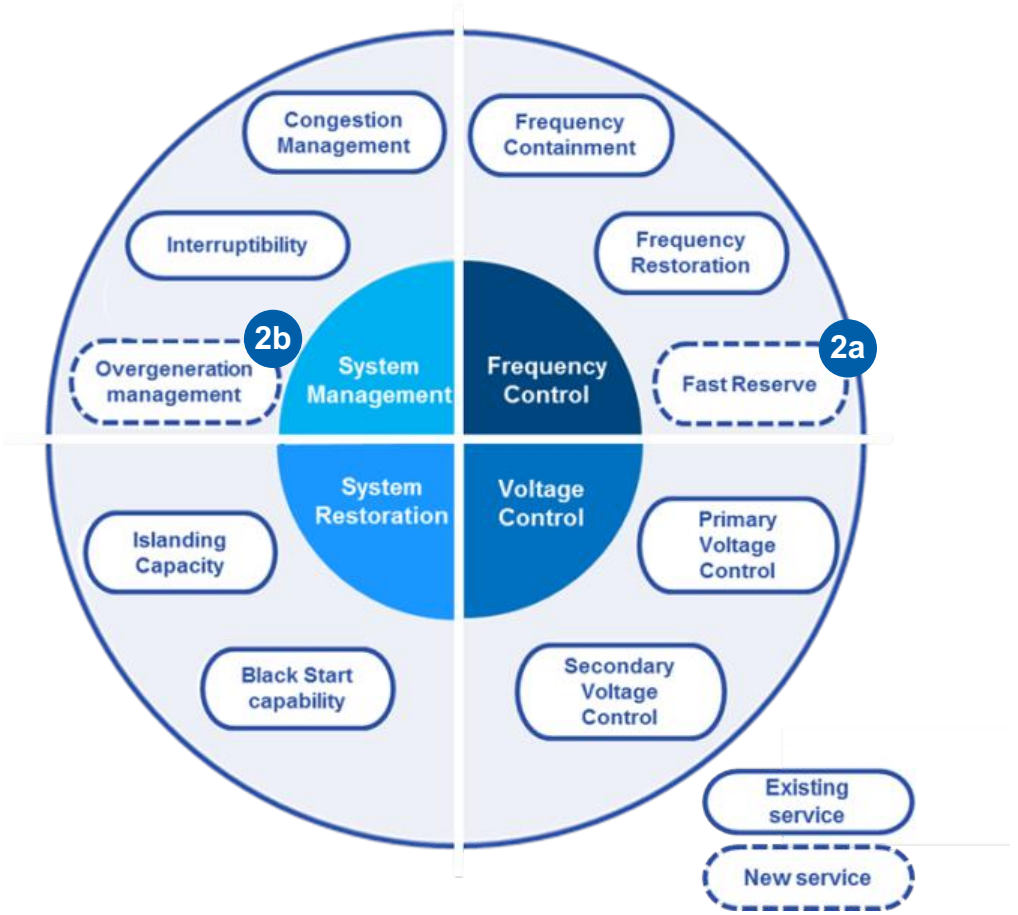
- **Evolution of the structure of the ancillary services market** to cope with new needs (voltage regulation, inertia,…)
- **Participation of new flexibility resources in ancillary services market,** i.e. demand, distributed generation, variable renewable energy sources and storage, including electric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

4 Innovation and digitalisation

- **Digitalization** of the **Transmission Grid** (Assets and processes) and of **electricity system operation**

Market evolution

Overview of ancillary services



Redesign areas

1

1. Provision of **existing ancillary services from new resources** in order to diversify and adapt to the changing generation mix.

2

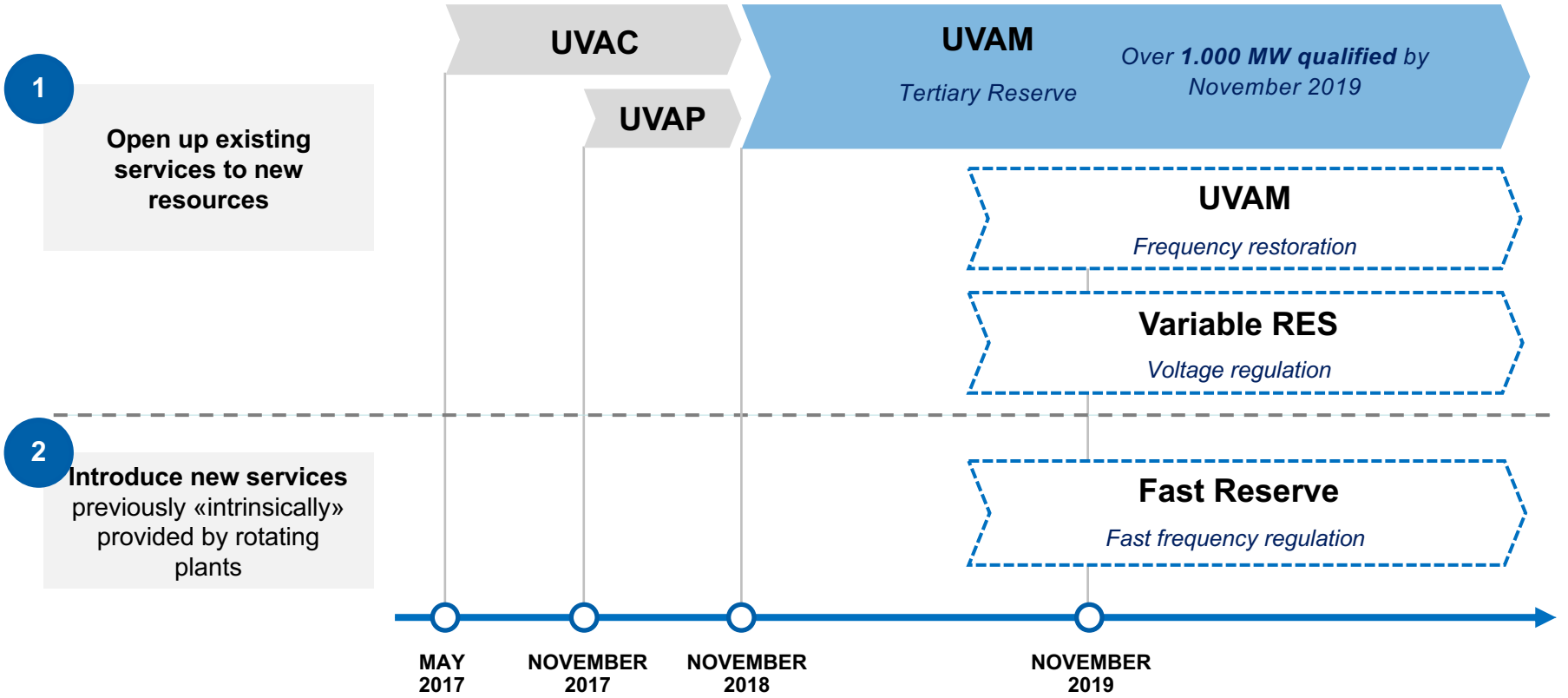
2. Introduction of new services that are required to ensure a secure system operation but were previously provided implicitly by other resources "for free" or simply not needed.

A comprehensive re-design of ancillary services markets is an essential ingredient to support the full integration of renewables

Market evolution

Evolution and redesign of the ancillary services market

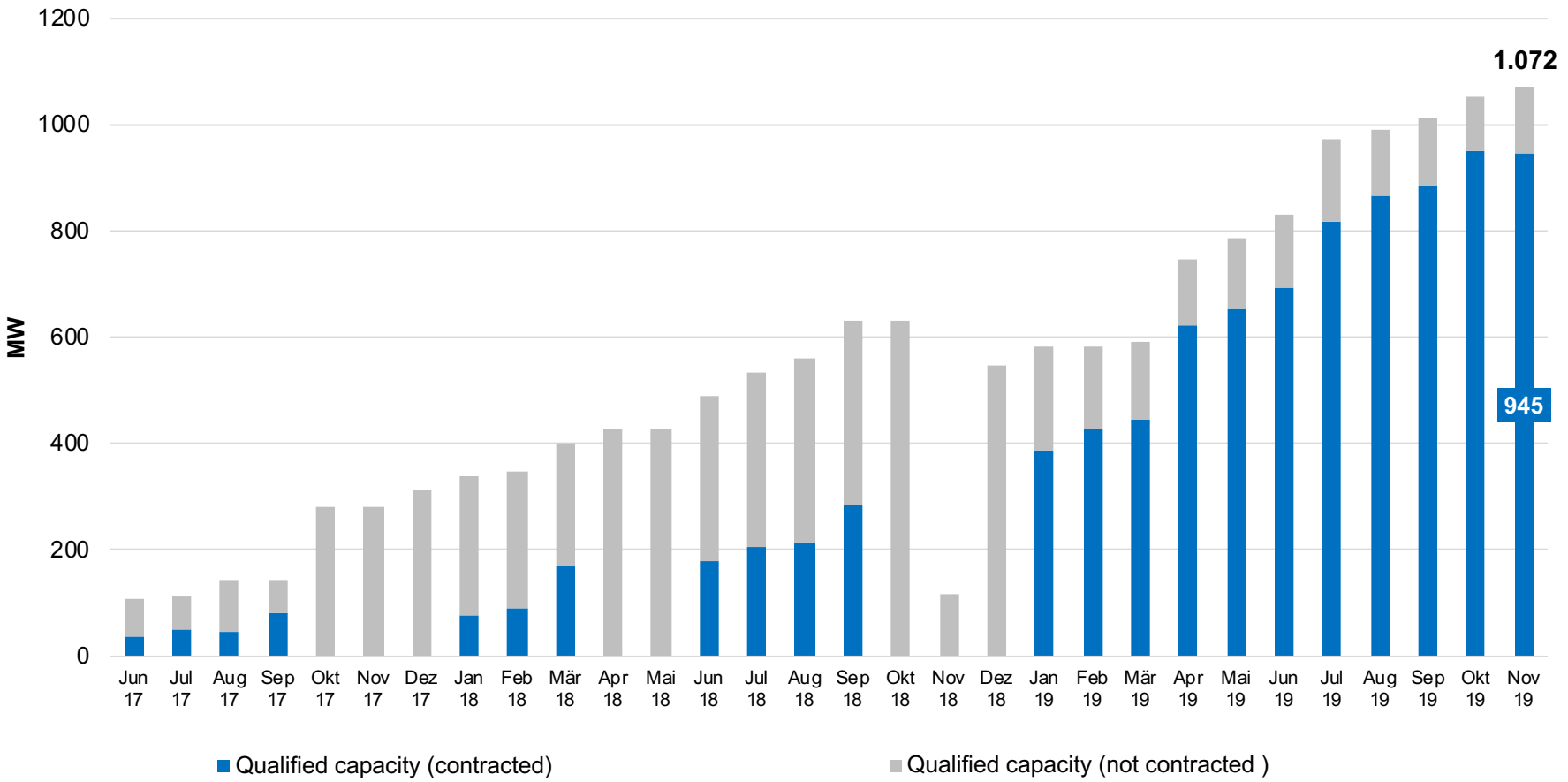
A profound redesign of the services market is needed. Terna has started this process, working on two fronts and leveraging on the experience gained



Starting from 2017, Terna started a series of pilot projects aimed at increasing the resources able to offer explicit grid services, previously intrinsically provided by thermoelectric plants.
The strong will of Terna is to continue in the implementation of further pilot projects.

Market evolution

New flexibility resource

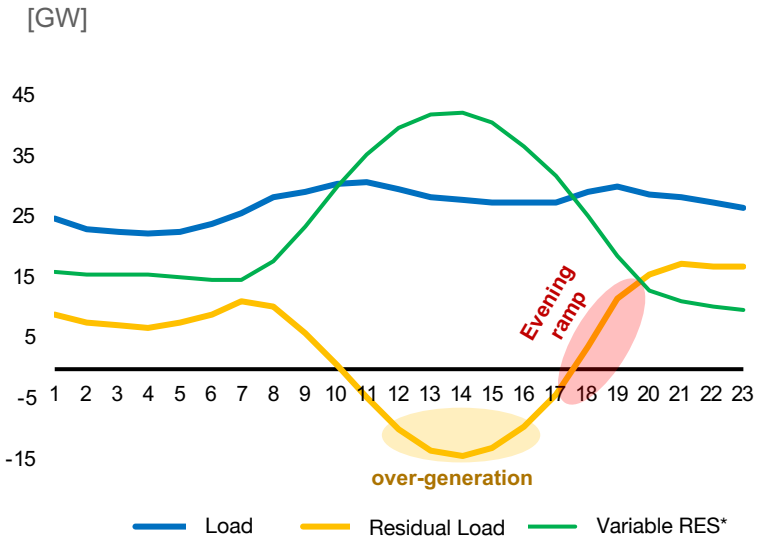


With the last auctions in November, more than 1,000 MW of mixed aggregates have been qualified for the Italian ancillary services market, of which about 90% by means of forward contracts

Market evolution

New service: overgeneration management (electricity storage)

Residual load at 2030



- Increasing **over-generation** periods during the central hours of the day
- Increasing steepness of the **evening ramp** of the residual load

OBJECTIVES

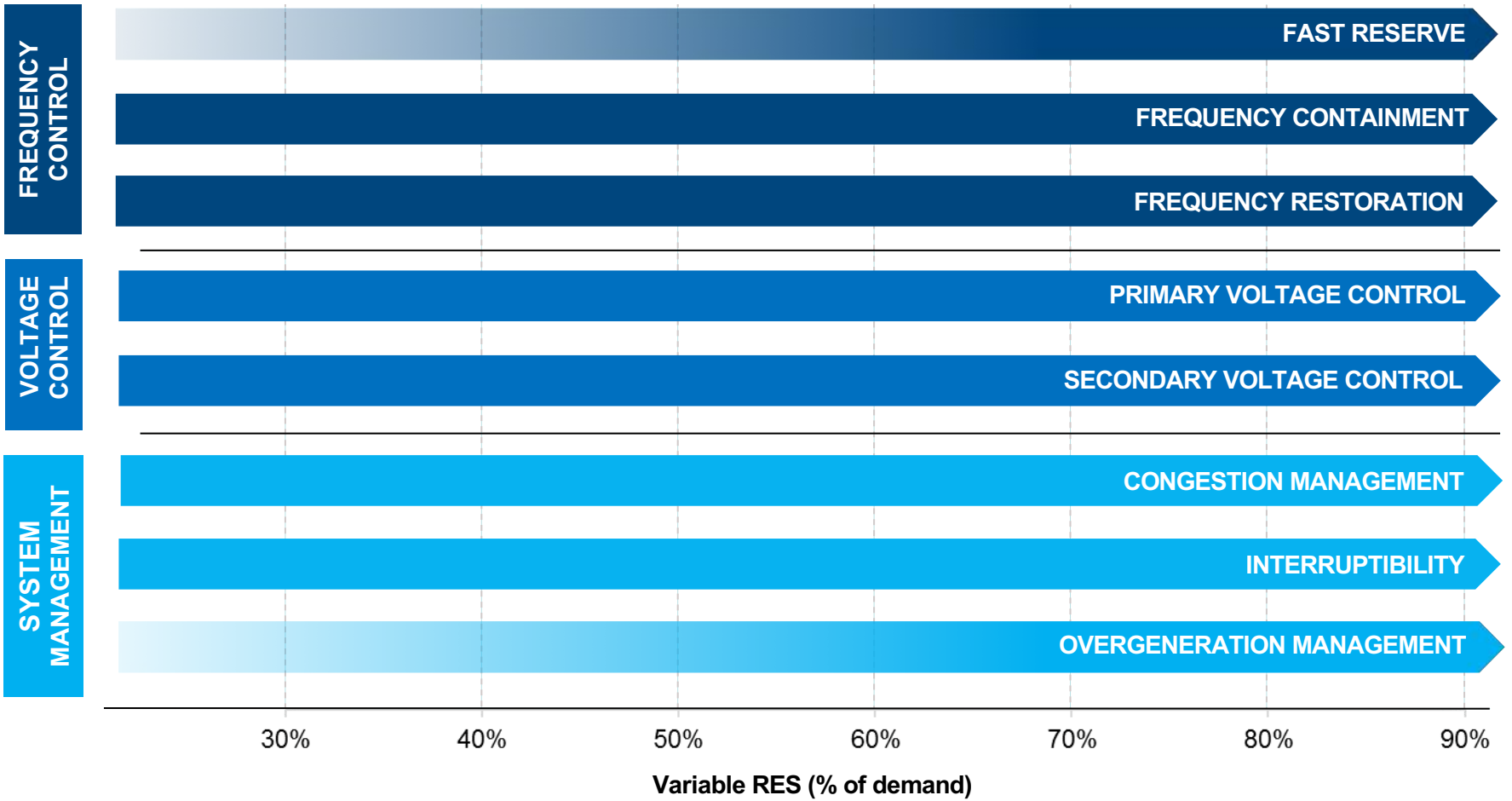
- **Reduce grid congestions and overgeneration**
- Accumulate energy around **noon hours** (high RES production) and discharge when required by the system (e.g. during the steep evening ramp)
- **Supply frequency and voltage regulation services**
- **Increase short circuit power and the inertia of the system**

It is necessary to build new storage facilities to deal with structural overgeneration problems and to provide valuable services to support a safe management of the Electricity System

*Variable RES include wind, PV and run-of-river

Market evolution

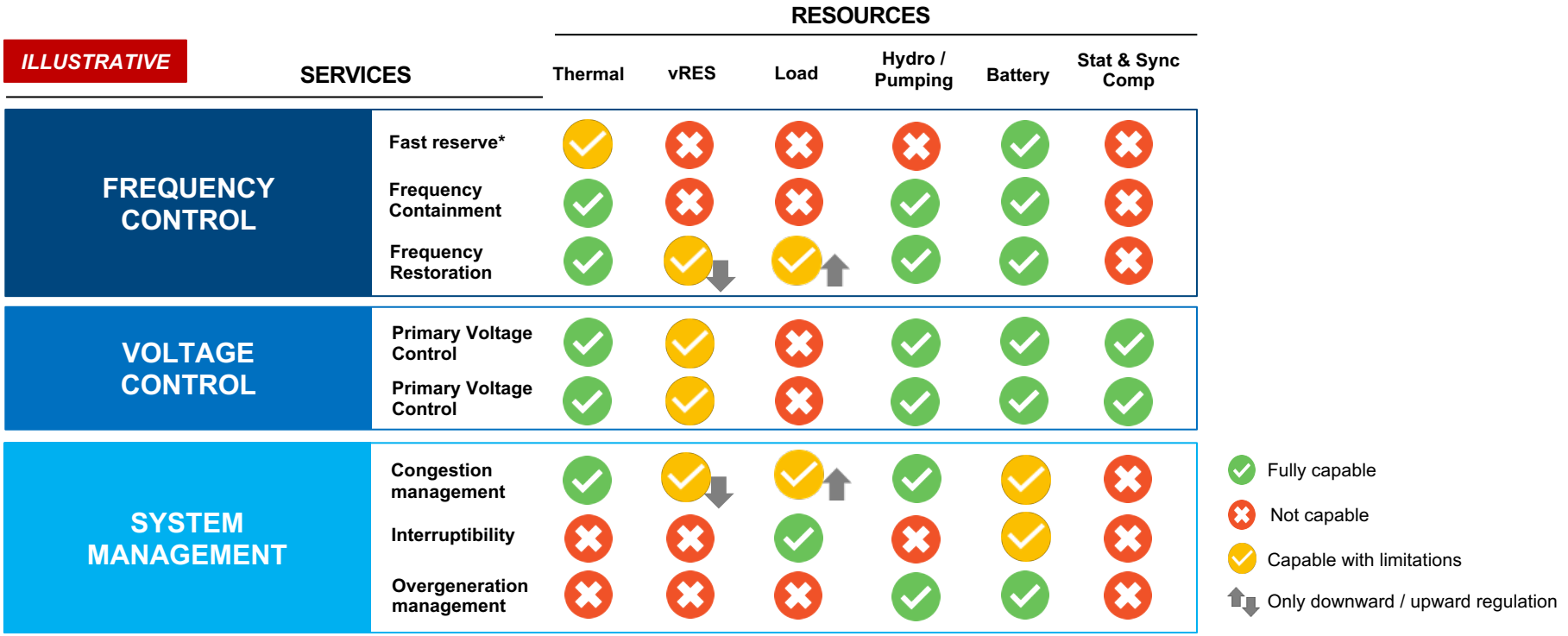
Evolution of services portfolio



There are services that have always been necessary to manage the electricity system, but that need to be progressively provided by new resources. Moreover, new services will emerge as the percentage of demand covered by variable RES increases.

Market evolution

Grid services and technologies able to provide them



It will be necessary to build a regulatory framework that can ensure the development and market participation of new flexibility resources, while considering the different capabilities of each technology

* Activation time < 1 second

Key messages

- Variable RES are the **enabling factor to decarbonize** global economy but their integration in the electric system poses **unprecedented technical challenges**

- The exact recipe varies from country to country but **main ingredients** are always the same:
  - **Grid and interconnections development**
  - **Long term, capacity/availability based price signals** to support capex-only investments and complement short term energy and services markets
  - **Market design evolution** to unlock flexibility from new resources and procure new services
  - Investments in **innovation and digitalization** to observe and control DERs

- RES can contribute in providing flexibility to the system, but **active power services from RES always imply loss of renewable generation**; is this really acceptable?

- All the “new” resources – RES, storage, DSR – are **capital intensive** (high Capex, low or null Opex). In many cases short term scarcity price signals are not adequate to foster private investments and financing; when pricing signals emerge it’s already too late

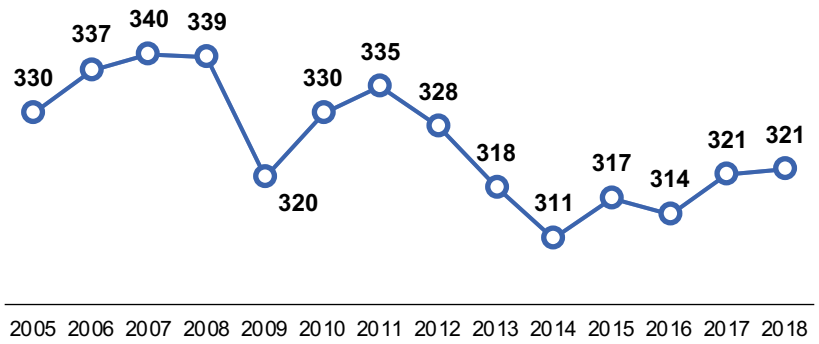
BACKUP

Power sectors in transformation

The example of Italy

Total electricity demand

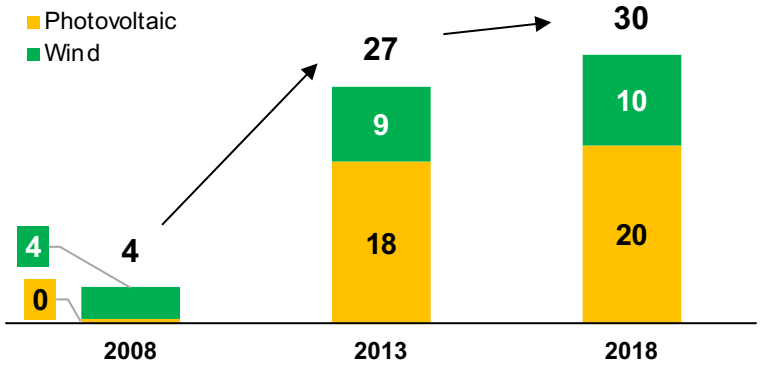
[TWh]



Electricity demand still under pre-crisis level

Installed capacity of PV and Wind

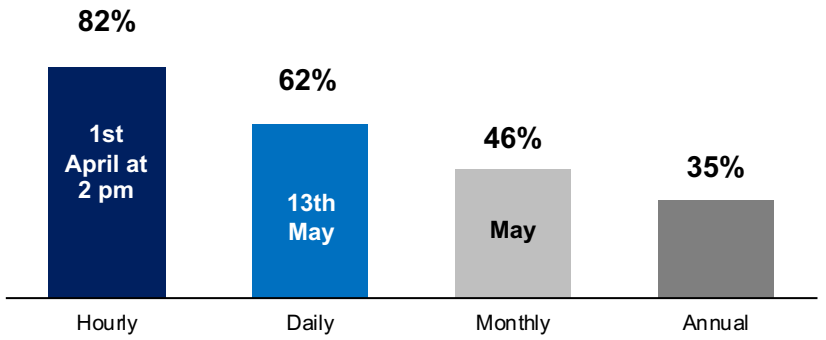
[GW]



Significant increase of RES capacity over 10 years

Peaks of RES coverage (2018)

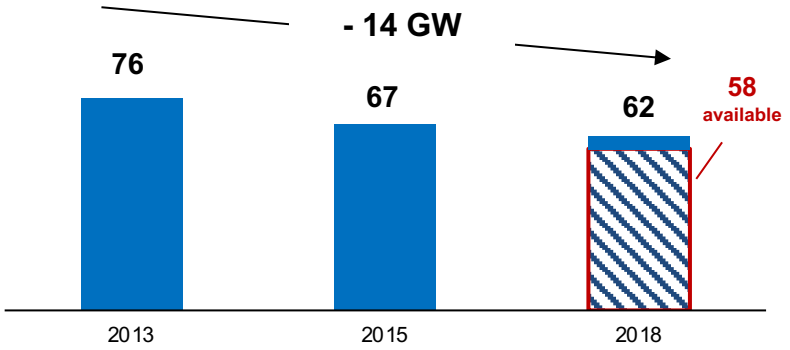
[%]



Ever-increasing share of RES

Installed capacity of conventional power plants

[GW]



Progressive reduction of thermal capacity

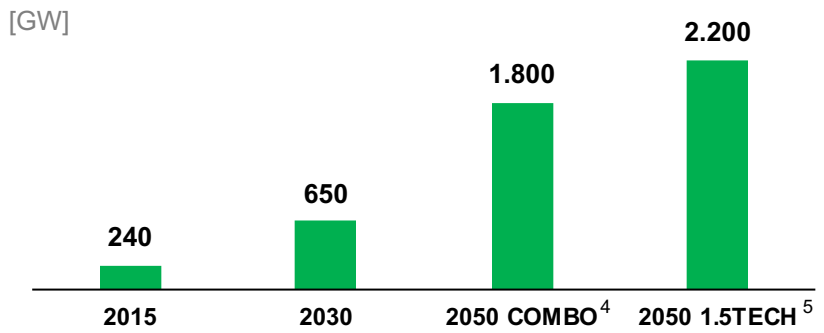
Power sectors in transformation

Looking towards 2050

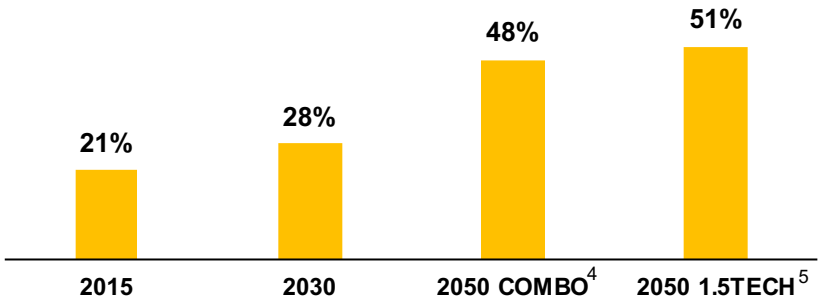
2020 ("20-20-20") and 2030 ("Clean Energy Package") targets, 2050 EU Energy Strategy

	2020 EU 20-20-20		2030 Clean Energy Package		2050 EU Energy Strategy
GHG reduction (cp. to 1990)	*- 20%*		*- 40%*		*Up to -95%*
Energy Efficiency (vs BAU scenario)	*+ 20%*	*+ 24%* ✓	*+32,5%*	*+35%*	*Up to +35%* [1] *Compared to 2030*
RES share in final energy	*≥20%*	*≥17%* ✓	*≥32%*	*≥30%*	*Up to 60%* [2]
RES share in electricity	*≈35%*	*≈26%* ✓	*≥50%*	*≥55%*	*≥ 80%* [3]

Variable RES (wind and solar) installed capacity



Electricity in final energy consumption



The electricity sector holds the key for the EU's low-carbon economy, thanks to the intrinsic efficiency of electricity and the technological maturity of renewables such as wind and solar.

1 Change in primary energy consumption, EE Scenario
2 RES Share in Gross inland consumption, 1.5TECH Scenario
3 Decarbonised 2050 scenario
4 COMBO Scenario: -90% GHG
5 1.5TECH Scenario: -100% GHG ["1.5° C" ambition]

Market evolution

Fast Reserve

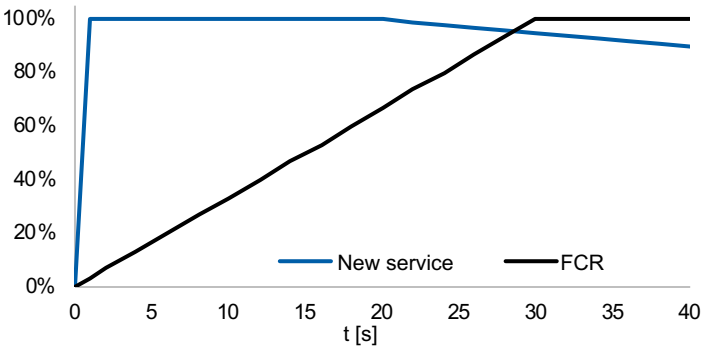
Objective: Introduction of a new service with fast activation (< 1 s) to support system inertia

Operating mechanism

- Fast activation (< 1 secondo)
- **Proportional response to frequency variations** and/or continous operation
- Possibility to be remotely activated for the Defense System
- Gradual release to reduce network disturbances

Service **not replacing FCR nor synthetic inertia** but a service coordinated with them to contribute to the dynamic stability of frequency

Illustrative functioning: activation

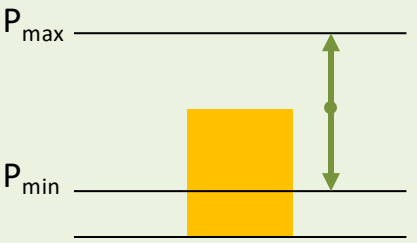
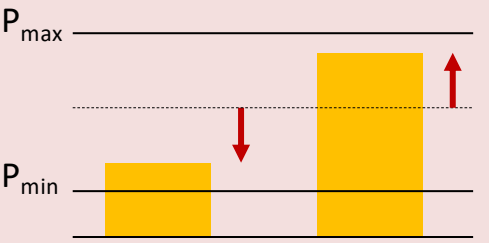
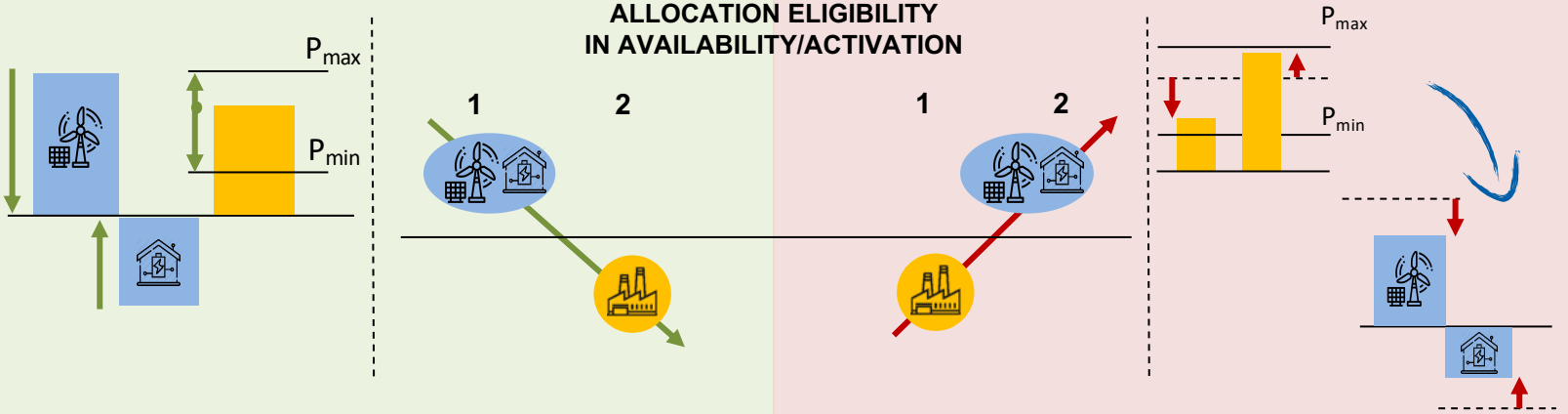


Need for a service to assist frequency dynamics in the **very first moments**

Participants, remuneration and requirements

- Resources meeting technical requirements for the provision of the service
- **Capacity remuneration**: procurement through auctions for multii-annual contracts for the hours of availability required [€/MW/h]
- **Variable remuneration**: none (negligible)
- **Requirements**: defined by Terna
- **Revenue stacking**:possibility to accumulate cash flow from other markets in the hours when availability for the Fast Reserve is not required

Availability and activation of flexibility resources

	Availability	Activation
TODAY		
	Today traditional plants provide reserve and balancing services to the grid, offering flexibility «downward» and «upward»	
FUTURE		
	The new resources are probably not suited to provide «symmetrical» flexibility because of their intrinsic characteristics as well as technical constraints	

The new flexibility resources are very different from the traditional flexibility providers and it is essential to explicitly remunerate availability of flexibility services in order to facilitate their participation