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For power system expertise

Italian grid planning, impact of growing RES and Storage

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The EU roadmap is targeting a 100% carbon free of human activities by 2050

2020
climate
and energy
package

23 April 2009

25 February 2015

2020-2030
Energy Union
Package

2030
Framework for climate
and energy policies

23 October 2014

Nov. 2019 Clean Energy
for all Europeans
package

Dec 2019

2050
Roadmap for moving to a
zero-carbon economy

EC, Sept. 2020

2030 Targets	Old objective	Green Deal
GHG reduction vs 1990	-40%	-55%
%RES on energy consumption	32%	40%
Energy saving on consumption[1]	-33%	-36%

Need for **flexibility** to operate a highly decarbonized power system in compliance with **reliability** and **security** standards

[1]Energy Savings evaluated against the 2007 Baseline projections for 2030

Current situation and targets for energy transition: focus on Italy

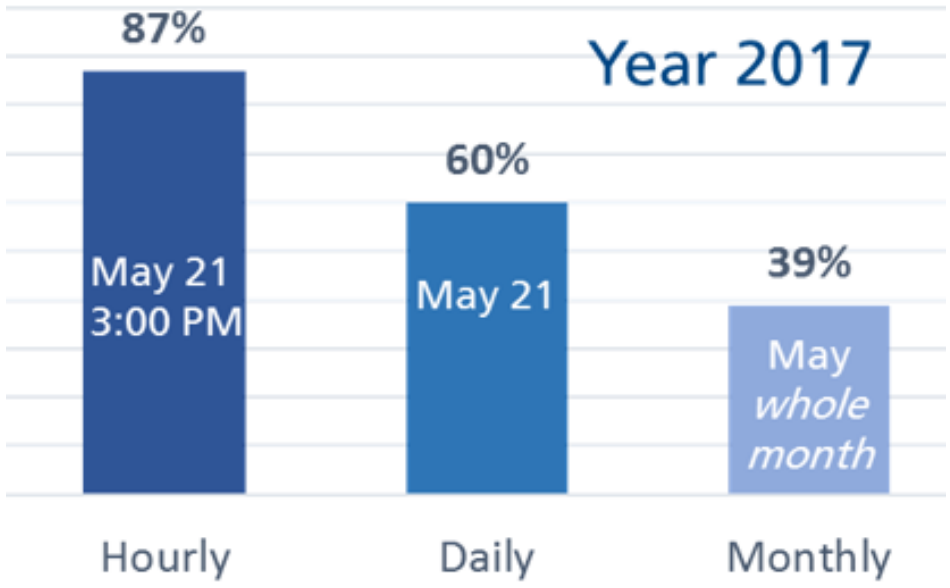
	2020 Preliminary[1]	2030 Target PNIEC 2019	2030 Potential new target[1]
GHG reduction vs 1990	**-25%**	**-40%**	**-55%**
%RES on electric consumption	**38%**	**55%**	**70%**
%RES on energy consumption	**19%**	**30%**	**40%**

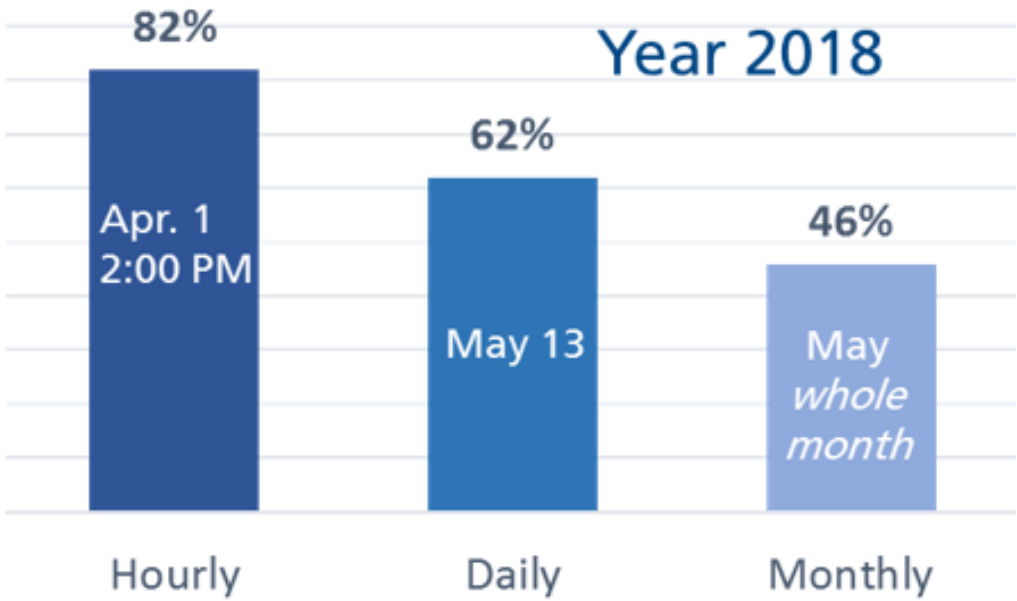
To attain the new 2030 target on the power sector, **6.5 GW/yr of new RES power plants** shall be commissioned. The current trend is 1 GW/yr of new RES power plants

[1]Elettricità Futura estimates, Parliamentary Hearing on National Resilience and Recovery Plan (PNRR)

The Future is coming on soon…

Despite a still moderate RES penetration, peaks of RES generation, namely V-RES, are already occurring now



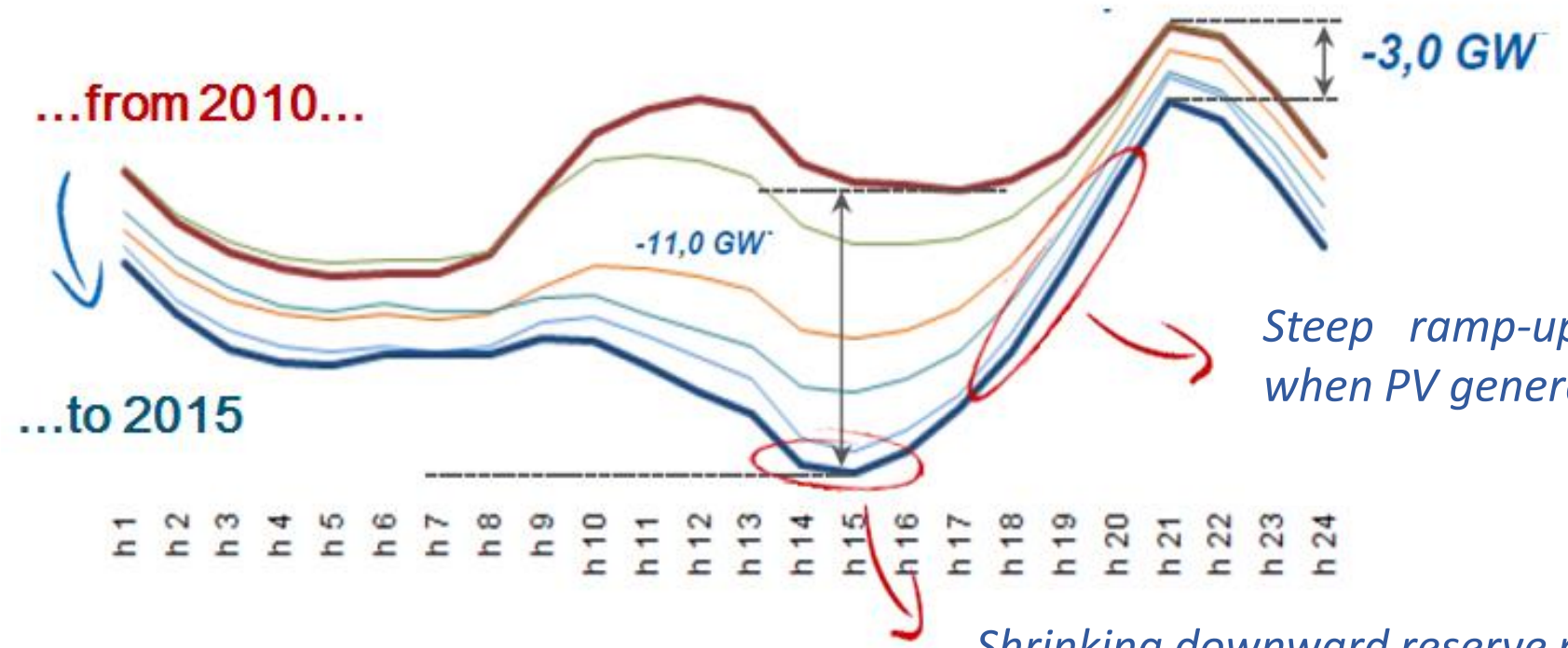


Source Terna CESI elaborations

The Future is Now…

The "duck curve" belly grows as solar output grows

Average residual demand on Sundays in April



Steep ramp-up of the evening load when PV generation reduces

Shrinking downward reserve margins

Problems of voltage regulation in the grid

Source of the graphs: Terna, the Italian TSO

Challenges to deal with highly decarbonized power systems shall be addressed now

- Additional reserve & balancing capability
- Difficult up/down ramp hours
- Over-generation risk
- More challenging frequency regulation

- TSO/DSO interaction
- Incentive framework

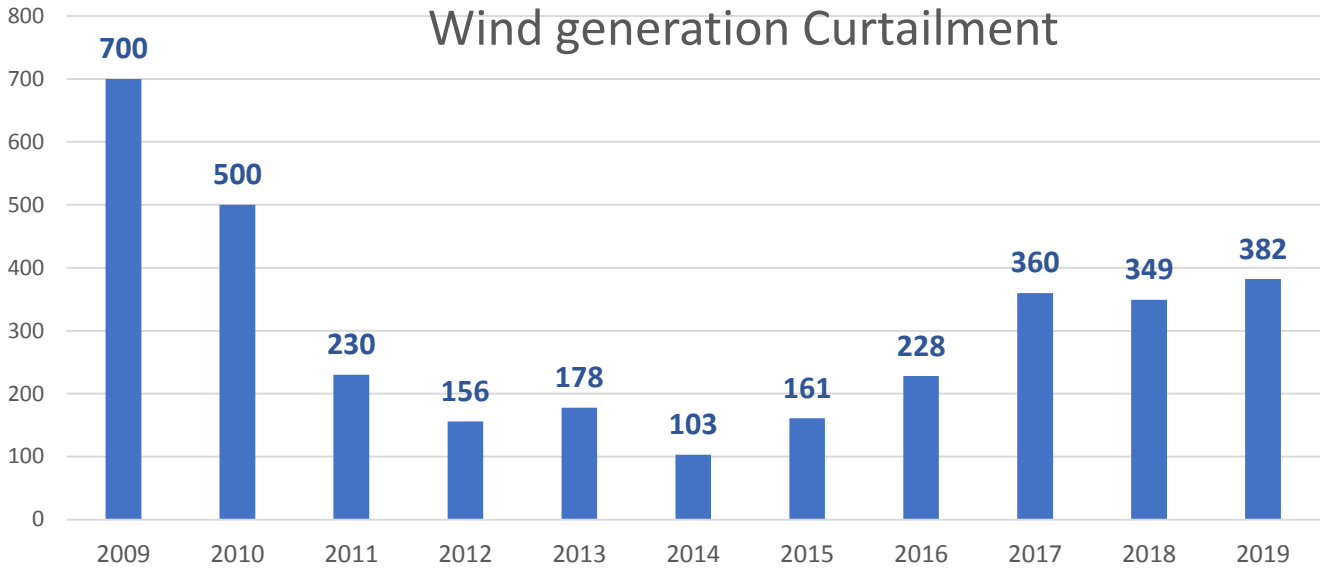
- Reduction of GHG emissions

- Network congestions
- Voltage profile & reactive power management
- System protection

- Risk of day-ahead market price distortion
- Enhanced effort in the Ancillary Service Market to ensure security margins

NEED FOR COMBINED ACTIONS TO MINIMIZE RENEWABLE GENERATION CURTAILMENT WHILE MAINTAINING SYSTEM SECURITY

Challenges in Operating Power Systems with a High Share of RES Generation: Situation Experienced in Italy

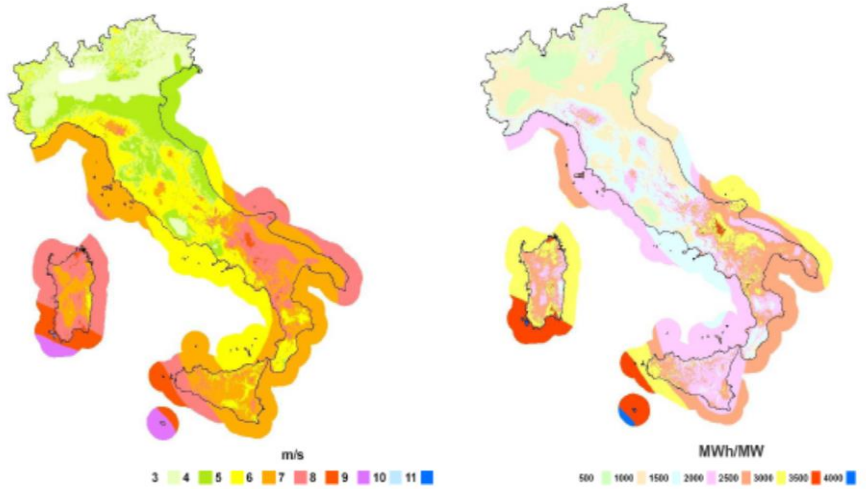


Wind generation (GWh)	6.542	9.125	9.856	13.407	14.897	15.178	14.844	17.689	17.565	17.557
Gen. curtailment (%)	10,7%	5,5%	2,3%	1,1%	1,2%	0,7%	1,1%	1,2%	2,0%	2,2%

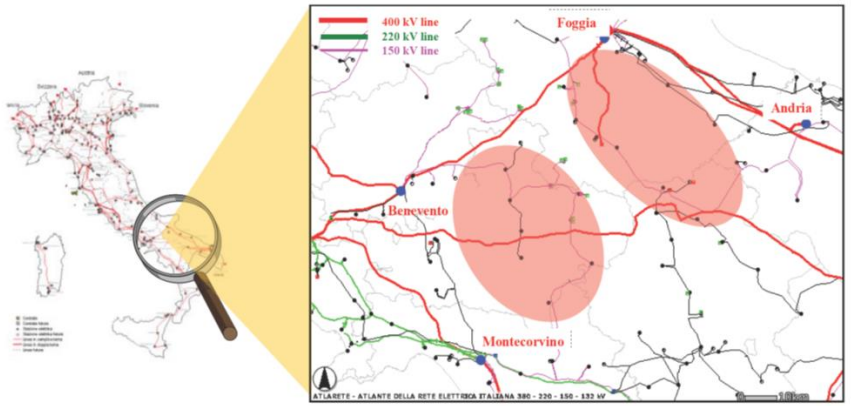
Source: Terna and CESI elaborations

Main causes of wind gen. curtailment:

- ✓ Congestion at HV network
- ✓ Congestion at EHV network
- ✓ Balancing problems



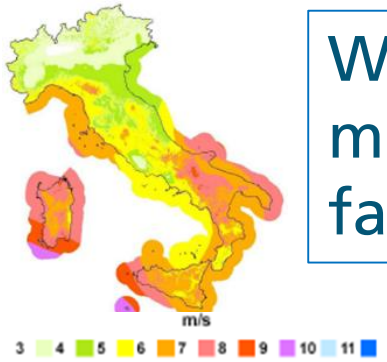
Wind generation concentrated in the far South and the Islands



Congestion on the 150 kV grid

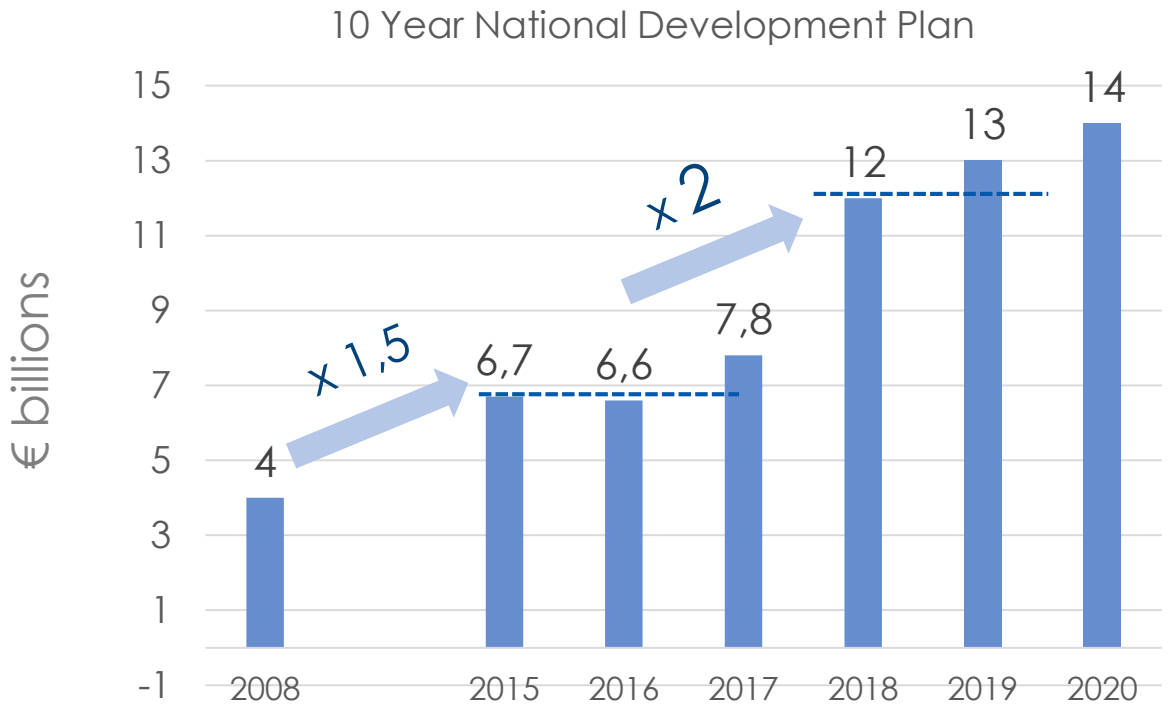
Actions for reducing the risk of overgeneration: growing effort in investing in transmission assets

NETWORK IMPACTS



Wind and solar resources mostly concentrated in the far South and the Islands

Need for substantial investments within the country and cross-border



Multiple links in HVDC technology

RES curtailment: types and causes

SYSTEM-WIDE IMPACTS

The RES curtailment due to **system constraints**:

- ✓ the minimum reserve margin
- ✓ (in)flexibility of traditional generation fleet

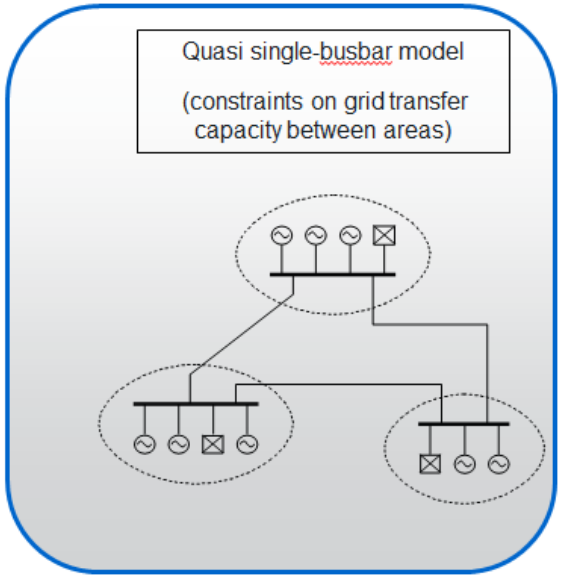
Power system curtailment: system balance

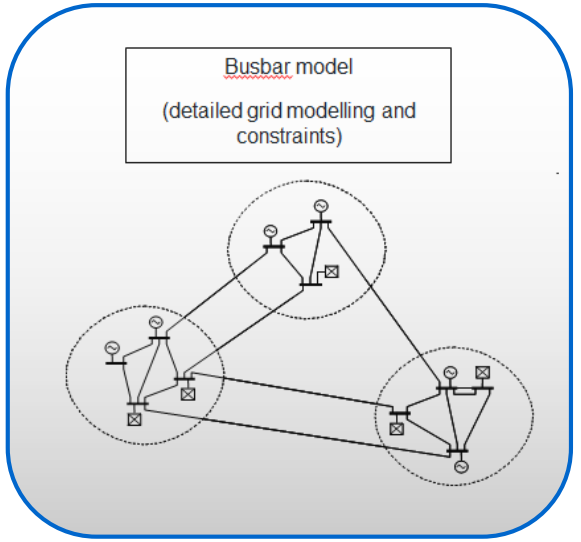
NETWORK IMPACTS

RES curtailment due **network constraints**:

- ✓ RES cut to alleviate network bottlenecks

Network curtailment: lack of adequate grid infrastructures



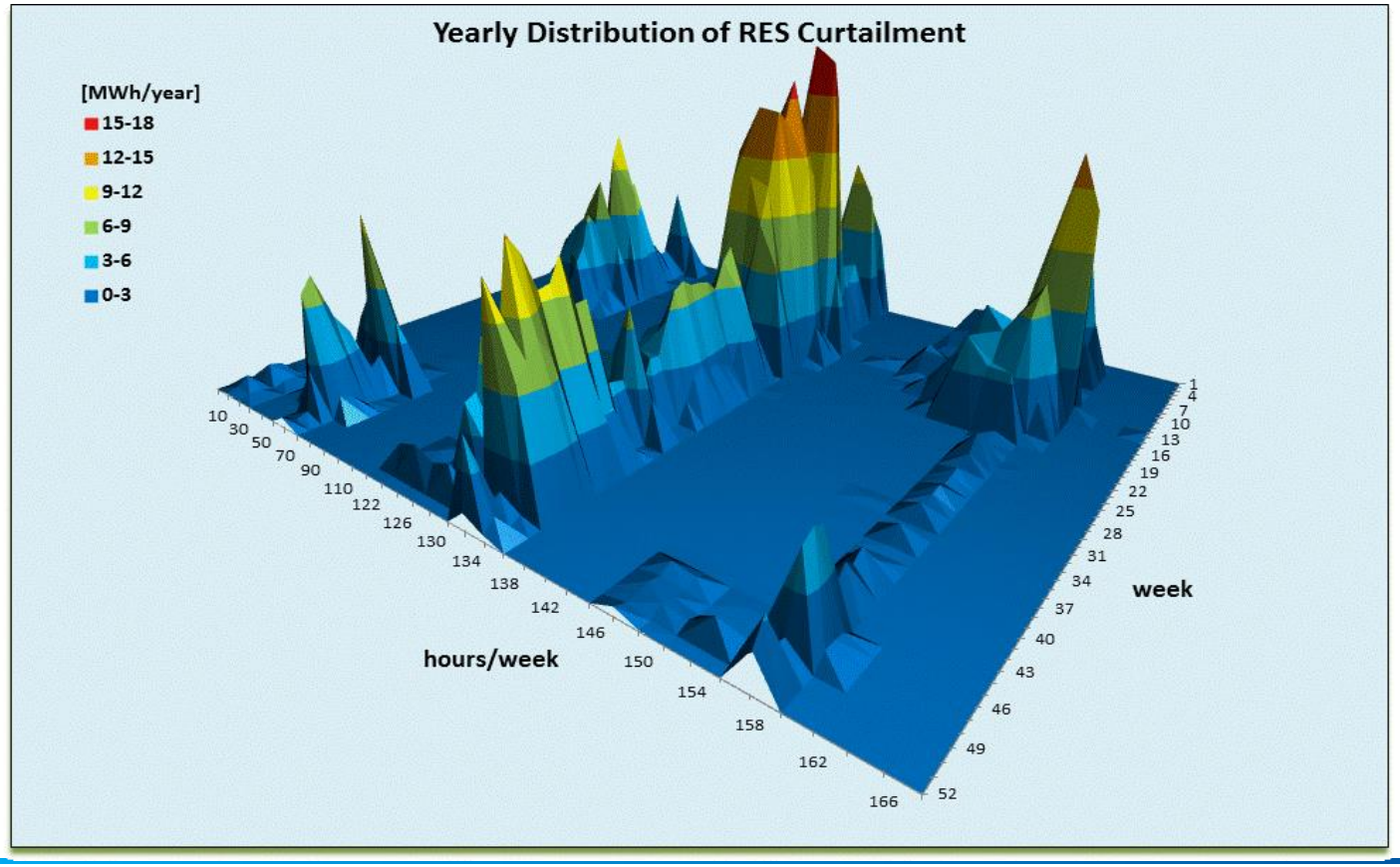


The development of the transmission grid can help to reduce the risk of RES curtailment, "exporting" the over-generation to areas with more possibilities to receive the extra renewable generation

Assessment of V-RES curtailment risk: distribution over the year

Need for a **probabilistic approach**:

- ✓ MonteCarlo simulation
- ✓ Intermittency of wind and solar generation together with forecast error of power demand
- ✓ Detailed modelling of the grid
- ✓ Different climatic years



Possibility to **quantify the annual benefits** in terms of **avoided RES generation curtailment** arising **from network reinforcement** or **storage facilities**

GRARE
GRID RELIABILITY AND ADEQUACY RISK EVALUATOR

Terna SpA computational tool developed by CESI spa: www.cesi.it/grare

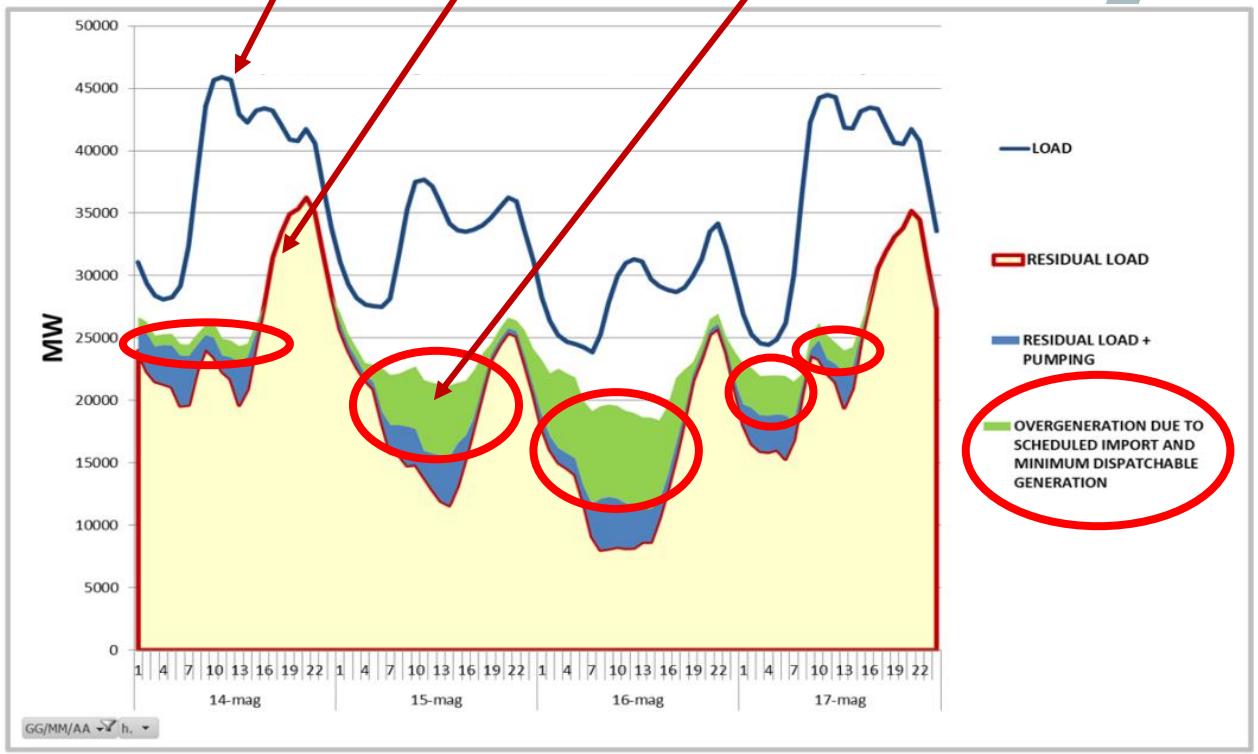
Power system balance and risk of over-generation

SYSTEM-WIDE IMPACTS

Load

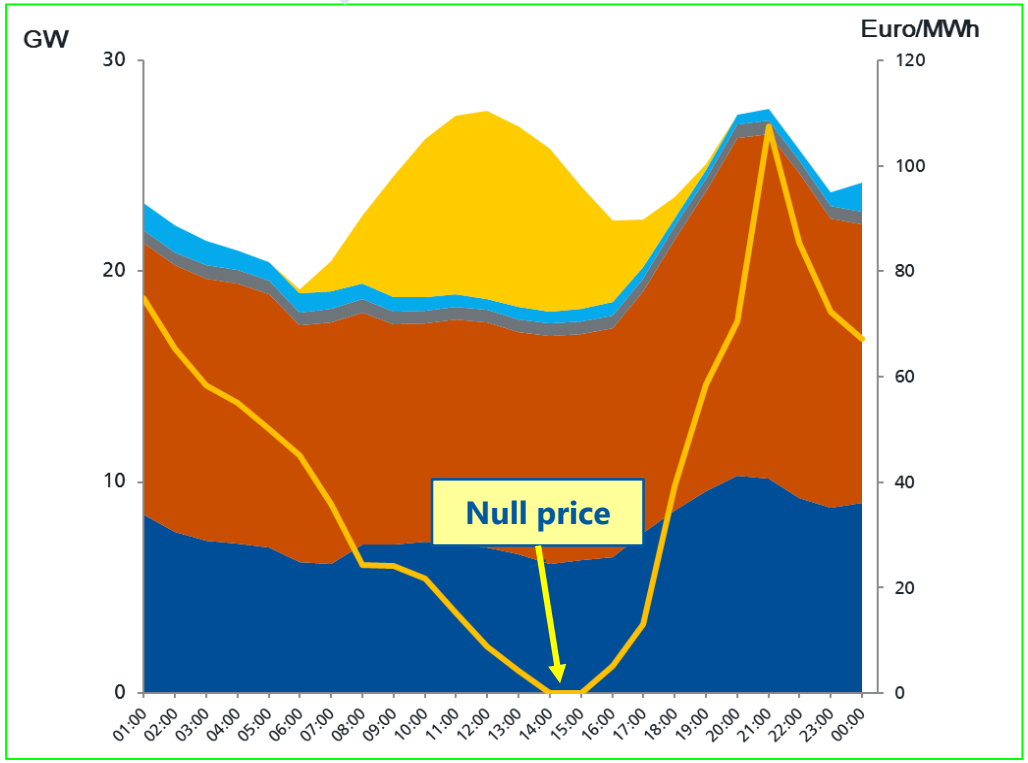
Net Load

RES overgeneration



Difficulties in balancing the system during critical hours with high V-RES generation

MARKET IMPACTS



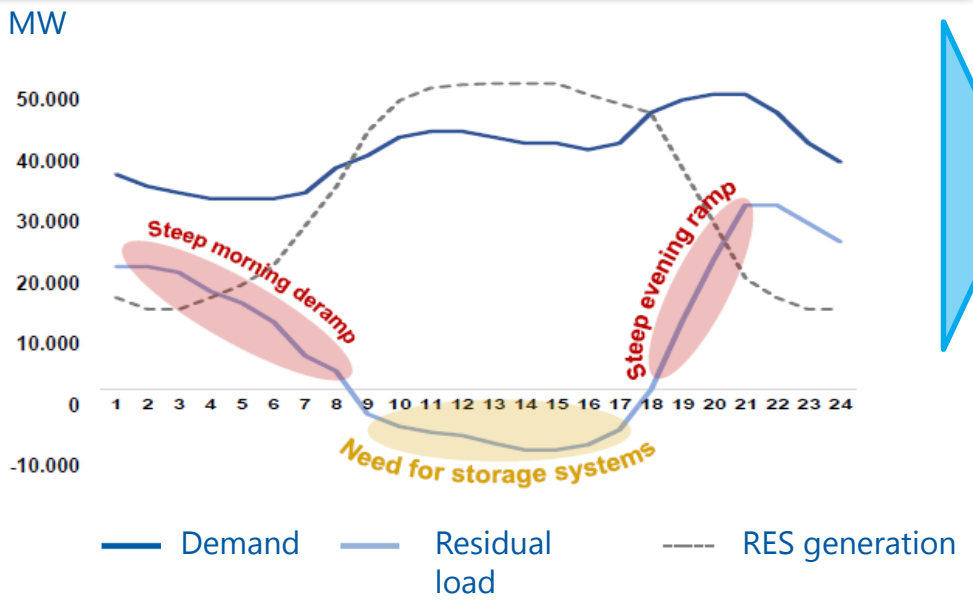
Market price distortion due to the priority given to RES generation

Need of higher system flexibility

- RES generation growth will be largely based on variable energy sources (wind and solar) calling for an **enhanced system flexibility**:
  - ✓ storage capacity √ **other solutions** (e.g.: changing operation paradigms, DR, TSO/DSO integr., VPP, etc.)
- **New paradigms for storage** facilities, not only hydro pumping, but:
  - ✓ **Utility scale batteries; √ clusters of EV; √ non conventional devices (cryogenics energy storage, etc.)**

SYSTEM-WIDE IMPACTS

Example of residual load with high RES penetration Simulation at 2030*



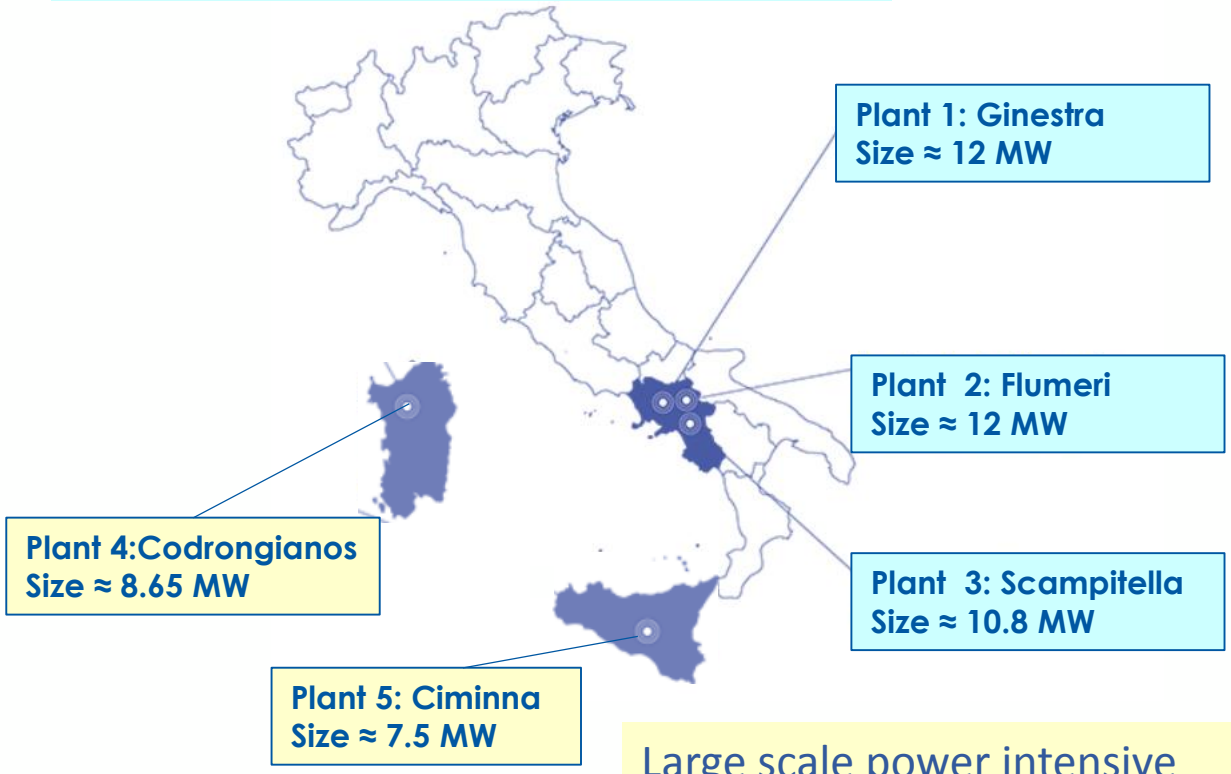
- ❑ Ramps up until 10000 MW/h in 2030
- ❑ Up to 15÷20 GW of RES generation would be curtailed in many occurrences without appropriate energy storage facilities

** Simulation applied to Italy referring to the National Energy Strategy*

Storage solutions in Italy: pilot projects and future needs

Battery Storage Pilot Projects

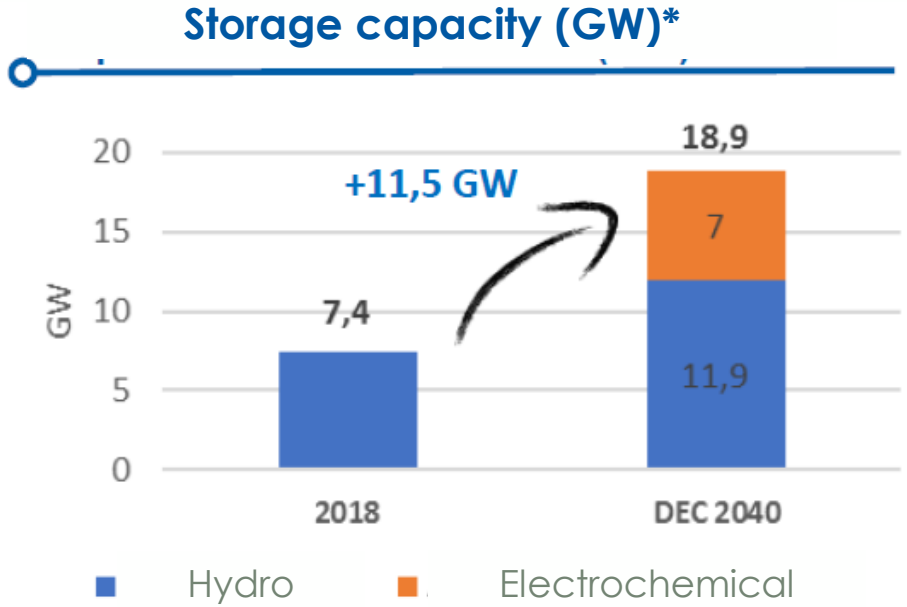
Large scale energy intensive
Role: congestion relief / Technology: NaS



Large scale power intensive
Role: provision of ancillary services
Technologies: Li-ion, ZEBRA, Flow

Source Terna CESI elaborations

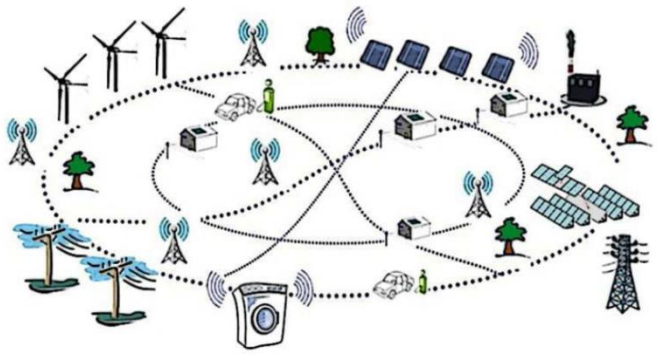
Future needs



** Estimation based on "decentralized" scenario 2019*

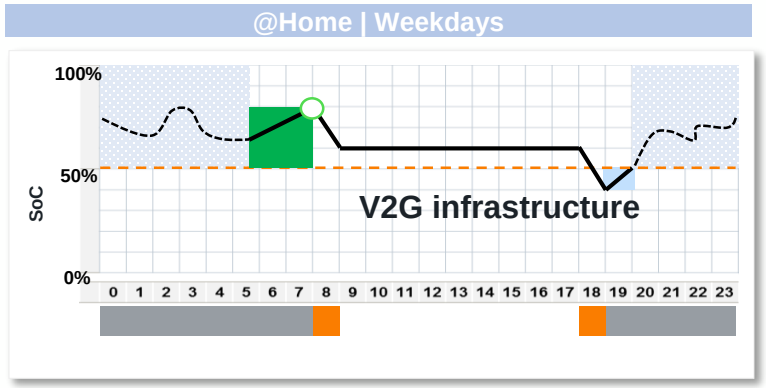
Integration between TSO and DSO: active role of demand and distributed generation

FLEXIBLE GENERATION AND DEMAND ASSETS



- ✓ Including Energy Storage, to balance the ever increasing non-programmable RES generation...
- ✓ ...coupled with a more "intelligent" grid considering a large share of RES generation connected to MV and LV grids and the active role of demand.

E.g.: active role of Electric Vehicle clusters for system security and reliability: from contribution to system adequacy to ancillary services



- ➢ Interaction of TSO and Regulators with new actors
- ➢ For TSO, need for appropriate tools to interact with system resources not directly connected to the transmission grid

VGI and potential grid services in Italy

There are multiple services needed by TSOs in order to maintain power system security. Among them, the most "mature" considering **technology** and **regulatory** requirements are:

Balancing Services

- Primary regulation
- Secondary and Tertiary reg.
- Balancing

Demand Response

- Interruptible load program

Capacity

- Capacity market

Each service is characterized by its own:

- ❑ **Technical requirements** (activation time, duration, ...)
- ❑ **Remuneration scheme** (market, regulated prices,...)
- ❑ **Resource request** (capacity and/or energy)

In the framework of Motus-e association, CESI examined the current framework of grid services in Italy to assess technical and/or regulatory barriers for provision of system services by EV.

VGI potential in Italy for different grid services

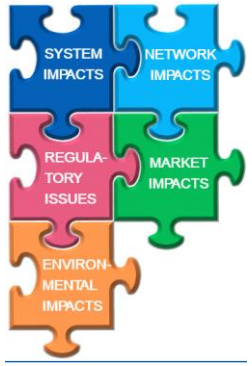
Grid service *(Entso-E wording)*	Technical Feasibility	Regulatory Adequacy	Market Attractiveness	Potential market for 1 million of EVs [M€]*
Primary regulation *(FCR - Frequency Containment Reserve)*				30
Secondary regulation *(FRRa - Frequency Restoration Reserve with automatic activation)*				130
Tertiary regulation *(FRRm - Frequency Restoration Reserve with manual activation and RR – Replacement Reserve)*				330
Balancing *(FRRm - Frequency Restoration Reserve with manual activation)*				
Interruptible load program				20
Capacity market				120

* Displayed values have to be considered as a qualitative estimation of current market potential in case of an opening of the service provision to VGI in V1G mode.

Key actions to evolve towards Fully Decarbonized Power Systems

1 Investments in transmission

- ✓ Interconnections
  - *enhanced cross-border power flows caused by periodical surplus or shortfall of RES generation*
- ✓ Var compensation equipment
  - *voltage profile and Q management*
- ✓ Synchronous compensators
  - *inertia*



…but beyond certain limits of V-RES penetration, a mix of solutions shall be put in place to ensure reliability and security

2 Market integration

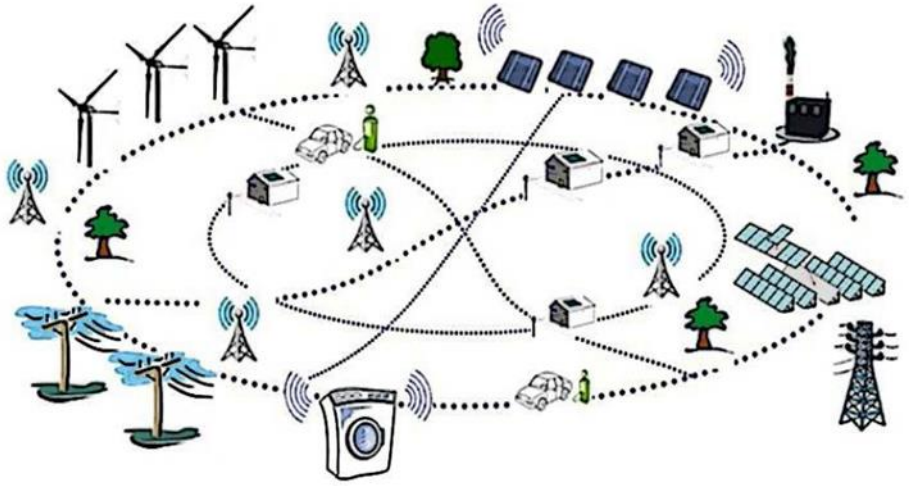
- ✓ Cross-border ancillary markets
- ✓ Capacity market
- ✓ Participation of new resources to the markets *(EV, VPP)*
- ✓ Evolution of the structure of the markets *(e.g.: continuous intraday negotiation)* and introduction of new products

Key actions to evolve towards Fully Decarbonized Power Systems

…a mix of solutions to ensure reliability and security

3 **Storage facilities**

- ✓ New hydro pumping
- ✓ Utility scale batteries
- ✓ Clusters of EV
- ✓ Non-conventional devices (CAES) and solutions (power-to-gas)



4 **TSO/DSO integration and digitalisation**

- ✓ Demand response
- ✓ Distributed Generation
- ✓ Distributed Storage
- ✓ Concept of prosumers / energy communities
- ✓ ….

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