New flexibility resources:
the role of hybrid pumped hydropower
14th May 2021

New rules for assets and novel regulation services to increase the Italian power system flexibility
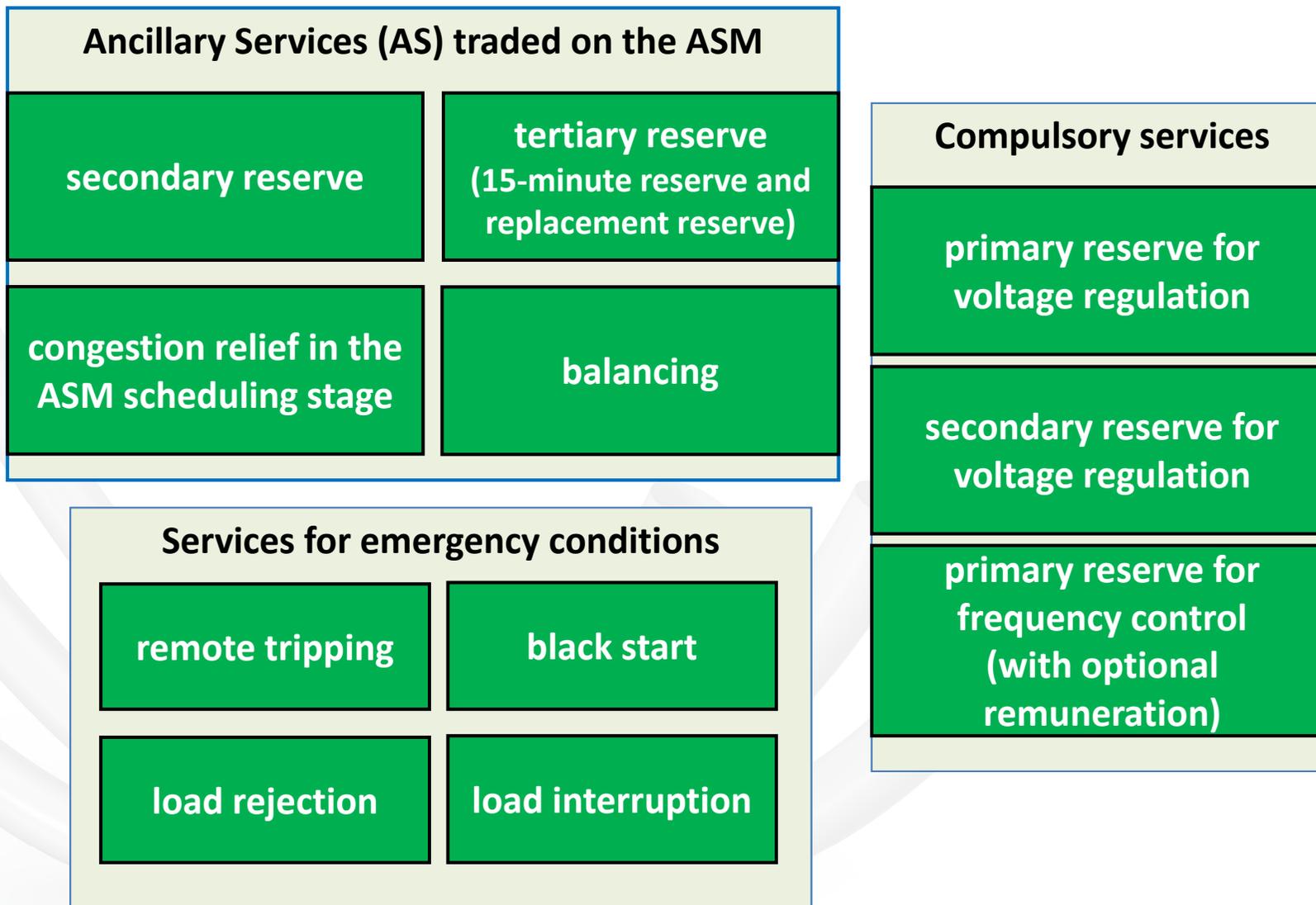
Silvia Canevese, Antonio Gatti

Need for flexibility in the Italian power system

- ↑ generation from Non-Programmable Renewable Energy Sources (NP-RES), mainly PV and onshore wind
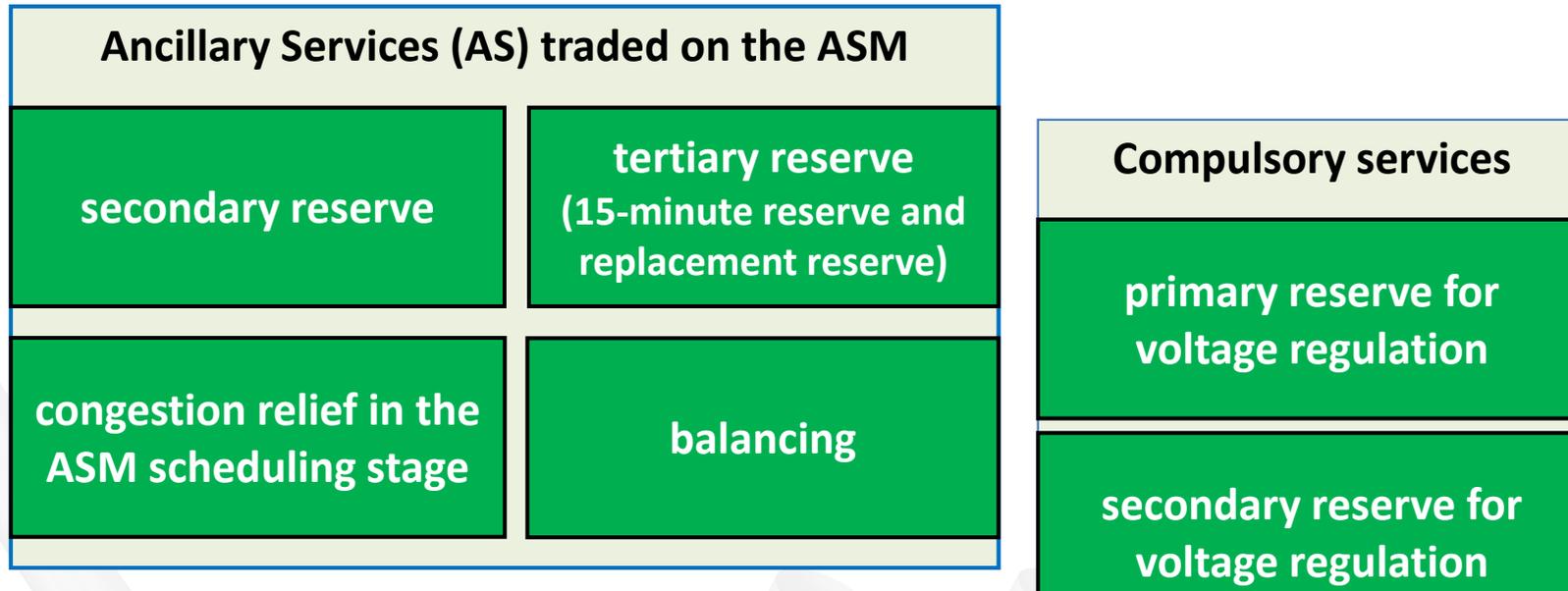- ↑ need for ancillary services to guarantee, e.g., balancing (↑ costs for the Transmission System Operator - TSO)

- ↓ programmable regulating plants in service (↓ operating reserve margin)
- ↑ performance requested to dispatchable plants (↑ fast power modulation)
- ↑ redispatching, RES curtailment and interventions on import profiles to guarantee system security

- need for new ancillary services, with enhanced performance requirements
  - e.g., "fast" frequency response, synthetic inertia, fast ramping…
- need for new flexible resources for ancillary service supply
  - Italian Energy Authority* Consultation doc. 298/2016, towards an opening of the Ancillary Service Market (ASM) to…
- also in view of a European energy integration

Autorità per l'Energia Elettrica il Gas e il Sistema Idrico (AEEGSI), now *Autorità di Regolazione per Energia Reti e Ambiente* (ARERA)

Ancillary services in Italy: current status

Ancillary Services (AS) traded on the ASM

secondary reserve	tertiary reserve (15-minute reserve and replacement reserve)
congestion relief in the ASM scheduling stage	balancing

Compulsory services

- primary reserve for voltage regulation
- secondary reserve for voltage regulation
- primary reserve for frequency control (with optional remuneration)

Services for emergency conditions

remote tripping	black start
load rejection	load interruption

Ancillary services in Italy: current status

Ancillary Services (AS) traded on the ASM		Compulsory services
secondary reserve	**tertiary reserve (15-minute reserve and replacement reserve)**	**primary reserve for voltage regulation**
congestion relief in the ASM scheduling stage	**balancing**	**secondary reserve for voltage regulation**

Ancillary Service Market («Mercato per il Servizio di Dispacciamento» - MSD):
- after Day-Ahead Market (DAM) and intra-day market
- **two stages:**
  - **scheduling stage (ex-ante ASM),** to relieve congestions and procure reserve margins
  - **real-time stage (ex-post ASM or Balancing Market – BM),** to balance injection/absorption (activation of procured reserve margins, also to relieve congestions)
- **remuneration**: **pay-as-bid** and **energy only** (price per manoeuvre for plant start-ups and configuration changes)

ASM eligibility: current versus new requirements

Ante ARERA Decision 300/2017

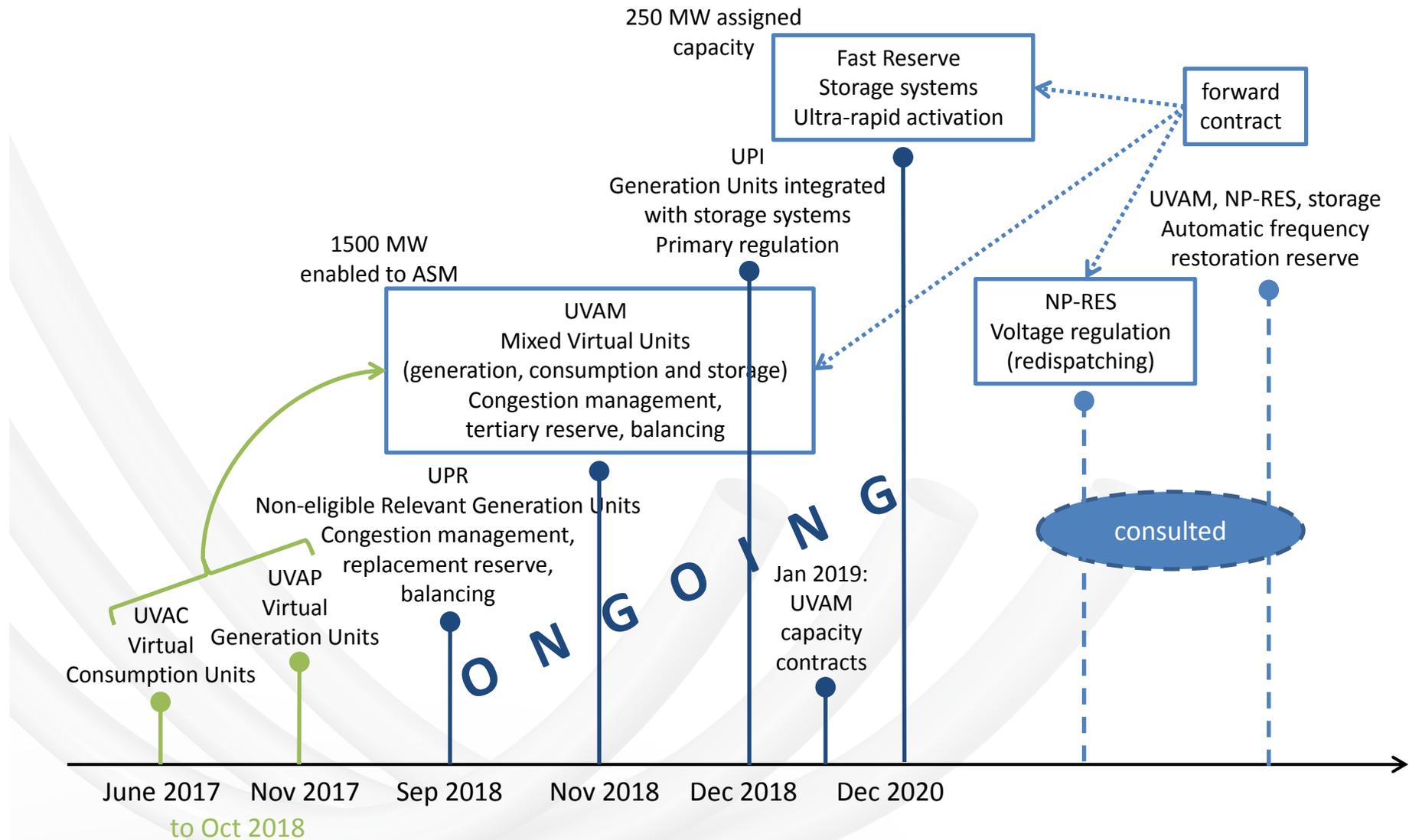| Generation				Load
Relevant		Non Relevant		
Programmable	Non Programmable			
✓	✗	✗	✗	

- Relevant: ≥ 10 MVA
- Minimal gradient for tertiary and congestion: 10 MW in 15 minutes

Post ARERA Decision 300/2017 (pilot projects)

Generation, including BESS (Battery Energy Storage Systems)				Mixed	Load
Relevant		Non Relevant			
Programmable	Non Programmable				
✓	✓	✓ (UVAP)	✓ (UVAM)		✓ (UVAC)

- **Aggregated resources: UVA («Unità Virtuali Abilitate»)**, i.e. **virtual eligible units**, referring to
  - geographical perimeters (based on TSO's evaluation of network constraints)
  - typologies of resources

Decision N. 300/2017: projects/resources and timeline

250 MW assigned capacity

Fast Reserve
Storage systems
Ultra-rapid activation

forward contract

UPI
Generation Units integrated with storage systems
Primary regulation

UVAM, NP-RES, storage
Automatic frequency restoration reserve

1500 MW enabled to ASM

UVAM
Mixed Virtual Units
(generation, consumption and storage)
Congestion management, tertiary reserve, balancing

NP-RES
Voltage regulation
(redispatching)

UPR
Non-eligible Relevant Generation Units
Congestion management, replacement reserve, balancing

ONGOING

Jan 2019: UVAM capacity contracts

consulted

UVAP
Virtual Generation Units

UVAC
Virtual Consumption Units

June 2017 Nov 2017 Sep 2018 Nov 2018 Dec 2018 Dec 2020

to Oct 2018

Adapted from E.M. Carlini, «Terna's strategy and best practices to operate the Italian power system with high share of RES», Industrial distinguished lecture and 2020 Italy Section PE Chapter Award, 30 April 2021

UVAM project: specifications

Project	Assets	Min. power	Services	Mode: be able to…	Remuneration

UVAM	• Points of withdrawal with no PUs
	• Small-scale PUs
	• Larger PUs not subject to mandatory ASM participation
	• Storage systems: stand-alone or combined with PUs
		1 MW	• UPW and/or DWW
			  • congestion management
			  • tertiary spinning reserve
			  • tertiary replacement reserve
			  • balancing
				• supply UPW and/or DWW flexibility
				• ≥ 1 MW
				• within 15 minutes of Terna request (120 minutes for replacement reserve)
				• keep it for ≥ 120 minutes (480 minutes for replacement reserve)
					• Activation: energy quantity accepted on ASM/penalties
					• Availability

PU = Production Unit
UPW/DWW = upward/downward

Remuneration of quantity accepted on ASM/penalties + availability

«standard» pay-as-bid remuneration for energy

new: availability price for capacity (power) in defined periods

• **commit to present bids in a prescribed time interval, Mon to Fri, for N consecutive hours**
• **descending-price auction mechanism**
• pay-as-bid allocation
• fixed remuneration paid for by Terna for each day in which the bid obligations are observed
• **strike price on bids**
• **two procurement areas**: A = North and Centre-North, B = Centre-South, South, Sicily and Sardinia Calabria,

UVAM project: latest rules

Decision n. 70/2021 (23 Feb 2021): changes to previous specifications, procurement procedure and contract agreement:

- **definition of an annual auction and monthly auctions with dedicated needed amounts**
- definition of 2 availability time slots and introduction of **3 products** (to better represent the system need for resources, which is mostly concentrated in the evening), **one in the afternoon and two in the evening with (auction) price cap = 30 k€/MW/yr and (bid) strike price = 400-200 €/MWh**

Auction timing	Product target	*Strike price*	Max quantity – Area A	Max quantity – Area B
annual	**afternoon**	**200 €/MWh**	**112 MW**	**28 MW**
annual	**evening**	**400 €/MWh**	**224 MW**	**56 MW**
annual	**evening**	**200 €/MWh**	**224 MW**	**56 MW**
intra-annual products			Annual product quantity not met or quantity left by BSPs (*)	
monthly	afternoon	200 €/MWh	Set by Terna according to system needs	Set by Terna according to system needs
monthly	evening	400 €/MWh		
monthly	evening	200 €/MWh		

(*) possibility for Balance Service Providers to reduce commitment (and consequently pro quota the amount due) during the year, to take into account events which may compromise contractual performance

- the total quantity keeps 1000 MW
- **afternoon/evening products: commit to UPW balancing bids for at least N = 2 consecutive hours in 15.00-18.00/18.00-22.00 for each day Mon-Fri**
  - fixed daily remuneration for each product: (auction output/days)*(num of consecutive hours/4)
- **unannounced reliability tests, to check the UVAM effective operation and reliability**

Fast Reserve project: specifications

- Decision n. 200/2020
- **Aim: contribute to improving dynamic response in the first instants during frequency transients**
- Service distinct from, but coordinated with primary frequency regulation

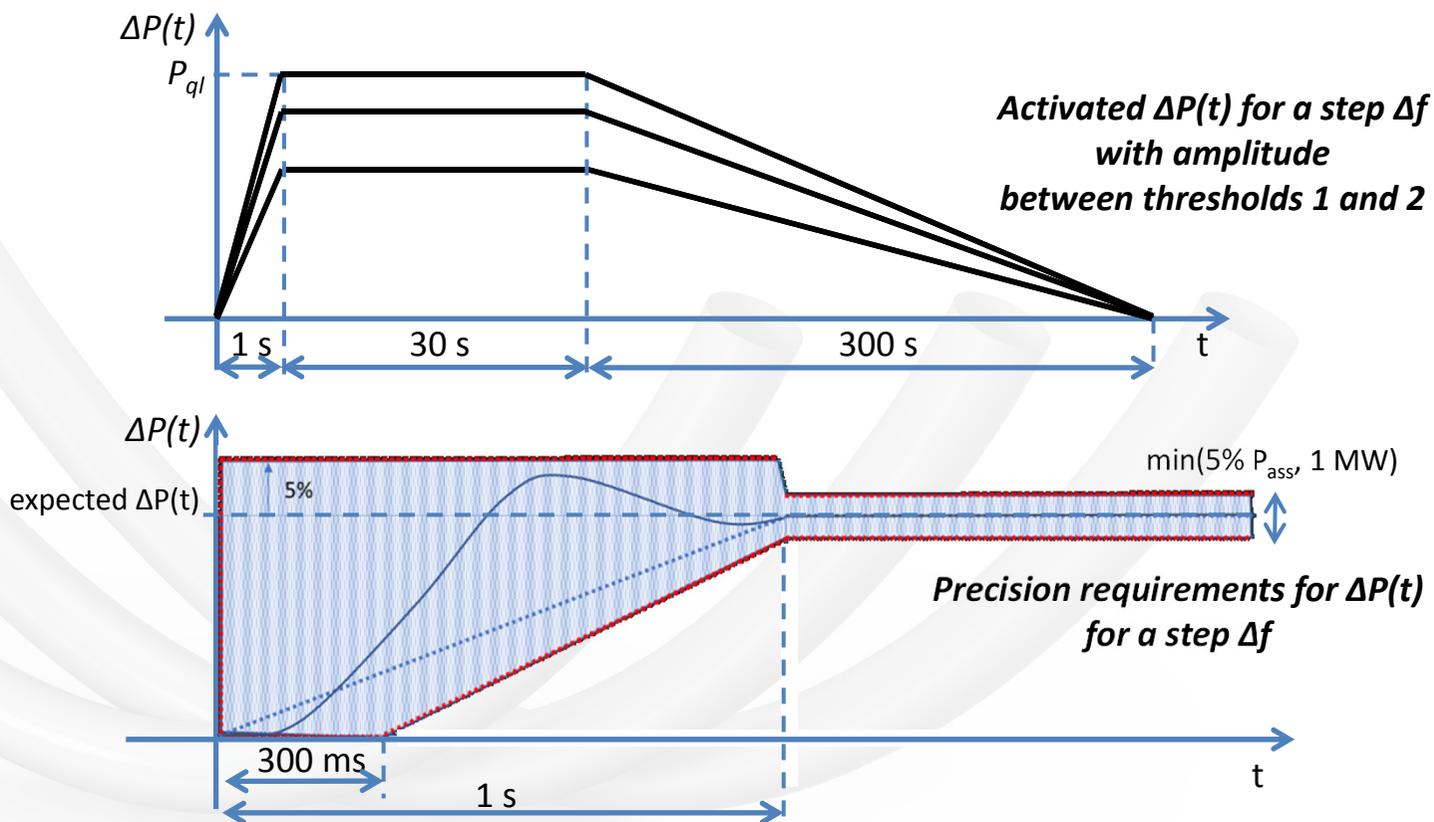| Assets in a Fast Reserve Unit (FRU)	Qualified power P_{ql}	Service	Requirements on energy	Remuneration
• Non-interruptible **load units** • stand-alone **PUs** • PUs with non-auxiliary load(s) and/or with storage systems (behind the meter PUs) • **storage systems**: stand-alone, with PUs and/or with load units (behind the meter storage) ➤ **single or aggregated** ➤ **in the same market zone**	$5\text{ MW} \leq P_{ql} \leq 25\text{ MW}$ ➤ same for P_{ass} (normally, assigned power P_{ass}= qualified power P_{ql})	• **Symmetric service!** • UPW and DWW flexibility in **response to** • **measured Δf, according to Δf-ΔP characteristic** • **power setpoint signal sent by Terna** ➤ **algebraic sum of the two contributions** ➤ no power oscillations	• 1000 h/yr availability of ±P_{ql} (so of ±P_{ass}), also in the presence of other services • be able to keep exchanging at least ±P_{ql} for ≥ 15 minutes • energy management logics, for devices with limited energy	Remuneration of energy exchanged/ penalties + **availability payment (power)**
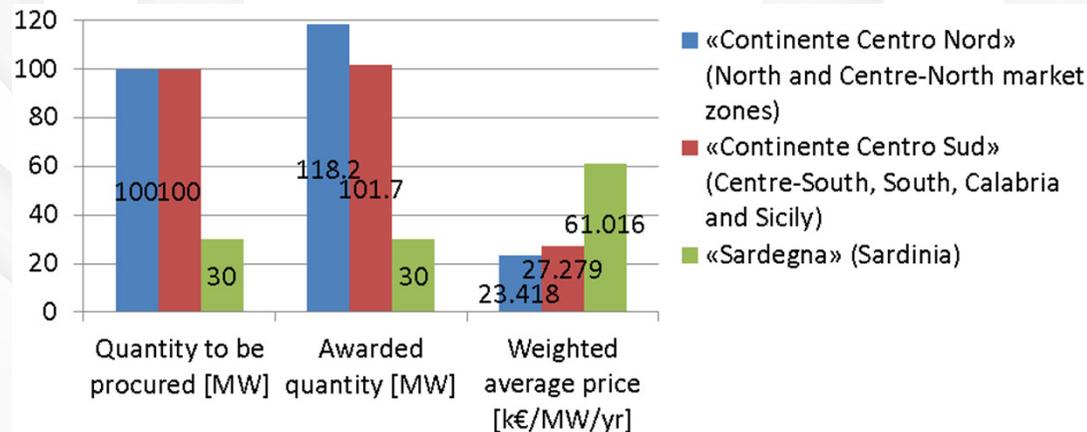
- 5-yr contracts (1 Jan 2023 - 31 Dec 2027)
- **descending-price auction** starting from price cap = **80 k€/MW/yr**
- **10 Dec 2020: first auction:**
  53 operators,
  117 FRUs,
  1327.3 MW overall P_{ql}

Fast Reserve project: response to measured Δf

- ΔP in response to frequency error $\Delta f := f_{measured} - 50$ Hz

Full Activation Time (FAT)	Time of response initiation	Time to keep regulation	Stop service (via a de-ramp) after...	Be able to keep exchanging...	Main features
≤ 1 s Also for inversion	≤ 300 ms No intentional delays	≥ 30 s	5 min	±P_{ql} for ≥ 15 minutes	• automatic, symmetric, continuous • **based on Δf thresholds and timings**

Activated ΔP(t) for a step Δf with amplitude between thresholds 1 and 2

Precision requirements for ΔP(t) for a step Δf

min(5% P_{ass}, 1 MW)

Secondary regulation project: preliminary specifications

- Aim: **test reliability, and impacts on the power system**, of secondary frequency regulation (power/frequency regulation - aFRR) by **resources other than those compulsorily enabled**, so with **different technical characteristics**

Assets	• **Relevant PUs**
	  • **fed with P-RES or NP-RES**
	  • **composed of storage systems**
	• **UVAM** with requested technical features and with at least 1/4 h-ly validated measured data

Service features	• **Secondary frequency regulation, i.e. power/frequency regulation, also asymmetric:**
	  • **UPW and/or DWW**
	  • **different Half-Bands (HBs)**
	• **1 MW half-band(s) at least**
	!!! The total procured half-bands will be symmetric
	!!! In each hour, max 60% of the total procured UPW/DWW quantity can come from limited energy units or UVAM without limited energy points

Bids	• **Bids = quantity (MW) and price (€/MWh)**
	• **symmetric bid: 1 UPW bid and 1 DWW bid, with = quantity**
	• **asymmetric bid:**
	  • **1 UPW bid and 1 DWN bid, with ≠ quantity**
	  • **1 UPW or 1 DWN bid**

Mode	• **Real-time regulation according to centralized level signal and accepted HB(s)**
Remuneration	• **Pay-as-bid remuneration of exchanged energy** • **Penalties for energy not exchanged/imbalances**

Conclusion

- **Need for new flexibility services and for more/new suppliers in the ancillary service market**
  - small/distributed generators
  - renewables
  - loads
  - storage

- **Activation + availability remuneration should attract participation**
  - beneficial for return on investment

- **Secondary frequency regulation is considered as a refined service, currently carried out almost exclusively by thermal units and hydro reservoir units**
  - good if UVAMs and fast reserve units can participate

- **Faster services, e.g. fast reserve:**
  - to increase "prompt" support to power system stability
  - interest in battery storage, also coupled with other technologies

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Thank you for your attention!

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