The impact of utility-scale RES power production on the Italian electricity prices

Damiano Alessi, Cinzia Bonaldo, Fulvio Fontini

November 29, 2024

cinzia.bonaldo@rse-web.it

Agenda

1. Introduction
2. Model description
3. Results
4. Conclusions

Agenda

(1) Aim of the study

Evaluate the impact of new investments in VRES on the electricity system

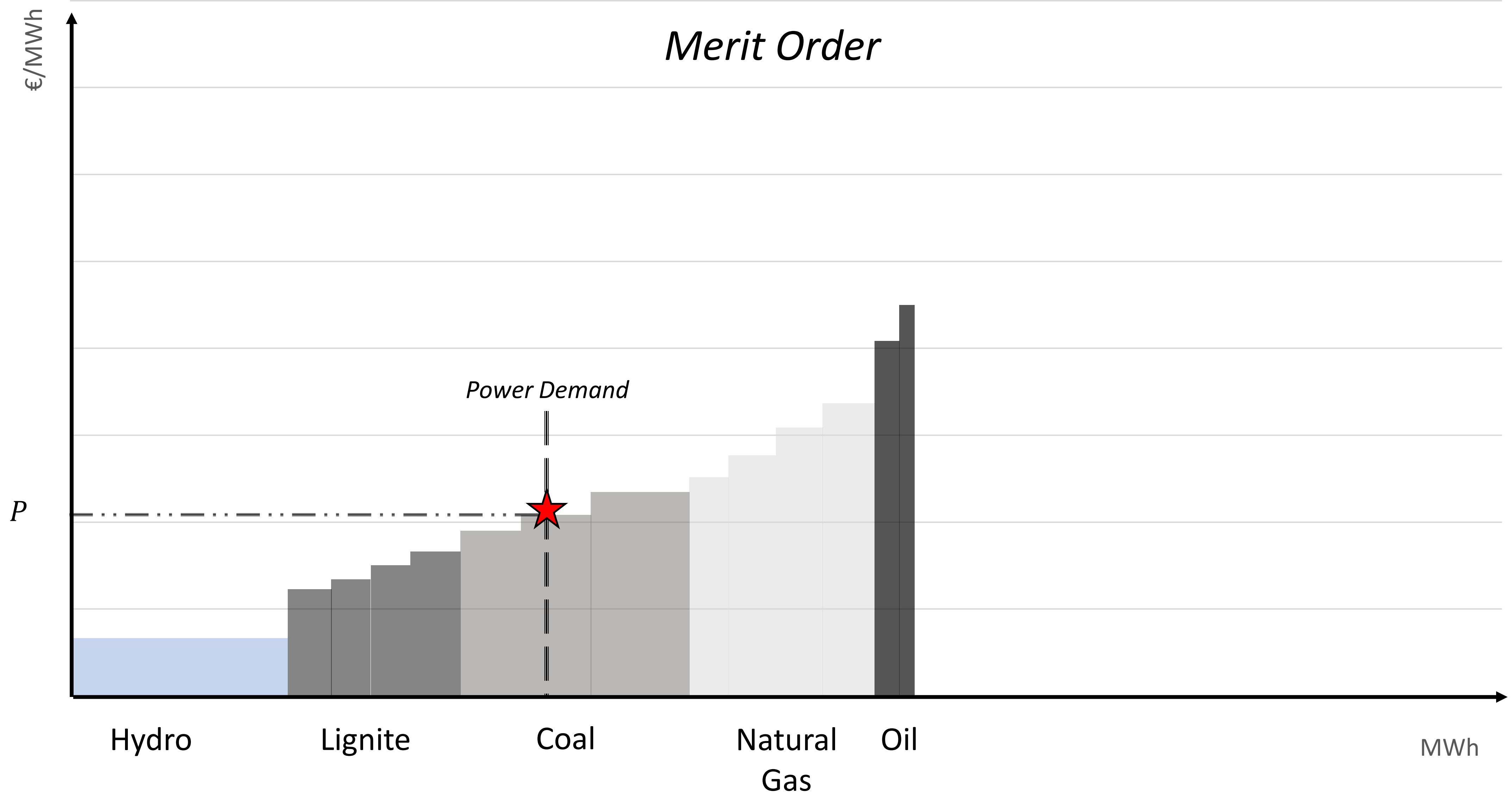
Focus on Italian market

D and S curves of the DAM of some representative days and periods of the year are simulated

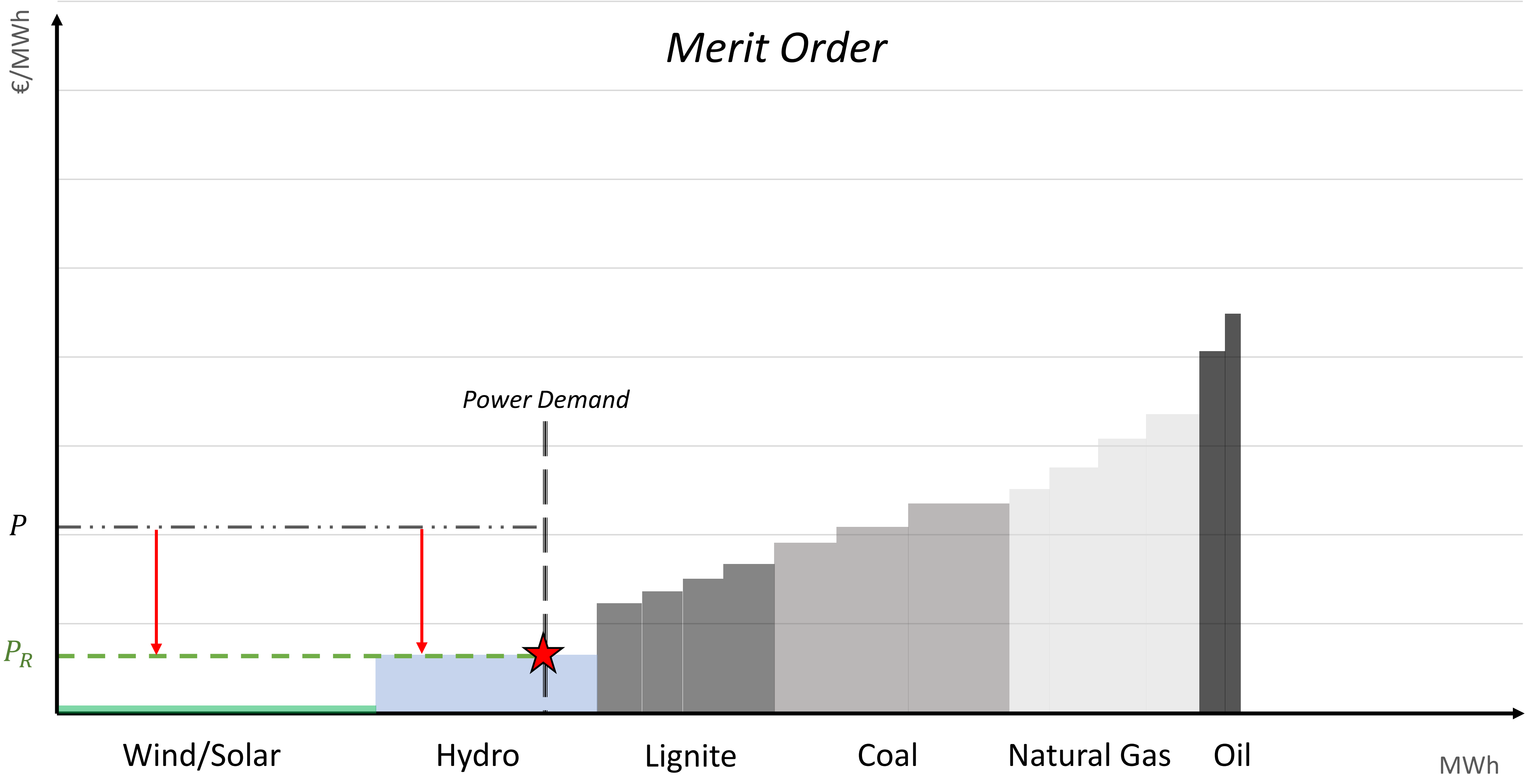
Zonal configuration of the ITA market and the transmission constraints are considered

New VRES investments affect significantly only the prices of southernmost zones. North (↑ load) shows lower benefit

(1) Market Clearing Price – No VRES



(1) Market Clearing Price – with VRES



(1) Italian bidding zones e transmission capacity

Italian zonal configuration and consumption (2022)

Transmission constraints are critical in determining whether energy produced in one zone can be efficiently transported to zones with higher demand

Development Plan

From	To	Capacity 2022	Capacity 2030
Sicily	Calabria	1300	4000
Calabria	Sicily	1500	4000
Calabria	South	2350	5200
South	Calabria	1100	5200
South	Centre-South	5100	8800
Centre-South	South	2400	8800
Sardinia	Centre-South	900	1900
Centre-South	Sardinia	720	1900
Centre-South	Centre-North	2800	8300
Centre-North	Centre-South	2900	8300
Centre-North	North	3100	8500
North	Centre-North	4300	8500

In order take trans. capacity into account, we consider the maximum possible capacity that can be transfer across zones as released by TERNA (ITA TSO), regardless of the specific season and market configurations.*

*TERNA simulates several possible scenarios for the transmission limits, depending on the availability of different power plants and seasonal conditions. We cannot replicate here the power dispatching of all Italian system in each scenario.

Agenda

(2) INPUT

New VRES capacity (July 2023)

Type	zone	Capacity (MW)	TOT
solar	CALA	117	
wind	CALA	417	
wind off-shore	CALA	2 211	2 475
solar	CNOR	450	
wind	CNOR	361	811
solar	CSUD	2 218	
wind	CSUD	1 515	
wind off-shore	CSUD	2 424	6 157
solar	NORD	1 599	
wind	NORD	109	
wind off-shore	NORD	700	2 408
solar	SARD	7 268	
wind	SARD	5 094	
wind off-shore	SARD	5 139	17 501
solar	SICI	8 114	
wind	SICI	2 475	
wind off-shore	SICI	6 225	16 814
solar	SUD	15 824	
wind	SUD	5 402	
wind off-shore	SUD	10 014	31 240
solar	ITA	35 590	
wind	ITA	15 374	
wind off-shore	ITA	26 713	77 677

Data from the EIA* repository managed by the Italian ministry (MASE) that maps all large-scale investments (no very small-scale or small-scale)

* National Energy and Climate Plan Technical Committee

Obviously not all this capacity is always available.........

De-rating capacity factors

Hour	Solar	Wind
1	0.0	0.6
2	0.0	0.4
3	0.0	0.45
4	0.0	0.5
5	0.0	0.45
6	0.05	0.4
7	0.08	0.45
8	0.1	0.45
9	0.3	0.5
10	0.55	0.45
11	0.75	0.7
12	0.8	0.8
13	0.85	0.75
14	0.75	0.7
15	0.7	0.7
16	0.6	0.6
17	0.4	0.5
18	0.2	0.6
19	0.1	0.6
20	0.05	0.5
21	0.0	0.7
22	0.0	0.75
23	0.0	0.7
24	0.0	0.6

ZONE	MONTH	Solar	Wind
NORD	Mar	0.75	0.6
NORD	Lug	0.7	0.1
NORD	Nov	0.3	0.6
CNOR	Mar	0.75	0.65
CNOR	Lug	0.75	0.2
CNOR	Nov	0.3	0.6
CSUD	Mar	0.75	0.65
CSUD	Lug	0.8	0.3
CSUD	Nov	0.4	0.8
SUD	Mar	0.8	0.65
SUD	Lug	0.9	0.3
SUD	Nov	0.4	0.8
CALA	Mar	0.8	0.7
CALA	Lug	0.9	0.3
CALA	Nov	0.4	0.7
SICI	Mar	0.8	0.7
SICI	Lug	0.9	0.3
SICI	Nov	0.4	0.9
SARD	Mar	0.75	0.75
SARD	Lug	0.85	0.3
SARD	Nov	0.3	0.9

$$Prod_{solar,nord}\ [€/\mathrm{MWh}] = Capacity_{solar,\,nord} * DeRatFac_{solar,h1} * DeRatFac_{solar,nord,\,Mar}$$

(2) Model and simulation

1. Use offer and demand bids of each zone from GME (IT NEMO).
Reference years: 2019 & 2022 – 2 representative day (Wed. & Sun.) of 3 months (Mar. & Jul. & Nov.)

ALGORITHM

2. Starting by southern most zones (Sicily, Sardinia, Calabria for 2022, and South), which are typically net exporters of VRES energy but face significant transmission constraints.

3. Moving northward, examining the potential for market coupling, as northern zones are net importers and face fewer transmission constraints.

Status quo scenario

Simulation of all zones clearings based on **historical offer and demand bids**

RES scenario

Simulation of all zones clearings based on historical offer and demand bids

+

new VRES generation

(2) Model and simulation

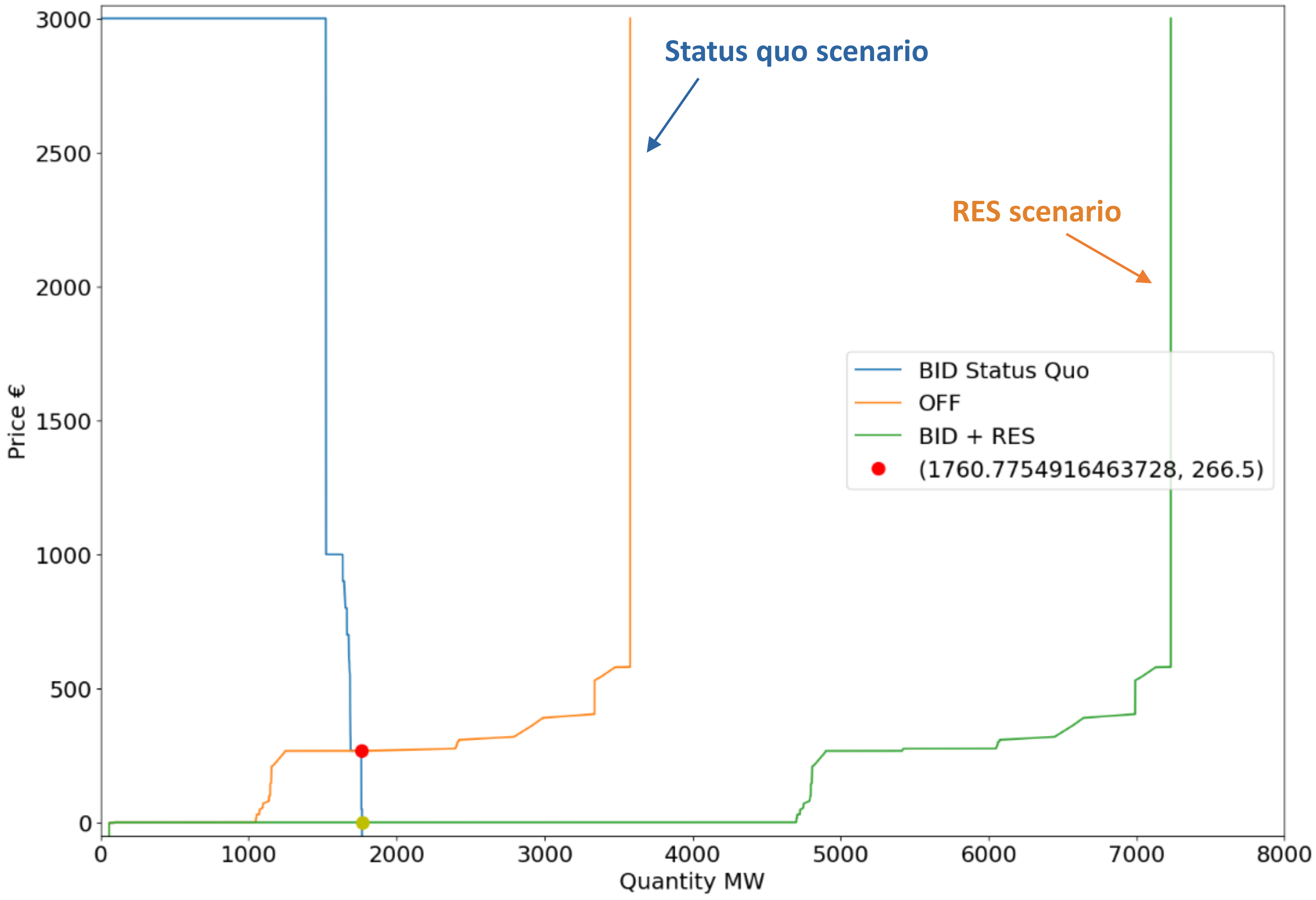
Status quo scenario

Zona	Mean Absolute Error	Mean Percentage Error
CALA	5.85818	2.23022
CNOR	1.62203	0.69399
CSUD	0.96310	1.13648
NORD	1.37137	0.65877
PUN	1.31528	0.97122
SARD	0.96627	1.13761
SICI	7.05844	6.70795
SUD	1.41003	2.12422

Mean Absolute Error (€/MWh) &
Mean Percentage Error by Zone (%)

The deviation from observed prices in percentage terms are quite negligible

Example of market clearing of the two scenarios, for a given hour and zone



Agenda

(3) Results – overall impact of VRES

Median values of clearing prices

zone	2019	
	Status Quo	RES
PUN	50.64	26.50
NORD	50.59	48.75
CNOR	50.59	48.73
CSUD	50.64	0.00
SUD	50.02	0.00
CALA	–	–
SICI	47.76	0.00
SARD	50.64	0.00

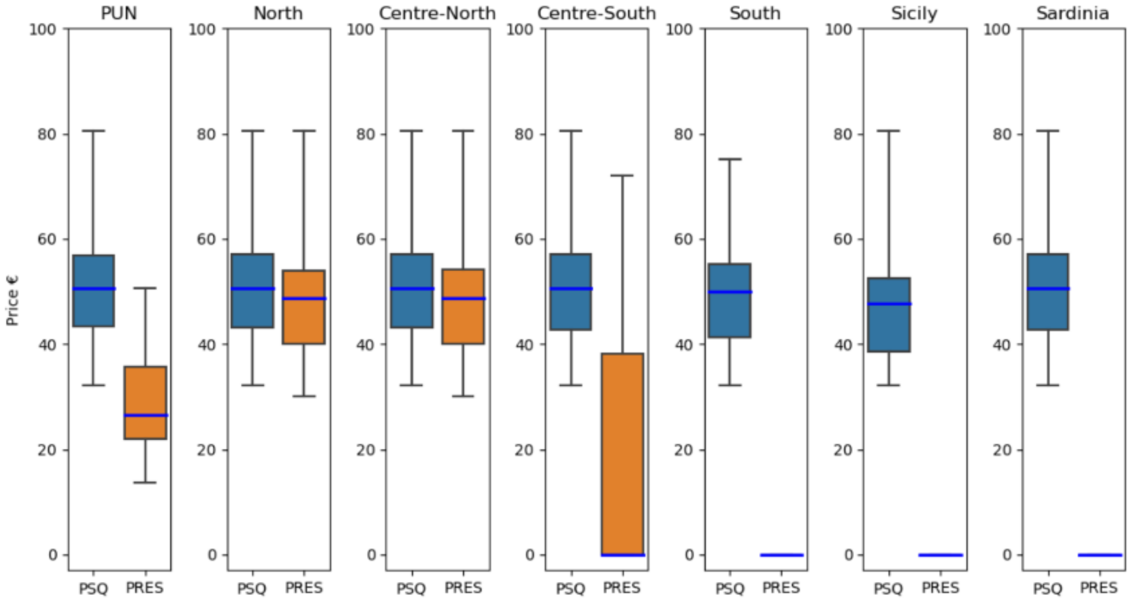
Median values of clearing prices

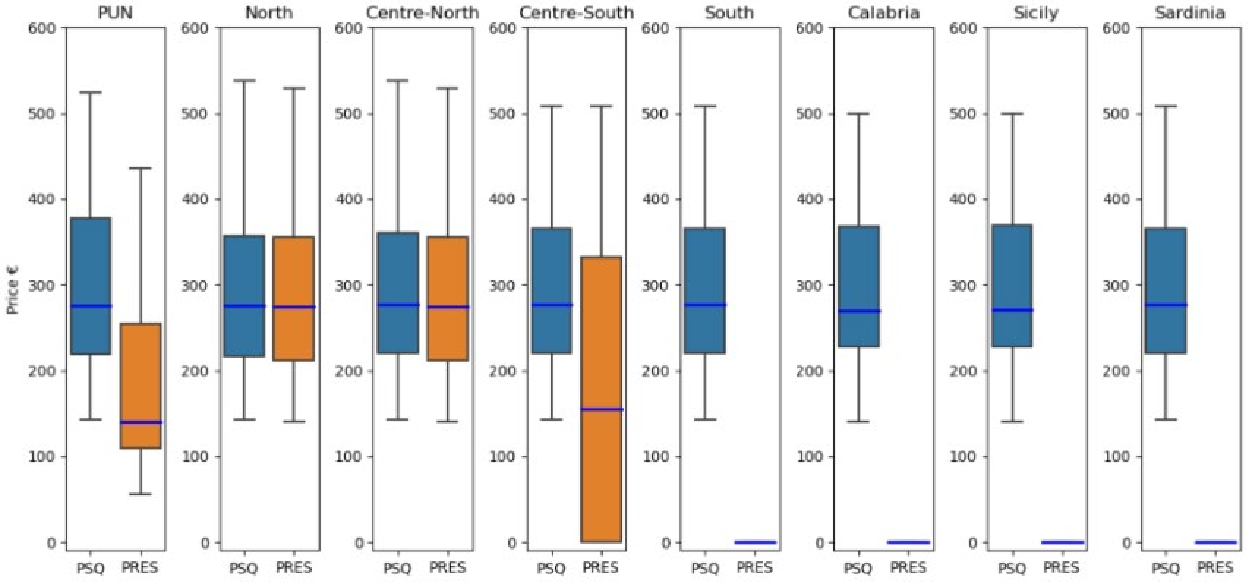
zone	2022	
	Status Quo	RES
PUN	276.03	140.28
NORD	276.03	275.04
CNOR	276.70	275.00
CSUD	276.54	155.60
SUD	276.54	0.00
CALA	270.13	0.00
SICI	270.25	0.00
SARD	276.54	0.00

It seems that the different impact across zones depend on the one hand on the **differences in VRES investments** and on the other hand on the **transmission capacity limits**

Status quo scenario

RES scenario





(3) Results – relative impact of VRES

Analysis replication considering each sources (PW, onshore W, offshore W) singularly

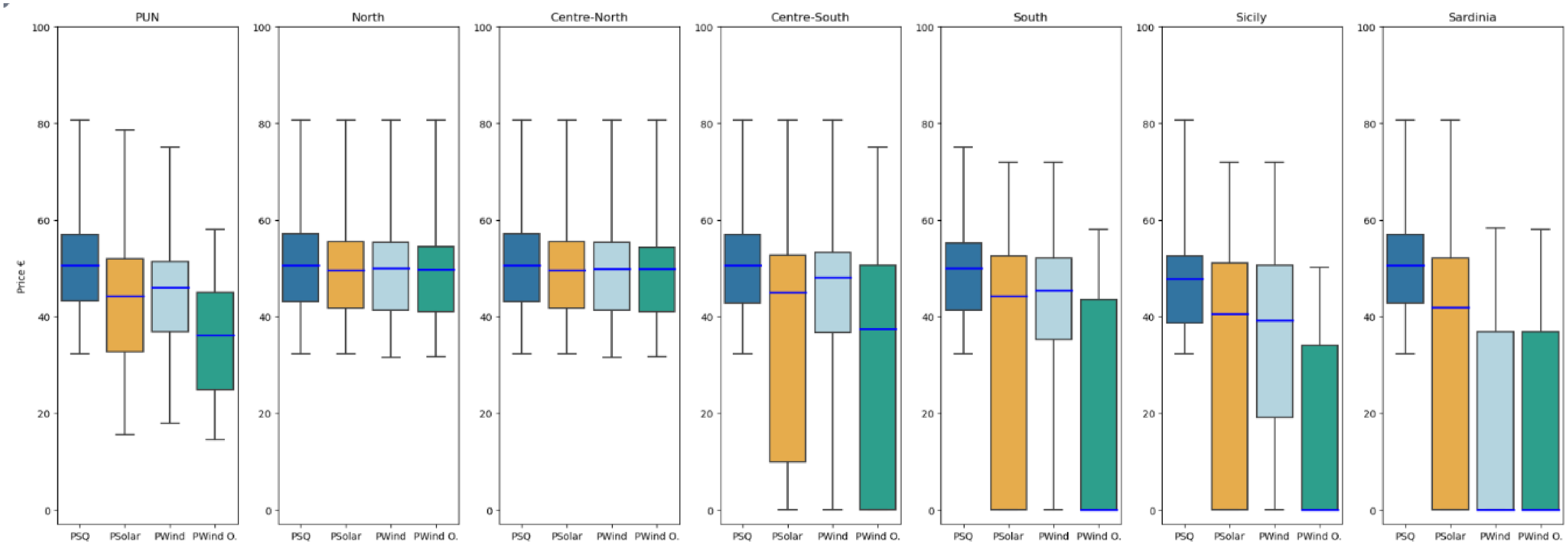
2019

Status quo scenario

PV scenario

W onshore scenario

W offshore scenario



highest impact derives from offshore wind

followed by solar

(3) Results – relative impact of VRES

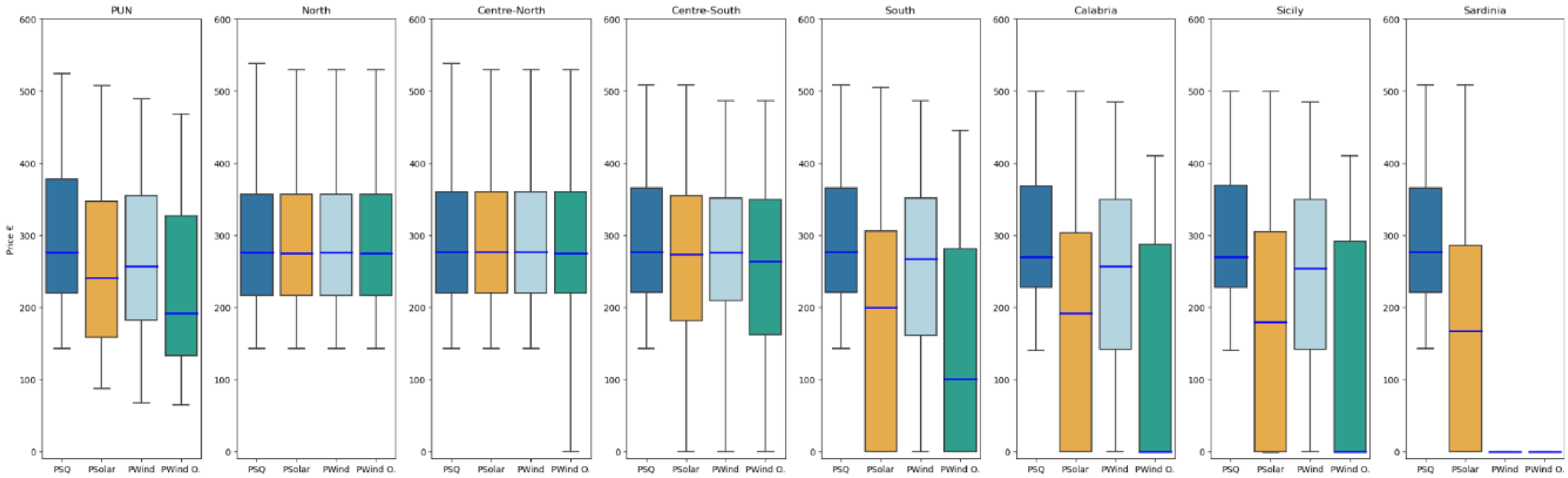
2022

Status quo scenario

PV scenario

W onshore scenario

W offshore scenario



The frequency with which price goes to 0 in some zones, but not in all of them signals the difficulties in dispatching the full amount of VRES energy, in particular from C-South to C-North (2019) and from South to C-South (2022). This is confirmed by the figures of the curtailments.

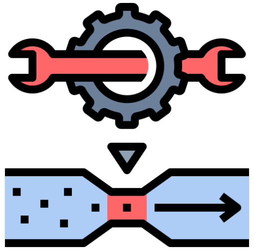
(3) Results – curtailments

Average curtailments with 2022 transmission capacity

zone	% of new RES (2022 sim.)	% of new RES (2019 sim.)
SARD	85.25	80.68
SICI	59.43	56.17
CALA	19.57	/
SUD	86.95	82.81
CSUD	53.87	79.30
CNOR	0	0

In **Southern regions** where **VRES gen. potential is higher**, **trans. cap. constraints** significantly **limit** the ability to **transport energy to northern** area

$$\frac{Net\ Excess\ VRES\ Supply - Trans.Capacity}{Quantity\ of\ new\ VRES}$$



Percentage of the total energy produced from VRES that cannot be dispatched due to the insufficient demand and transmission capacity.

(3) Results – overall impact of VRES

Median values of clearing prices

zone	2019		
	Status Quo	Price RES	Price RES TC 2030
PUN	50.64	26.50	18.99
NORD	50.59	48.75	38.73
CNOR	50.59	48.73	38.98
CSUD	50.64	0.00	0.00
SUD	50.02	0.00	0.00
CALA	–	–	–
SICI	47.76	0.00	0.00
SARD	50.64	0.00	0.00

Development Plan

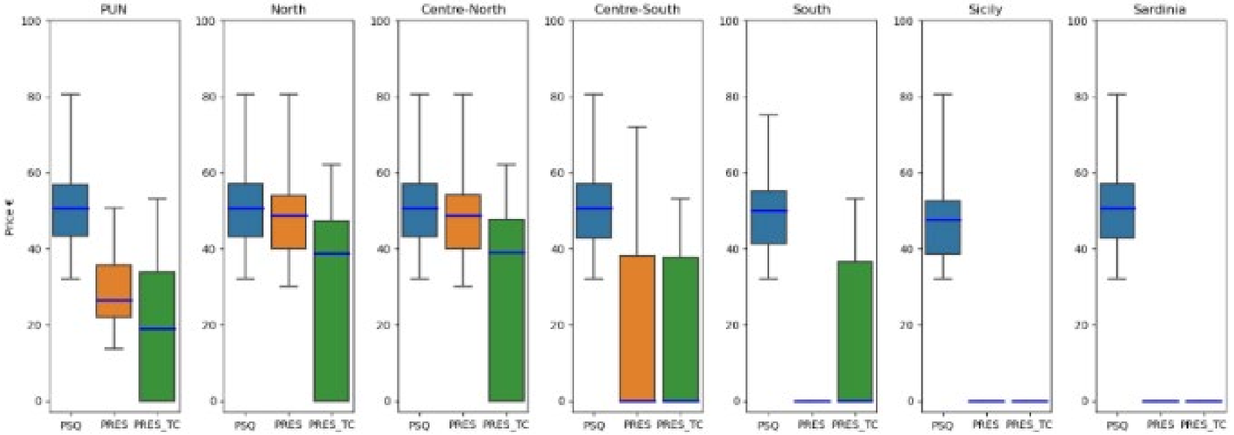
Best case scenario for trans. cap. expansion

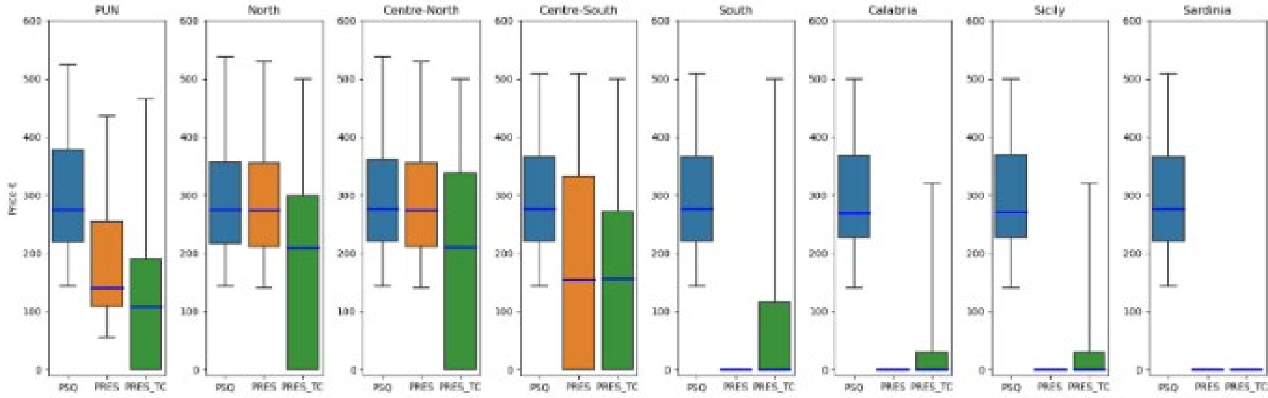
Transmission capacity expansion has a positive impact reducing the average prices of the northern zones

Median values of clearing prices

zone	2022		
	Status Quo	Price Res	Price Res TC 2030
PUN	276.03	140.28	108.63
NORD	276.03	275.04	209.55
CNOR	276.70	275.00	210.33
CSUD	276.54	155.60	156.13
SUD	276.54	0.00	0.00
CALA	270.13	0.00	0.00
SICI	270.25	0.00	0.00
SARD	276.54	0.00	0.00

Development Plan





Development Plan

Status quo scenario

RES scenario

RES TC 2030 scenario

(3) Results – relative impact of VRES

Analysis replication considering each sources (PW, onshore W, offshore W) singularly

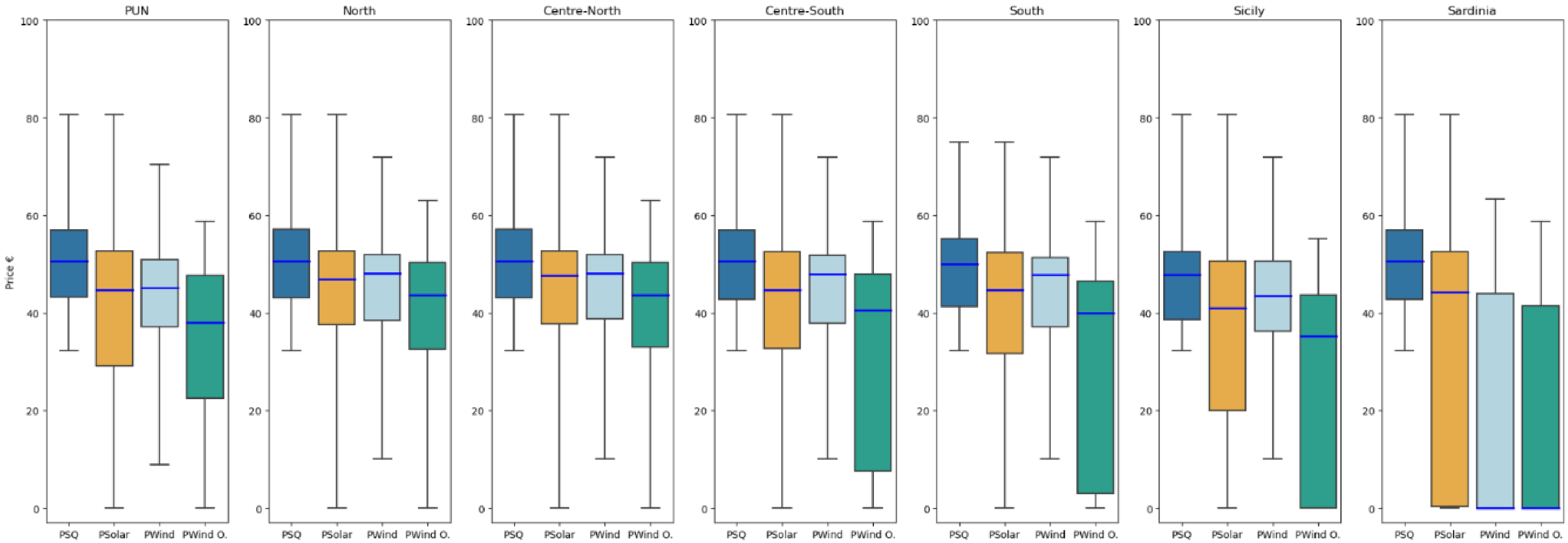
2019

Status quo scenario

PV scenario

W onshore scenario

W offshore scenario



highest impact derives from offshore wind

followed by solar

(3) Results – relative impact of VRES

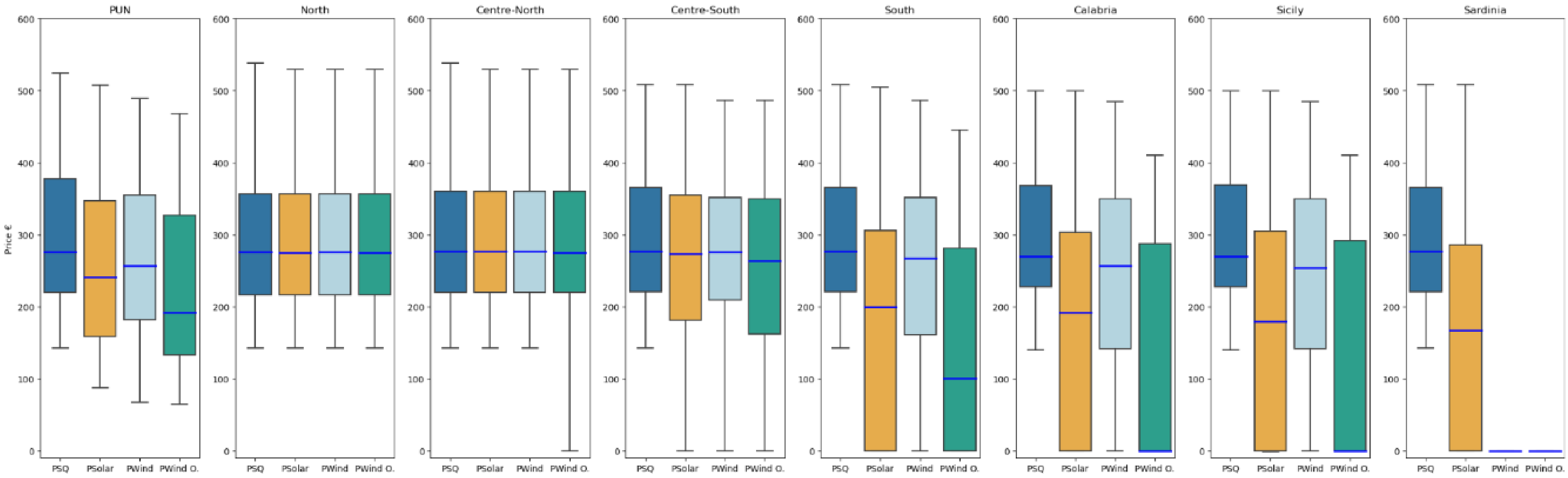
2022

Status quo scenario

PV scenario

W onshore scenario

W offshore scenario



(3) Results – curtailments

Average curtailments with 2030 transmission capacity

zone	% of new RES (2022 sim.)	% of new RES (2019 sim.)
SARD	65.84	62.76
SICI	21.80	19.64
CALA	8.96	/
SUD	51.00	49.08
CSUD	23.96	40.72
CNOR	0.00	0.00

Curtailments

Still high in SARD

Still high in SOUTH & CSOUTH

CNORTH

Agenda

(4) Conclusions

Simulate the impact on the equilibrium prices of two reference years accruing from the huge flow of investments in VRES capacity in Italy.

Market clearings

Different impact across technologies.

PV has the highest capacity investment values but has not the highest positive impact on prices

There is price and quantity risk due to curtailments.

Even the TSO ambitious plan will not eliminate them

The foreseen investments suggest that **investors are neglecting investment risks** when requesting authorizations for utility-scale VRES

Contatti

Rimani sempre aggiornato con RSE perché

#wemoversearch

Cinzia Bonaldo

cinzia.bonaldo@rse-web.it

www.rse-web.it

@Ricerca sul Sistema Energetico - RSE SpA

@RSEnergetico

RSE SpA - Ricerca sul Sistema Energetico