1 Supplementary Material of: The impact of utility-scale RES power production on the Italian electricity prices

The content displayed here is made available as supplementary material in a data repository.

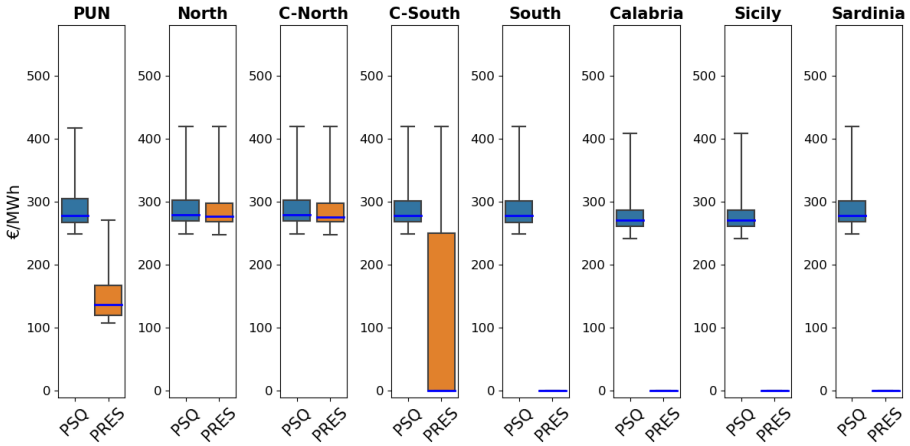

Figure S1: March 2019. Price distributions without (in blue) and with (in red) RES investments per each Zone. The bars report the median (horizontal blue line), the 75% confidence interval and the min-max of the price distribution per each period.

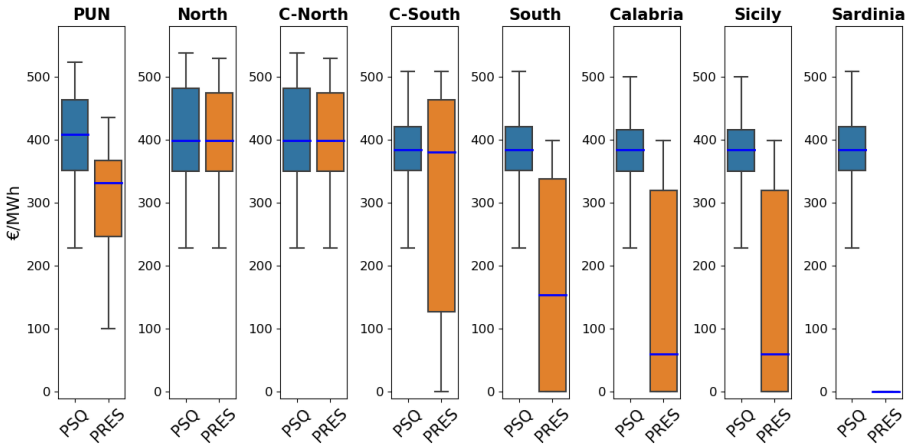

Figure S2: July 2019. Price distributions without (in blue) and with (in red) RES investments per each Zone. The bars report the median (horizontal blue line), the 75% confidence interval and the min-max of the price distribution per each period.

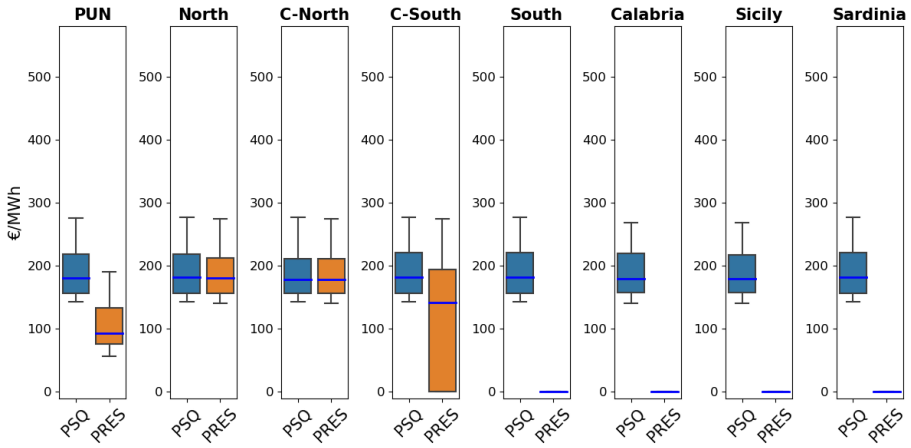

Figure S3: November 2019. Price distributions without (in blue) and with (in red) RES investments per each Zone. The bars report the median (horizontal blue line), the 75% confidence interval and the min-max of the price distribution per each period.

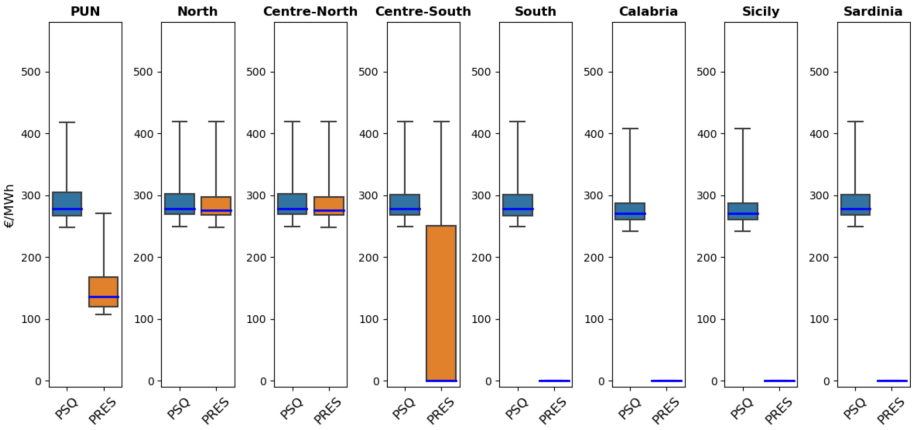

Figure S4: March 2022. Price distributions without (in blue) and with (in red) RES investments per each Zone. The bars report the median (horizontal blue line), the 75% confidence interval and the min-max of the price distribution per each period.

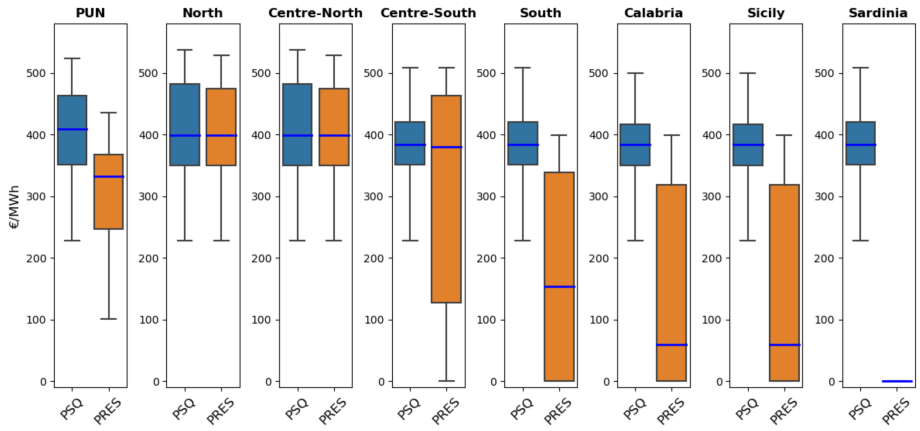

Figure S5: July 2022. Price distributions without (in blue) and with (in red) RES investments per each Zone. The bars report the median (horizontal blue line), the 75% confidence interval and the min-max of the price distribution per each period.

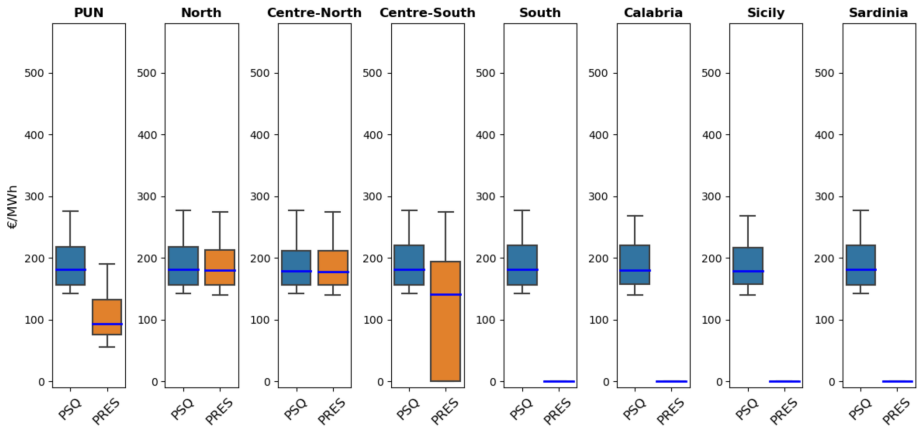

Figure S6: November 2022. Price distributions without (in blue) and with (in red) RES investments per each Zone. The bars report the median (horizontal blue line), the 75% confidence interval and the min-max of the price distribution per each period.

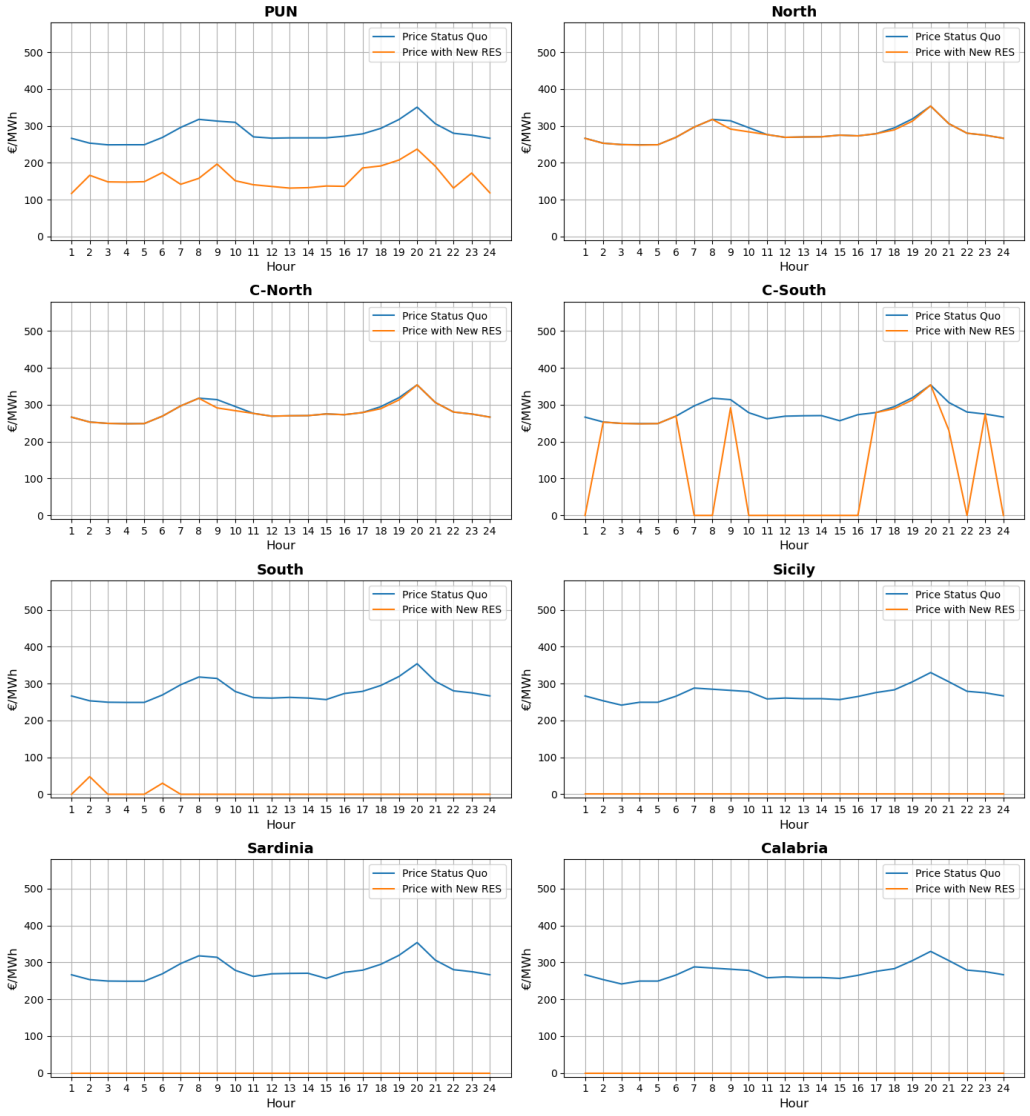

Figure S7: March 2022. Wednesday. Daily price distribution without (in blue) and with (in red) RES power production in each zone.

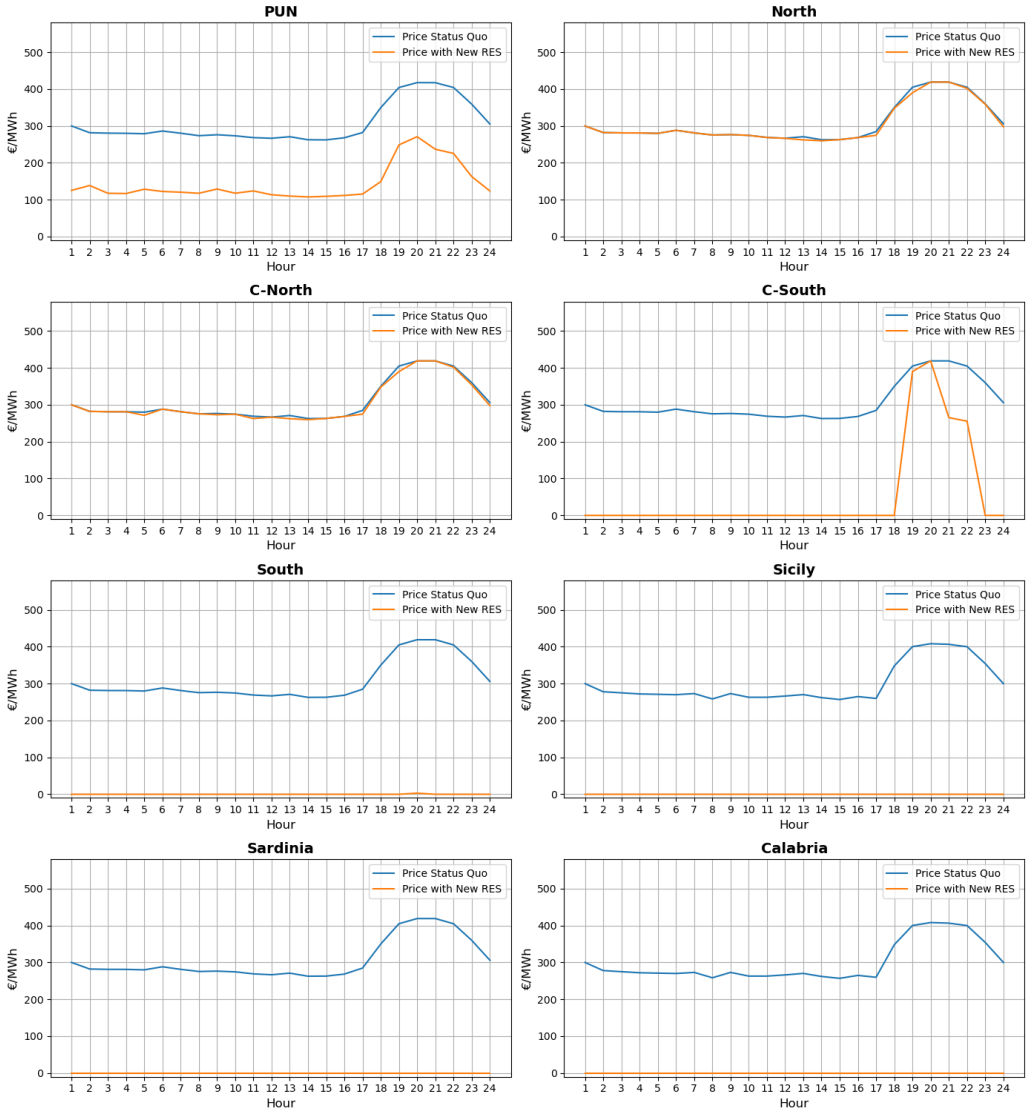

Figure S8: March 2022. Sunday. Daily price distribution without (in blue) and with (in red) RES power production in each zone.

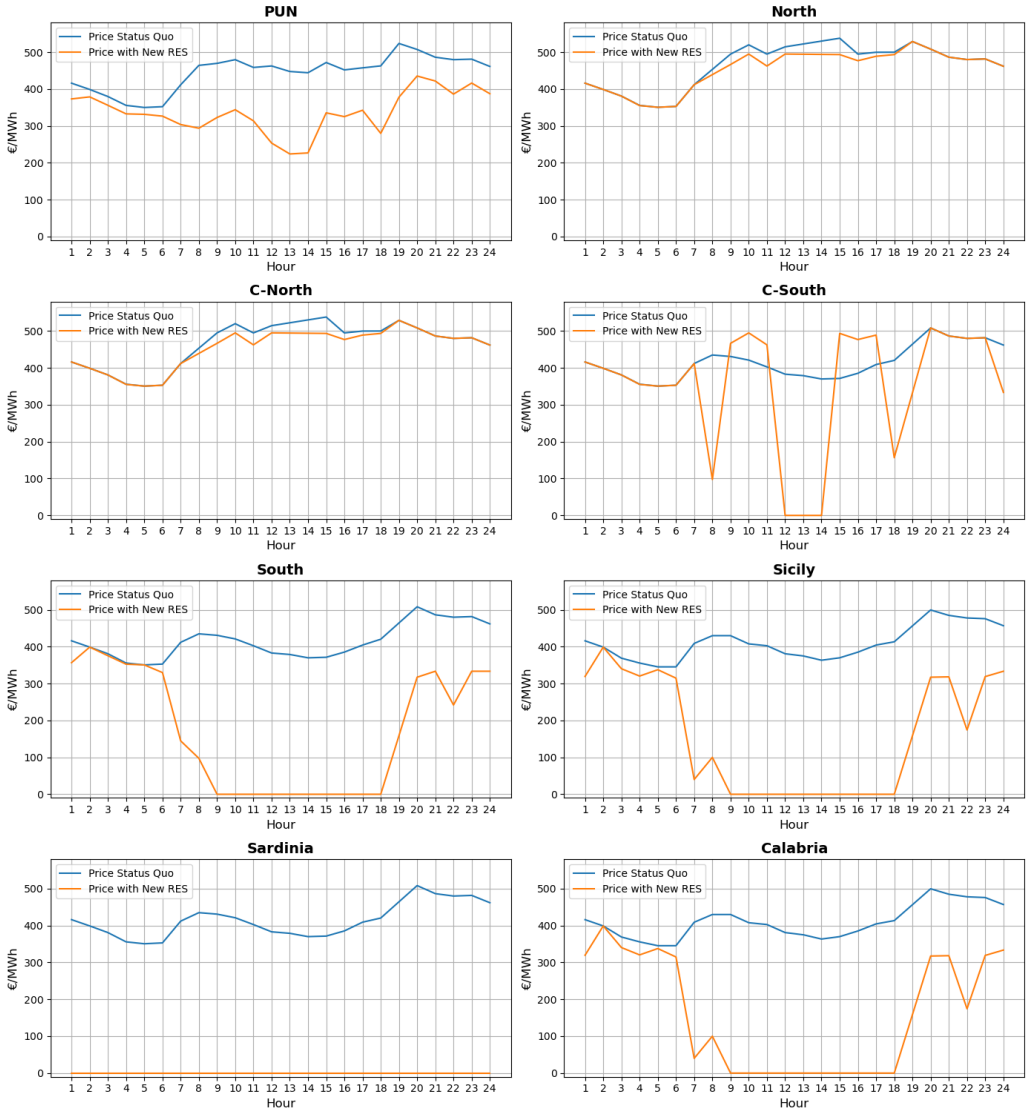

Figure S9: July 2022. Wednesday. Daily price distribution without (in blue) and with (in red) RES power production in each zone.

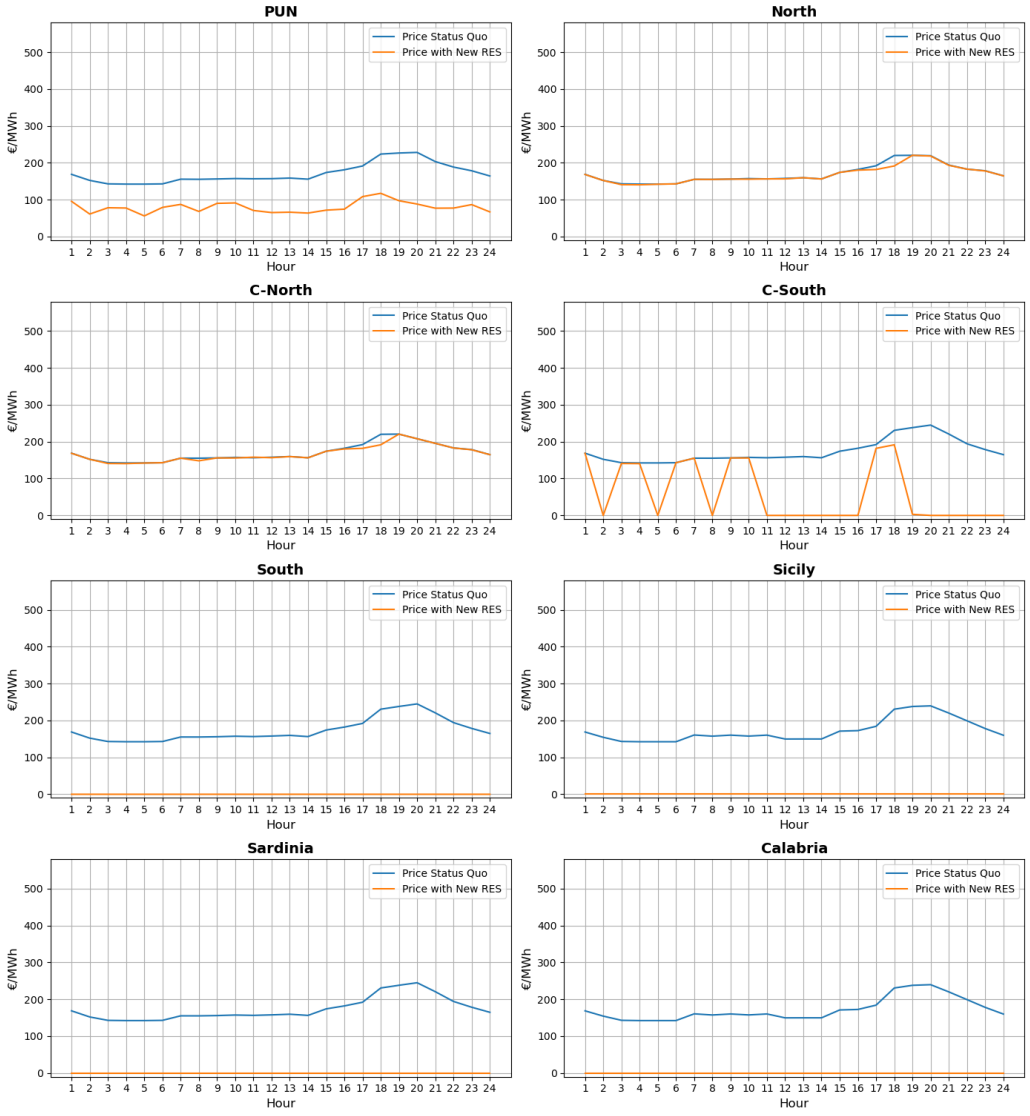

Figure S10: November 2022. Sunday. Daily price distribution without (in blue) and with (in red) RES power production in each zone.

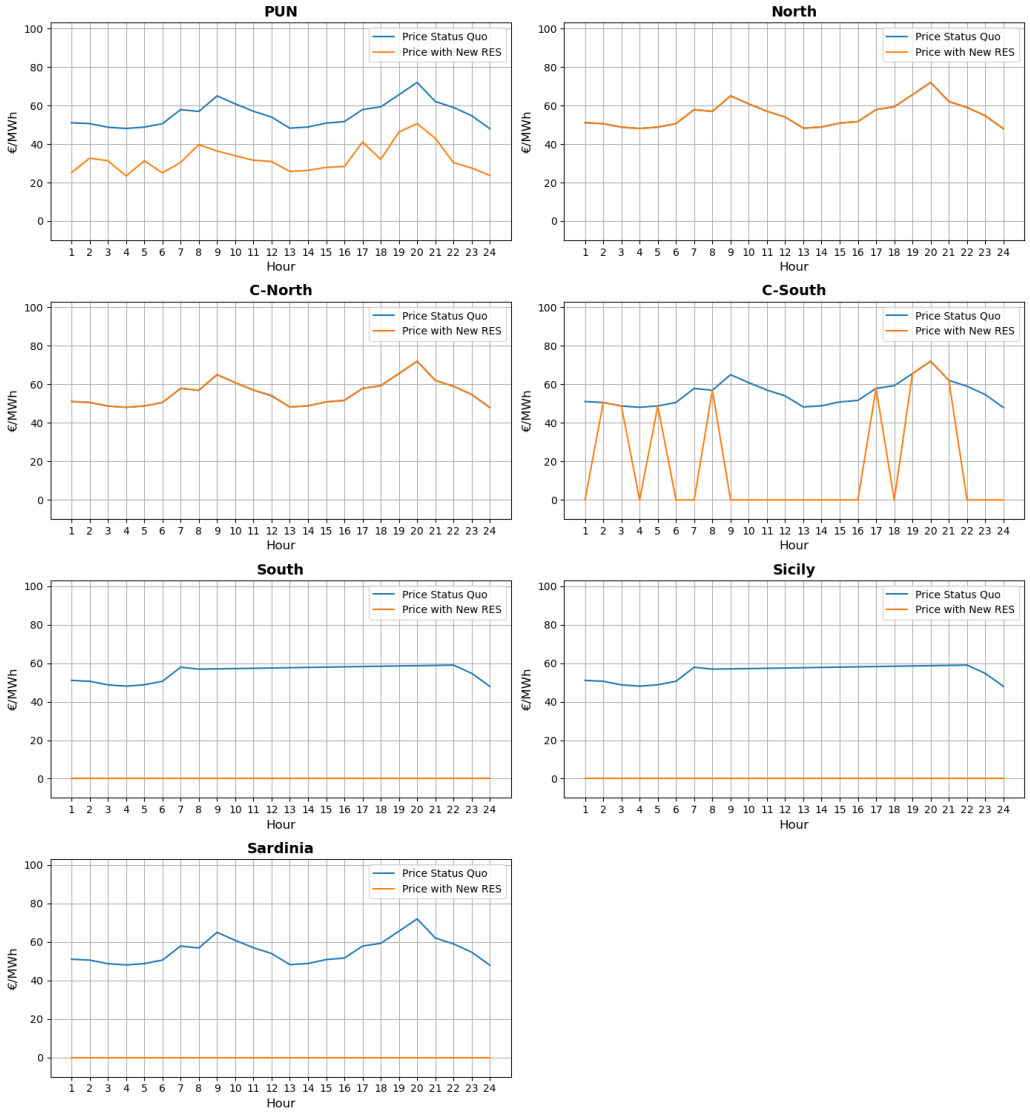

Figure S11: March 2019. Wednesday. Daily price distribution without (in blue) and with (in red) RES power production in each zone.

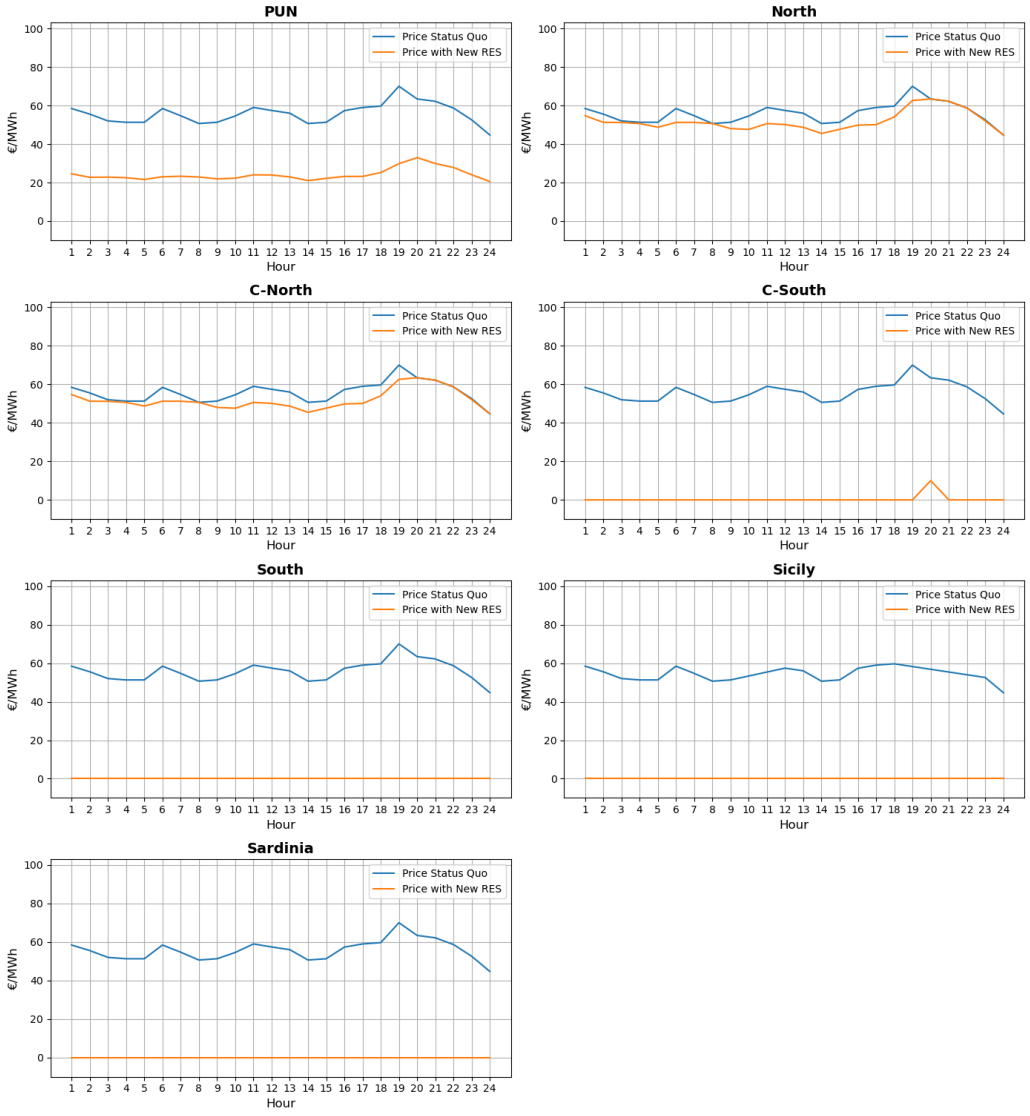

Figure S12: March 2019. Sunday. Daily price distribution without (in blue) and with (in red) RES power production in each zone.

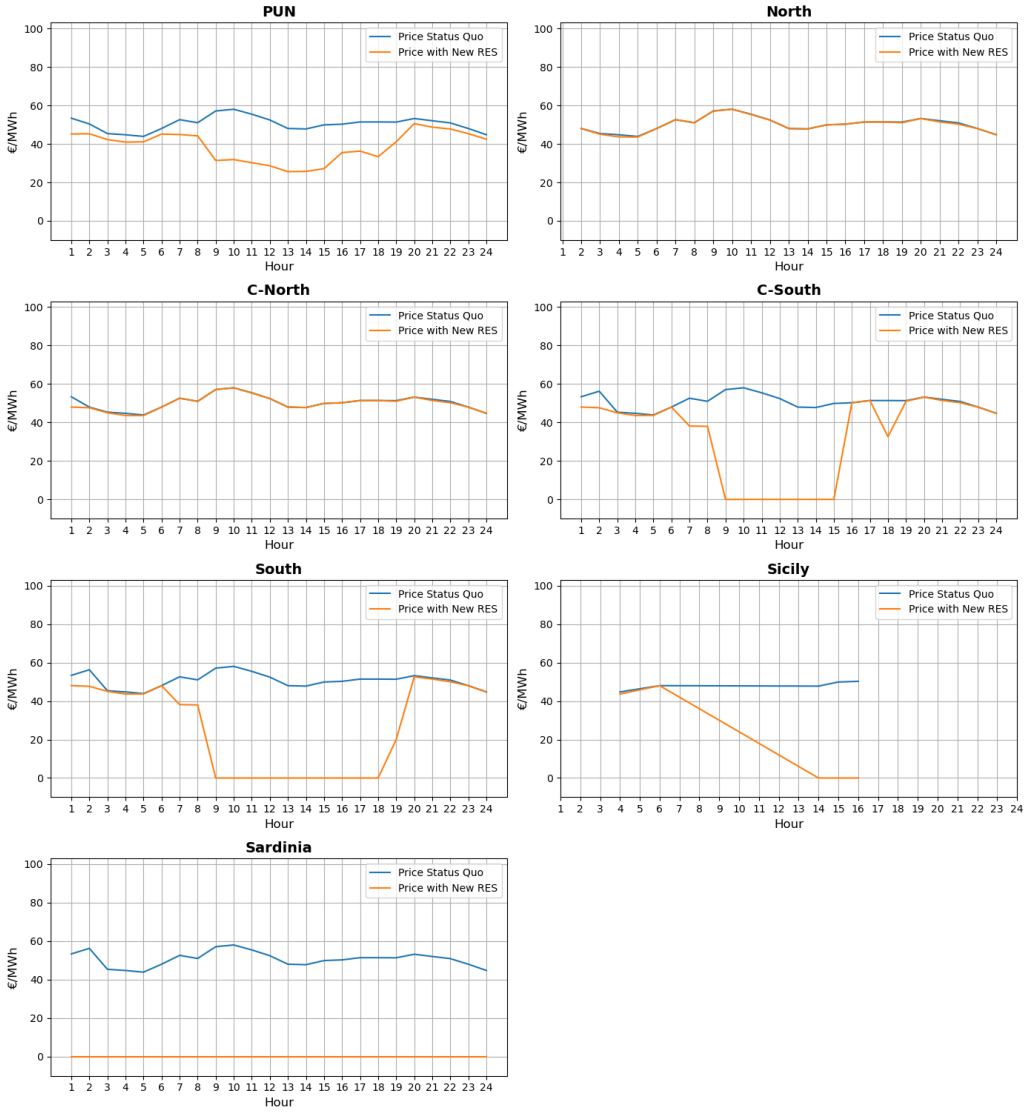

Figure S13: July 2019. Wednesday. Daily price distribution without (in blue) and with (in red) RES power production in each zone.

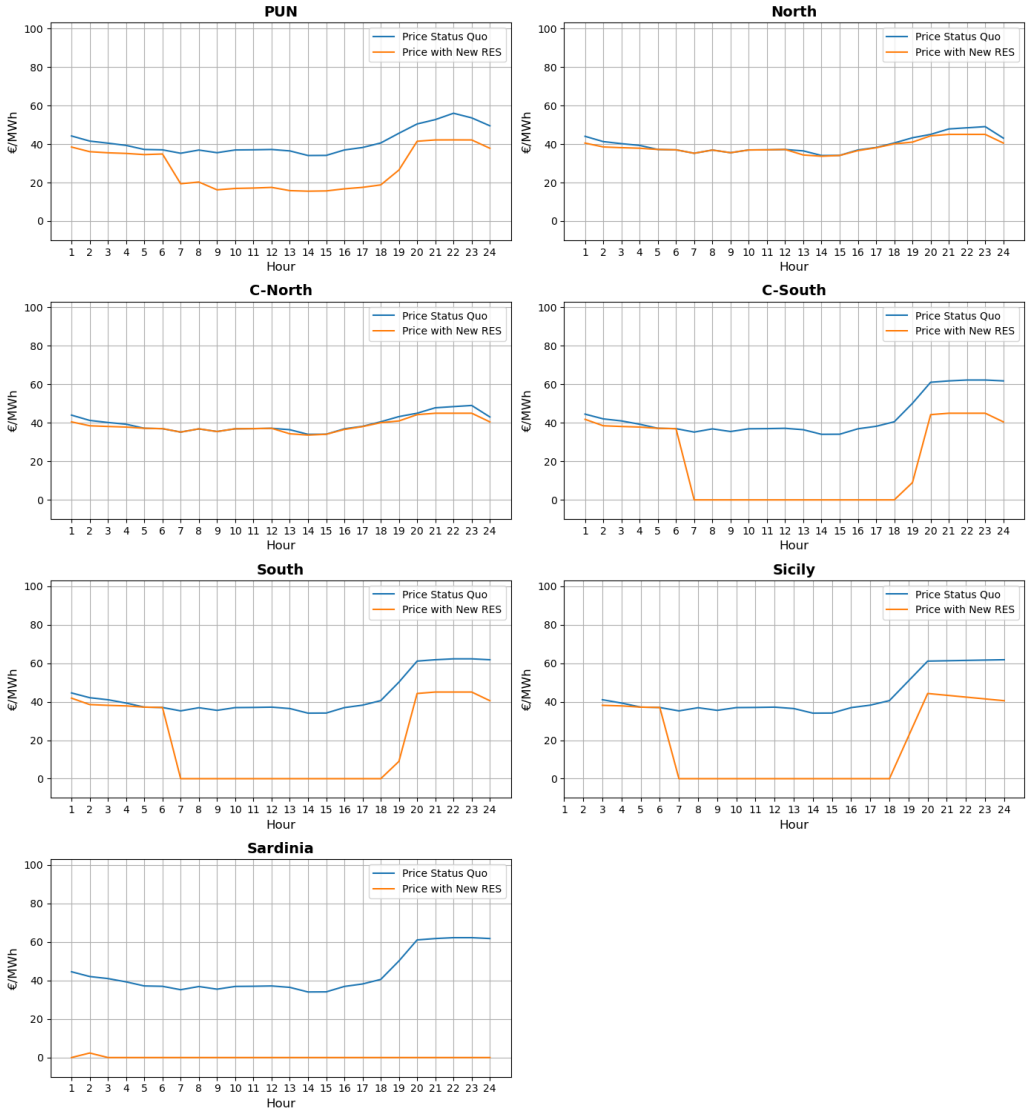

Figure S14: July 2019. Sunday. Daily price distribution without (in blue) and with (in red) RES power production in each zone.

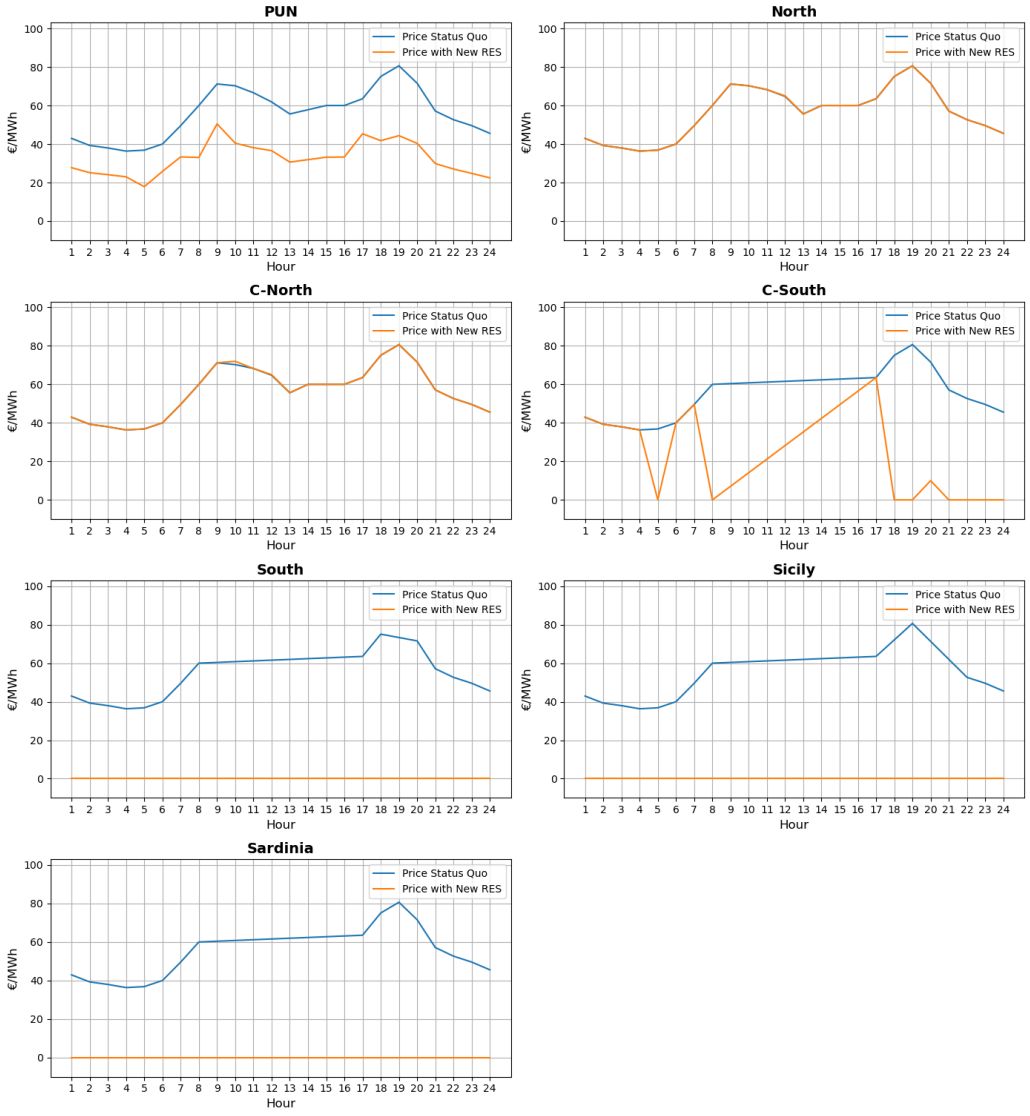

Figure S15: November 2019. Wednesday. Daily price distribution without (in blue) and with (in red) RES power production in each zone.

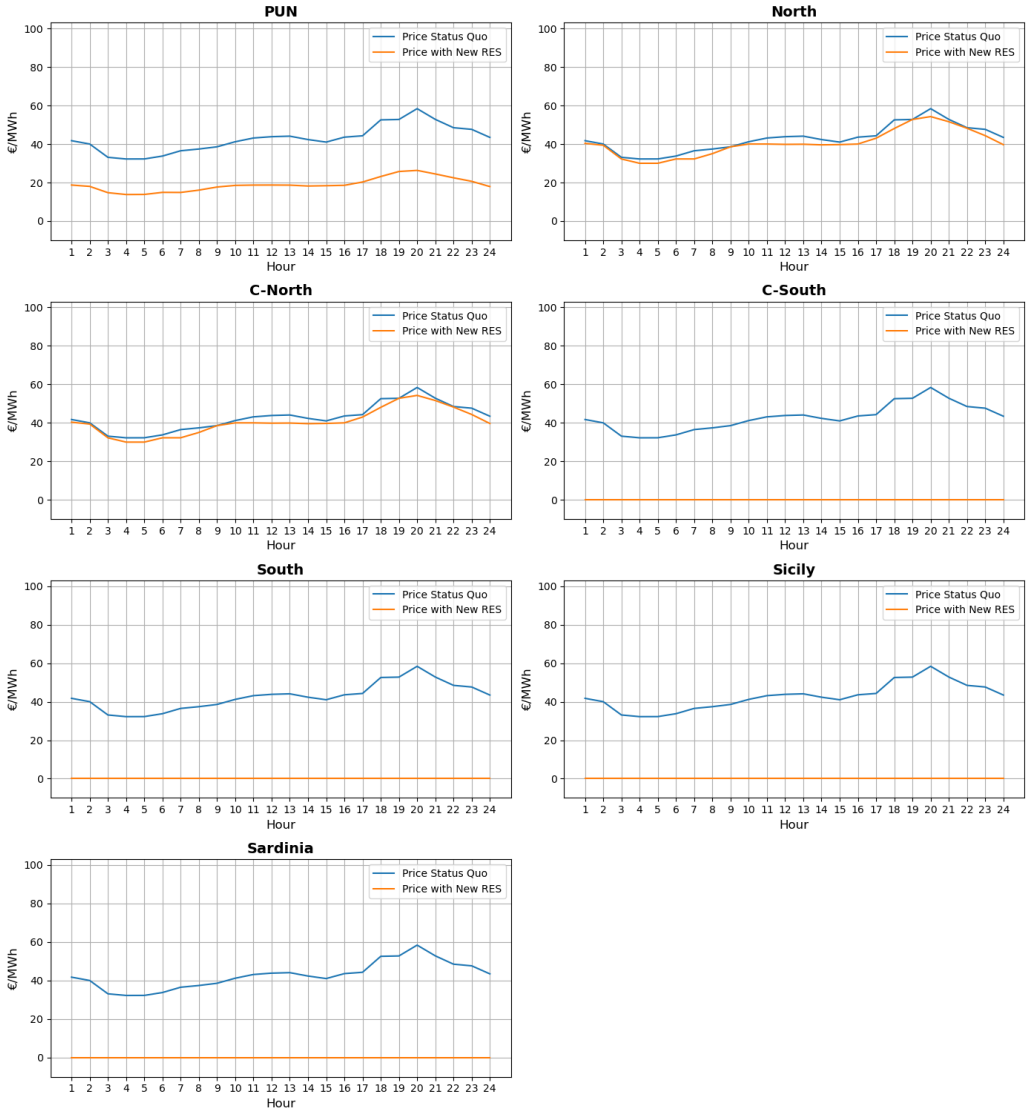

Figure S16: November 2019. Sunday. Daily price distribution without (in blue) and with (in red) RES power production in each zone.

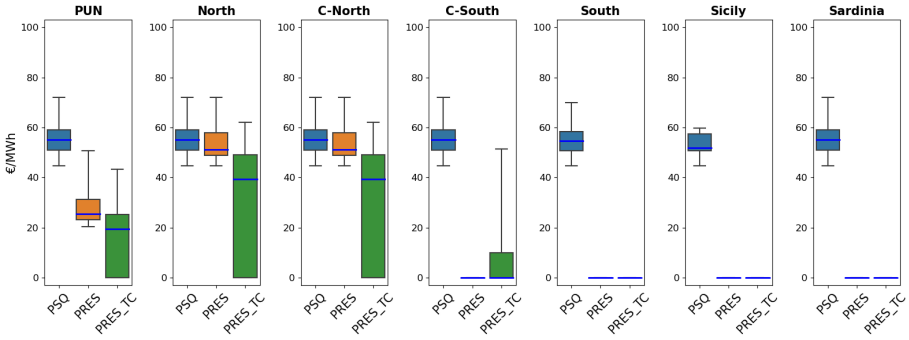

Figure S17: March 2019. Price distributions without (in blue) and with (in red) RES investments per each Zone; (in green) the foreseen investment in transmission capacity between zones for 2030 has been taken into account. The bars report the median (horizontal blue line), the 75% confidence interval and the min-max of the price distribution per each period.

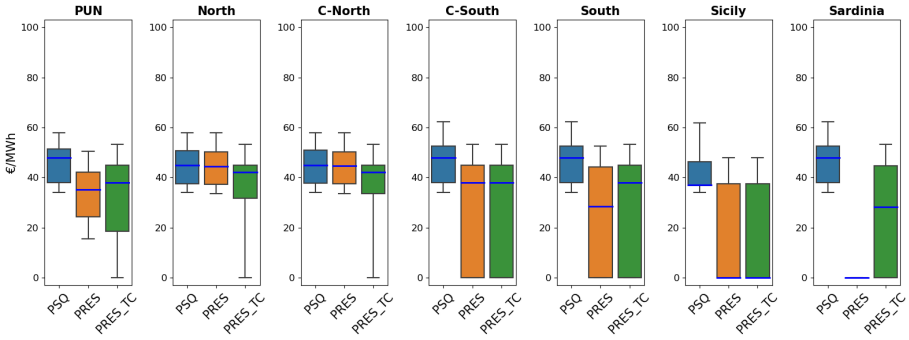

Figure S18: July 2019. Price distributions without (in blue) and with (in red) RES investments per each Zone; (in green) the foreseen investment in transmission capacity between zones for 2030 has been taken into account. The bars report the median (horizontal blue line), the 75% confidence interval and the min-max of the price distribution per each period.

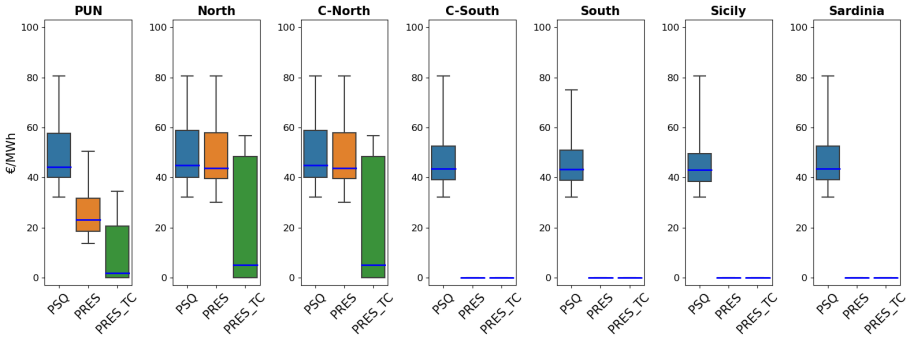

Figure S19: November 2019. Price distributions without (in blue) and with (in red) RES investments per each Zone; (in green) the foreseen investment in transmission capacity between zones for 2030 has been taken into account. The bars report the median (horizontal blue line), the 75% confidence interval and the min-max of the price distribution per each period.

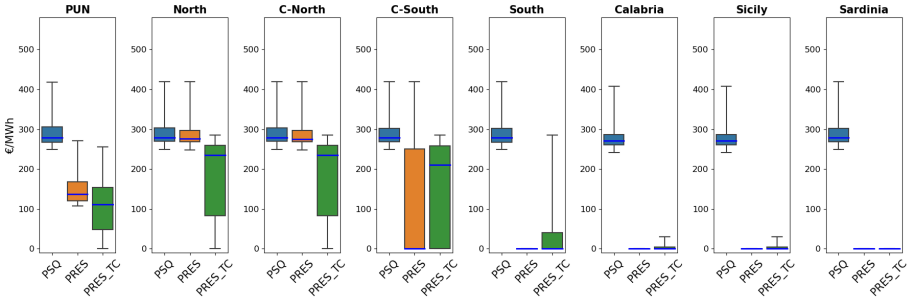

Figure S20: March 2022. Price distributions without (in blue) and with (in red) RES investments per each Zone; (in green) the foreseen investment in transmission capacity between zones for 2030 has been taken into account. The bars report the median (horizontal blue line), the 75% confidence interval and the min-max of the price distribution per each period.

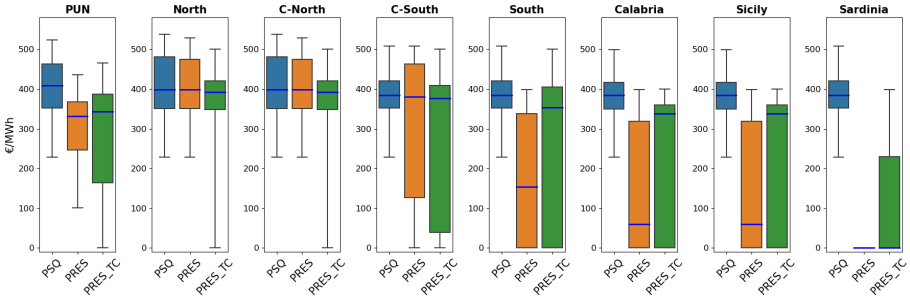

Figure S21: July 2022. Price distributions without (in blue) and with (in red) RES investments per each Zone; (in green) the foreseen investment in transmission capacity between zones for 2030 has been taken into account. The bars report the median (horizontal blue line), the 75% confidence interval and the min-max of the price distribution per each period.

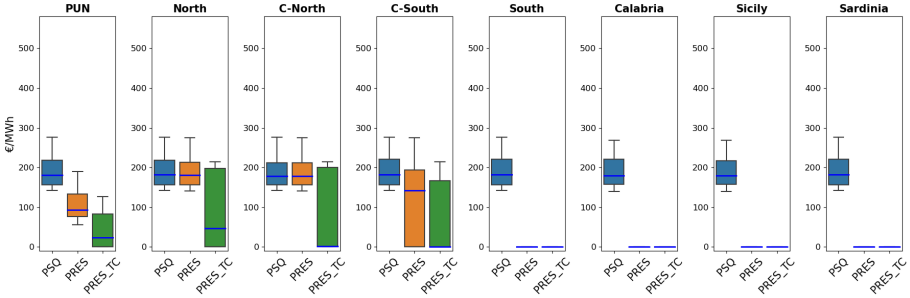

Figure S22: November 2022. Price distributions without (in blue) and with (in red) RES investments per each Zone; (in green) the foreseen investment in transmission capacity between zones for 2030 has been taken into account. The bars report the median (horizontal blue line), the 75% confidence interval and the min-max of the price distribution per each period.

2 Robustness check: random selection of days

In this section we perform a robustness check to see if the choice of the days of the simulation might bias the result. To do so, we perform a random selection of the days, and replicate the analyses. We point out, however, that the load has a specific pattern that calls for a semi-random selection of the data, able to respect the specific daily, weekly, and seasonal pattern of the data. The load is reported in the following figures.

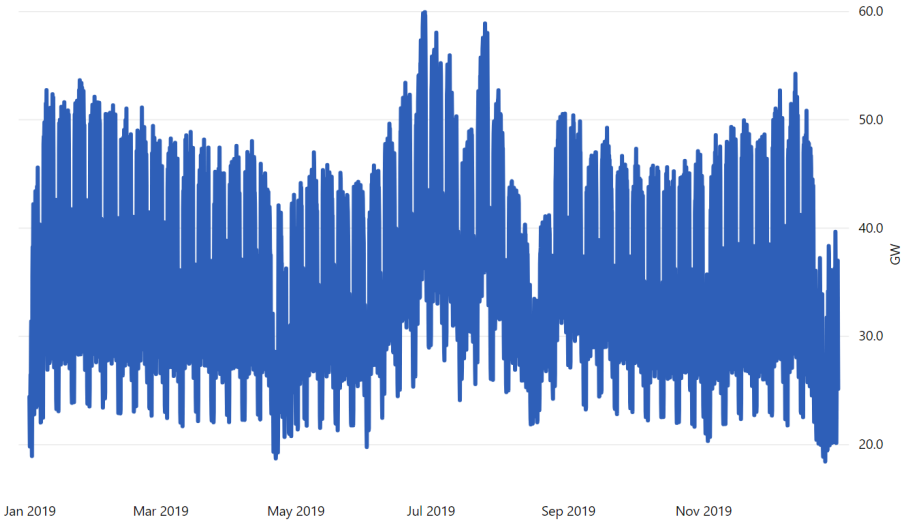

Figure S23: Total Load 2019. Source: Terna Transparency Report

Note the weekly trends, and that Sundays are off-peak days with the lowest weekly load; similarly, august is the month of the week with the minimum load, due to summer holidays. Finally, spring, fall and winter have a different seasonal loads. A purely random choice of the days would not capture the specific pattern of power load. Thus, we have first performed a simulation in which the off peak day has been randomly selected provided that it was a Sunday. the other days have been randomly selected maintaining the same selected month to pick up the same seasonal pattern. The following days were selected March 20, 22; July 19, 24; and November 17, 20 in 2022, and March 24, 26; July 15, 21; and November 7, 10 in 2019. None of these days coincide with the ones selected or the simulations reported in the text. Secondly, another semi-random selection has been performed, with a random selection of days, keeping fixed just Sundays as the off-peak day (but not necessarily the same Sundays of the previous robustness check and of the analyses

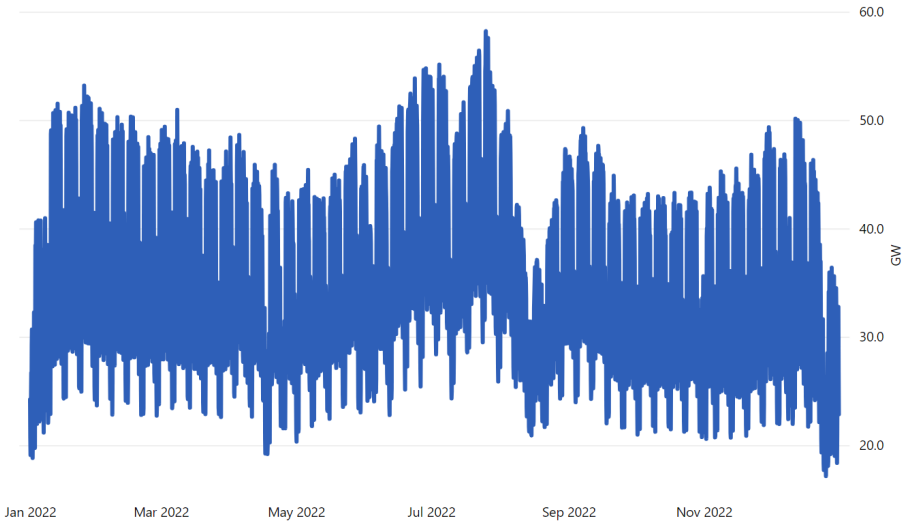

Figure S24: Total Load 2022. Source: Terna Transparency Report

reported in the text) and another random day of spring, fall and winter (excluding the Christmas period for December), respectively. The following days were selected: February 24, 27; June 21, 26; and December 4, 8 in 2022, while for 2019 they were February 17, 19; June 27, 30; and December 5, 8. Results are summarized in table 1:

They can be compared it with the results reported in the text, Table 2:

For simplicity, we have not replicated the full scope of simulations, but just the scenarios with all RES. The prices without RES differ, since different days have been chosen. However, the simulations are comparable to the one reported in the text. We believe that this makes our analysis robust to the sample selection of days adopted in the text.

Table 1: Median values (€/MWh) for the first and second simulations (2019 and 2022)

Zone	First Simulation 2019			First Simulation 2022		
	Status Quo	Price RES	Price RES TC 2030	Status Quo	Price RES	Price RES TC 2030
PUN	45.61	25.45	16.69	265.92	146.87	105.18
North	44.54	44.16	34.32	266.80	266.34	208.37
Centre-North	44.54	44.00	34.84	266.80	266.34	208.37
Centre-South	47.13	0.00	0.00	252.14	221.09	144.24
South	46.83	0.00	0.00	266.80	0.00	0.00
Calabria	–	–	–	263.61	0.00	0.00
Sicily	43.53	0.00	0.00	263.61	0.00	0.00
Sardinia	47.13	0.00	0.00	252.14	0.00	0.00
Zone	Second Simulation 2019			Second Simulation 2022		
	Status Quo	Price RES	Price RES TC 2030	Status Quo	Price RES	Price RES TC 2030
PUN	54.29	29.40	22.29	288.90	164.64	98.54
North	53.82	53.16	47.17	288.27	283.77	186.54
Centre-North	54.25	53.03	46.20	288.27	283.77	186.54
Centre-South	57.92	0.00	0.00	281.89	178.89	40.00
South	57.81	0.00	0.00	281.89	0.00	0.00
Calabria	–	–	–	281.89	0.00	0.00
Sicily	54.78	0.00	0.00	281.89	0.00	0.00
Sardinia	57.69	0.00	0.00	281.89	0.00	0.00

Table 2: Median prices (€/MWh); transmission capacity 2023 and 2030

zone	2019			2022		
	Status Quo	Price RES	Price RES TC 2030	Status Quo	Price Res	Price Res TC 2030
PUN	50.64	26.50	18.99	276.03	140.28	108.63
North	50.59	48.75	38.73	276.03	275.04	209.55
Centre-North	50.59	48.73	38.98	276.70	275.00	210.33
Centre-South	50.64	0.00	0.00	276.54	155.60	156.13
South	50.02	0.00	0.00	276.54	0.00	0.00
Calabria	–	–	–	270.13	0.00	0.00
Sicily	47.76	0.00	0.00	270.25	0.00	0.00
Sardinia	50.64	0.00	0.00	276.54	0.00	0.00

Table 3 reports the errors of the simulations compared to the observed data disaggregated per hour, without including the data of Sicily.

Hour	**Mean Absolute Error**	**Mean Percentage Error**
1	0.54	0.55
2	0.44	0.38
3	0.65	0.40
4	0.45	0.32
5	0.51	0.24
6	0.57	0.23
7	0.39	0.18
8	2.71	0.80
9	2.32	1.82
10	4.00	2.79
11	1.85	2.19
12	1.91	2.22
13	2.89	2.54
14	3.03	2.96
15	3.01	2.37
16	1.41	1.13
17	1.15	0.82
18	1.30	0.77
19	5.02	1.79
20	1.54	1.05
21	0.98	0.88
22	1.46	1.52
23	0.49	0.55
24	0.44	0.45

Table 3: Hourly Error Metrics Excluding Sicily