

Online Appendix

A Additional Results and Details

Table A.1: Installed capacity targets in 2030 under baseline and closure scenarios

(a) PNIEC baseline

Installed capacity (GW)	PNIEC baseline	Closure 2030 + 100% inv.	Closure 2030 + 75% inv.	Closure 2030 + 50% inv.
Wind	60,5	60,5	53,2	46,0
Solar PV	72,1	72,1	62,0	52,0
Solar thermal	4,8	4,8	4,2	3,5
Nuclear	3,0	5,3	5,3	5,3
CCGTs	24,5	24,5	24,5	24,5
Hydro	14,6	14,6	14,6	14,6
Storage	17,6	17,6	14,0	10,5

(b) Feasible baseline

Installed capacity (GW)	Feasible baseline	Closure 2030 + 100% inv.	Closure 2030 + 75% inv.	Closure 2030 + 50% inv.
Wind	45,0	45,0	41,6	38,2
Solar PV	65,0	65,0	56,7	48,4
Solar thermal	2,3	2,3	2,3	2,3
Nuclear	3,0	5,3	5,3	5,3
CCGTs	24,5	24,5	24,5	24,5
Hydro	14,6	14,6	14,6	14,6
Storage	15,4	15,4	12,4	9,4

Table A.2: Wholesale electricity prices under the *PNIEC* and *Feasible* baselines

	Market prices (€/MWh)			
	2028	2029	2030	2031
<i>PNIEC</i> baseline				
Closure 2027 + 100% inv.	66,0	66,2	66,7	70,8
Closure 2030 + 100% inv.	63,2	61,0	63,1	70,8
Closure 2030 + 75% inv.	69,8	69,2	71,5	78,6
Closure 2030 + 50% inv.	77,6	76,8	79,9	87,5
<i>Feasible</i> baseline				
Closure 2027 + 100% inv.	64,3	63,8	63,8	67,2
Closure 2030 + 100% inv.	60,9	56,6	58,4	67,2
Closure 2030 + 75% inv.	65,8	62,8	65,1	73,5
Closure 2030 + 50% inv.	71,1	67,9	70,7	79,7

Notes: The table reports annual average wholesale electricity prices (€/MWh) under the two baselines.

Table A.3: Captured prices by solar and wind under the *PNIEC* baseline and counterfactual scenarios

<i>PNIEC</i> baseline	Captured prices by solar (€/MWh)			
	2028	2029	2030	2031
Closure 2027 + 100% inv.	25,4	27,0	25,8	30,3
Closure 2030 + 100% inv.	22,6	22,5	22,8	30,3
Closure 2030 + 75% inv.	31,2	32,9	33,5	44,0
Closure 2030 + 50% inv.	45,4	44,5	48,3	64,8
	Captured prices by wind (€/MWh)			
	2028	2029	2030	2031
Closure 2027 + 100% inv.	68,5	68,2	69,2	73,6
Closure 2030 + 100% inv.	65,5	62,6	65,6	73,6
Closure 2030 + 75% inv.	71,7	70,5	73,6	80,9
Closure 2030 + 50% inv.	78,8	78,1	81,6	88,5

Notes: The table reports annual average captured prices (€/MWh) for solar PV (upper panel) and wind (lower panel) in the wholesale electricity market under the baseline *PNIEC* scenario and the counterfactual delayed-closure scenarios.

Table A.4: Captured prices by solar and wind under the *Feasible* baseline and counterfactual scenarios

Feasible Baseline	Captured prices by solar (€/MWh)			
	2028	2029	2030	2031
Closure 2027 + inv.	23,6	24,6	23,0	25,6
Closure 2030 + 100% inv.	20,6	19,6	19,7	25,6
Closure 2030 + 75% inv.	26,7	27,0	26,5	35,5
Closure 2030 + 50% inv.	34,6	34,0	35,0	47,8
	Captured prices by wind (€/MWh)			
	2028	2029	2030	2031
Closure 2027 + inv.	66,8	65,8	66,5	70,1
Closure 2030 + 100% inv.	63,2	57,8	60,8	70,1
Closure 2030 + 75% inv.	67,7	63,7	67,1	76,0
Closure 2030 + 50% inv.	72,6	68,6	72,6	81,5

Notes: The table reports annual average captured prices (€/MWh) for solar PV (upper panel) and wind (lower panel) in the wholesale electricity market under the baseline *Feasible* scenario and the counterfactual delayed-closure scenarios.

Table A.5: Changes in storage outcomes under alternative *PNIEC* investment scenarios

<i>Baseline: PNIEC</i>	Change in storage profits (%)			
	2028	2029	2030	2031
Closure 2030 +100% inv.	3,57	3,30	1,47	—
Closure 2030 +75% inv.	-8,37	0,37	-3,16	-18,69
Closure 2030 +50% inv.	-29,42	-10,86	-19,73	-46,44
	Change in the capacity factor (%)			
	2028	2029	2030	2031
Closure 2030 +100% inv.	8,14	7,37	6,77	—
Closure 2030 +75% inv.	-10,41	2,93	-3,24	-17,55
Closure 2030 +50% inv.	-30,09	-11,95	-18,61	-44,57
	Change in arbitrage spreads (%)			
	2028	2029	2030	2031
Closure 2030 + 100% inv.	-4,21	-4,55	-5,34	—
Closure 2030 +75% inv.	3,07	-0,44	2,11	1,03
Closure 2030 +50% inv.	3,29	3,84	3,02	1,23

Notes: The top panel reports the change in storage arbitrage profits per MW relative to the *PNIEC* baseline. The decomposition highlights two drivers: the capacity factor (middle panel) and the average arbitrage spread (bottom panel). The capacity factor is computed as total annual energy charged divided by installed capacity. The arbitrage spread is the difference between the discharge-price average and the charge-price average, with each price weighted by the corresponding discharged/charged energy.

Table A.6: Wholesale electricity prices and effects of delaying the closure of Almaraz — Medium Demand Growth (3,4%)

	Market prices (€/MWh)			
	2028	2029	2030	2031
<i>PNIEC</i> Baseline	50,8	48,0	46,1	48,3
Closure 2030 + 100% <i>PNIEC</i> inv.	46,5	41,0	40,3	48,3
Closure 2030 + 75% <i>PNIEC</i> inv.	54,4	49,4	50,8	60,0
Closure 2030 + 50% <i>PNIEC</i> inv.	63,4	59,5	61,3	70,9
Price effect of the delayed closure (%)				
Closure 2030 + 100% <i>PNIEC</i> inv.	-8,44	-14,52	-12,65	—
Closure 2030 + 75% <i>PNIEC</i> inv.	7,10	2,88	10,29	24,32
Closure 2030 + 50% <i>PNIEC</i> inv.	24,79	24,03	33,09	46,80

Notes: Market prices are annual average wholesale prices assuming an expected demand growth of 3,383% year-on-year, using 2024 actual hourly demand values. Percentage price effects are computed relative to the *PNIEC* baseline with closure according to the original schedule. The effect for 2031 under full *PNIEC* investment is not reported because market prices coincide with the baseline.

Table A.7: Wholesale electricity prices and effects of delaying the closure of Almaraz — Low Demand Growth (1,7%)

	Market prices (€/MWh)			
	2028	2029	2030	2031
<i>PNIEC</i> Baseline	42,5	37,8	35,0	36,2
Closure 2030 + 100% <i>PNIEC</i> inv.	37,1	29,7	28,7	36,2
Closure 2030 + 75% <i>PNIEC</i> inv.	45,8	39,1	38,4	47,4
Closure 2030 + 50% <i>PNIEC</i> inv.	54,0	48,7	49,2	59,7
Effect of the delay on market prices (%)				
Closure 2030 +100% <i>PNIEC</i> inv.	-12,77	-21,49	-18,01	—
Closure 2030 +75% <i>PNIEC</i> inv.	7,76	3,41	9,86	30,88
Closure 2030 +50% <i>PNIEC</i> inv.	27,02	28,76	40,74	64,87

Notes: The table reports annual average wholesale electricity prices assuming low electricity demand growth (1,69% per year). Percentage effects are computed relative to the *PNIEC* baseline with nuclear phase-out according to the original schedule. Dashes indicate years in which prices coincide with the baseline.

Table A.8: Wholesale electricity prices and effects of delaying the closure of Almaraz — High marginal cost of gas-fired generation

	Market prices (€/MWh)			
	2028	2029	2030	2031
<i>PNIEC</i> Baseline	90,3	89,5	90,6	96,2
Closure 2030 + 100% <i>PNIEC</i> inv.	86,2	81,6	85,4	96,2
Closure 2030 + 75% <i>PNIEC</i> inv.	95,9	93,3	97,5	107,8
Closure 2030 + 50% <i>PNIEC</i> inv.	107,7	105,7	109,8	120,5
Effect of the delay on market prices (%)				
Closure 2030 +100% <i>PNIEC</i> inv.	-4,51	-8,89	-5,79	—
Closure 2030 +75% <i>PNIEC</i> inv.	6,46	4,70	8,02	12,07
Closure 2030 +50% <i>PNIEC</i> inv.	18,09	17,32	19,68	22,55

Notes: The table reports annual average wholesale electricity prices assuming all the baseline assumptions, except for the price of gas, which is assumed to be 50 €/MWh instead of 30 €/MWh, giving rise to a higher marginal cost of gas-fired generation.

Table A.9: Wholesale electricity prices and effects of delaying the closure of Almaraz — Low marginal cost of gas-fired generation

	Market prices (€/MWh)			
	2028	2029	2030	2031
<i>PNIEC</i> Baseline	61,6	61,8	62,4	65,9
Closure 2030 + 100% <i>PNIEC</i> inv.	59,0	57,2	59,2	65,9
Closure 2030 + 75% <i>PNIEC</i> inv.	65,0	64,7	66,8	73,4
Closure 2030 + 50% <i>PNIEC</i> inv.	72,1	71,4	74,3	81,5
Effect of the delay on market prices (%)				
100% <i>PNIEC</i> inv.	-4,16	-7,35	-5,07	—
75% <i>PNIEC</i> inv.	5,71	5,16	7,43	11,40
50% <i>PNIEC</i> inv.	16,17	14,93	17,88	21,31

Notes: The table reports annual average wholesale electricity prices assuming all the baseline assumptions, except for the price of CO₂, which is assumed to be 60 €/Ton instead of 80 €/Ton, giving rise to a lower marginal cost of gas-fired generation.