

Annexes

Annex 1 | Model output tables

TABLE A1 | 'NO TARGET' SCENARIO

			2016	2020	2025	2030	2035	2040	2045	2050	
Installed capacity, MW	Coal, lignite	Existing	24 154	21 338	15 520	10 980	7 426	2 360	1 472	693	
		New	0	2 690	4 440	5 340	5 340	5 340	5 940	5 940	
	Natural gas	Existing	8 855	8 150	7 827	6 922	5 350	3 398	2 113	0	
		New	0	1 685	2 125	3 425	6 919	9 419	9 419	8 508	
	Nuclear	Existing	3 413	3 413	3 413	3 413	3 413	3 413	3 413	3 413	3 413
		New	0	0	0	1 400	1 400	1 400	1 400	1 400	1 400
	HFO/LFO		2 229	2 045	1 580	284	284	0	0	0	
	Hydro		21 756	23 091	23 512	24 178	25 346	27 216	28 982	30 523	
	Wind		6 073	6 466	6 096	3 559	1 946	5 905	11 234	20 050	
	Solar		5 033	5 394	5 394	5 396	4 498	8 105	15 574	22 685	
Other RES		270	615	770	981	1 195	1 615	2 392	3 118		
Gross consumption, GWh			212 529	224 791	229 910	234 516	242 315	251 977	260 582	272 411	
Total			211 614	231 455	247 309	233 420	232 430	245 960	264 374	236 653	
Coal and lignite			97 836	109 030	99 460	79 162	57 565	46 047	39 243	8 442	
Natural gas			17 126	22 326	47 249	47 422	67 875	73 013	68 216	35 600	
Nuclear			24 739	24 739	24 739	35 079	35 079	35 079	35 079	35 079	
HFO/LFO			2 132	2 105	1 684	0	0	0	0	0	
Hydro			50 157	51 495	52 487	54 392	57 959	63 598	70 077	75 781	
Wind			12 234	13 065	12 416	7 222	3 745	11 449	21 944	39 746	
Solar			6 091	6 399	6 399	6 403	5 436	10 171	19 608	28 300	
Other RES			1 299	2 296	2 875	3 739	4 770	6 602	10 208	13 706	
Net import total, GWh			915	-6 664	-17 399	1 096	9 886	6 017	-3 792	35 758	
Net import ratio, %			0.4%	-3.0%	-7.6%	0.5%	4.1%	2.4%	-1.5%	13.1%	
RES-E share (RES-E production/gross consumption, %)			32.8%	32.6%	32.3%	30.6%	29.7%	36.4%	46.8%	57.8%	
Utilisation rates of RES-E technical potential, %	Hydro		na	na	na	na	na	na	na	45%	
	Wind		na	na	na	na	na	na	na	32%	
	Solar		na	na	na	na	na	na	na	30%	
Utilisation rates of conventional power production, %	Coal and lignite		46.2%	51.8%	56.9%	55.4%	51.5%	68.3%	60.4%	14.5%	
	Natural gas		22.1%	25.9%	54.2%	52.3%	63.2%	65.0%	67.5%	47.8%	
	Nuclear		82.7%	82.7%	82.7%	83.2%	83.2%	83.2%	83.2%	83.2%	
Natural gas consumption of power generation, TWh			33.48	42.49	88.10	87.27	121.74	128.42	118.96	62.37	
Security of supply	Generation adequacy margin		53%	54%	41%	32%	27%	22%	26%	24%	
	System adequacy margin		191%	206%	264%	244%	221%	192%	185%	187%	
CO₂ emission	Emission, Mt CO ₂		123.0	134.3	128.9	102.5	84.0	72.1	58.8	15.6	
	CO ₂ emission reduction compared to 1990, %		27.7%	21.1%	24.3%	39.8%	50.6%	57.6%	65.5%	90.8%	
Price impacts	Electricity wholesale price, €(2015)/MWh		35.1	41.0	52.6	60.2	68.4	77.7	90.5	90.5	
	Total RES-E support/gross consumption, €(2015)/MWh, five year average		na	5.1	3.3	4.2	1.2	0.4	0.3	0.1	
	Revenue from CO ₂ auction/gross consumption, €(2015)/MWh		3.0	5.1	6.4	14.6	14.6	14.3	15.6	5.0	
Investment cost, m€/5 year period	Coal and lignite		na	7 007	4 473	2 254	480	0	2 390	0	
	Natural gas		na	1 556	405	1 193	3 019	2 285	0	444	
	Total Fossil		na	8 563	4 878	3 447	3 499	2 285	2 390	444	
	Total RES-E		na	2 635	614	1 661	4 064	12 920	16 289	19 566	
	Total		na	11 198	5 492	5 107	7 563	15 204	18 679	20 010	
Main assumptions	Coal price, €(2015)/GJ		1.78	1.95	1.93	1.89	1.98	2.04	2.04	2.04	
	Lignite price, €(2015)/GJ		0.98	1.07	1.06	1.04	1.09	1.12	1.12	1.12	
	Natural gas price, €(2015)/MWh		na	na	na	na	na	na	na	na	
	CO ₂ price, €(2015)/t		8.60	15.00	22.50	33.50	42.00	50.00	69.00	88.00	

TABLE A2 | 'DELAYED' SCENARIO

			2016	2020	2025	2030	2035	2040	2045	2050	
Installed capacity, MW	Coal, lignite	Existing	24 154	21 338	15 520	10 980	7 426	2 360	1 472	693	
		New	0	2 690	4 440	5 340	5 340	5 340	5 940	5 940	
	Natural gas	Existing	8 855	8 150	7 827	6 922	5 350	3 398	2 113	0	
		New	0	1 685	2 125	2 125	3 619	3 619	3 619	2 308	
	Nuclear	Existing	3 413	3 413	3 413	3 413	3 413	3 413	3 413	3 413	3 413
		New	0	0	0	1 400	1 400	1 400	1 400	1 400	1 400
	HFO/LFO		2 229	2 045	1 580	284	284	0	0	0	
	Hydro		21 756	23 091	25 221	26 057	27 432	29 648	31 448	33 558	
	Wind		6 073	6 468	9 188	7 074	6 719	14 932	26 848	40 693	
	Solar		5 033	5 394	9 618	9 716	9 914	18 111	27 612	38 145	
Other RES		270	611	1 160	1 460	1 763	2 548	3 606	4 779		
Gross consumption, GWh			212 529	224 793	229 850	233 978	242 208	251 502	260 846	273 033	
Net electricity generation, GWh	Total		211 608	231 265	250 108	225 739	220 297	238 157	258 912	278 857	
	Coal and lignite		97 834	108 980	98 229	71 468	53 589	43 664	26 282	9 172	
	Natural gas		17 122	22 198	33 308	27 528	35 300	25 945	16 793	4 053	
	Nuclear		24 739	24 739	24 739	35 079	35 079	35 079	35 006	31 953	
	HFO/LFO		2 132	2 105	1 684	0	0	0	0	0	
	Hydro		50 157	51 495	57 665	60 106	64 491	71 222	77 806	84 674	
	Wind		12 234	13 069	18 365	13 952	12 789	28 850	52 577	80 410	
	Solar		6 091	6 399	11 750	11 865	12 163	22 443	33 745	45 795	
	Other RES		1 299	2 280	4 368	5 742	6 887	10 954	16 703	22 800	
Net import total, GWh			921	-6 473	-20 258	8 239	21 910	13 345	1 934	-5 824	
Net import ratio, %			0.4%	-2.9%	-8.8%	3.5%	9.0%	5.3%	0.7%	-2.1%	
RES-E share (RES-E production/gross consumption, %)			32.8%	32.6%	40.1%	39.2%	39.8%	53.1%	69.3%	85.6%	
Utilisation rates of RES-E technical potential, %	Hydro		na	na	na	na	na	na	na	51%	
	Wind		na	na	na	na	na	na	na	66%	
	Solar		na	na	na	na	na	na	na	51%	
Utilisation rates of conventional power production, %	Coal and lignite		46.2%	51.8%	56.2%	50.0%	47.9%	64.7%	40.5%	15.8%	
	Natural gas		22.1%	25.8%	38.2%	34.7%	44.9%	42.2%	33.4%	20.0%	
	Nuclear		82.7%	82.7%	82.7%	83.2%	83.2%	83.2%	83.0%	75.8%	
Natural gas consumption of power generation, TWh			33.47	42.25	62.10	51.69	64.89	47.75	30.43	7.48	
Security of supply	Generation adequacy margin		53%	54%	47%	36%	26%	19%	27%	29%	
	System adequacy margin		191%	206%	281%	264%	254%	225%	220%	223%	
CO₂ emission	Emission, Mt CO ₂		123.0	134.2	122.4	86.3	68.1	53.5	28.2	7.0	
	CO ₂ emission reduction compared to 1990, %		27.7%	21.1%	28.1%	49.3%	60.0%	68.6%	83.4%	95.9%	
Price impacts	Electricity wholesale price, €(2015)/MWh		35.1	41.0	50.6	58.9	67.0	80.2	87.1	73.0	
	Total RES-E support/gross consumption, €(2015)/MWh, five year average		na	5.1	3.8	4.0	1.8	2.6	4.0	24.3	
	Revenue from CO ₂ auction/gross consumption, €(2015)/MWh		3.0	5.1	5.8	12.4	11.8	10.6	7.5	2.3	
Investment cost, m€ / 5 year period	Coal and lignite		na	7 007	4 473	2 254	480	0	2 390	0	
	Natural gas		na	1 556	405	0	1 185	0	0	0	
	Total Fossil		na	8 563	4 878	2 254	1 665	0	2 390	0	
	Total RES-E		na	2 625	11 770	2 676	6 777	23 216	29 243	31 865	
	Total		na	11 188	16 648	4 929	8 441	23 216	31 634	31 865	
Main assumptions	Coal price, €(2015)/GJ		1.78	1.95	1.93	1.89	1.98	2.04	2.04	2.04	
	Lignite price, €(2015)/GJ		0.98	1.07	1.06	1.04	1.09	1.12	1.12	1.12	
	Natural gas price, €(2015)/MWh		na	na	na	na	na	na	na	na	
	CO ₂ price, €(2015)/t		8.60	15.00	22.50	33.50	42.00	50.00	69.00	88.00	

TABLE A3 | 'DECARBONISATION' SCENARIO

			2016	2020	2025	2030	2035	2040	2045	2050	
Installed capacity, MW	Coal, lignite	Existing	24 154	21 338	15 520	10 980	7 426	2 360	1 472	693	
		New	0	500	500	500	500	500	500	500	
	Natural gas	Existing	8 855	8 150	7 827	6 922	5 350	3 398	2 113	0	
		New	0	1 007	1 007	1 007	2 807	2 807	2 807	2 174	
	Nuclear	Existing	3 413	3 413	3 413	3 413	3 413	3 413	3 413	3 413	3 413
		New	0	0	0	1 400	1 400	1 400	1 400	1 400	
	HFO/LFO		2 229	2 045	1 580	284	284	0	0	0	
	Hydro		21 756	23 096	25 792	27 886	29 766	31 616	32 884	33 708	
	Wind		6 073	6 468	10 299	11 592	13 798	18 205	26 308	35 977	
	Solar		5 033	5 394	9 950	15 658	21 871	27 466	33 950	40 134	
Other RES		270	611	1 379	2 072	2 604	3 597	4 407	5 109		
Gross consumption, GWh			212 529	224 721	229 744	233 784	242 634	251 710	260 873	272 787	
Net electricity generation, GWh	Total		211 608	220 240	230 207	218 106	220 448	232 090	249 197	263 599	
	Coal and lignite		97 834	94 082	70 643	39 088	16 897	9 563	3 340	763	
	Natural gas		17 122	26 051	35 799	27 798	33 154	25 937	17 283	4 013	
	Nuclear		24 739	24 739	24 739	35 079	35 079	35 079	34 423	31 854	
	HFO/LFO		2 132	2 105	1 684	0	0	0	0	0	
	Hydro		50 157	51 515	59 164	65 556	71 313	76 941	81 943	85 386	
	Wind		12 234	13 069	20 675	22 902	26 644	35 027	51 075	70 104	
	Solar		6 091	6 399	12 167	19 253	26 787	33 473	40 600	47 541	
	Other RES		1 299	2 280	5 337	8 431	10 575	16 069	20 534	23 939	
Net import total, GWh			921	4 481	-463	15 679	22 185	19 620	11 676	9 188	
Net import ratio, %			0.4%	2.0%	-0.2%	6.7%	9.1%	7.8%	4.5%	3.4%	
RES-E share (RES-E production/gross consumption, %)			32.8%	32.6%	42.4%	49.7%	55.8%	64.2%	74.4%	83.2%	
Utilisation rates of RES-E technical potential, %	Hydro		na	na	na	na	na	na	na	51%	
	Wind		na	na	na	na	na	na	na	58%	
	Solar		na	na	na	na	na	na	na	53%	
Utilisation rates of conventional power production, %	Coal and lignite		46.2%	49.2%	50.3%	38.9%	24.3%	38.2%	19.3%	7.3%	
	Natural gas		22.1%	32.5%	46.3%	40.0%	46.4%	47.7%	40.1%	21.1%	
	Nuclear		82.7%	82.7%	82.7%	83.2%	83.2%	83.2%	81.6%	75.6%	
Natural gas consumption of power generation, TWh			33.47	49.57	67.43	52.44	60.62	47.43	31.06	7.37	
Security of supply	Generation adequacy margin		53%	46%	37%	29%	23%	14%	17%	15%	
	System adequacy margin		191%	145%	216%	222%	220%	188%	187%	190%	
CO₂ emission	Emission, Mt CO ₂		123.0	120.8	96.1	55.0	30.7	19.7	9.7	2.3	
	CO ₂ emission reduction compared to 1990, %		27.7%	29.0%	43.5%	67.7%	81.9%	88.4%	94.3%	98.7%	
Price impacts	Electricity wholesale price, €(2015)/MWh		35.1	42.1	52.2	59.5	65.9	81.4	86.9	74.5	
	Total RES-E support/gross consumption, €(2015)/MWh, five year average		na	5.1	3.6	6.6	4.5	3.0	1.6	2.0	
	Revenue from CO ₂ auction/gross consumption, €(2015)/MWh		3.0	5.1	5.9	7.9	5.3	3.9	2.6	0.7	
Investment cost, m€/5 year period	Coal and lignite		na	1 306	0	0	0	0	0	0	
	Natural gas		na	930	0	0	1 648	0	0	0	
	Total Fossil		na	2 236	0	0	1 648	0	0	0	
	Total RES-E		na	2 606	16 625	14 572	17 391	18 825	26 144	27 995	
	Total		na	4 843	16 625	14 572	19 039	18 825	26 144	27 995	
Main assumptions	Coal price, €(2015)/GJ		1.8	2.0	1.9	1.9	2.0	2.0	2.0	2.0	
	Lignite price, €(2015)/GJ		0.98	1.07	1.06	1.04	1.09	1.12	1.12	1.12	
	Natural gas price, €(2015)/MWh		na	na	na	na	na	na	na	na	
	CO ₂ price, €(2015)/t		8.60	15.00	22.50	33.50	42.00	50.00	69.00	88.00	

TABLE A4 | SENSITIVITY ANALYSIS – LOW CARBON PRICE

			2016	2020	2025	2030	2035	2040	2045	2050
Installed capacity, MW	Coal, lignite	Existing	24 154	21 338	15 520	10 980	7 426	2 360	1 472	693
		New	0	500	500	500	500	500	500	500
	Natural gas	Existing	8 855	8 150	7 827	6 922	5 350	3 398	2 113	0
		New	0	1 007	1 007	1 007	2 307	2 307	2 307	1 674
	Nuclear	Existing	3 413	3 413	3 413	3 413	3 413	3 413	3 413	3 413
		New	0	0	0	1 400	1 400	1 400	1 400	1 400
	HFO/LFO		2 229	2 045	1 580	284	284	0	0	0
	Hydro		21 756	23 031	25 933	28 170	30 265	32 184	33 597	34 643
	Wind		6 073	6 338	10 408	12 997	17 113	24 193	35 418	47 164
	Solar		5 033	5 394	10 882	17 035	23 242	29 533	35 146	43 904
Other RES		270	623	1 693	2 496	3 207	4 005	4 888	5 426	
Gross consumption, GWh			212 698	224 929	230 144	234 508	243 378	252 667	261 853	274 530
Net electricity generation, GWh	Total		213 540	219 959	226 751	226 212	235 018	242 745	265 925	287 368
	Coal and lignite		99 092	96 722	71 836	50 193	33 216	12 384	7 552	3 084
	Natural gas		17 830	23 608	28 517	18 010	18 940	16 771	9 294	2 347
	Nuclear		24 739	24 739	24 739	35 079	35 072	34 228	30 997	25 915
	HFO/LFO		2 113	2 105	1 684	0	0	0	0	0
	Hydro		50 157	51 276	59 322	66 078	72 514	78 292	83 549	87 138
	Wind		12 218	12 782	20 855	25 589	33 406	47 302	69 680	92 791
	Solar		6 091	6 399	13 341	20 898	28 100	35 333	41 577	50 811
	Other RES		1 299	2 327	6 457	10 365	13 769	18 435	23 275	25 282
Net import total, GWh			-842	4 970	3 393	8 297	8 360	9 922	-4 073	-12 838
Net import ratio, %			-0.4%	2.2%	1.5%	3.5%	3.4%	3.9%	-1.6%	-4.7%
RES-E share (RES-E production/gross consumption, %)			32.8%	32.4%	43.4%	52.4%	60.7%	71.0%	83.3%	93.3%
Utilisation rates of RES-E technical potential, %	Hydro		na	na	na	na	na	na	na	52.5%
	Wind		na	na	na	na	na	na	na	76.5%
	Solar		na	na	na	na	na	na	na	58.5%
Utilisation rates of conventional power production, %	Coal and lignite		46.8%	50.6%	51.2%	49.9%	47.8%	49.4%	43.7%	29.5%
	Natural gas		23.0%	29.4%	36.9%	25.9%	28.2%	33.6%	24.0%	16.0%
	Nuclear		82.7%	82.7%	82.7%	83.2%	83.2%	81.2%	73.5%	61.5%
Natural gas consumption of power generation, TWh			0	0	0	0	0	0	0	0
Security of supply	Generation adequacy margin		53%	46%	38%	31%	27%	17%	22%	21%
	System adequacy margin		191%	144%	216%	223%	222%	193%	191%	193%
CO₂ emission	Emission, Mt CO ₂		124.5	122.7	94.6	64.8	44.5	19.7	11.4	4.0
	CO ₂ emission reduction compared to 1990, %		26.8%	27.9%	44.4%	61.9%	73.9%	88.4%	93.3%	97.6%
Price impacts	Electricity wholesale price, €(2015)/MWh		31.8	38.5	46.5	48.7	53.5	71.6	68.6	49.9
	Total RES-E support/gross consumption, €(2015)/MWh, five year average		na	5.2	7.3	13.8	15.1	15.5	17.7	35.0
	Revenue from CO ₂ auction/gross consumption, €(2015)/MWh		0	0	0	13.2	12.1	5.6	3.7	3.0
Investment cost, m€/5 year period	Coal and lignite		na	1 306	0	0	0	0	0	0
	Natural gas		na	930	0	0	1 191	0	0	0
	Total Fossil		na	2 236	0	0	1 191	0	0	0
	Total RES-E		na	2 388	17 481	16 766	19 187	20 119	26 628	31 192
	Total		na	4 625	17 481	16 766	20 377	20 119	26 628	31 192
Main assumptions	Coal price, €(2015)/GJ		1.78	1.95	1.93	1.89	1.98	2.04	2.04	2.04
	Lignite price, €(2015)/GJ		0.98	1.07	1.06	1.04	1.09	1.12	1.12	1.12
	Natural gas price, €(2015)/MWh		na	na	na	na	na	na	na	na
	CO ₂ price, €(2015)/t		4.30	7.50	11.25	16.75	21.00	25.00	34.50	44.00

TABLE A5 | SENSITIVITY ANALYSIS – LOW DEMAND

			2016	2020	2025	2030	2035	2040	2045	2050
Installed capacity, MW	Coal, lignite	Existing	24 154	21 338	15 520	10 980	7 426	2 360	1 472	693
		New	0	500	500	500	500	500	500	500
	Natural gas	Existing	8 855	8 150	7 827	6 922	5 350	3 398	2 113	0
		New	0	1 007	1 007	1 007	1 807	1 807	1 807	1 174
	Nuclear	Existing	3 413	3 413	3 413	3 413	3 413	3 413	3 413	3 413
		New	0	0	0	1 400	1 400	1 400	1 400	1 400
	HFO/LFO		2 229	2 045	1 580	284	284	0	0	0
	Hydro		21 756	23 094	25 506	26 955	28 739	30 276	32 022	32 896
	Wind		6 073	6 458	9 928	8 981	10 091	13 717	23 133	28 186
	Solar		5 033	5 394	9 809	11 066	12 807	20 664	29 421	36 025
Other RES		270	611	1 300	1 695	1 973	2 417	3 529	4 160	
Gross consumption, GWh			212 529	222 526	224 690	225 847	231 394	236 551	243 076	251 347
Net electricity generation, GWh	Total		211 603	218 324	227 613	210 688	204 813	205 896	225 624	235 846
	Coal and lignite		97 835	93 785	70 661	42 642	22 978	11 019	3 336	902
	Natural gas		17 125	24 458	35 274	32 209	35 321	24 813	11 620	2 359
	Nuclear		24 739	24 739	24 739	35 079	35 079	35 079	34 349	32 377
	HFO/LFO		2 132	2 105	1 684	0	14	0	0	0
	Hydro		50 157	51 507	58 275	62 680	68 159	73 002	79 402	83 119
	Wind		12 224	13 051	20 004	17 819	19 526	26 352	44 874	54 474
	Solar		6 091	6 399	11 994	13 522	15 671	25 377	35 430	42 909
	Other RES		1 299	2 280	4 982	6 736	8 065	10 254	16 614	19 705
	Net import total, GWh			926	4 203	-2 923	15 159	26 581	30 655	17 451
Net import ratio, %			0.4%	1.9%	-1.3%	6.7%	11.5%	13.0%	7.2%	6.2%
RES-E share (RES-E production/gross consumption, %)			32.8%	32.9%	42.4%	44.6%	48.2%	57.1%	72.5%	79.7%
Utilisation rates of RES-E technical potential, %	Hydro		na	na	na	na	na	na	na	49.5%
	Wind		na	na	na	na	na	na	na	45.4%
	Solar		na	na	na	na	na	na	na	48.0%
Utilisation rates of conventional power production, %	Coal and lignite		46.2%	49.0%	50.4%	42.4%	33.1%	44.0%	19.3%	8.6%
	Natural gas		22.1%	30.5%	45.6%	46.4%	56.3%	54.4%	33.8%	22.9%
	Nuclear		82.7%	82.7%	82.7%	83.2%	83.2%	83.2%	81.5%	76.8%
Natural gas consumption of power generation, TWh			0	0	0	0	0	0	0	0
Security of supply	Generation adequacy margin		53%	47%	38%	28%	22%	11%	18%	16%
	System adequacy margin		191%	147%	218%	220%	215%	191%	194%	200%
CO₂ emission	Emission, Mt CO ₂		123.0	119.8	95.9	60.8	38.6	21.0	7.8	1.8
	CO ₂ emission reduction compared to 1990, %		27.7%	29.6%	43.7%	64.2%	77.3%	87.6%	95.4%	98.9%
Price impacts	Electricity wholesale price, €(2015)/MWh		34.7	41.8	52.4	60.0	70.2	89.0	84.1	75.3
	Total RES-E support/gross consumption, €(2015)/MWh, five year average		na	5.1	4.6	5.3	2.9	0.4	0	0
	Revenue from CO ₂ auction/gross consumption, €(2015)/MWh		0	0	0	12.6	8.4	5.4	2.0	1.1
Investment cost, m€/5 year period	Coal and lignite		na	1 306.1	0	0	0	0	0	0
	Natural gas		na	930.3	0	0	732.5	0	0	0
	Total Fossil		na	2 236	0	0	732	0	0	0
	Total RES-E		na	2 590	13 961	6 088	10 425	15 938	26 512	17 411
	Total		na	4 826	13 961	6 088	11 158	15 938	26 512	17 411
Main assumptions	Coal price, €(2015)/GJ		1.8	2.0	1.9	1.9	2.0	2.0	2.0	2.0
	Lignite price, €(2015)/GJ		0.98	1.07	1.06	1.04	1.09	1.12	1.12	1.12
	Natural gas price, €(2015)/MWh		na	na	na	na	na	na	na	na
	CO ₂ price, €(2015)/t		8.60	15.00	22.50	33.50	42.00	50.00	69.00	88.00

TABLE A6 | SENSITIVITY ANALYSIS – HIGH DEMAND

			2016	2020	2025	2030	2035	2040	2045	2050	
Installed capacity, MW	Coal, lignite	Existing	24 154	21 338	15 520	10 980	7 426	2 360	1 472	693	
		New	0	500	500	500	500	500	500	500	
	Natural gas	Existing	8 855	8 150	7 827	6 922	5 350	3 398	2 113	0	
		New	0	1 007	1 007	1 007	3 407	3 407	3 407	2 774	
	Nuclear	Existing	3 413	3 413	3 413	3 413	3 413	3 413	3 413	3 413	3 413
		New	0	0	0	1 400	1 400	1 400	1 400	1 400	
	HFO/LFO		2 229	2 045	1 580	284	284	0	0	0	
	Hydro		21 756	23 094	25 994	28 225	30 339	32 293	33 626	34 695	
	Wind		6 073	6 458	10 554	12 677	16 970	24 321	34 827	47 437	
	Solar		5 033	5 404	10 908	18 121	23 932	30 398	36 325	43 928	
Other RES		270	611	1 677	2 510	3 185	3 868	4 882	5 477		
Gross consumption, GWh			212 529	226 929	234 906	242 052	254 160	267 441	280 190	296 728	
Net electricity generation, GWh	Total		211 602	222 115	234 336	224 064	234 330	250 886	271 983	294 705	
	Coal and lignite		97 835	94 341	70 712	37 828	16 077	8 895	3 106	1 016	
	Natural gas		17 125	27 683	36 713	27 311	34 709	26 959	17 914	5 410	
	Nuclear		24 739	24 739	24 739	35 079	35 079	34 906	32 437	29 853	
	HFO/LFO		2 132	2 105	1 684	0	0	0	0	0	
	Hydro		50 157	51 507	59 548	66 279	72 790	78 662	83 744	87 687	
	Wind		12 224	13 051	21 179	24 883	33 144	47 654	68 630	93 692	
	Solar		6 091	6 410	13 367	22 293	29 040	36 459	42 995	51 506	
	Other RES		1 299	2 280	6 394	10 392	13 490	17 350	23 157	25 542	
Net import total, GWh			926	4 814	570	17 988	19 830	16 555	8 208	2 023	
Net import ratio, %			0.4%	2.1%	0.2%	7.4%	7.8%	6.2%	2.9%	0.7%	
RES-E share (RES-E production/gross consumption, %)			32.8%	32.3%	42.8%	51.2%	58.4%	67.4%	78.0%	87.1%	
Utilisation rates of RES-E technical potential, %	Hydro		na	na	na	na	na	na	na	52.6%	
	Wind		na	na	na	na	na	na	na	76.9%	
	Solar		na	na	na	na	na	na	na	58.5%	
Utilisation rates of conventional power production, %	Coal and lignite		46.2%	49.3%	50.4%	37.6%	23.2%	35.5%	18.0%	9.7%	
	Natural gas		22.1%	34.5%	47.4%	39.3%	45.2%	45.2%	37.0%	22.3%	
	Nuclear		82.7%	82.7%	82.7%	83.2%	83.2%	82.8%	76.9%	70.8%	
Natural gas consumption of power generation, TWh			0	0	0	0	0	0	0	0	
Security of supply	Generation adequacy margin		53%	45%	36%	28%	25%	14%	18%	16%	
	System adequacy margin		191%	143%	211%	213%	209%	180%	174%	174%	
CO₂ emission	Emission, Mt CO ₂		123.0	121.6	96.5	53.4	30.3	19.3	9.7	3.0	
	CO ₂ emission reduction compared to 1990, %		27.7%	28.5%	43.3%	68.6%	82.2%	88.6%	94.3%	98.2%	
Price impacts	Electricity wholesale price, €(2015)/MWh		34.7	42.4	52.7	59.5	66.5	79.5	82.3	72.2	
	Total RES-E support/gross consumption, €(2015)/MWh, five year average		na	5.1	7.1	11.4	10.7	9.0	8.4	20.3	
	Revenue from CO ₂ auction/gross consumption, €(2015)/MWh		0	0	0	10.5	5.4	4.0	1.6	1.0	
Investment cost, m€/5 year period	Coal and lignite		na	930.3	0	0	1 190.5	0	0	0	
	Natural gas		na	1 306.1	0	0	0	0	0	0	
	Total Fossil		na	2 236	0	0	1 191	0	0	0	
	Total RES-E		na	2 600	17 526	17 236	19 223	20 362	26 031	31 176	
	Total		na	4 837	17 526	17 236	20 413	20 362	26 031	31 176	
Main assumptions	Coal price, €(2015)/GJ		1.8	2.0	1.9	1.9	2.0	2.0	2.0	2.0	
	Lignite price, €(2015)/GJ		0.98	1.07	1.06	1.04	1.09	1.12	1.12	1.12	
	Natural gas price, €(2015)/MWh		na	na	na	na	na	na	na	na	
	CO ₂ price, €(2015)/t		8.60	15.00	22.50	33.50	42.00	50.00	69.00	88.00	

TABLE A7 | SENSITIVITY ANALYSIS – NATIONAL RES TARGETS

			2016	2020	2025	2030	2035	2040	2045	2050	
Installed capacity, MW	Coal, lignite	Existing	24 154	21 338	15 520	10 980	7 426	2 360	1 472	693	
		New	0	500	500	500	500	500	500	500	
	Natural gas	Existing	8 855	8 150	7 827	6 922	5 350	3 398	2 113	0	
		New	0	1 007	1 007	1 007	2 607	2 607	2 607	1 974	
	Nuclear	Existing	3 413	3 413	3 413	3 413	3 413	3 413	3 413	3 413	3 413
		New	0	0	0	1 400	1 400	1 400	1 400	1 400	
	HFO/LFO		2 229	2 045	1 580	284	284	0	0	0	
	Hydro		21 756	23 096	25 556	27 633	29 430	31 147	32 682	33 737	
	Wind		6 073	6 468	10 487	14 497	18 718	27 009	36 615	46 030	
	Solar		5 033	5 394	8 525	11 594	14 929	22 718	33 835	40 938	
Other RES		270	611	1 309	2 157	2 756	3 246	4 358	5 325		
Gross consumption, GWh			212 529	224 721	229 755	233 829	242 336	251 560	260 693	272 938	
Net electricity generation, GWh	Total		211 608	220 240	229 110	218 158	222 255	237 786	265 931	284 357	
	Coal and lignite		97 834	94 082	70 672	38 429	16 957	9 071	2 905	629	
	Natural gas		17 122	26 051	37 030	27 716	32 848	23 374	15 242	3 573	
	Nuclear		24 739	24 739	24 739	35 079	35 079	34 933	33 371	31 417	
	HFO/LFO		2 132	2 105	1 684	0	0	0	0	0	
	Hydro		50 157	51 515	58 556	64 720	70 117	75 324	81 151	85 190	
	Wind		12 234	13 069	21 178	29 379	37 912	54 348	73 428	91 325	
	Solar		6 091	6 399	10 261	13 840	17 573	26 631	39 395	46 924	
	Other RES		1 299	2 280	4 990	8 996	11 770	14 105	20 439	25 299	
Net import total, GWh			921	4 481	645	15 671	20 080	13 774	-5 238	-11 419	
Net import ratio, %			0.4%	2.0%	0.3%	6.7%	8.3%	5.5%	-2.0%	-4.2%	
RES-E share (RES-E production/gross consumption, %)			32.8%	32.6%	41.3%	50.0%	56.7%	67.7%	82.2%	91.1%	
Utilisation rates of RES-E technical potential, %	Hydro		na	na	na	na	na	na	na	51.0%	
	Wind		na	na	na	na	na	na	na	74.3%	
	Solar		na	na	na	na	na	na	na	54.6%	
Utilisation rates of conventional power production, %	Coal and lignite		46.2%	49.2%	50.4%	38.2%	24.4%	36.2%	16.8%	6.0%	
	Natural gas		22.1%	32.5%	47.9%	39.9%	47.1%	44.4%	36.9%	20.7%	
	Nuclear		82.7%	82.7%	82.7%	83.2%	83.2%	82.9%	79.1%	74.5%	
Natural gas consumption of power generation, TWh			0	0	0	0	0	0	0	0	
Security of supply	Generation adequacy margin		53%	46%	36%	30%	26%	15%	20%	20%	
	System adequacy margin		191%	145%	215%	218%	205%	180%	181%	184%	
CO₂ emission	Emission, Mt CO ₂		123.0	120.8	96.6	54.2	30.7	18.2	8.6	2.0	
	CO ₂ emission reduction compared to 1990, %		27.7%	29.0%	43.3%	68.2%	82.0%	89.3%	95.0%	98.8%	
Price impacts	Electricity wholesale price, €(2015)/MWh		34.7	42.1	52.5	59.4	66.7	80.4	84.1	71.6	
	Total RES-E support/gross consumption, €(2015)/MWh, five year average		na	5.1	4.5	10.7	8.3	6.4	5.4	17.3	
	Revenue from CO ₂ auction/gross consumption, €(2015)/MWh		0	0	0	11.1	6.0	4.3	1.6	0.7	
Investment cost, m€/5 year period	Coal and lignite		na	1 306.1	0	0	0	0	0	0	
	Natural gas		na	930.3	0	0	732.5	0	0	0	
	Total Fossil		na	2 236	0	0	732	0	0	0	
	Total RES-E		na	2 606	13 189	15 722	16 205	21 820	28 981	28 245	
	Total		na	4 843	13 189	15 722	16 938	21 820	28 981	28 245	
Main assumptions	Coal price, €(2015)/GJ		1.8	2.0	1.9	1.9	2.0	2.0	2.0	2.0	
	Lignite price, €(2015)/GJ		0.98	1.07	1.06	1.04	1.09	1.12	1.12	1.12	
	Natural gas price, €(2015)/MWh		na	na	na	na	na	na	na	na	
	CO ₂ price, €(2015)/t		8.60	15.00	22.50	33.50	42.00	50.00	69.00	88.00	

TABLE A8 | SENSITIVITY ANALYSIS – LOW RENEWABLE POTENTIAL

			2016	2020	2025	2030	2035	2040	2045	2050
Installed capacity, MW	Coal, lignite	Existing	24 154	21 338	15 520	10 980	7 426	2 360	1 472	693
		New	0	500	500	500	500	500	500	500
	Natural gas	Existing	8 855	8 150	7 827	6 922	5 350	3 398	2 113	0
		New	0	1 007	1 007	1 007	3 307	3 307	3 307	2 674
	Nuclear	Existing	3 413	3 413	3 413	3 413	3 413	3 413	3 413	3 413
		New	0	0	0	1 400	1 400	1 400	1 400	1 400
	HFO/LFO		2 229	2 045	1 580	284	284	0	0	0
	Hydro		21 756	23 055	25 703	27 421	29 189	30 403	31 205	31 737
	Wind		6 073	6 135	9 317	9 763	10 889	15 563	23 516	28 756
	Solar		5 033	5 494	11 615	19 247	27 351	36 945	46 683	56 903
Other RES		270	587	1 601	2 260	2 928	3 420	4 206	5 813	
Gross consumption, GWh			212 528	224 715	229 747	233 806	242 931	251 829	261 224	272 613
Net electricity generation, GWh	Total		211 570	219 792	230 269	217 531	222 749	234 707	252 299	263 086
	Coal and lignite		97 847	94 152	70 670	39 336	17 086	9 649	3 520	923
	Natural gas		17 138	26 417	35 335	27 184	35 368	28 597	19 651	5 165
	Nuclear		24 739	24 739	24 739	35 079	35 079	35 074	33 422	31 497
	HFO/LFO		2 132	2 105	1 684	0	0	0	0	0
	Hydro		50 157	51 361	58 873	64 112	69 500	72 952	76 023	77 818
	Wind		12 171	12 330	18 605	19 108	20 937	30 138	46 117	56 216
	Solar		6 106	6 500	14 238	23 615	32 638	43 896	55 187	66 284
	Other RES		1 279	2 187	6 126	9 098	12 140	14 401	18 379	25 183
Net import total, GWh			959	4 923	-521	16 275	20 183	17 122	8 925	9 527
Net import ratio, %			0.5%	2.2%	-0.2%	7.0%	8.3%	6.8%	3.4%	3.5%
RES-E share (RES-E production/gross consumption, %)			32.8%	32.2%	42.6%	49.6%	55.7%	64.1%	74.9%	82.7%
Utilisation rates of RES-E technical potential, %	Hydro		na	na	na	na	na	na	na	47.6%
	Wind		na	na	na	na	na	na	na	46.4%
	Solar		na	na	na	na	na	na	na	75.7%
Utilisation rates of conventional power production, %	Coal and lignite		46.2%	49.2%	50.4%	39.1%	24.6%	38.5%	20.4%	8.8%
	Natural gas		22.1%	32.9%	45.7%	39.1%	46.6%	48.7%	41.4%	22.1%
	Nuclear		82.7%	82.7%	82.7%	83.2%	83.2%	83.2%	79.3%	74.7%
Natural gas consumption of power generation, TWh			0	0	0	0	0	0	0	0
Security of supply	Generation adequacy margin		53%	46%	37%	27%	23%	11%	13%	11%
	System adequacy margin		191%	145%	211%	211%	200%	173%	162%	151%
CO₂ emission	Emission, Mt CO ₂		123.0	121.0	95.9	55.1	31.7	20.7	10.7	2.8
	CO ₂ emission reduction compared to 1990, %		27.7%	28.9%	43.6%	67.6%	81.4%	87.8%	93.7%	98.3%
Price impacts	Electricity wholesale price, €(2015)/MWh		34.7	42.2	52.5	59.6	66.8	81.7	85.6	74.5
	Total RES-E support/gross consumption, €(2015)/MWh, five year average		na	4.9	6.9	9.2	8.4	7.7	10.0	78.0
	Revenue from CO ₂ auction/gross consumption, €(2015)/MWh		0	0	0	11.4	6.1	4.6	2.0	1.0
Investment cost, m€/5 year period	Coal and lignite		na	930.3	0	0	732.5	0	0	0
	Natural gas		na	0	0	0	0	0	0	0
	Total Fossil		na	930	0	0	732	0	0	0
	Total RES-E		na	2 124	16 731	14 061	17 046	17 815	23 607	24 067
	Total		na	3 054	16 731	14 061	17 778	17 815	23 607	24 067
Main assumptions	Coal price, €(2015)/GJ		1.8	2.0	1.9	1.9	2.0	2.0	2.0	2.0
	Lignite price, €(2015)/GJ		0.98	1.07	1.06	1.04	1.09	1.12	1.12	1.12
	Natural gas price, €(2015)/MWh		na	na	na	na	na	na	na	na
	CO ₂ price, €(2015)/t		8.60	15.00	22.50	33.50	42.00	50.00	69.00	88.00

TABLE A9 | STRANDED COSTS, TOTAL (m€) AND IN CAPACITY FEE EQUIVALENT (€/MWh)

Scenario	Country	Total stranded cost (m€)	Capacity fee for 10 years (€/MWh)
NO TARGET	AL	-102	-0.8
	BA FED	-878	-6.3
	BA SRP	-634	-9.5
	BG	-984	-2.5
	GR	-2 089	-3.9
	KO*	-629	-7.8
	ME	-133	-2.7
	MK	-287	-2.9
	RO	-117	-0.2
	RS	-1 033	-2.2
	SEERMAP	-6 886	-2.6
DELAYED	AL	-97	-0.8
	BA FED	-912	-6.5
	BA SRP	-653	-9.8
	BG	-872	-2.2
	GR	-1 932	-3.6
	KO*	-664	-8.2
	ME	-140	-2.8
	MK	-287	-2.9
	RO	12	0
	RS	-1 056	-2.3
	SEERMAP	-6 600	-2.5
DECARBONISATION	AL	-7	-0.1
	BA FED	0	0
	BA SRP	0	0
	BG	-874	-2.3
	GR	-739	-1.4
	KO*	-9	-0.1
	ME	0	0
	MK	0	0
	RO	-14	0
	RS	-7	0
	SEERMAP	-1 650	-0.6

TABLE A10 | BREAKDOWN OF CUMULATIVE CAPITAL EXPENDITURE BY RES TECHNOLOGY 2016-2050 (m€)

Capital expenditures in m€	No target 2016-2050	Delayed 2016-2050	Decarbonisation 2016-2050
Biogas	1 220	1 649	5 174
Solid biomass	1 733	2 054	9 855
Biowaste	1 379	1 411	1 221
Geothermal ele.	1 409	2 486	1 970
Hydro large-scale	7 712	11 487	12 243
Hydro small-scale	3 980	5 665	6 781
Central PV	5 060	10 631	14 237
Decentralised PV	10 129	18 821	21 653
CSP	–	52	–
Wind onshore	24 629	54 041	50 979
Wind offshore	499	906	940
RES-E total	57 749	109 204	125 053
of which CHP	3 629	3 968	8 690

TABLE A11 | DEVELOPMENT OF SUPPORT EXPENDITURES (FOR RES TOTAL) OVER TIME (5-YEAR TIME PERIODS)

Support expenditures in m€	2016-2020	2021-2025	2026-2030	2031-2035	2036-2040	2041-2045	2046-2050	Total
No target	11 041	7 013	5 156	1 571	585	384	119	25 868
Central PV	3 584	2 084	1 650	435	149	66	–	7 968
Decentralised PV	4 271	2 804	2 383	610	126	57	–	10 251
Wind onshore	1 859	1 237	555	216	54	–	–	3 921
Delayed	11 070	8 034	4 998	2 237	3 492	5 433	34 482	69 746
Central PV	3 589	2 053	1 538	431	318	582	3 743	12 253
Decentralised PV	4 274	2 915	2 311	662	494	826	4 785	16 268
Wind onshore	1 868	1 519	530	525	1 468	2 394	16 163	24 468
Decarbonisation	11 041	7 597	8 215	5 765	3 945	2 140	2 883	41 586
Central PV	3 584	2 100	2 252	1 625	1 604	1 206	1 613	13 985
Decentralised PV	4 271	3 035	3 077	1 738	958	291	639	14 008
Wind onshore	1 858	1 872	2 358	1 967	972	100	368	9 496

**TABLE A12 | NTC VALUE CHANGES IN 2030 AND 2050
IN THE 'DELAYED' AND 'DECARBONISATION' SCENARIOS COMPARED TO THE BASE CASE**

	Delayed Scenario				Decarbonisation Scenario			
	2030 winter	2030 summer	2050 winter	2050 summer	2030 winter	2030 summer	2050 winter	2050 summer
RS – RO	0	0	300	250	-300	-50	-50	150
RO – RS	150	150	500	450	-150	50	100	300
BG – RS	200	250	500	550	550	600	1 000	1 050
RS – BG	350	400	450	450	650	700	800	800
KO* – MK	100	100	0	0	100	100	0	0
MK – KO*	100	100	0	0	100	100	0	0
RS – MK	-250	-200	-50	-50	-550	-400	-450	-300
MK – RS	-700	-700	0	0	-750	-700	-200	0
KO* – AL	150	140	700	700	150	140	700	700
AL – KO*	150	140	200	500	150	140	200	500
RS – AL	0	0	0	0	0	0	0	0
AI – RS	0	0	0	0	0	0	0	0
RS – KO*	0	0	0	0	0	0	0	0
KO* – RS	0	0	0	0	0	0	0	0
KO* – ME	0	0	0	0	0	0	0	0
ME – KO*	0	0	0	0	0	0	0	0
RS – ME	-50	300	0	250	-350	-250	-350	-350
ME – RS	200	250	150	200	-150	-100	-250	-200
RS – BA	0	550	0	500	-550	-250	-550	-300
BA – RS	-100	400	0	500	-200	200	-100	250
BA – ME	550	800	150	300	250	400	-150	-100
ME – BA	1 350	1 100	450	350	850	700	-50	-50
AL – ME	0	0	0	0	0	50	0	50
ME – AL	0	0	0	0	200	200	250	250
AL – GR	-100	-100	0	0	-250	-250	-200	-200
GR – AL	-50	-50	0	0	-100	-100	-50	-50
AL – MK	200	200	0	0	300	300	150	400
MK – AL	400	400	0	0	450	450	50	50
MK – GR	250	400	0	0	-50	-50	-350	-450
GR – MK	300	500	0	0	250	400	-50	-100
BG – MK	70	100	0	0	-80	0	-200	-100
MK – BG	250	300	0	0	200	200	-50	-100
RO – BG	750	1 150	0	500	1 250	1 400	500	700
BG – RO	1 150	1 650	0	550	1 750	2 000	600	900
BG – GR	-878	-750	0	0	-1 128	-1 000	-550	-550
GR – BG	-32	0	0	0	-332	-350	-250	-350

Annex 2 | Assumptions

Assumed technology investment cost trajectories: RES and fossil

TABLE A13 ASSUMED SPECIFIC COST TRAJECTORIES FOR THE VARIOUS TECHNOLOGIES (2016 €/kW)					
Technology	CCS	2020	2030	2040	2050
Thermal	no	2 586	2 460	2 339	2 225
	yes	5 472	4 705	4 045	3 477
OCGT	no	879	877	876	874
	yes	1 688	1 496	1 326	1 175
CCGT	no	922	918	913	909
	yes	1 747	1 502	1 291	1 110
Biogas (low cost options: landfill and sewage gas)	no	1 608	1 504	1 406	1 315
Biogas (high cost options: agricultural digestion in small-scale CHP plants)	no	5 378	4 956	4 568	4 210
Solid biomass (low cost options: cofiring)	no	597	553	513	476
Solid biomass (medium cost options: large-scale CHP)	no	2 410	2 230	2 064	1 910
Solid biomass (high cost options: small/medium-scale CHP)	no	3 912	3 621	3 351	3 101
Biowaste	no	6 573	6 070	5 606	5 177
Geothermal electricity (average cost trend for SEERMAP region – i.e. mix of high-temperature (default technology concepts) and medium-temperature resources (novel enhanced systems))	–	3 273	2 963	3 269	3 167
Hydro large-scale	–	1 333	1 396	1 667	1 765
Hydro small-scale	–	1 338	1 763	1 956	1 994
Photovoltaics	–	1 015	824	693	596
Wind onshore	–	1 395	1 271	1 199	1 125
Wind offshore	–	2 693	2 521	2 293	2 346

Source: Green-X database and EEMM database

Infrastructure

TABLE A14 NEW GAS INFRASTRUCTURE				
Pipeline	From	To	Capacity, GWh/day	Date of commissioning
BG-RS	BG	RS	51	2018
RS-BG	RS	BG	51	2018
TR-GR2 TAP	TR	GR	350	2019
GR-MK TAP	GR	MK	25	2019
AZ-TR TANAP	AZ	TR	490	2018
GR-BG	GR	BG	90	2018
GR-BG	GR	BG	151	2021
GR-IT TAP	GR	IT	334	2019
SI-HR2	SI	HR	162	2019
HR-SI	HR	SI	162	2019
GR-AL	GR	AL	40	2019
BG-MK	BG	MK	27	2020
HR-LNG		HR	108	2020
BG-RO	BG	RO	14	2016
RO-BG	RO	BG	14	2016
GR-LNG expansion		GR	81	2017
RO-HU (BRUA)	RO	HU	126	2020
HU-RO (BRUA)	HU	RO	77	2020

Source: ENTSO-G TYNDP

FIGURE A1
NEW GAS
INFRASTRUCTURE
INVESTMENT
ASSUMED TO
TAKE PLACE IN
ALL SCENARIOS



Source: ENTSO-G TYNDP 2017

TABLE A15 | NEW CROSS BORDER TRANSMISSION NETWORK CAPACITIES

From	To	Year of commissioning	Capacity, MW O → D	Capacity, MW D → O
ME	IT	2019	500	500
ME	IT	2023	700	700
BA FED	HR	2022	650	950
BG	RO	2020	1 000	1 200
GR	BG	2021	0	650
RS	RO	2023	500	950
ME	RS	2025	400	600
AL	RS	2016	700	700
AL	MK	2020	250	250
RS	ME	2025	500	500
RS	BA SRP	2025	600	500
BA SRP	HR	2030	350	250
HR	RS	2030	750	300
HU	RO	2035	200	800
RS	RO	2035	500	550
RS	BG	2034	50	200
RS	RO	2035	0	100
RS	BG	2034	400	1 500
GR	BG	2030	250	450
KO*	MK	2030	1 100	1 200
KO*	AL	2035	1 400	1 300
MD	RO	2030	500	500
BG	GR	2045	1 000	1 000
HU	RO	2043	1 000	1 000
HU	RO	2047	1 000	1 000
IT	ME	2045	2 000	2 000
IT	GR	2037	2 000	2 000
IT	GR	2045	3 000	3 000

Source: ENTSO-E TYNDP 2017

