ATTACHMENTS

A. Generation Figures

The first part of the attachments includes tables depicting the generation in TWh of each technology in each EU27++ country for the three main scenarios.

Two remarks are important to add:

1) The figures accounted for „Pumped Storage” - marked with an asterisk - refer to the energy consumption of pumped storage power plants and are thus negative figures. Generation from pumped storage power plants is subsumed in the large – scale hydro figures.

2) Columns highlighted in grey indicate that in the respective country and in the respective year, integration challenges require the deployment of a model-intern backstop flexibility technology, which simulates different flexibility options. This backstop technology has a net electricity loss, which increases the generation in these countries.

EU27 HQS	generation in TWh			
	2007	2015	2020	2030
Coal	571	589	521	275
Lignite	351	347	369	377
Gas	724	490	481	426
Oil	107	50	49	43
Nuclear	885	884	887	817
Large Hydro	292	312	325	335
Small-scale Hydro	41	50	52	52
Pumped Storage*	-45	-31	-49	-64
Other non-renewables	18	17	17	17
Wind Onshore	104	281	407	546
Wind Offshore	0	62	153	339
Biomass	96	269	298	302
Photovoltaics	4	5	13	39
Concentrating Solar	0	13	31	70
Geothermal	5	17	27	54
Tidal	0	0	0	0
Wave	0	0	0	0
Net Import	10	18	30	26
Windreduction	0	-13	-27	-70
Sum	**3165**	**3359**	**3585**	**3585**
RES-E Share	**15%**	**28%**	**34%**	**45%**

EU27 BAU	generation in TWh			
	2007	2015	2020	2030
Coal	571	657	559	303
Lignite	351	349	376	396
Gas	724	507	480	481
Oil	107	49	46	46
Nuclear	885	885	894	835
Large Hydro	292	304	320	329
Small-scale Hydro	41	46	46	46
Pumped Storage*	-45	-20	-42	-55
Other non-renewables	34	17	17	17
Wind Onshore	104	188	292	362
Wind Offshore	0	51	136	274
Biomass	96	211	236	222
Photovoltaics	4	88	155	243
Concentrating Solar	0	10	18	24
Geothermal	5	16	37	80
Tidal	0	0	0	2
Wave	0	0	0	4
Net Import	10	2	21	22
Windreduction	0	-1	-4	-35
Sum	**3181**	**3360**	**3587**	**3593**
RES-E Share	**15%**	**26%**	**32%**	**41%**

EU27 Cluster	generation in TWh			
	2007	2015	2020	2030
Coal	571	641	553	323
Lignite	351	349	377	389
Gas	724	512	483	477
Oil	107	46	46	46
Nuclear	885	885	895	836
Large Hydro	292	305	321	329
Small-scale Hydro	41	46	46	46
Pumped Storage*	-45	-21	-44	-55
Other non-renewables	34	17	17	17
Wind Onshore	104	200	311	391
Wind Offshore	0	52	126	291
Biomass	96	212	233	205
Photovoltaics	4	88	152	228
Concentrating Solar	0	10	18	24
Geothermal	5	16	37	62
Tidal	0	0	0	2
Wave	0	0	0	4
Net Import	10	3	21	24
Windreduction	0	-1	-7	-45
Sum	**3181**	**3360**	**3588**	**3593**
RES-E Share	**15%**	**26%**	**32%**	**41%**

EU27++ HQS	generation in TWh			
	2007	2015	2020	2030
Coal	571	589	521	275
Lignite	351	347	369	377
Gas	725	490	482	427
Oil	107	50	49	43
Nuclear	912	900	918	845
Large Hydro	454	459	472	483
Small-scale Hydro	50	60	62	62
Pumped Storage*	-49	-33	-52	-68
Other non-renewables	18	17	17	17
Wind Onshore	105	288	414	553
Wind Offshore	0	70	161	348
Biomass	99	274	304	307
Photovoltaics	4	5	13	39
Concentrating Solar	0	13	31	70
Geothermal	5	17	27	54
Tidal	0	0	0	0
Wave	0	0	0	0
Net Import	-2	13	12	12
Windreduction	0	-13	-27	-70
Sum	**3351**	**3546**	**3775**	**3775**
RES-E Share	**19%**	**31%**	**37%**	**47%**

EU27++ BAU	generation in TWh			
	2007	2015	2020	2030
Coal	571	657	559	303
Lignite	351	349	376	396
Gas	725	508	481	481
Oil	107	49	46	46
Nuclear	912	901	920	864
Large Hydro	454	450	466	476
Small-scale Hydro	50	55	55	55
Pumped Storage*	-49	-21	-44	-57
Other non-renewables	35	17	17	17
Wind Onshore	105	189	299	369
Wind Offshore	0	51	136	274
Biomass	99	214	239	225
Photovoltaics	4	89	156	243
Concentrating Solar	0	10	18	24
Geothermal	5	16	45	87
Tidal	0	0	0	2
Wave	0	0	0	4
Net Import	-2	13	12	11
Windreduction	0	-1	-4	-35
Sum	**3368**	**3547**	**3777**	**3783**
RES-E Share	**19%**	**29%**	**35%**	**44%**

EU27++ Cluster	generation in TWh			
	2007	2015	2020	2030
Coal	571	641	553	323
Lignite	351	349	377	389
Gas	725	513	484	478
Oil	107	46	46	46
Nuclear	912	901	921	867
Large Hydro	454	451	467	476
Small-scale Hydro	50	55	55	55
Pumped Storage*	-49	-22	-45	-57
Other non-renewables	35	17	17	17
Wind Onshore	105	201	317	397
Wind Offshore	0	52	126	291
Biomass	99	215	236	208
Photovoltaics	4	89	152	228
Concentrating Solar	0	10	18	24
Geothermal	5	16	45	70
Tidal	0	0	0	2
Wave	0	0	0	4
Net Import	-2	13	13	11
Windreduction	0	-1	-7	-45
Sum	**3368**	**3547**	**3778**	**3783**
RES-E Share	**19%**	**29%**	**35%**	**43%**

Austria HQS	generation in TWh			
	2007	2015	2020	2030
Coal	6	3	3	1
Lignite	0	0	0	0
Gas	11	14	14	14
Oil	1	2	2	2
Nuclear	0	0	0	0
Large Hydro	31	34	35	35
Small-scale Hydro	5	5	5	5
Pumped Storage*	-3	0	-1	-1
Other non-renewables	1	1	1	1
Wind Onshore	2	3	4	5
Wind Offshore	0	0	0	0
Biomass	4	4	4	5
Photovoltaics	0	0	0	0
Concentrating Solar	0	0	0	0
Geothermal	0	0	0	0
Tidal	0	0	0	0
Wave	0	0	0	0
Net Import	7	2	6	6
Windreduction	0	0	0	0
Sum	**63**	**68**	**73**	**73**
RES-E Share	**55%**	**65%**	**61%**	**64%**

Austria BAU	generation in TWh			
	2007	2015	2020	2030
Coal	6	3	3	1
Lignite	0	0	0	0
Gas	11	14	14	14
Oil	1	2	2	2
Nuclear	0	0	0	0
Large Hydro	31	34	34	35
Small-scale Hydro	5	5	5	5
Pumped Storage*	-3	0	0	-1
Other non-renewables	0	1	1	1
Wind Onshore	2	2	2	0
Wind Offshore	0	0	0	0
Biomass	4	3	2	3
Photovoltaics	0	4	7	10
Concentrating Solar	0	0	0	0
Geothermal	0	0	0	0
Tidal	0	0	0	0
Wave	0	0	0	0
Net Import	7	0	3	4
Windreduction	0	0	0	0
Sum	**63**	**68**	**73**	**73**
RES-E Share	**55%**	**67%**	**65%**	**68%**

Austria Cluster	generation in TWh			
	2007	2015	2020	2030
Coal	6	3	3	1
Lignite	0	0	0	0
Gas	11	14	14	14
Oil	1	2	2	2
Nuclear	0	0	0	0
Large Hydro	31	34	34	35
Small-scale Hydro	5	5	5	5
Pumped Storage*	-3	0	0	-1
Other non-renewables	0	1	1	1
Wind Onshore	2	2	2	0
Wind Offshore	0	0	0	0
Biomass	4	3	2	3
Photovoltaics	0	4	7	10
Concentrating Solar	0	0	0	0
Geothermal	0	0	0	0
Tidal	0	0	0	0
Wave	0	0	0	0
Net Import	7	0	3	4
Windreduction	0	0	0	0
Sum	**63**	**68**	**73**	**73**
RES-E Share	**55%**	**67%**	**65%**	**68%**

Belgium HQS	generation in TWh			
	2007	2015	2020	2030
Coal	6	10	11	17
Lignite	0	0	0	0
Gas	26	9	11	12
Oil	1	0	0	0
Nuclear	46	35	27	0
Large Hydro	1	1	2	2
Small-scale Hydro	0	0	0	0
Pumped Storage*	-2	-1	-2	-3
Other non-renewables	1	1	1	1
Wind Onshore	0	8	9	10
Wind Offshore	0	4	8	8
Biomass	3	7	7	9
Photovoltaics	0	0	0	0
Concentrating Solar	0	0	0	0
Geothermal	0	0	0	0
Tidal	0	0	0	0
Wave	0	0	0	0
Net Import	7	23	33	50
Windreduction	0	0	0	0
Sum	**90**	**98**	**106**	**106**
RES-E Share	**4%**	**19%**	**22%**	**24%**

Belgium BAU	generation in TWh			
	2007	2015	2020	2030
Coal	6	12	14	18
Lignite	0	0	0	0
Gas	26	10	10	11
Oil	1	0	0	0
Nuclear	46	35	27	0
Large Hydro	1	1	2	2
Small-scale Hydro	0	0	0	0
Pumped Storage*	-2	-1	-2	-2
Other non-renewables	2	1	1	1
Wind Onshore	0	7	9	10
Wind Offshore	0	1	7	9
Biomass	3	7	7	9
Photovoltaics	0	0	0	1
Concentrating Solar	0	0	0	0
Geothermal	0	0	0	7
Tidal	0	0	0	0
Wave	0	0	0	0
Net Import	7	26	30	42
Windreduction	0	0	0	0
Sum	**91**	**98**	**106**	**106**
RES-E Share	**4%**	**15%**	**22%**	**33%**

Belgium Cluster	generation in TWh			
	2007	2015	2020	2030
Coal	6	11	16	29
Lignite	0	0	0	0
Gas	26	10	10	10
Oil	1	0	0	0
Nuclear	46	35	28	0
Large Hydro	1	1	1	2
Small-scale Hydro	0	0	0	0
Pumped Storage*	-2	-1	-2	-2
Other non-renewables	2	1	1	1
Wind Onshore	0	9	9	9
Wind Offshore	0	1	4	9
Biomass	3	7	7	5
Photovoltaics	0	0	0	0
Concentrating Solar	0	0	0	0
Geothermal	0	0	0	0
Tidal	0	0	0	0
Wave	0	0	0	0
Net Import	7	24	30	43
Windreduction	0	0	0	0
Sum	**91**	**98**	**106**	**106**
RES-E Share	**4%**	**17%**	**19%**	**22%**

Bulgaria HQS	generation in TWh			
	2007	2015	2020	2030
Coal	5	1	1	1
Lignite	14	7	7	7
Gas	2	2	2	2
Oil	0	1	1	1
Nuclear	14	14	22	21
Large Hydro	3	4	4	4
Small-scale Hydro	1	1	1	1
Pumped Storage*	-1	-2	-1	-2
Other non-renewables	0	0	0	0
Wind Onshore	0	0	0	0
Wind Offshore	0	0	0	0
Biomass	0	6	6	8
Photovoltaics	0	0	0	0
Concentrating Solar	0	0	0	0
Geothermal	0	0	0	0
Tidal	0	0	0	0
Wave	0	0	0	0
Net Import	-4	0	-4	-5
Windreduction	0	0	0	0
Sum	**34**	**33**	**37**	**37**
RES-E Share	**7%**	**28%**	**26%**	**30%**

Bulgaria BAU	generation in TWh			
	2007	2015	2020	2030
Coal	5	4	3	1
Lignite	14	7	7	8
Gas	2	2	2	2
Oil	0	1	1	1
Nuclear	14	14	14	12
Large Hydro	3	3	3	5
Small-scale Hydro	1	0	0	0
Pumped Storage*	-1	-1	-1	-3
Other non-renewables	0	0	0	0
Wind Onshore	0	0	0	0
Wind Offshore	0	0	0	0
Biomass	0	1	1	0
Photovoltaics	0	0	3	9
Concentrating Solar	0	0	0	0
Geothermal	0	0	0	0
Tidal	0	0	0	0
Wave	0	0	0	0
Net Import	-4	2	3	3
Windreduction	0	0	0	0
Sum	**34**	**33**	**37**	**37**
RES-E Share	**7%**	**12%**	**18%**	**32%**

Bulgaria Cluster	generation in TWh			
	2007	2015	2020	2030
Coal	5	3	3	1
Lignite	14	7	7	8
Gas	2	2	2	2
Oil	0	1	1	1
Nuclear	14	14	14	12
Large Hydro	3	3	3	4
Small-scale Hydro	1	0	0	0
Pumped Storage*	-1	-1	0	-2
Other non-renewables	0	0	0	0
Wind Onshore	0	0	0	0
Wind Offshore	0	0	0	0
Biomass	0	1	1	0
Photovoltaics	0	0	3	9
Concentrating Solar	0	0	0	0
Geothermal	0	0	0	0
Tidal	0	0	0	0
Wave	0	0	0	0
Net Import	-4	2	4	3
Windreduction	0	0	0	0
Sum	**34**	**33**	**37**	**37**
RES-E Share	**7%**	**12%**	**18%**	**32%**

Cyprus HQS	generation in TWh			
	2007	2015	2020	2030
Coal	0	0	0	0
Lignite	0	0	0	0
Gas	0	0	0	0
Oil	5	3	3	1
Nuclear	0	0	0	0
Large Hydro	0	0	0	0
Small-scale Hydro	0	0	0	0
Pumped Storage*	0	0	0	0
Other non-renewables	0	0	0	0
Wind Onshore	0	0	0	0
Wind Offshore	0	0	0	0
Biomass	0	0	0	0
Photovoltaics	0	0	1	3
Concentrating Solar	0	1	1	1
Geothermal	0	0	0	1
Tidal	0	0	0	0
Wave	0	0	0	0
Net Import	0	0	0	0
Windreduction	0	0	0	0
Sum	**5**	**4**	**5**	**6**
RES-E Share	**0%**	**24%**	**45%**	**99%**

Cyprus BAU	generation in TWh			
	2007	2015	2020	2030
Coal	0	0	0	0
Lignite	0	0	0	0
Gas	0	0	0	0
Oil	5	2	2	2
Nuclear	0	0	0	0
Large Hydro	0	0	0	0
Small-scale Hydro	0	0	0	0
Pumped Storage*	0	0	0	0
Other non-renewables	0	0	0	0
Wind Onshore	0	0	0	0
Wind Offshore	0	0	0	0
Biomass	0	0	0	0
Photovoltaics	0	2	2	3
Concentrating Solar	0	0	1	1
Geothermal	0	0	0	0
Tidal	0	0	0	0
Wave	0	0	0	0
Net Import	0	0	0	0
Windreduction	0	0	0	0
Sum	**5**	**5**	**5**	**5**
RES-E Share	**0%**	**55%**	**67%**	**72%**

Cyprus Cluster	generation in TWh			
	2007	2015	2020	2030
Coal	0	0	0	0
Lignite	0	0	0	0
Gas	0	0	0	0
Oil	5	2	2	2
Nuclear	0	0	0	0
Large Hydro	0	0	0	0
Small-scale Hydro	0	0	0	0
Pumped Storage*	0	0	0	0
Other non-renewables	0	0	0	0
Wind Onshore	0	0	0	0
Wind Offshore	0	0	0	0
Biomass	0	0	0	0
Photovoltaics	0	2	2	3
Concentrating Solar	0	0	1	1
Geothermal	0	0	0	0
Tidal	0	0	0	0
Wave	0	0	0	0
Net Import	0	0	0	0
Windreduction	0	0	0	0
Sum	**5**	**5**	**5**	**5**
RES-E Share	**0%**	**55%**	**67%**	**72%**

Czech Republic HQS	generation in TWh			
	2007	2015	2020	2030
Coal	7	2	3	1
Lignite	42	51	63	66
Gas	4	1	1	1
Oil	0	0	0	0
Nuclear	25	26	26	20
Large Hydro	2	2	2	3
Small-scale Hydro	1	1	1	1
Pumped Storage*	-1	-1	-2	-2
Other non-renewables	0	0	0	0
Wind Onshore	0	11	19	20
Wind Offshore	0	0	0	0
Biomass	1	6	7	8
Photovoltaics	0	0	0	0
Concentrating Solar	0	0	0	0
Geothermal	0	0	0	0
Tidal	0	0	0	0
Wave	0	0	0	0
Net Import	-16	-31	-21	-18
Windreduction	0	0	0	0
Sum	**65**	**67**	**99**	**99**
RES-E Share	**5%**	**26%**	**27%**	**29%**

Czech Republic BAU	generation in TWh			
	2007	2015	2020	2030
Coal	7	1	1	0
Lignite	42	51	61	60
Gas	4	1	1	1
Oil	0	0	0	0
Nuclear	25	26	25	13
Large Hydro	2	2	4	3
Small-scale Hydro	1	1	1	1
Pumped Storage*	-1	-2	-3	-3
Other non-renewables	0	0	0	0
Wind Onshore	0	11	16	16
Wind Offshore	0	0	0	0
Biomass	1	8	10	11
Photovoltaics	0	10	15	22
Concentrating Solar	0	0	0	0
Geothermal	0	0	0	0
Tidal	0	0	0	0
Wave	0	0	0	0
Net Import	-16	-42	-30	-25
Windreduction	0	0	0	-1
Sum	**65**	**67**	**99**	**100**
RES-E Share	**5%**	**43%**	**40%**	**49%**

Czech Republic Cluster	generation in TWh			
	2007	2015	2020	2030
Coal	7	1	1	0
Lignite	42	51	61	59
Gas	4	1	1	1
Oil	0	0	0	0
Nuclear	25	26	25	13
Large Hydro	2	2	4	3
Small-scale Hydro	1	1	1	1
Pumped Storage*	-1	-2	-3	-3
Other non-renewables	0	0	0	0
Wind Onshore	0	11	16	16
Wind Offshore	0	0	0	0
Biomass	1	8	10	11
Photovoltaics	0	10	15	22
Concentrating Solar	0	0	0	0
Geothermal	0	0	0	0
Tidal	0	0	0	0
Wave	0	0	0	0
Net Import	-16	-42	-29	-24
Windreduction	0	0	0	0
Sum	**65**	**67**	**99**	**100**
RES-E Share	**5%**	**43%**	**40%**	**49%**

Denmark HQS	generation in TWh			
	2007	2015	2020	2030
Coal	19	12	12	12
Lignite	0	0	0	0
Gas	7	10	10	10
Oil	1	4	4	4
Nuclear	0	0	0	0
Large Hydro	0	0	0	0
Small-scale Hydro	0	0	0	0
Pumped Storage*	0	0	0	0
Other non-renewables	0	0	0	0
Wind Onshore	7	12	13	12
Wind Offshore	0	12	27	31
Biomass	4	6	5	2
Photovoltaics	0	0	0	0
Concentrating Solar	0	0	0	0
Geothermal	0	0	0	0
Tidal	0	0	0	0
Wave	0	0	0	0
Net Import	-1	-23	-29	-29
Windreduction	0	-2	-10	-9
Sum	**37**	**32**	**33**	**33**
RES-E Share	**28%**	**91%**	**130%**	**130%**

Denmark BAU	generation in TWh			
	2007	2015	2020	2030
Coal	19	12	12	12
Lignite	0	0	0	0
Gas	7	10	10	10
Oil	1	4	4	4
Nuclear	0	0	0	0
Large Hydro	0	0	0	0
Small-scale Hydro	0	0	0	0
Pumped Storage*	0	0	0	0
Other non-renewables	3	0	0	0
Wind Onshore	7	9	13	12
Wind Offshore	0	3	6	28
Biomass	4	6	6	6
Photovoltaics	0	0	0	0
Concentrating Solar	0	0	0	0
Geothermal	0	0	0	0
Tidal	0	0	0	0
Wave	0	0	0	0
Net Import	-1	-12	-18	-30
Windreduction	0	0	-1	-9
Sum	**39**	**32**	**33**	**33**
RES-E Share	**28%**	**52%**	**72%**	**130%**

Denmark Cluster	generation in TWh			
	2007	2015	2020	2030
Coal	19	12	12	12
Lignite	0	0	0	0
Gas	7	10	10	10
Oil	1	4	4	4
Nuclear	0	0	0	0
Large Hydro	0	0	0	0
Small-scale Hydro	0	0	0	0
Pumped Storage*	0	0	0	0
Other non-renewables	3	0	0	0
Wind Onshore	7	9	13	12
Wind Offshore	0	3	6	28
Biomass	4	6	6	6
Photovoltaics	0	0	0	0
Concentrating Solar	0	0	0	0
Geothermal	0	0	0	0
Tidal	0	0	0	0
Wave	0	0	0	0
Net Import	-1	-12	-18	-30
Windreduction	0	0	-1	-9
Sum	**39**	**32**	**33**	**33**
RES-E Share	**28%**	**52%**	**72%**	**130%**

Estonia HQS	generation in TWh			
	2007	2015	2020	2030
Coal	0	0	0	0
Lignite	10	7	8	10
Gas	1	0	0	0
Oil	0	0	0	0
Nuclear	0	0	0	0
Large Hydro	0	0	0	0
Small-scale Hydro	0	0	0	0
Pumped Storage*	0	0	0	0
Other non-renewables	0	0	0	0
Wind Onshore	0	8	8	10
Wind Offshore	0	0	0	0
Biomass	0	1	1	1
Photovoltaics	0	0	0	0
Concentrating Solar	0	0	0	0
Geothermal	0	0	0	0
Tidal	0	0	0	0
Wave	0	0	0	0
Net Import	-2	-5	-5	-8
Windreduction	0	-1	-1	-1
Sum	**8**	**10**	**12**	**12**
RES-E Share	**1%**	**88%**	**79%**	**88%**

Estonia BAU	generation in TWh			
	2007	2015	2020	2030
Coal	0	0	0	0
Lignite	10	7	9	11
Gas	1	0	0	0
Oil	0	0	0	0
Nuclear	0	0	0	0
Large Hydro	0	0	0	0
Small-scale Hydro	0	0	0	0
Pumped Storage*	0	0	0	0
Other non-renewables	0	0	0	0
Wind Onshore	0	3	10	10
Wind Offshore	0	0	0	0
Biomass	0	1	1	0
Photovoltaics	0	0	0	0
Concentrating Solar	0	0	0	0
Geothermal	0	0	0	0
Tidal	0	0	0	0
Wave	0	0	0	0
Net Import	-2	-1	-7	-9
Windreduction	0	0	-1	-1
Sum	**9**	**10**	**12**	**12**
RES-E Share	**1%**	**34%**	**88%**	**88%**

Estonia Cluster	generation in TWh			
	2007	2015	2020	2030
Coal	0	0	0	0
Lignite	10	7	8	11
Gas	1	0	0	0
Oil	0	0	0	0
Nuclear	0	0	0	0
Large Hydro	0	0	0	0
Small-scale Hydro	0	0	0	0
Pumped Storage*	0	0	0	0
Other non-renewables	0	0	0	0
Wind Onshore	0	3	10	10
Wind Offshore	0	0	0	0
Biomass	0	1	1	0
Photovoltaics	0	0	0	0
Concentrating Solar	0	0	0	0
Geothermal	0	0	0	0
Tidal	0	0	0	0
Wave	0	0	0	0
Net Import	-2	-1	-6	-9
Windreduction	0	0	-1	-1
Sum	**9**	**10**	**12**	**12**
RES-E Share	**1%**	**34%**	**88%**	**88%**

Finland HQS	generation in TWh			
	2007	2015	2020	2030
Coal	13	10	9	6
Lignite	7	7	7	7
Gas	11	9	9	9
Oil	0	1	1	1
Nuclear	23	31	21	38
Large Hydro	13	12	12	12
Small-scale Hydro	1	1	1	1
Pumped Storage*	0	0	0	0
Other non-renewables	0	0	0	0
Wind Onshore	0	2	7	8
Wind Offshore	0	0	0	0
Biomass	10	10	10	12
Photovoltaics	0	0	0	0
Concentrating Solar	0	0	0	0
Geothermal	0	0	0	0
Tidal	0	0	0	0
Wave	0	0	0	0
Net Import	13	12	23	7
Windreduction	0	0	0	0
Sum	**90**	**94**	**101**	**101**
RES-E Share	**25%**	**26%**	**30%**	**31%**

Finland BAU	generation in TWh			
	2007	2015	2020	2030
Coal	13	15	13	6
Lignite	7	6	6	7
Gas	11	9	9	9
Oil	0	1	1	1
Nuclear	23	31	33	41
Large Hydro	13	12	12	12
Small-scale Hydro	1	1	1	1
Pumped Storage*	0	0	0	0
Other non-renewables	2	0	0	0
Wind Onshore	0	0	0	0
Wind Offshore	0	0	0	0
Biomass	10	0	1	1
Photovoltaics	0	0	0	0
Concentrating Solar	0	0	0	0
Geothermal	0	0	0	0
Tidal	0	0	0	0
Wave	0	0	0	0
Net Import	13	19	24	23
Windreduction	0	0	0	0
Sum	**92**	**94**	**101**	**101**
RES-E Share	**25%**	**14%**	**14%**	**14%**

Finland Cluster	generation in TWh			
	2007	2015	2020	2030
Coal	13	15	12	6
Lignite	7	6	6	7
Gas	11	9	9	9
Oil	0	1	1	1
Nuclear	23	31	43	69
Large Hydro	13	12	12	12
Small-scale Hydro	1	1	1	1
Pumped Storage*	0	0	0	0
Other non-renewables	2	0	0	0
Wind Onshore	0	0	0	0
Wind Offshore	0	0	0	0
Biomass	10	1	1	0
Photovoltaics	0	0	0	0
Concentrating Solar	0	0	0	0
Geothermal	0	0	0	0
Tidal	0	0	0	0
Wave	0	0	0	0
Net Import	13	17	14	-5
Windreduction	0	0	0	0
Sum	**92**	**94**	**101**	**101**
RES-E Share	**25%**	**15%**	**14%**	**14%**

France HQS	generation in TWh			
	2007	2015	2020	2030
Coal	23	29	20	5
Lignite	0	0	0	0
Gas	24	17	24	19
Oil	6	1	1	1
Nuclear	419	427	442	465
Large Hydro	57	59	61	60
Small-scale Hydro	6	7	7	7
Pumped Storage*	-8	-5	-7	-7
Other non-renewables	1	1	1	1
Wind Onshore	4	32	42	63
Wind Offshore	0	3	16	37
Biomass	5	30	30	28
Photovoltaics	0	0	0	0
Concentrating Solar	0	0	0	0
Geothermal	0	1	1	0
Tidal	0	0	0	0
Wave	0	0	0	0
Net Import	-57	-86	-90	-133
Windreduction	0	0	0	0
Sum	**481**	**517**	**547**	**547**
RES-E Share	**13%**	**24%**	**26%**	**33%**

France BAU	generation in TWh			
	2007	2015	2020	2030
Coal	23	37	23	3
Lignite	0	0	0	0
Gas	24	20	19	21
Oil	6	1	1	1
Nuclear	419	427	443	460
Large Hydro	57	59	60	61
Small-scale Hydro	6	7	7	7
Pumped Storage*	-8	-4	-6	-7
Other non-renewables	2	1	1	1
Wind Onshore	4	10	21	32
Wind Offshore	0	7	19	43
Biomass	5	14	19	21
Photovoltaics	0	12	22	38
Concentrating Solar	0	0	0	0
Geothermal	0	1	1	0
Tidal	0	0	0	2
Wave	0	0	0	1
Net Import	-57	-74	-83	-136
Windreduction	0	0	0	0
Sum	**482**	**517**	**547**	**547**
RES-E Share	**13%**	**20%**	**25%**	**35%**

France Cluster	generation in TWh			
	2007	2015	2020	2030
Coal	23	36	23	3
Lignite	0	0	0	0
Gas	24	20	20	21
Oil	6	1	1	1
Nuclear	419	427	443	459
Large Hydro	57	59	60	61
Small-scale Hydro	6	7	7	7
Pumped Storage*	-8	-4	-6	-7
Other non-renewables	2	1	1	1
Wind Onshore	4	10	21	32
Wind Offshore	0	7	19	43
Biomass	5	14	19	21
Photovoltaics	0	12	22	38
Concentrating Solar	0	0	0	0
Geothermal	0	1	1	0
Tidal	0	0	0	2
Wave	0	0	0	1
Net Import	-57	-74	-84	-135
Windreduction	0	0	0	0
Sum	**482**	**517**	**547**	**547**
RES-E Share	**13%**	**20%**	**25%**	**35%**

Germany HQS	generation in TWh			
	2007	2015	2020	2030
Coal	123	107	98	36
Lignite	156	154	164	182
Gas	78	92	97	94
Oil	10	3	3	0
Nuclear	133	99	49	0
Large Hydro	18	18	21	24
Small-scale Hydro	8	11	13	13
Pumped Storage*	-9	-8	-12	-15
Other non-renewables	4	4	4	4
Wind Onshore	40	40	49	69
Wind Offshore	0	17	39	49
Biomass	28	44	43	45
Photovoltaics	3	3	3	0
Concentrating Solar	0	0	0	0
Geothermal	0	0	0	0
Tidal	0	0	0	0
Wave	0	0	0	0
Net Import	-17	-16	19	89
Windreduction	0	0	0	0
Sum	**576**	**570**	**590**	**590**
RES-E Share	**14%**	**21%**	**25%**	**30%**

Germany BAU	generation in TWh			
	2007	2015	2020	2030
Coal	123	132	108	42
Lignite	156	154	165	183
Gas	78	97	106	148
Oil	10	3	0	0
Nuclear	133	99	49	0
Large Hydro	18	15	19	20
Small-scale Hydro	8	9	9	9
Pumped Storage*	-9	-4	-8	-11
Other non-renewables	6	4	4	4
Wind Onshore	40	37	38	15
Wind Offshore	0	20	35	43
Biomass	28	37	36	15
Photovoltaics	3	6	6	0
Concentrating Solar	0	0	0	0
Geothermal	0	0	11	11
Tidal	0	0	0	0
Wave	0	0	0	0
Net Import	-17	-38	13	109
Windreduction	0	0	0	0
Sum	**579**	**570**	**590**	**590**
RES-E Share	**14%**	**20%**	**23%**	**17%**

Germany Cluster	generation in TWh			
	2007	2015	2020	2030
Coal	123	134	109	42
Lignite	156	154	165	183
Gas	78	108	107	150
Oil	10	0	0	0
Nuclear	133	99	49	0
Large Hydro	18	16	19	20
Small-scale Hydro	8	9	9	9
Pumped Storage*	-9	-4	-8	-11
Other non-renewables	6	4	4	4
Wind Onshore	40	37	38	15
Wind Offshore	0	20	35	43
Biomass	28	37	36	15
Photovoltaics	3	6	6	0
Concentrating Solar	0	0	0	0
Geothermal	0	0	11	11
Tidal	0	0	0	0
Wave	0	0	0	0
Net Import	-17	-49	11	108
Windreduction	0	0	0	0
Sum	**579**	**570**	**590**	**590**
RES-E Share	**14%**	**20%**	**23%**	**17%**

Greece HQS	generation in TWh			
	2007	2015	2020	2030
Coal	0	14	13	10
Lignite	32	23	23	25
Gas	13	3	2	1
Oil	9	1	1	1
Nuclear	0	0	0	0
Large Hydro	3	4	4	5
Small-scale Hydro	0	1	1	1
Pumped Storage*	-1	0	-1	-1
Other non-renewables	0	0	0	0
Wind Onshore	2	5	7	8
Wind Offshore	0	0	0	0
Biomass	0	3	3	3
Photovoltaics	0	0	0	0
Concentrating Solar	0	3	4	4
Geothermal	0	2	2	2
Tidal	0	0	0	0
Wave	0	0	0	0
Net Import	4	5	7	9
Windreduction	0	0	0	0
Sum	**62**	**63**	**67**	**67**
RES-E Share	**7%**	**26%**	**30%**	**32%**

Greece BAU	generation in TWh			
	2007	2015	2020	2030
Coal	0	7	6	3
Lignite	32	23	23	18
Gas	13	4	0	0
Oil	9	1	1	1
Nuclear	0	0	0	0
Large Hydro	3	4	5	5
Small-scale Hydro	0	0	0	0
Pumped Storage*	-1	-1	-1	-1
Other non-renewables	0	0	0	0
Wind Onshore	2	2	2	2
Wind Offshore	0	0	0	0
Biomass	0	0	0	0
Photovoltaics	0	15	25	36
Concentrating Solar	0	3	4	4
Geothermal	0	2	2	2
Tidal	0	0	0	0
Wave	0	0	0	0
Net Import	4	3	1	1
Windreduction	0	0	0	0
Sum	**62**	**64**	**68**	**71**
RES-E Share	**7%**	**39%**	**54%**	**70%**

Greece Cluster	generation in TWh			
	2007	2015	2020	2030
Coal	0	7	7	3
Lignite	32	23	23	18
Gas	13	4	0	0
Oil	9	1	1	1
Nuclear	0	0	0	0
Large Hydro	3	4	5	5
Small-scale Hydro	0	0	0	0
Pumped Storage*	-1	-1	-1	-1
Other non-renewables	0	0	0	0
Wind Onshore	2	2	2	2
Wind Offshore	0	0	0	0
Biomass	0	0	0	0
Photovoltaics	0	15	25	36
Concentrating Solar	0	3	4	4
Geothermal	0	2	2	2
Tidal	0	0	0	0
Wave	0	0	0	0
Net Import	4	3	1	1
Windreduction	0	0	0	0
Sum	**62**	**64**	**68**	**71**
RES-E Share	**7%**	**39%**	**54%**	**70%**

Hungary HQS	generation in TWh			
	2007	2015	2020	2030
Coal	1	2	2	0
Lignite	6	5	5	5
Gas	14	7	7	7
Oil	0	0	0	0
Nuclear	14	13	12	2
Large Hydro	0	0	0	0
Small-scale Hydro	0	0	0	0
Pumped Storage*	0	0	0	0
Other non-renewables	0	0	0	0
Wind Onshore	0	2	8	8
Wind Offshore	0	0	0	0
Biomass	2	14	18	23
Photovoltaics	0	0	0	0
Concentrating Solar	0	0	0	0
Geothermal	0	0	0	0
Tidal	0	0	0	0
Wave	0	0	0	0
Net Import	4	2	-4	4
Windreduction	0	0	0	-1
Sum	**41**	**46**	**48**	**48**
RES-E Share	**4%**	**34%**	**53%**	**64%**

Hungary BAU	generation in TWh			
	2007	2015	2020	2030
Coal	1	2	2	0
Lignite	6	3	5	5
Gas	14	7	7	7
Oil	0	0	0	0
Nuclear	14	13	12	3
Large Hydro	0	0	0	0
Small-scale Hydro	0	0	0	0
Pumped Storage*	0	0	0	0
Other non-renewables	1	0	0	0
Wind Onshore	0	2	8	8
Wind Offshore	0	0	0	0
Biomass	2	12	13	8
Photovoltaics	0	0	0	0
Concentrating Solar	0	0	0	0
Geothermal	0	0	0	0
Tidal	0	0	0	0
Wave	0	0	0	0
Net Import	4	6	1	16
Windreduction	0	0	0	-1
Sum	**42**	**46**	**48**	**48**
RES-E Share	**4%**	**32%**	**43%**	**35%**

Hungary Cluster	generation in TWh			
	2007	2015	2020	2030
Coal	1	2	1	0
Lignite	6	3	5	5
Gas	14	7	7	7
Oil	0	0	0	0
Nuclear	14	13	12	9
Large Hydro	0	0	0	0
Small-scale Hydro	0	0	0	0
Pumped Storage*	0	0	0	0
Other non-renewables	1	0	0	0
Wind Onshore	0	2	8	8
Wind Offshore	0	0	0	0
Biomass	2	13	13	8
Photovoltaics	0	0	0	0
Concentrating Solar	0	0	0	0
Geothermal	0	0	0	0
Tidal	0	0	0	0
Wave	0	0	0	0
Net Import	4	6	1	10
Windreduction	0	0	0	0
Sum	**42**	**46**	**48**	**48**
RES-E Share	**4%**	**33%**	**44%**	**35%**

Ireland HQS	generation in TWh			
	2007	2015	2020	2030
Coal	5	3	3	2
Lignite	2	1	2	2
Gas	15	3	3	3
Oil	2	0	0	0
Nuclear	0	0	0	0
Large Hydro	1	1	1	1
Small-scale Hydro	0	0	0	0
Pumped Storage*	-1	-1	-1	-1
Other non-renewables	3	3	3	3
Wind Onshore	2	22	25	29
Wind Offshore	0	0	0	0
Biomass	0	6	6	3
Photovoltaics	0	0	0	0
Concentrating Solar	0	0	0	0
Geothermal	0	0	0	0
Tidal	0	0	0	0
Wave	0	0	0	0
Net Import	1	0	1	1
Windreduction	0	-9	-9	-10
Sum	**32**	**30**	**33**	**33**
RES-E Share	**9%**	**91%**	**92%**	**97%**

Ireland BAU	generation in TWh			
	2007	2015	2020	2030
Coal	5	15	15	6
Lignite	2	2	2	1
Gas	15	4	5	2
Oil	2	0	0	0
Nuclear	0	0	0	0
Large Hydro	1	1	1	1
Small-scale Hydro	0	0	0	0
Pumped Storage*	-1	0	-1	-1
Other non-renewables	0	3	3	3
Wind Onshore	2	3	4	29
Wind Offshore	0	0	0	0
Biomass	0	0	0	0
Photovoltaics	0	0	0	0
Concentrating Solar	0	0	0	0
Geothermal	0	0	0	0
Tidal	0	0	0	0
Wave	0	0	0	0
Net Import	1	2	3	0
Windreduction	0	0	0	-8
Sum	**29**	**30**	**33**	**33**
RES-E Share	**9%**	**11%**	**15%**	**87%**

Ireland Cluster	generation in TWh			
	2007	2015	2020	2030
Coal	5	15	15	6
Lignite	2	2	2	1
Gas	15	4	5	2
Oil	2	0	0	0
Nuclear	0	0	0	0
Large Hydro	1	1	1	1
Small-scale Hydro	0	0	0	0
Pumped Storage*	-1	0	0	-1
Other non-renewables	0	3	3	3
Wind Onshore	2	3	4	29
Wind Offshore	0	0	0	0
Biomass	0	0	0	0
Photovoltaics	0	0	0	0
Concentrating Solar	0	0	0	0
Geothermal	0	0	0	0
Tidal	0	0	0	0
Wave	0	0	0	0
Net Import	1	2	3	0
Windreduction	0	0	0	-8
Sum	**29**	**30**	**33**	**33**
RES-E Share	**9%**	**11%**	**15%**	**87%**

Italy HQS	generation in TWh			
	2007	2015	2020	2030
Coal	42	84	69	32
Lignite	0	0	0	0
Gas	170	119	108	83
Oil	34	18	18	18
Nuclear	0	0	22	99
Large Hydro	31	39	39	41
Small-scale Hydro	7	9	9	9
Pumped Storage*	-8	-5	-5	-8
Other non-renewables	2	2	2	2
Wind Onshore	4	6	6	8
Wind Offshore	0	0	0	0
Biomass	6	21	22	23
Photovoltaics	0	0	8	22
Concentrating Solar	0	2	5	6
Geothermal	5	13	23	48
Tidal	0	0	0	0
Wave	0	0	0	0
Net Import	46	68	80	22
Windreduction	0	0	0	0
Sum	**340**	**376**	**405**	**405**
RES-E Share	**13%**	**22%**	**26%**	**36%**

Italy BAU	generation in TWh			
	2007	2015	2020	2030
Coal	42	69	53	23
Lignite	0	0	0	0
Gas	170	120	107	80
Oil	34	18	18	18
Nuclear	0	0	22	87
Large Hydro	31	37	39	40
Small-scale Hydro	7	9	9	9
Pumped Storage*	-8	-2	-5	-7
Other non-renewables	2	2	2	2
Wind Onshore	4	6	14	17
Wind Offshore	0	0	0	0
Biomass	6	22	22	23
Photovoltaics	0	17	28	40
Concentrating Solar	0	0	0	0
Geothermal	5	13	23	48
Tidal	0	0	0	0
Wave	0	0	0	0
Net Import	46	65	74	23
Windreduction	0	0	0	0
Sum	**341**	**376**	**405**	**405**
RES-E Share	**13%**	**26%**	**31%**	**41%**

Italy Cluster	generation in TWh			
	2007	2015	2020	2030
Coal	42	69	53	23
Lignite	0	0	0	0
Gas	170	121	107	79
Oil	34	18	18	18
Nuclear	0	0	22	90
Large Hydro	31	37	39	40
Small-scale Hydro	7	9	9	9
Pumped Storage*	-8	-2	-5	-7
Other non-renewables	2	2	2	2
Wind Onshore	4	6	14	17
Wind Offshore	0	0	0	0
Biomass	6	22	22	23
Photovoltaics	0	17	28	40
Concentrating Solar	0	0	0	0
Geothermal	5	13	23	48
Tidal	0	0	0	0
Wave	0	0	0	0
Net Import	46	65	73	23
Windreduction	0	0	0	0
Sum	**341**	**376**	**405**	**405**
RES-E Share	**13%**	**26%**	**31%**	**41%**

Latvia HQS	generation in TWh			
	2007	2015	2020	2030
Coal	0	0	0	0
Lignite	0	0	0	0
Gas	2	3	3	3
Oil	0	0	0	0
Nuclear	0	0	0	0
Large Hydro	3	3	3	3
Small-scale Hydro	0	0	0	0
Pumped Storage*	0	0	0	0
Other non-renewables	0	0	0	0
Wind Onshore	0	2	3	3
Wind Offshore	0	0	0	0
Biomass	0	2	2	2
Photovoltaics	0	0	0	0
Concentrating Solar	0	0	0	0
Geothermal	0	0	0	0
Tidal	0	0	0	0
Wave	0	0	0	0
Net Import	3	1	2	2
Windreduction	0	-1	-1	0
Sum	**8**	**11**	**12**	**12**
RES-E Share	**36%**	**77%**	**69%**	**69%**

Latvia BAU	generation in TWh			
	2007	2015	2020	2030
Coal	0	0	1	1
Lignite	0	0	0	0
Gas	2	3	3	3
Oil	0	0	0	0
Nuclear	0	0	0	0
Large Hydro	3	3	3	3
Small-scale Hydro	0	0	0	0
Pumped Storage*	0	0	0	0
Other non-renewables	0	0	0	0
Wind Onshore	0	2	2	2
Wind Offshore	0	0	0	0
Biomass	0	4	3	3
Photovoltaics	0	0	0	0
Concentrating Solar	0	0	0	0
Geothermal	0	0	0	0
Tidal	0	0	0	0
Wave	0	0	0	0
Net Import	3	0	1	1
Windreduction	0	0	0	0
Sum	**8**	**11**	**12**	**12**
RES-E Share	**36%**	**81%**	**69%**	**69%**

Latvia Cluster	generation in TWh			
	2007	2015	2020	2030
Coal	0	0	0	0
Lignite	0	0	0	0
Gas	2	3	3	3
Oil	0	0	0	0
Nuclear	0	0	0	0
Large Hydro	3	3	3	3
Small-scale Hydro	0	0	0	0
Pumped Storage*	0	0	0	0
Other non-renewables	0	0	0	0
Wind Onshore	0	2	2	2
Wind Offshore	0	0	0	0
Biomass	0	4	3	3
Photovoltaics	0	0	0	0
Concentrating Solar	0	0	0	0
Geothermal	0	0	0	0
Tidal	0	0	0	0
Wave	0	0	0	0
Net Import	3	0	2	2
Windreduction	0	0	0	0
Sum	**8**	**11**	**12**	**12**
RES-E Share	**36%**	**81%**	**69%**	**69%**

Lithuania HQS	generation in TWh			
	2007	2015	2020	2030
Coal	0	0	0	0
Lignite	0	0	0	0
Gas	2	2	2	2
Oil	0	1	1	1
Nuclear	9	8	9	0
Large Hydro	1	1	1	1
Small-scale Hydro	0	0	0	0
Pumped Storage*	-1	-1	-1	-1
Other non-renewables	0	0	0	0
Wind Onshore	0	0	1	2
Wind Offshore	0	0	0	0
Biomass	0	5	7	5
Photovoltaics	0	0	0	0
Concentrating Solar	0	0	0	0
Geothermal	0	0	0	0
Tidal	0	0	0	0
Wave	0	0	0	0
Net Import	-1	-3	-4	7
Windreduction	0	0	0	0
Sum	**11**	**14**	**17**	**17**
RES-E Share	**4%**	**43%**	**56%**	**45%**

Lithuania BAU	generation in TWh			
	2007	2015	2020	2030
Coal	0	0	0	0
Lignite	0	0	0	0
Gas	2	2	2	2
Oil	0	1	1	1
Nuclear	9	9	9	6
Large Hydro	1	1	1	1
Small-scale Hydro	0	0	0	0
Pumped Storage*	-1	-1	-1	-1
Other non-renewables	0	0	0	0
Wind Onshore	0	0	1	1
Wind Offshore	0	0	0	0
Biomass	0	0	0	0
Photovoltaics	0	0	0	0
Concentrating Solar	0	0	0	0
Geothermal	0	0	0	0
Tidal	0	0	0	0
Wave	0	0	0	0
Net Import	-1	2	4	7
Windreduction	0	0	0	0
Sum	**11**	**14**	**17**	**17**
RES-E Share	**4%**	**4%**	**6%**	**6%**

Lithuania Cluster	generation in TWh			
	2007	2015	2020	2030
Coal	0	0	0	0
Lignite	0	0	0	0
Gas	2	2	2	2
Oil	0	1	1	1
Nuclear	9	9	9	5
Large Hydro	1	1	1	1
Small-scale Hydro	0	0	0	0
Pumped Storage*	-1	-1	-1	-1
Other non-renewables	0	0	0	0
Wind Onshore	0	0	1	1
Wind Offshore	0	0	0	0
Biomass	0	0	0	0
Photovoltaics	0	0	0	0
Concentrating Solar	0	0	0	0
Geothermal	0	0	0	0
Tidal	0	0	0	0
Wave	0	0	0	0
Net Import	-1	2	4	8
Windreduction	0	0	0	0
Sum	**11**	**14**	**17**	**17**
RES-E Share	**4%**	**4%**	**6%**	**6%**

Luxembourg HQS	generation in TWh			
	2007	2015	2020	2030
Coal	0	0	1	2
Lignite	0	0	0	0
Gas	3	0	1	0
Oil	0	0	0	0
Nuclear	0	0	0	0
Large Hydro	1	0	0	0
Small-scale Hydro	0	0	0	0
Pumped Storage*	-1	0	0	0
Other non-renewables	0	0	0	0
Wind Onshore	0	1	1	1
Wind Offshore	0	0	0	0
Biomass	0	0	0	1
Photovoltaics	0	0	0	0
Concentrating Solar	0	0	0	0
Geothermal	0	0	0	0
Tidal	0	0	0	0
Wave	0	0	0	0
Net Import	4	5	4	3
Windreduction	0	0	0	0
Sum	**7**	**7**	**7**	**7**
RES-E Share	**4%**	**19%**	**21%**	**23%**

Luxembourg BAU	generation in TWh			
	2007	2015	2020	2030
Coal	0	0	0	3
Lignite	0	0	0	0
Gas	3	1	1	0
Oil	0	0	0	0
Nuclear	0	0	0	0
Large Hydro	1	0	0	0
Small-scale Hydro	0	0	0	0
Pumped Storage*	-1	0	0	0
Other non-renewables	0	0	0	0
Wind Onshore	0	0	0	0
Wind Offshore	0	0	0	0
Biomass	0	0	0	0
Photovoltaics	0	0	0	0
Concentrating Solar	0	0	0	0
Geothermal	0	0	0	0
Tidal	0	0	0	0
Wave	0	0	0	0
Net Import	4	5	5	4
Windreduction	0	0	0	0
Sum	**7**	**7**	**8**	**8**
RES-E Share	**4%**	**8%**	**8%**	**13%**

Luxembourg Cluster	generation in TWh			
	2007	2015	2020	2030
Coal	0	0	0	3
Lignite	0	0	0	0
Gas	3	1	1	0
Oil	0	0	0	0
Nuclear	0	0	0	0
Large Hydro	1	0	0	0
Small-scale Hydro	0	0	0	0
Pumped Storage*	-1	0	0	0
Other non-renewables	0	0	0	0
Wind Onshore	0	0	0	0
Wind Offshore	0	0	0	0
Biomass	0	0	0	0
Photovoltaics	0	0	0	0
Concentrating Solar	0	0	0	0
Geothermal	0	0	0	0
Tidal	0	0	0	0
Wave	0	0	0	0
Net Import	4	5	5	3
Windreduction	0	0	0	0
Sum	**7**	**7**	**8**	**8**
RES-E Share	**4%**	**8%**	**8%**	**13%**

Malta HQS	generation in TWh			
	2007	2015	2020	2030
Coal	0	0	0	0
Lignite	0	0	0	0
Gas	0	0	0	0
Oil	2	2	2	1
Nuclear	0	0	0	0
Large Hydro	0	0	0	0
Small-scale Hydro	0	0	0	0
Pumped Storage*	0	0	0	0
Other non-renewables	0	0	0	0
Wind Onshore	0	0	0	0
Wind Offshore	0	0	0	0
Biomass	0	0	0	0
Photovoltaics	0	0	0	1
Concentrating Solar	0	0	0	0
Geothermal	0	0	0	0
Tidal	0	0	0	0
Wave	0	0	0	0
Net Import	0	0	0	0
Windreduction	0	0	0	0
Sum	**2**	**2**	**2**	**2**
RES-E Share	**0%**	**9%**	**8%**	**63%**

Malta BAU	generation in TWh			
	2007	2015	2020	2030
Coal	0	0	0	0
Lignite	0	0	0	0
Gas	0	0	0	0
Oil	2	2	2	2
Nuclear	0	0	0	0
Large Hydro	0	0	0	0
Small-scale Hydro	0	0	0	0
Pumped Storage*	0	0	0	0
Other non-renewables	0	0	0	0
Wind Onshore	0	0	0	0
Wind Offshore	0	0	0	0
Biomass	0	0	0	0
Photovoltaics	0	0	0	0
Concentrating Solar	0	0	0	0
Geothermal	0	0	0	0
Tidal	0	0	0	0
Wave	0	0	0	0
Net Import	0	0	0	0
Windreduction	0	0	0	0
Sum	**2**	**2**	**2**	**2**
RES-E Share	**0%**	**2%**	**8%**	**9%**

Malta Cluster	generation in TWh			
	2007	2015	2020	2030
Coal	0	0	0	0
Lignite	0	0	0	0
Gas	0	0	0	0
Oil	2	2	2	2
Nuclear	0	0	0	0
Large Hydro	0	0	0	0
Small-scale Hydro	0	0	0	0
Pumped Storage*	0	0	0	0
Other non-renewables	0	0	0	0
Wind Onshore	0	0	0	0
Wind Offshore	0	0	0	0
Biomass	0	0	0	0
Photovoltaics	0	0	0	0
Concentrating Solar	0	0	0	0
Geothermal	0	0	0	0
Tidal	0	0	0	0
Wave	0	0	0	0
Net Import	0	0	0	0
Windreduction	0	0	0	0
Sum	**2**	**2**	**2**	**2**
RES-E Share	**0%**	**2%**	**8%**	**9%**

Netherlands HQS	generation in TWh			
	2007	2015	2020	2030
Coal	24	17	16	6
Lignite	0	0	0	0
Gas	60	59	61	59
Oil	2	0	0	0
Nuclear	4	3	3	2
Large Hydro	0	0	0	0
Small-scale Hydro	0	0	0	0
Pumped Storage*	0	0	0	0
Other non-renewables	1	1	1	1
Wind Onshore	3	9	11	13
Wind Offshore	0	9	25	78
Biomass	5	11	11	11
Photovoltaics	0	0	0	0
Concentrating Solar	0	0	0	0
Geothermal	0	0	0	0
Tidal	0	0	0	0
Wave	0	0	0	0
Net Import	18	16	-4	-35
Windreduction	0	-1	-2	-12
Sum	**118**	**125**	**124**	**124**
RES-E Share	**7%**	**23%**	**38%**	**79%**

Netherlands BAU	generation in TWh			
	2007	2015	2020	2030
Coal	24	19	18	6
Lignite	0	0	0	0
Gas	60	59	60	60
Oil	2	0	0	0
Nuclear	4	3	3	2
Large Hydro	0	0	0	0
Small-scale Hydro	0	0	0	0
Pumped Storage*	0	0	0	0
Other non-renewables	3	1	1	1
Wind Onshore	3	5	11	13
Wind Offshore	0	11	27	78
Biomass	5	5	5	3
Photovoltaics	0	4	6	10
Concentrating Solar	0	0	0	0
Geothermal	0	0	0	0
Tidal	0	0	0	0
Wave	0	0	0	0
Net Import	18	18	-6	-39
Windreduction	0	0	-1	-12
Sum	**120**	**125**	**124**	**124**
RES-E Share	**7%**	**19%**	**38%**	**81%**

Netherlands Cluster	generation in TWh			
	2007	2015	2020	2030
Coal	24	19	18	7
Lignite	0	0	0	0
Gas	60	58	61	60
Oil	2	0	0	0
Nuclear	4	3	3	2
Large Hydro	0	0	0	0
Small-scale Hydro	0	0	0	0
Pumped Storage*	0	0	0	0
Other non-renewables	3	1	1	1
Wind Onshore	3	5	11	13
Wind Offshore	0	11	27	78
Biomass	5	5	5	3
Photovoltaics	0	4	6	10
Concentrating Solar	0	0	0	0
Geothermal	0	0	0	0
Tidal	0	0	0	0
Wave	0	0	0	0
Net Import	18	18	-7	-40
Windreduction	0	0	-1	-12
Sum	**120**	**125**	**124**	**124**
RES-E Share	**7%**	**19%**	**38%**	**81%**

Norway HQS	generation in TWh			
	2007	2015	2020	2030
Coal	0	0	0	0
Lignite	0	0	0	0
Gas	1	1	1	1
Oil	0	0	0	0
Nuclear	0	0	0	0
Large Hydro	129	116	116	116
Small-scale Hydro	5	6	6	6
Pumped Storage*	-2	0	0	0
Other non-renewables	0	0	0	0
Wind Onshore	1	7	7	7
Wind Offshore	0	8	8	8
Biomass	0	1	1	0
Photovoltaics	0	0	0	0
Concentrating Solar	0	0	0	0
Geothermal	0	0	0	0
Tidal	0	0	0	0
Wave	0	0	0	0
Net Import	-10	-13	-11	-11
Windreduction	0	0	0	0
Sum	**125**	**125**	**127**	**127**
RES-E Share	**105%**	**105%**	**103%**	**103%**

Norway BAU	generation in TWh			
	2007	2015	2020	2030
Coal	0	0	0	0
Lignite	0	0	0	0
Gas	1	1	1	1
Oil	0	0	0	0
Nuclear	0	0	0	0
Large Hydro	129	116	116	116
Small-scale Hydro	5	6	6	6
Pumped Storage*	-2	0	0	0
Other non-renewables	0	0	0	0
Wind Onshore	1	1	6	7
Wind Offshore	0	0	0	0
Biomass	0	0	0	0
Photovoltaics	0	0	0	0
Concentrating Solar	0	0	0	0
Geothermal	0	0	0	0
Tidal	0	0	0	0
Wave	0	0	0	0
Net Import	-10	2	-2	-2
Windreduction	0	0	0	0
Sum	**125**	**125**	**127**	**127**
RES-E Share	**105%**	**94%**	**96%**	**97%**

Norway Cluster	generation in TWh			
	2007	2015	2020	2030
Coal	0	0	0	0
Lignite	0	0	0	0
Gas	1	1	1	1
Oil	0	0	0	0
Nuclear	0	0	0	0
Large Hydro	129	116	116	116
Small-scale Hydro	5	6	6	6
Pumped Storage*	-2	0	0	0
Other non-renewables	0	0	0	0
Wind Onshore	1	1	6	7
Wind Offshore	0	0	0	0
Biomass	0	0	0	0
Photovoltaics	0	0	0	0
Concentrating Solar	0	0	0	0
Geothermal	0	0	0	0
Tidal	0	0	0	0
Wave	0	0	0	0
Net Import	-10	2	-2	-2
Windreduction	0	0	0	0
Sum	**125**	**125**	**127**	**127**
RES-E Share	**105%**	**94%**	**96%**	**97%**

Poland HQS	generation in TWh			
	2007	2015	2020	2030
Coal	83	31	30	20
Lignite	50	61	62	49
Gas	5	7	7	7
Oil	2	0	0	0
Nuclear	0	0	0	0
Large Hydro	2	3	4	5
Small-scale Hydro	1	1	1	1
Pumped Storage*	-1	-3	-4	-5
Other non-renewables	0	0	0	0
Wind Onshore	1	25	48	82
Wind Offshore	0	0	0	0
Biomass	2	22	23	27
Photovoltaics	0	0	0	0
Concentrating Solar	0	0	0	0
Geothermal	0	0	0	0
Tidal	0	0	0	0
Wave	0	0	0	0
Net Import	-5	0	-6	-11
Windreduction	0	0	-3	-13
Sum	**139**	**148**	**163**	**163**
RES-E Share	**3%**	**31%**	**42%**	**64%**

Poland BAU	generation in TWh			
	2007	2015	2020	2030
Coal	83	56	44	20
Lignite	50	64	70	74
Gas	5	7	7	7
Oil	2	0	0	0
Nuclear	0	0	9	17
Large Hydro	2	1	2	3
Small-scale Hydro	1	1	1	1
Pumped Storage*	-1	0	-1	-3
Other non-renewables	1	0	0	0
Wind Onshore	1	4	14	26
Wind Offshore	0	0	0	0
Biomass	2	14	14	17
Photovoltaics	0	0	0	0
Concentrating Solar	0	0	0	0
Geothermal	0	0	0	0
Tidal	0	0	0	0
Wave	0	0	0	0
Net Import	-5	-1	2	0
Windreduction	0	0	0	0
Sum	**139**	**148**	**163**	**163**
RES-E Share	**3%**	**13%**	**17%**	**25%**

Poland Cluster	generation in TWh			
	2007	2015	2020	2030
Coal	83	41	33	20
Lignite	50	64	72	70
Gas	5	7	7	7
Oil	2	0	0	0
Nuclear	0	0	0	0
Large Hydro	2	2	4	4
Small-scale Hydro	1	1	1	1
Pumped Storage*	-1	-1	-3	-4
Other non-renewables	1	0	0	0
Wind Onshore	1	21	44	65
Wind Offshore	0	0	0	0
Biomass	2	19	20	17
Photovoltaics	0	0	0	0
Concentrating Solar	0	0	0	0
Geothermal	0	0	0	0
Tidal	0	0	0	0
Wave	0	0	0	0
Net Import	-5	-8	-14	-13
Windreduction	0	0	-2	-5
Sum	**139**	**148**	**163**	**163**
RES-E Share	**3%**	**27%**	**38%**	**48%**

Portugal HQS	generation in TWh			
	2007	2015	2020	2030
Coal	12	27	30	20
Lignite	0	0	0	0
Gas	13	11	4	3
Oil	5	2	2	2
Nuclear	0	0	0	0
Large Hydro	10	12	12	13
Small-scale Hydro	1	1	1	1
Pumped Storage*	-1	0	-1	-1
Other non-renewables	0	0	0	0
Wind Onshore	4	4	9	11
Wind Offshore	0	0	0	3
Biomass	2	4	4	4
Photovoltaics	0	0	0	4
Concentrating Solar	0	3	6	6
Geothermal	0	1	1	1
Tidal	0	0	0	0
Wave	0	0	0	0
Net Import	7	0	0	4
Windreduction	0	0	0	0
Sum	**53**	**65**	**70**	**70**
RES-E Share	**30%**	**38%**	**46%**	**58%**

Portugal BAU	generation in TWh			
	2007	2015	2020	2030
Coal	12	24	23	16
Lignite	0	0	0	0
Gas	13	8	6	6
Oil	5	2	2	2
Nuclear	0	0	0	0
Large Hydro	10	12	13	13
Small-scale Hydro	1	1	1	1
Pumped Storage*	-1	-1	-2	-2
Other non-renewables	0	0	0	0
Wind Onshore	4	4	4	0
Wind Offshore	0	0	0	0
Biomass	2	4	4	2
Photovoltaics	0	12	21	31
Concentrating Solar	0	3	6	6
Geothermal	0	0	0	0
Tidal	0	0	0	0
Wave	0	0	0	2
Net Import	7	-5	-9	-5
Windreduction	0	0	0	0
Sum	**53**	**65**	**71**	**73**
RES-E Share	**30%**	**54%**	**68%**	**76%**

Portugal Cluster	generation in TWh			
	2007	2015	2020	2030
Coal	12	24	23	16
Lignite	0	0	0	0
Gas	13	8	7	6
Oil	5	2	2	2
Nuclear	0	0	0	0
Large Hydro	10	12	13	13
Small-scale Hydro	1	1	1	1
Pumped Storage*	-1	-1	-2	-2
Other non-renewables	0	0	0	0
Wind Onshore	4	4	4	0
Wind Offshore	0	0	0	0
Biomass	2	4	4	2
Photovoltaics	0	12	21	31
Concentrating Solar	0	3	6	6
Geothermal	0	0	0	0
Tidal	0	0	0	0
Wave	0	0	0	2
Net Import	7	-4	-9	-5
Windreduction	0	0	0	0
Sum	**53**	**65**	**71**	**73**
RES-E Share	**30%**	**54%**	**68%**	**76%**

Romania HQS	generation in TWh			
	2007	2015	2020	2030
Coal	2	3	4	2
Lignite	21	18	18	16
Gas	11	6	6	6
Oil	1	1	1	1
Nuclear	6	5	13	13
Large Hydro	15	16	16	16
Small-scale Hydro	1	1	1	1
Pumped Storage*	0	0	0	0
Other non-renewables	0	0	0	0
Wind Onshore	0	1	3	3
Wind Offshore	0	0	0	0
Biomass	0	10	11	12
Photovoltaics	0	0	0	3
Concentrating Solar	0	0	0	0
Geothermal	0	0	0	0
Tidal	0	0	0	0
Wave	0	0	0	0
Net Import	-2	5	4	3
Windreduction	0	0	0	0
Sum	**54**	**66**	**76**	**76**
RES-E Share	**26%**	**42%**	**40%**	**46%**

Romania BAU	generation in TWh			
	2007	2015	2020	2030
Coal	2	4	4	2
Lignite	21	18	18	20
Gas	11	6	6	6
Oil	1	1	1	1
Nuclear	6	5	6	7
Large Hydro	15	16	16	16
Small-scale Hydro	1	1	1	1
Pumped Storage*	0	0	0	0
Other non-renewables	0	0	0	0
Wind Onshore	0	1	3	3
Wind Offshore	0	0	0	0
Biomass	0	9	12	12
Photovoltaics	0	0	4	9
Concentrating Solar	0	0	0	0
Geothermal	0	0	0	0
Tidal	0	0	0	0
Wave	0	0	0	0
Net Import	-2	5	6	-1
Windreduction	0	0	0	0
Sum	**54**	**66**	**76**	**76**
RES-E Share	**26%**	**41%**	**46%**	**53%**

Romania Cluster	generation in TWh			
	2007	2015	2020	2030
Coal	2	4	3	2
Lignite	21	18	18	20
Gas	11	6	6	6
Oil	1	1	1	1
Nuclear	6	5	16	27
Large Hydro	15	16	16	16
Small-scale Hydro	1	1	1	1
Pumped Storage*	0	0	0	0
Other non-renewables	0	0	0	0
Wind Onshore	0	1	1	1
Wind Offshore	0	0	0	0
Biomass	0	9	9	3
Photovoltaics	0	0	0	0
Concentrating Solar	0	0	0	0
Geothermal	0	0	0	0
Tidal	0	0	0	0
Wave	0	0	0	0
Net Import	-2	5	4	0
Windreduction	0	0	0	0
Sum	**54**	**66**	**76**	**76**
RES-E Share	**26%**	**40%**	**35%**	**27%**

Slovakia HQS	generation in TWh			
	2007	2015	2020	2030
Coal	3	2	2	2
Lignite	2	2	3	3
Gas	2	6	6	6
Oil	1	0	0	0
Nuclear	14	15	15	12
Large Hydro	4	5	5	5
Small-scale Hydro	0	0	0	0
Pumped Storage*	0	-1	-1	-1
Other non-renewables	0	0	0	0
Wind Onshore	0	3	3	3
Wind Offshore	0	0	0	0
Biomass	0	2	3	3
Photovoltaics	0	0	0	0
Concentrating Solar	0	0	0	0
Geothermal	0	0	0	0
Tidal	0	0	0	0
Wave	0	0	0	0
Net Import	2	-4	0	2
Windreduction	0	0	0	0
Sum	**27**	**32**	**37**	**37**
RES-E Share	**15%**	**31%**	**27%**	**29%**

Slovakia BAU	generation in TWh			
	2007	2015	2020	2030
Coal	3	2	2	2
Lignite	2	2	3	3
Gas	2	6	6	6
Oil	1	0	0	0
Nuclear	14	15	15	6
Large Hydro	4	5	5	5
Small-scale Hydro	0	0	0	0
Pumped Storage*	0	-1	-2	-1
Other non-renewables	0	0	0	0
Wind Onshore	0	0	4	4
Wind Offshore	0	0	0	0
Biomass	0	2	3	4
Photovoltaics	0	0	6	13
Concentrating Solar	0	0	0	0
Geothermal	0	0	0	0
Tidal	0	0	0	0
Wave	0	0	0	0
Net Import	2	0	-5	-4
Windreduction	0	0	0	0
Sum	**27**	**32**	**37**	**38**
RES-E Share	**15%**	**19%**	**43%**	**64%**

Slovakia Cluster	generation in TWh			
	2007	2015	2020	2030
Coal	3	2	2	2
Lignite	2	2	3	3
Gas	2	6	6	6
Oil	1	0	0	0
Nuclear	14	15	15	6
Large Hydro	4	5	5	5
Small-scale Hydro	0	0	0	0
Pumped Storage*	0	-1	-1	-1
Other non-renewables	0	0	0	0
Wind Onshore	0	0	4	4
Wind Offshore	0	0	0	0
Biomass	0	2	3	4
Photovoltaics	0	0	6	13
Concentrating Solar	0	0	0	0
Geothermal	0	0	0	0
Tidal	0	0	0	0
Wave	0	0	0	0
Net Import	2	0	-5	-4
Windreduction	0	0	0	0
Sum	**27**	**32**	**37**	**37**
RES-E Share	**15%**	**19%**	**43%**	**64%**

Slovenia HQS	generation in TWh			
	2007	2015	2020	2030
Coal	0	0	0	0
Lignite	4	3	4	5
Gas	0	0	0	0
Oil	0	0	0	0
Nuclear	5	5	16	12
Large Hydro	3	3	3	3
Small-scale Hydro	0	0	0	0
Pumped Storage*	0	0	0	0
Other non-renewables	0	0	0	0
Wind Onshore	0	0	0	0
Wind Offshore	0	0	0	0
Biomass	0	1	1	1
Photovoltaics	0	0	0	0
Concentrating Solar	0	0	0	0
Geothermal	0	0	0	0
Tidal	0	0	0	0
Wave	0	0	0	0
Net Import	0	3	-8	-4
Windreduction	0	0	0	0
Sum	**14**	**16**	**18**	**18**
RES-E Share	**22%**	**30%**	**28%**	**28%**

Slovenia BAU	generation in TWh			
	2007	2015	2020	2030
Coal	0	0	0	0
Lignite	4	3	4	5
Gas	0	0	0	0
Oil	0	0	0	0
Nuclear	5	5	9	8
Large Hydro	3	3	3	3
Small-scale Hydro	0	0	0	0
Pumped Storage*	0	0	0	0
Other non-renewables	0	0	0	0
Wind Onshore	0	0	0	0
Wind Offshore	0	0	0	0
Biomass	0	1	1	1
Photovoltaics	0	0	0	0
Concentrating Solar	0	0	0	0
Geothermal	0	0	0	0
Tidal	0	0	0	0
Wave	0	0	0	0
Net Import	0	3	0	-1
Windreduction	0	0	0	0
Sum	**14**	**16**	**18**	**18**
RES-E Share	**22%**	**28%**	**26%**	**26%**

Slovenia Cluster	generation in TWh			
	2007	2015	2020	2030
Coal	0	0	0	0
Lignite	4	3	4	5
Gas	0	0	0	0
Oil	0	0	0	0
Nuclear	5	5	8	9
Large Hydro	3	3	3	3
Small-scale Hydro	0	0	0	0
Pumped Storage*	0	0	0	0
Other non-renewables	0	0	0	0
Wind Onshore	0	0	0	0
Wind Offshore	0	0	0	0
Biomass	0	1	1	1
Photovoltaics	0	0	0	0
Concentrating Solar	0	0	0	0
Geothermal	0	0	0	0
Tidal	0	0	0	0
Wave	0	0	0	0
Net Import	0	3	0	-1
Windreduction	0	0	0	0
Sum	**14**	**16**	**18**	**18**
RES-E Share	**22%**	**28%**	**26%**	**26%**

Spain HQS	generation in TWh			
	2007	2015	2020	2030
Coal	66	75	78	46
Lignite	4	7	3	0
Gas	90	70	58	38
Oil	18	7	7	7
Nuclear	53	56	55	47
Large Hydro	26	25	27	28
Small-scale Hydro	4	5	5	5
Pumped Storage*	-4	0	-2	-5
Other non-renewables	0	0	0	0
Wind Onshore	27	34	47	57
Wind Offshore	0	0	0	5
Biomass	3	24	42	38
Photovoltaics	1	1	1	7
Concentrating Solar	0	5	16	53
Geothermal	0	0	0	0
Tidal	0	0	0	0
Wave	0	0	0	0
Net Import	-6	17	13	24
Windreduction	0	0	0	-4
Sum	**281**	**327**	**349**	**349**
RES-E Share	**20%**	**28%**	**38%**	**53%**

Spain BAU	generation in TWh			
	2007	2015	2020	2030
Coal	66	76	79	60
Lignite	4	7	3	0
Gas	90	68	56	34
Oil	18	7	7	7
Nuclear	53	56	55	50
Large Hydro	26	25	26	28
Small-scale Hydro	4	5	5	5
Pumped Storage*	-4	0	-2	-4
Other non-renewables	1	0	0	0
Wind Onshore	27	28	34	42
Wind Offshore	0	0	5	6
Biomass	3	24	42	59
Photovoltaics	1	7	10	15
Concentrating Solar	0	5	8	13
Geothermal	0	0	0	0
Tidal	0	0	0	0
Wave	0	0	0	0
Net Import	-6	19	21	34
Windreduction	0	0	0	-1
Sum	**282**	**327**	**349**	**349**
RES-E Share	**20%**	**28%**	**36%**	**46%**

Spain Cluster	generation in TWh			
	2007	2015	2020	2030
Coal	66	77	79	60
Lignite	4	7	3	0
Gas	90	68	57	35
Oil	18	7	7	7
Nuclear	53	56	55	50
Large Hydro	26	25	26	28
Small-scale Hydro	4	5	5	5
Pumped Storage*	-4	0	-2	-4
Other non-renewables	1	0	0	0
Wind Onshore	27	28	34	42
Wind Offshore	0	0	5	6
Biomass	3	24	42	59
Photovoltaics	1	7	10	15
Concentrating Solar	0	5	8	13
Geothermal	0	0	0	0
Tidal	0	0	0	0
Wave	0	0	0	0
Net Import	-6	18	20	34
Windreduction	0	0	0	-1
Sum	**282**	**327**	**349**	**349**
RES-E Share	**20%**	**28%**	**36%**	**46%**

Sweden HQS	generation in TWh			
	2007	2015	2020	2030
Coal	1	1	1	1
Lignite	0	0	0	0
Gas	1	2	2	2
Oil	1	1	1	1
Nuclear	64	70	70	49
Large Hydro	62	62	63	63
Small-scale Hydro	4	3	3	3
Pumped Storage*	0	-1	-2	-3
Other non-renewables	1	1	1	1
Wind Onshore	1	4	11	13
Wind Offshore	0	0	0	0
Biomass	10	4	4	4
Photovoltaics	0	0	0	0
Concentrating Solar	0	0	0	0
Geothermal	0	0	0	0
Tidal	0	0	0	0
Wave	0	0	0	0
Net Import	1	12	4	23
Windreduction	0	0	0	0
Sum	**147**	**159**	**158**	**158**
RES-E Share	**51%**	**45%**	**49%**	**51%**

Sweden BAU	generation in TWh			
	2007	2015	2020	2030
Coal	1	1	1	1
Lignite	0	0	0	0
Gas	1	2	2	2
Oil	1	1	1	1
Nuclear	64	70	70	49
Large Hydro	62	62	63	63
Small-scale Hydro	4	3	3	3
Pumped Storage*	0	-1	-2	-2
Other non-renewables	1	1	1	1
Wind Onshore	1	12	14	14
Wind Offshore	0	6	11	17
Biomass	10	15	15	9
Photovoltaics	0	0	0	5
Concentrating Solar	0	0	0	0
Geothermal	0	0	0	10
Tidal	0	0	0	0
Wave	0	0	0	0
Net Import	1	-12	-21	-14
Windreduction	0	0	0	0
Sum	**147**	**159**	**158**	**158**
RES-E Share	**51%**	**60%**	**65%**	**74%**

Sweden Cluster	generation in TWh			
	2007	2015	2020	2030
Coal	1	1	1	1
Lignite	0	0	0	0
Gas	1	2	2	2
Oil	1	1	1	1
Nuclear	64	70	70	49
Large Hydro	62	62	63	63
Small-scale Hydro	4	3	3	3
Pumped Storage*	0	-1	-2	-1
Other non-renewables	1	1	1	1
Wind Onshore	1	5	5	5
Wind Offshore	0	0	0	0
Biomass	10	4	4	2
Photovoltaics	0	0	0	0
Concentrating Solar	0	0	0	0
Geothermal	0	0	0	0
Tidal	0	0	0	0
Wave	0	0	0	0
Net Import	1	11	9	33
Windreduction	0	0	0	0
Sum	**147**	**159**	**158**	**158**
RES-E Share	**51%**	**45%**	**46%**	**45%**

Switzerland HQS	generation in TWh			
	2007	2015	2020	2030
Coal	0	0	0	0
Lignite	0	0	0	0
Gas	1	0	0	0
Oil	0	0	0	0
Nuclear	26	16	31	28
Large Hydro	33	31	31	32
Small-scale Hydro	3	5	5	5
Pumped Storage*	-2	-2	-3	-4
Other non-renewables	0	0	0	0
Wind Onshore	0	0	0	0
Wind Offshore	0	0	0	0
Biomass	2	4	5	5
Photovoltaics	0	0	0	0
Concentrating Solar	0	0	0	0
Geothermal	0	0	0	0
Tidal	0	0	0	0
Wave	0	0	0	0
Net Import	-2	7	-6	-4
Windreduction	0	0	0	0
Sum	**61**	**62**	**63**	**63**
RES-E Share	**56%**	**60%**	**60%**	**60%**

Switzerland BAU	generation in TWh			
	2007	2015	2020	2030
Coal	0	0	0	0
Lignite	0	0	0	0
Gas	1	0	0	0
Oil	0	0	0	0
Nuclear	26	16	26	29
Large Hydro	33	30	31	31
Small-scale Hydro	3	3	3	3
Pumped Storage*	-2	-1	-1	-2
Other non-renewables	1	0	0	0
Wind Onshore	0	0	0	0
Wind Offshore	0	0	0	0
Biomass	2	4	3	3
Photovoltaics	0	1	1	0
Concentrating Solar	0	0	0	0
Geothermal	0	0	7	7
Tidal	0	0	0	0
Wave	0	0	0	0
Net Import	-2	9	-7	-9
Windreduction	0	0	0	0
Sum	**63**	**62**	**63**	**63**
RES-E Share	**56%**	**58%**	**67%**	**66%**

Switzerland Cluster	generation in TWh			
	2007	2015	2020	2030
Coal	0	0	0	0
Lignite	0	0	0	0
Gas	1	0	0	0
Oil	0	0	0	0
Nuclear	26	16	26	31
Large Hydro	33	30	31	31
Small-scale Hydro	3	3	3	3
Pumped Storage*	-2	-1	-1	-2
Other non-renewables	1	0	0	0
Wind Onshore	0	0	0	0
Wind Offshore	0	0	0	0
Biomass	2	4	3	3
Photovoltaics	0	1	1	0
Concentrating Solar	0	0	0	0
Geothermal	0	0	7	7
Tidal	0	0	0	0
Wave	0	0	0	0
Net Import	-2	9	-6	-10
Windreduction	0	0	0	0
Sum	**63**	**62**	**63**	**63**
RES-E Share	**56%**	**58%**	**67%**	**66%**

United Kingdom HQS	generation in TWh			
	2007	2015	2020	2030
Coal	132	157	117	55
Lignite	0	0	0	0
Gas	160	35	43	46
Oil	5	1	1	1
Nuclear	57	78	85	35
Large Hydro	8	6	8	10
Small-scale Hydro	1	0	0	0
Pumped Storage*	-5	-2	-6	-7
Other non-renewables	3	3	3	3
Wind Onshore	5	42	70	107
Wind Offshore	0	16	38	128
Biomass	10	27	28	23
Photovoltaics	0	0	0	0
Concentrating Solar	0	0	0	0
Geothermal	0	0	0	0
Tidal	0	0	0	0
Wave	0	0	0	0
Net Import	5	15	8	15
Windreduction	0	0	0	-19
Sum	**380**	**378**	**396**	**396**
RES-E Share	**6%**	**23%**	**34%**	**64%**

United Kingdom BAU	generation in TWh			
	2007	2015	2020	2030
Coal	132	167	134	78
Lignite	0	0	0	0
Gas	160	47	41	49
Oil	5	1	1	1
Nuclear	57	78	92	74
Large Hydro	8	5	8	9
Small-scale Hydro	1	0	0	0
Pumped Storage*	-5	-1	-5	-6
Other non-renewables	8	3	3	3
Wind Onshore	5	43	69	106
Wind Offshore	0	3	25	51
Biomass	10	20	20	14
Photovoltaics	0	0	0	0
Concentrating Solar	0	0	0	0
Geothermal	0	0	0	0
Tidal	0	0	0	0
Wave	0	0	0	0
Net Import	5	12	8	20
Windreduction	0	0	0	-3
Sum	**385**	**378**	**396**	**396**
RES-E Share	**6%**	**18%**	**29%**	**43%**

United Kingdom Cluster	generation in TWh			
	2007	**2015**	**2020**	**2030**
Coal	132	163	139	88
Lignite	0	0	0	0
Gas	160	42	39	46
Oil	5	1	1	1
Nuclear	57	78	82	36
Large Hydro	8	5	8	9
Small-scale Hydro	1	0	0	0
Pumped Storage*	-5	-1	-5	-7
Other non-renewables	8	3	3	3
Wind Onshore	5	42	68	107
Wind Offshore	0	10	30	84
Biomass	10	25	23	17
Photovoltaics	0	0	0	0
Concentrating Solar	0	0	0	0
Geothermal	0	0	0	0
Tidal	0	0	0	0
Wave	0	0	0	0
Net Import	5	10	8	19
Windreduction	0	0	0	-8
Sum	**385**	**378**	**396**	**396**
RES-E Share	**6%**	**21%**	**31%**	**52%**

B. Case Studies

The following chapter illustrates the diversity of the designs of different RES-E promotion systems currently existing in EU27++. As already stated in chapter 3, current promotion systems are in most cases modifications of the pure promotion systems described in chapter 3. The case studies of the promotion system in UK and Sweden demonstrate how diverse quota systems can be designed. The case study of Germany serves as an example for a feed-in-tariff system while the case study of Spain shows the example of a combined feed-in-tariff and premium system.

B.1 Case Study United Kingdom

The UK´s RES-E promotion system is often taken as an example for the quota system. It is characterized by several modifications of a basic quota system, i.e. the banding which was introduced in April 2009. This case study thus permits an illustration of a quota system incorporating several of the characteristics discussed in Chapter 3.

The British quota system has been introduced in 2002 and was last modified by the Renewables Obligation Order 2009. Before, RES-E in the UK have been supported by the so-called Non Fossil Fuels Obligation (NFFO), which was enacted in 1990 by the Electricity Act. It established a regular tendering procedure for electricity generation capacities on the basis of renewable energies. In Scotland and Northern Ireland, there were similar promotion policies in force (Scottish Renewables Obligation (SRO) and NI-NFFO in the case of Northern Ireland). Within these tendering schemes, 933 projects with a total capacity of 3,638 MW were assigned for promotion. Yet, the described tendering scheme is considered to have failed because not even one third of the assigned projects´ total capacity was realized in the end (449 projects with a total of 1,209 MW installed capacity)[54].

In 2002 England and Wales (Renewables Obligation Order) as well as Scotland (Renewables Obligation (Scotland) Order) switched their promotion scheme to a

[54] BERR (2007), p. 20, for further details and discussions of the UK tendering system, see Agnolucci, P(2006).

quota system. Northern Ireland followed in 2005 (Renewables Obligation Order (Northern Ireland)).

Characteristics of the UK quota system

In the UK, the suppliers of electricity are committed to source a part of their electricity from renewable sources. The obligation was designed with a yearly increasing target which rose from an initial 3% in the obligation period 2002-2003 up to 9.1% in the previous period 2008-2009.[55] In Northern Ireland, starting 2005-2006 at 2.5%, the obligation level was 2.6% in 2006-2007 and 3% in 2008-2009.[56]

From April 2009 the obligation changed from a percentage obligation to an obligation to present a certain number of Renewable Obligation Certificates (ROCs). This change was necessary due to the introduction of the banding in the RO 2009. Before April 2009, one Renewable Obligation Certificate (ROC) accounted for 1 MWh, regardless of the RES-E technology by which the renewable energy was produced. Thus, before 2009, the suppliers were indifferent from which RES-E plant their ROCs came. Since the introduction of the banding, one ROC can now also account for more or less than 1 MWh, depending on the different RES-E technologies. While for example wind onshore still accounts for 1 MWh, wave and solar photovoltaics account for ½ MWh and electricity generated from landfill gas for 4 MWh.[57] Under a percentage obligation, suppliers would therefore try to fulfill their obligation by ROCs which account for a higher number of MWh. The target of a banding, to support also more expensive RES-E technologies, would thus be counteracted by a percentage obligation. However, the determination of the number of ROCs the suppliers have to present per MWh of electricity sold, also poses challenges. A reference is constituted by Schedule 1 in RO (2009) which states that the number of ROCs required per MWh of electricity supplied in Great Britain is 0.097 in the current obligation period 2009-2010 and will increase up to 0.154 in the period 2015-2016 where it will stay until 2026-2027. For 1 MWh of electricity supplied in Northern Ireland, currently 0.035

---

[55] RO (2006), Schedule 1.
[56] NIRO (2005).
[57] See RO (2009), Schedule 2, Part 2 and note also that the amount of electricity to be stated in ROCs remains at 1 MWh for power from most RES-E plants which were accredited as at 11th July 2006 (see RO (2009) Schedule 2, Part 3).

ROCs are required. This obligation will mount to 0.063 ROCs in 2012-2013 and remain at this level until 2026-2027. Still, in order to pursue target achievement (the RES-E target being defined as a percentage of electricity consumption and not as a certain number of certificates produced), the exact number of ROCs required per MWh results from calculation A, B, and C, presented in the following.[58]

Calculation A:

Before the start of each obligation period, the total amount of electricity likely to be supplied to customers in Great Britain and Ireland has to be estimated by the Secretary of State. This estimated total electricity supply is then multiplied by the obligation for this period (corresponding to the figures in Schedule 1 from RO (2009)). As an example, the expected overall consumption of 100,000 MWh of electricity combined with a 0.12 ROC per MWh-obligation would lead to a total obligation of 12,000 ROCs. Thus, calculation A correctly delivers the required number of ROCs if one certificate equals exactly 1 MWh. On the contrary, if suppliers would purchase all ROCs from i.e. wave and photovoltaics power accounting for ½ MWh, the total amount of RES-E would be bisected. To take the different MWh-values of the RES-E technologies into account, calculation B is needed.

Calculation B:

For calculation B, the total amount of *renewable* electricity likely to be supplied to customers in Great Britain and Ireland has to be estimated. Furthermore it has to be estimated, which amount of RES-E will be contributed by which RES-E technology in order to calculate how many ROCs are likely to be issued in the obligation period. Then, this estimated number of ROCs is increased by 8% (the so-called headroom). The head-room serves as a kind of safety margin in order to allow for a higher electricity supply by weather dependent technologies without admitting overcompliance of the quota and therefore a deterioration of the ROC prices. Thereby the headroom enhances the investment climate and contributes to a better performance of the support system in terms of stimulation.

[58] For the first period of the new RO (2009-2010), the ROC-obligation is equal to the number stated in Schedule 1 (RO 2009), without further calculations. (DECC (2008), p.28).

In the above example, the expected generation of 10,000 MWh by means of onshore wind turbines (1 ROC per MWh) and 3,000 MWh out of dedicated energy crops (2 ROCs per MWh) would generate 10,000*1 + 3,000*2 = 16,000 certificates. Given an 8%-headroom, this figure would then be increased by multiplying it with 1.08. Thus, the outcome of *Calculation B* in the example would be at 17,280 ROCs or 17.28 ROCs per 100 MWh.

Calculation C:
Thirdly, *calculation C* leads to the maximum upper limit of the obligation level (C), as well expressed in ROCs per 100 MWh, by multiplying the expected electricity consumption by 20%. In our example, this figure would be 20,000 ROCs or 20 ROCs per 100 MWh.

The obligation of ROCs per MWh of electricity sold depend finally on a comparison of the results of A, B and C: If (A) is greater than (B), (A) is set as ROC obligation. If (B) is greater than (A) but less than (C), (B) is taken as ROC obligation. Ultimately, if (B) is the greatest of the three, (C) will be the ROC obligation. In the above example, the following figures were computed:
= 12,000 ROCs
= 17,280 ROCs
= 20,000 ROCs
Obviously, (B) is greater than (A) and less than (C) so (B) is taken as the quota obligation. Every electricity supplier in the example would thus be committed to present 17,28 ROCs per 100 MWh or to pay the buy-out price in the case of underfulfilment.

Buy-out and ROC prices

If a supplier does not present the sufficient number of ROCs to meet the obligation, a buy-out price has to be paid for every missing ROC into the buy-out fund. This buy-out price is calculated each year by adjustment to reflect changes in the Retail prices Index. In 2002, the buy-out price was set at 30 £ per MWh while in the period 2008-2009 35.76 £ per MWh had to be paid.[59]

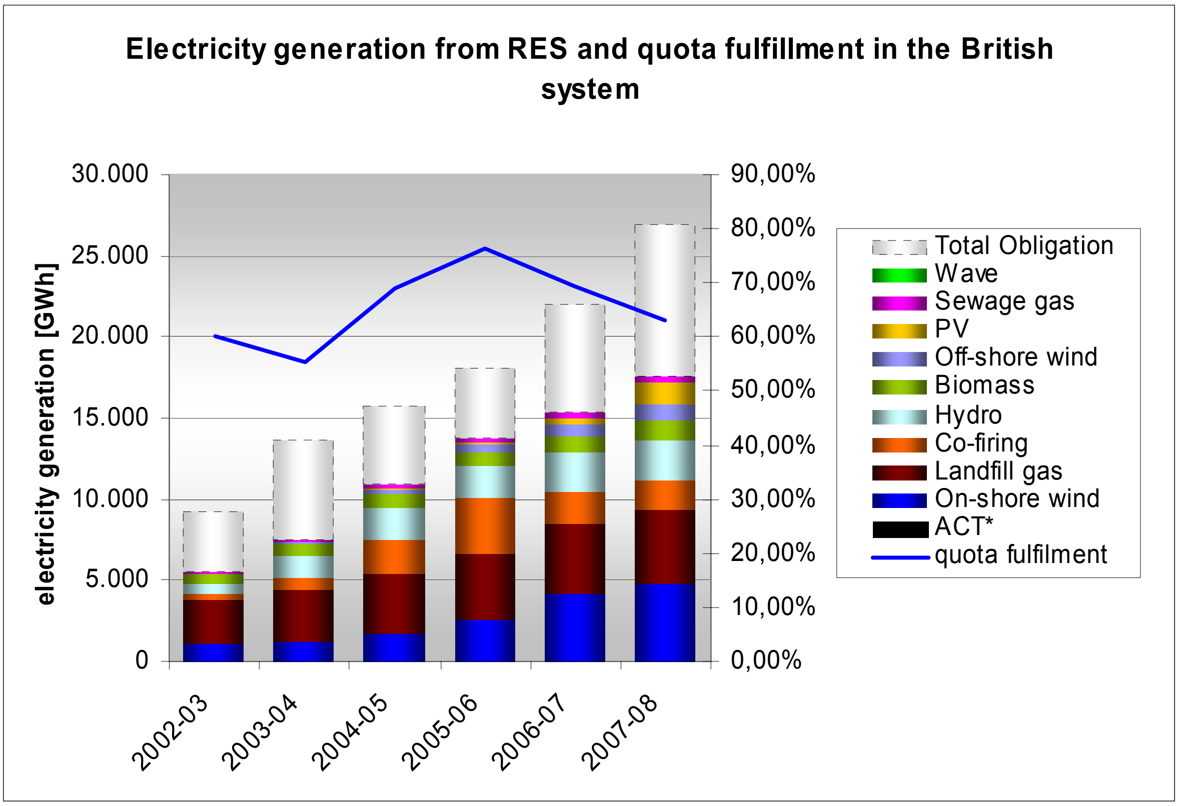
[59] OFGEM (2008).

In an “ordinary” quota system, the abovementioned buy-out price would simultaneously be the upper limit of the ROC price. The British system, however, has a specialty which permits a higher certificate price than the buy-out price. At the end of each obligation period, the buy-out fund, i.e. the aggregate of all the penalty payments of the expired obligation period, is paid back proportionally to all those suppliers that have presented ROCs (this is called the “recycle payment”). Therefore, in the British configuration of a quota system, the value of a ROC for an obligated party equals the buy-out price that would have to be paid in the case of non-compliance plus the expected recycle payment at the end of the obligation period. As there is no official market price determined, it is possible that different producers negotiate different ROC prices, but the only reasonable value to take for the market price is the ROC value described above. It has to be noted that this is only true as long as the quota obligation exceeds the number of ROCs produced. Since only in this case a recycle payment can be expected, only in this case it is worthwhile for the supplier to pay more than the buy-out price per ROC. At least in the medium term it can be considered as certain that the quota obligation will be higher than the effective RES-E generation because of the headroom mechanism explained above. The described design hence provides for a self-adapting ROC price, i.e. the lower the expected quota fulfillment, the higher the ROC value and thus the incentive for RES-E producers to enter the market. So on the one side, the buy-out fund and the associated recycle payment is an additional incentive to present ROCs, but on the other side it introduces an additional uncertainty into the market of certificates which has evoked a broad supply of ROC price predictions.

Market outcomes

As the banding was only introduced in April 2009, data describing the performance of the British RES-E support system is only available for the period of technology-neutral RES-E support. The consequences of the quota system in which one ROC was equal to one MWh, can be seen in Figure B-1: The cheapest technologies have expanded first, whereas more expensive technologies have only been able to capture larger market shares with a rising quota (displayed as “Total Obligation” in Figure B-1 and representing the respective amount of electricity to be generated out of RES in order to fulfill the quota).

Figure B-1: Electricity generation from RES and quota fulfillment in the British System

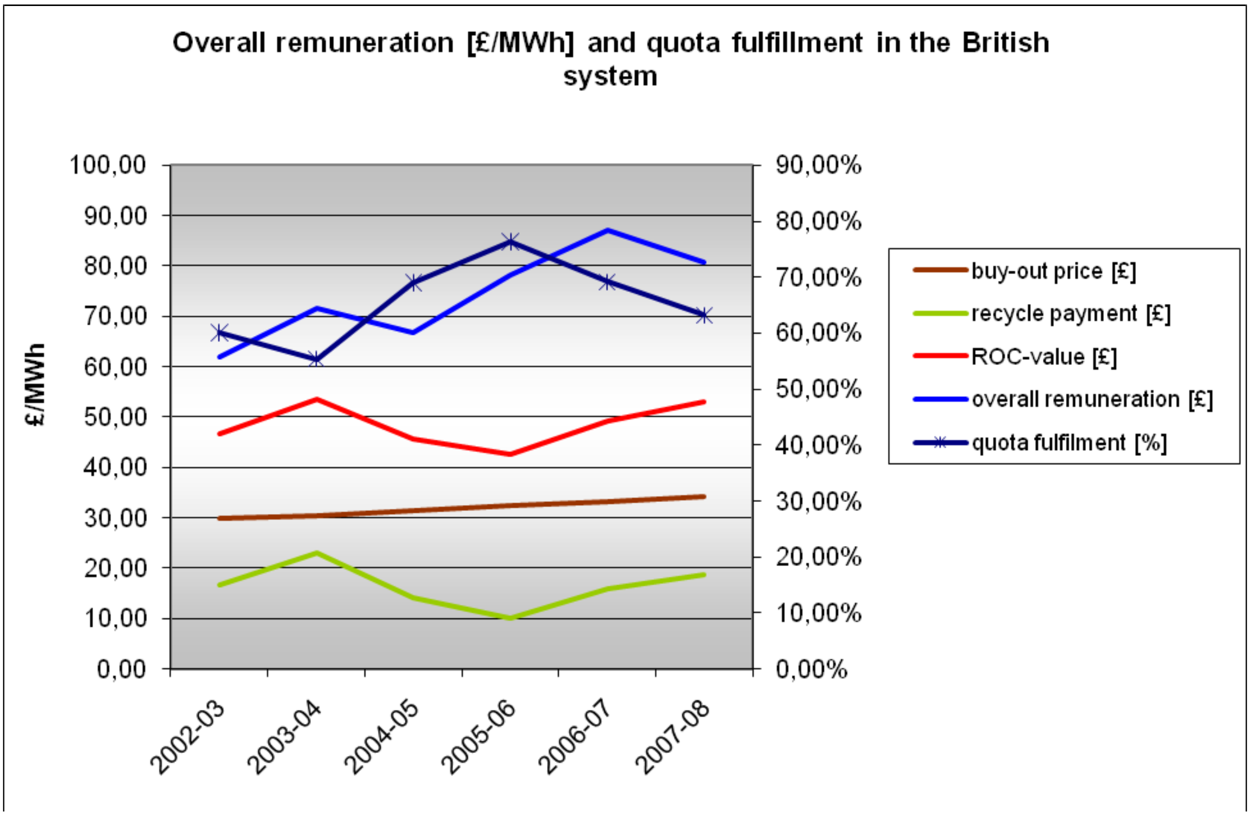


Source: EWI based on data from OFGEM (2009).

It can be observed for example that a notable expansion of onshore wind energy started only in the 2005/2006 obligation period when the utilization of landfill gas and the exploitation of co-firing possibilities had already been far advanced.

With respect to the ROC market price, the buy-out price and the recycle payments out of the buy-out fund play the lead (the latter depend on the degree of the quota fulfillment). For the quota has always been set high enough to avoid overfulfillment and hence a deterioration of the ROC value, the buy-out price has hitherto been constituting a bottom line for the ROCs´ market price and it is likely to do so further on. The recycle payments are then added to the buy-out price in order to calculate the ROC-value. As there is no official market price ascertained, this value can be taken as the ROC market price. Thus, in a well functioning market, producers are able to estimate the level of quota fulfillment and the resulting proportion of the recycle payments they will get out of the buy-out fund to calculate the ROC-value. The market price should therefore be close to the ROC-value. And since the recycle payments are the higher the more obligated parties pay the buy-out price instead of presenting certificates, the ROC-value increases with a decreasing quota fulfillment and vice versa, as shown in Figure B-2.

Figure B-2: Remuneration and Quota fulfillment in the British System



Source: EWI based on data from OFGEM (2009).

B.2 Case Study Sweden

Another system that is often cited as an example for a quota system is the Swedish one. It does not comprise a technology-specific support like the British system, but it has its own properties explained in the following.[60] It started May 1st 2003 and lasts until 2030.[61] The original objective was to increase RES-E generation by 10 TWh until 2010, relative to the corresponding production level in 2002. In 2007 the objective has been adjusted and is now to increase the level by 17 TWh until 2016, relative to the production in 2002. One important characteristic of the Swedish quota system is, that it supports also electricity production from peat.

Electricity producers receive one TGC for each MWh if they meet the requirements of the Electricity Certificates Act. In order to foster the construction of new plants and limit the overall cost for the electricity consumers, there have been established some restrictions to the allocation of TGCs. Plants that were connected to the grid since the start of the quota system receive TGCs for 15 years but at the latest until 2030.Through this support, these RES-E plants are expected to be competitive (also after the expiration of the 15 years). Plants commissioned prior to system establishment in 2003, however, receive TGCs for a shorter period of time, normally until the end of 2012, except for those plants which received a public investment grant after 15th February 1998. These will receive TGCs until the end of 2014.

In the Swedish system, quota obligated parties are electricity suppliers, electricity intensive companies and self-generating electricity consumers, imported or bought on the Nordic power exchange. Quota-obliged parties have to present an annual return to the Swedish Energy Agency with detailed data about the amount of electricity sold during the previous year and the TGCs that correspond to the respective quota (proportion of their sold electricity). If the obligated companies do not fulfil the required quota, the penalty fee for each missing TGC is 150% of the last period’s average TGC price. Table B-1 provides an overview of the quotas set by the government for each year from 2003 until 2030. The quota is increasing each year until 2012 to create the corresponding demand for TGCs. In 2012 however, most of the abovementioned RES-E plants commissioned before 2003 will be phased out of

[60] Swedish Energy Agency (2008).

[61] A proposal for a prolonged TGC system until 2035 is currently in the swedish legislation process. A new quota curve is proposed in order to reach the ambition to increase electricity production of RES-E to 25 TWh in 2025 (see Swedish Energy Agency (2009)).

the system. As a consequence, fewer certificates will be distributed. To avoid an imbalance between demand and supply of TGCs which causes extreme price increases and high costs for end consumers, the government has decided to reduce the quota in 2013 and then raise it again slightly until 2020. The reduction of the quota after 2020 is due to the fact that further producers of RES-E that reach the 15 years of receiving TGCs will phase out of the system between 2020 and 2030.

Table B-1: Quotas for the period 2003-2030, forecast new renewable electricity production capacity and actual renewable electricity production[62]

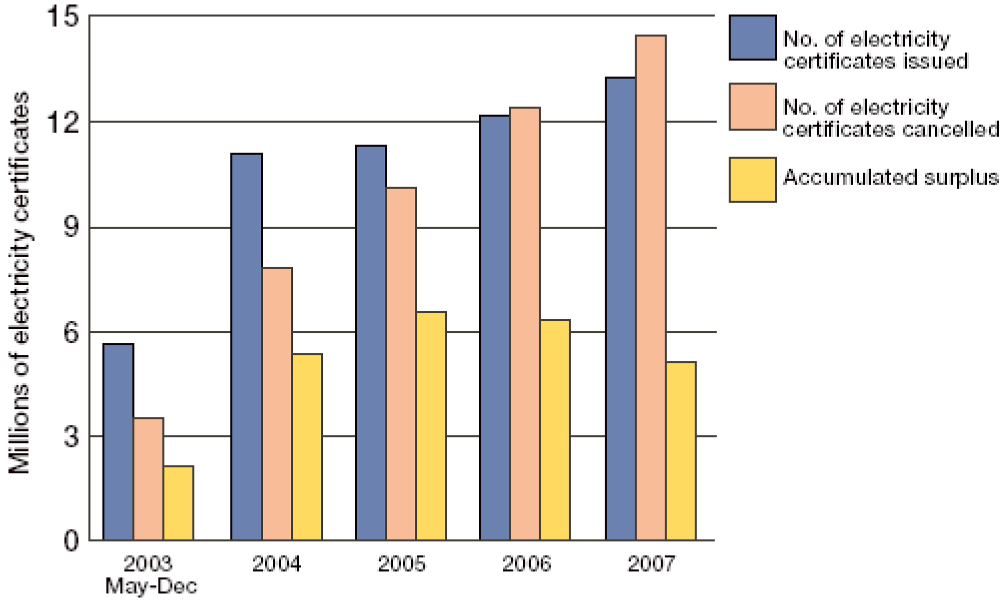
Year	Quota (%)	Forecast of new renewable electricity [TWh]
2003	7.4%	0.64
2004	8.1%	1.35
2005	10.4%	3.65
2006	12.6%	5.89
2007	15.1%	8.96
2008	16.3%	10.3
2009	17,0%	11.15
2010	17.9%	12.22
2011	17.9%	11.76
2012	17.9%	12.36
2013	8.9%	12.96
2014	9.4%	13.56
2015	9.7%	15.55
2016	11.1%	17.02
2017	11.1%	17.11
2018	11.1%	17.2
2019	11.2%	17.29
2020	11.2%	17.38
2021	11.3%	17.47
2022	10.6%	17.56
2023	9.4%	17.65
2024	9,0%	17.74
2025	8.3%	17.83
2026	7.5%	17.92
2027	6.7%	18.01
2028	5.9%	18.1
2029	5,0%	18.2
2030	4.2%	18.29

Source: Swedish Energy Agency (2008).

[62] Note again that a proposal for a new quota curve is currently in the swedish legislation process. (see Swedish Energy Agency (2009)).

As the production from the phased-out plants is supposed to continue outside the quota system, the overall RES-E production is expected to increase constantly.
So far, the Swedish RES-E promotion system is very close to a “pure” quota system described in chapter 3 and should have the explained effects on the assessment criteria for public support schemes: from a static perspective, the efficiency is high because only the most economic technologies will be built under such a system. In comparison to the original design, dynamic efficiency in the Swedish system is improved by the limited support time, because older and market-approved plants will be phased out of the quota system. If the quota is set high enough, prices will rise due to scarcity of TGCs and new (i.e. more expensive) RES-E plants will become profitable so that technical improvements will be triggered.
The stimulation effect depends on the quota level and the resulting market price of the certificates which improves the economic situation of RES-E producers by granting them an extra income. But just in this point, it seems as if the Swedish system has had some difficulties at the beginning. During 2003 and 2004, the Swedish government had limited the penalty fee to SEK 175 and SEK 240 respectively for each TGC to prevent their prices to rise too much. But this indirect restriction to the TGC price had a negative influence on stimulation because it fixed the cost for buy-out at a relatively low level. As a result, there has been a surplus in the number of TGCs from the beginning on which entails relatively low certificate prices until the surplus is depleted.

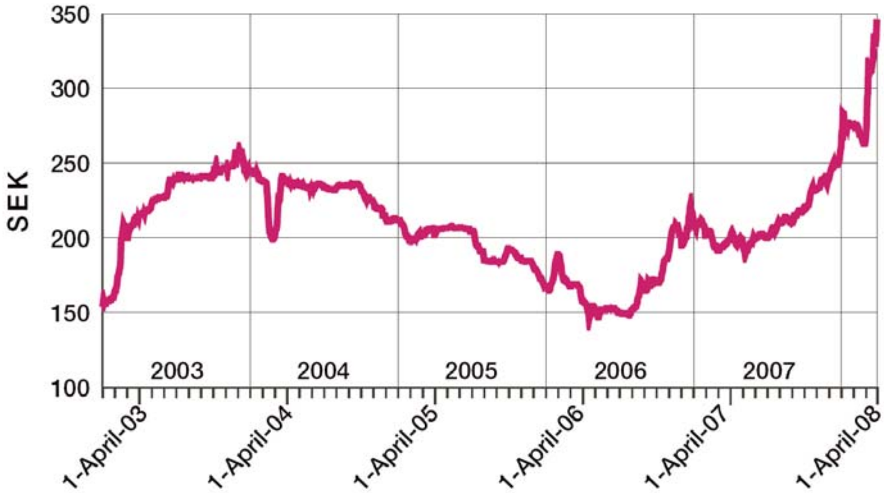
Figure B-3: Number of TGCs issued and cancelled, together with accumulated surplus over the period 2003-2007.



Source: Swedish Energy Agency (2008).

The reduction of the surplus takes place very slowly because of one further speciality of the Swedish system which is the open-ended validity of the certificates. That means that the TGCs, once owned by a market participant, can be carried forward. This specialty has been explained in chapter 3 as banking. Large producers of RES-E, whose economic survival does not depend on regular extra revenue from the certificate sales, can bank the TGCs until their price rises again. The surplus in TGCs has therefore only recently declined while the TGC price has risen, as can be seen in Figure B-3 and Figure B-4.

Figure B-4: Average price of spot traded electricity certificates.

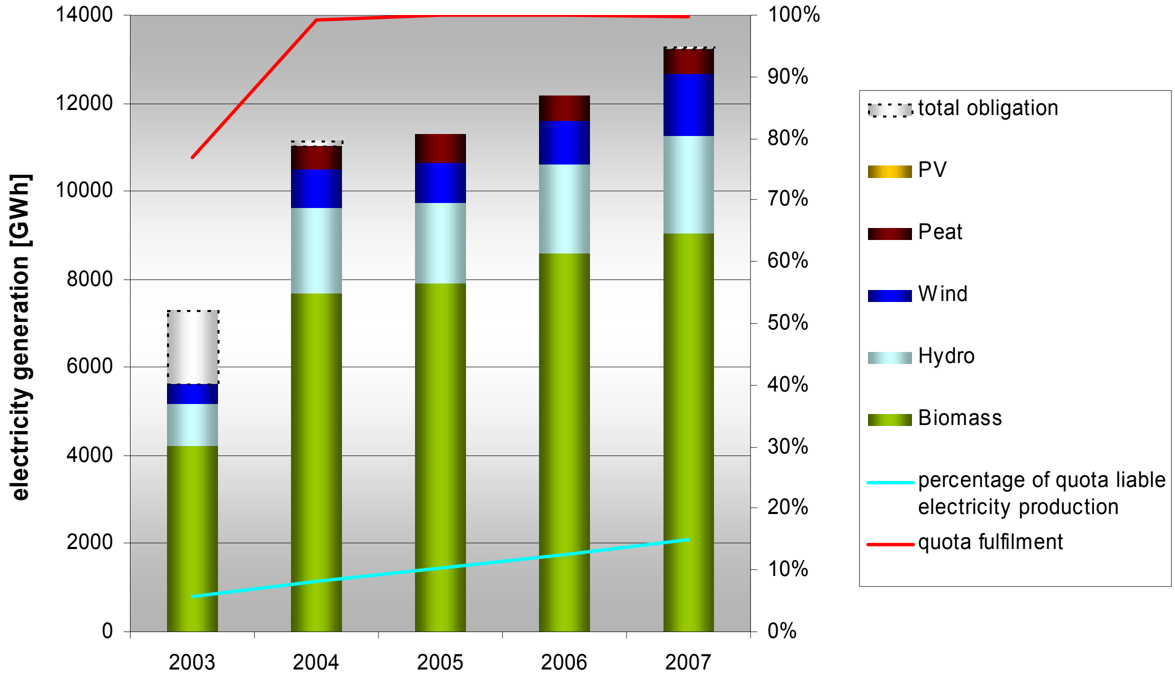


Source: Swedish Energy Agency (2008).

Figure B-5, Figure B-6 and Figure B-7 give an impression of the market outcome of the Swedish quota system and the total net support in terms of the aggregate cost of the sold TGCs in the last years.

Figure B-5 shows the RES-E production from all plants that participate in the quota system, the percentage that this electricity makes up of the total certificate liable electricity production and the quota fulfilment rate.

Figure B-5: Electricity generation from RES within the Swedish quota system [GWh]

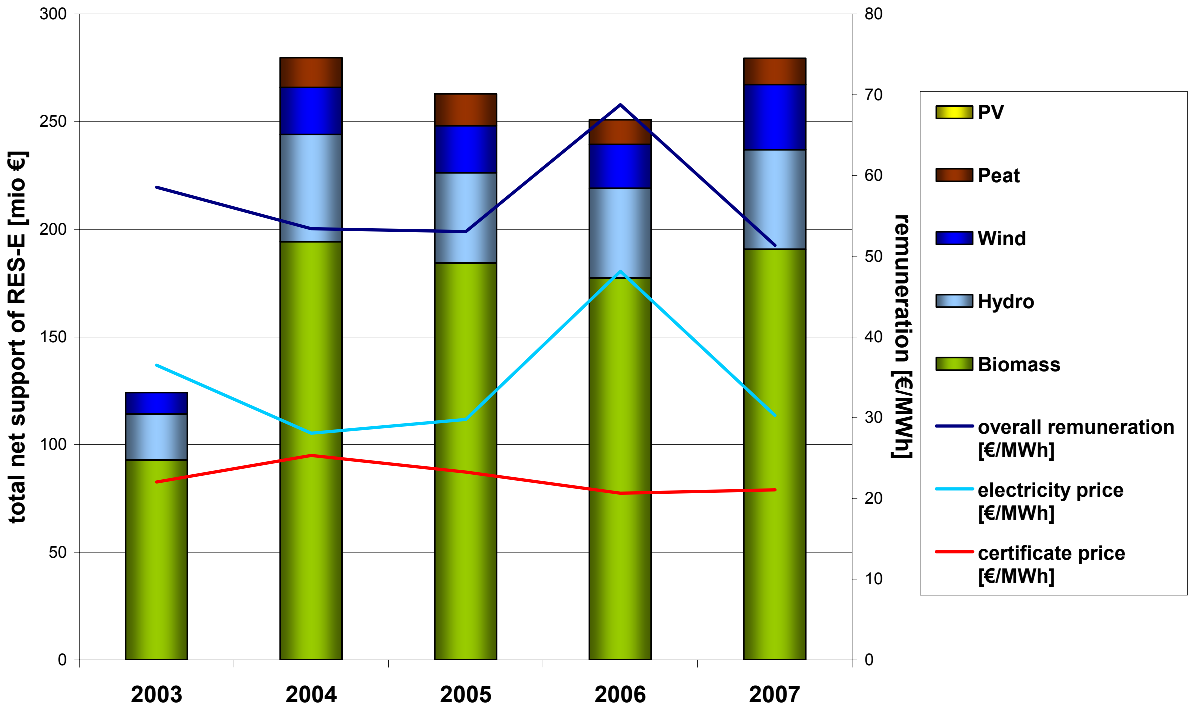


Source: EWI based on data from Swedish Energy Agency (2008).

Irrespective of the above mentioned starting difficulties, the increase in RES-E production from about 5.6 TWh in the year 2003 to more than 13.2 TWh in 2007 corresponds very well to the indicative targets of the Swedish government. Except in the year 2003 when the fulfilment level was at 77 % (-the underfulfillment being triggered by the abovementioned buy-out price limitations-), the quota was fulfilled to a degree of over 99 % in all the following years. Corresponding to this, the blue line that marks the RES-E share in the total quota liable electricity production almost matches the quota set by the government.

The total net support of RES-E in the Swedish system is illustrated in Figure B-6. Considering Figure B-6 together with Figure B-5, it becomes obvious that the yearly costs of RES-E support in a quota system like the Swedish one depends on the amount of generated RES-E but also - and most notably - on the certificate price.

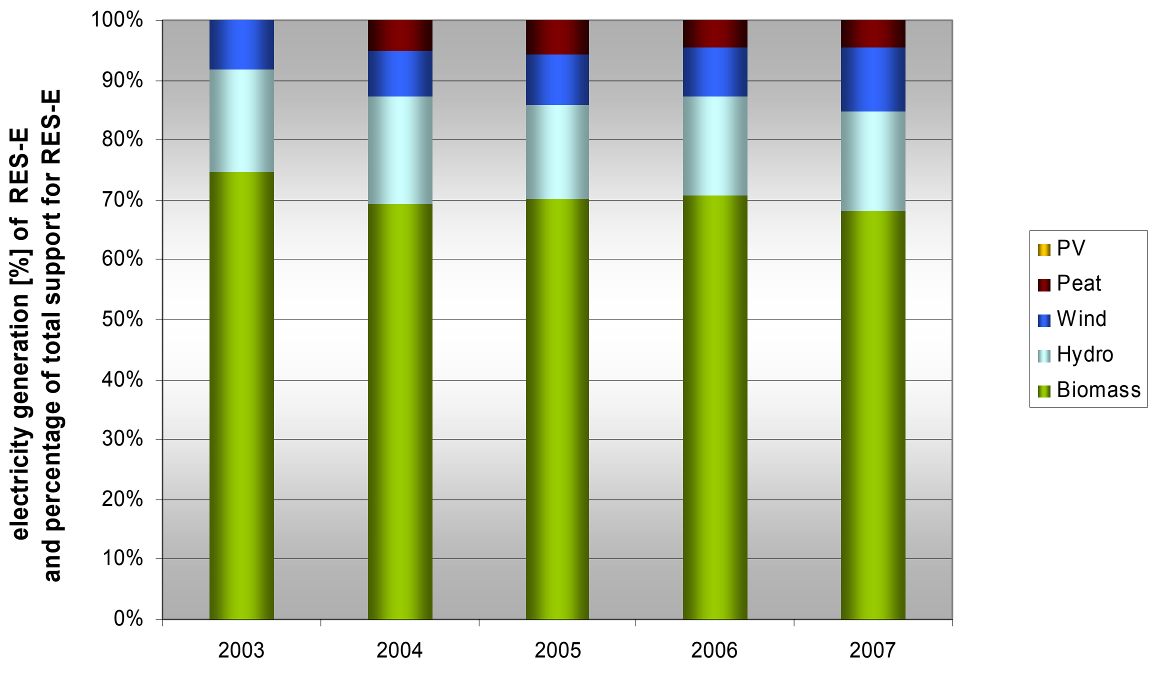
Figure B-6: Total net support of RES-E by energy source in the Swedish quota system [mio. €]



Source: EWI based on data from Swedish Energy Agency (2008).

The good performance of the technology-neutral Swedish system in terms of static efficiency is illustrated in Figure B-7 which shows the contribution to the total RES-E production of each energy source and the respective share of the total support for RES-E by energy source.

Figure B-7: RES-E generation structure and fraction of the total support by energy source in the Swedish quota system



Source: EWI based on data from Swedish Energy Agency (2008).

As every produced electricity unit (MWh) receives the same overall remuneration, the relation is exactly the same. Consequently the most economic technologies that are eligible (in this case biomass fuelled power plants) are expanded first, while more expensive technologies like photovoltaics have only imperceptibly entered the market until now.[63]

[63] The Swedish government has a clear interest in limited costs for the electricity consumers caused by the promotion system. Therefore, as already mentioned above, the Swedish system only provides support for recently built RES-E power plants. Out of these, biomass is the most economic one. The total RES-E production in Sweden evidently has a much higher level due to production from large scale hydro power plants, which is not supported by the quota system.

B.3 Case Study Germany

Germany is a typical example for Feed In Tariff Systems (FIT), because it combines almost every conceivable peculiarity that these remuneration systems can have. As for Europe moreover, it was the first FIT system to be implemented (1991).

The first promotion of RES-E has been made in 1991 with the adoption of the Energy Feed-In Law (Stromeinspeisungsgesetz)[64], which introduced the compulsory purchase of RES-E. A fixed price regime was also established, although the prices were still defined as a fraction of the average proceeds out of the sale of electricity to the customers by the electricity suppliers.

In 2000, the Renewable Energy Law (Gesetz für den Vorrang Erneuerbarer Energien - EEG)[65] was enacted, integrating geothermal energy into the promotion scheme and concentrating the support on rather small utilities in order to preserve the character of a start-up funding.

At August 1st 2004, the first amendment to the Renewable Energy Law came into force.[66] The main modifications were made in the range of remuneration levels, and the legal position of operators has been improved.

The latest amendment to the Renewable Energy Law[67] took effect in 2009.

The Renewable Energy Law regulates the remunerations to be paid to the operators of every eligible RES-E installation subject to the respective technology and the date of commissioning. In the German case, the transmission system operators (TSOs) are obliged to refund the RES-E operators. Very important in this context is the obligation on the part of the TSO to buy the electricity at any time, which means that there is no incentive for the RES-E generator to produce demand-oriented. The only exception of the obligation to buy is in cases of emergency, i.e. if the absorption of RES-E would cause a grid overload – only then, the system operator is allowed to deny grid access and RES-E producers are obligated to reduce or shut down their production.[68]

[64] StromEinspG (1990).
[65] EEG (2000).
[66] EEG (2004).
[67] EEG (2008).
[68] For a detailed description see EEG (2008), §§ 8-12.

In the following, the different features of the German FIT regulation will be discussed. The German FIT regulation includes a yearly degression of the initial tariffs depending on the employed technology. The degression rates range from 0% (hydro smaller than 5MW) and 1% (biomass, hydro larger than 5MW, geothermal energy, onshore wind) up to 10% (solar energy). These distinctions are to reflect the unequal opportunities of cost reductions across the different technologies and therefore to prevent too challenging tariff cut-downs in the case of already mature technologies on the one hand and, on the other hand, to avoid too lax requirements in the case of technologies offering a great cost reduction potential. In other words, the tariff degression is designed to implement dynamic efficiency into the FIT system.

In the case of solar energy, there are some particular regulations concerning the degression rates: Firstly, they differ depending on plant size and type of solar electricity generation. Secondly, the degression rates are contingent upon the development of the installed capacity during the preceding year. A target corridor for the yearly expansion of capacity is scheduled in the Renewable Energy Law, requiring a spread between 1000 MW and 1500 MW capacity expansion in the year 2009 (1100-1700MW in 2010; 1200-1900MW in 2011) for the validity of the abovementioned degression rates. If the yearly extension is inferior (superior), the degression rates of the tariffs decrease (increase) in order to make it more probable that the target corridor is met in the following year.

Concerning the calculation of the individual plants´ remunerations, the German FIT regulation also includes very detailed arrangements. The payments to installations generating electricity by means of hydro power, biomass, geothermal energy or solar energy (only if installed on a building) are calculated as a function of their effective electricity generation, i.e. the nominal capacity of the respective power plant is irrelevant for the applicable tariff. As an outcome of the calculations, the operators of the respective power stations receive the higher tariffs (in €ct/kWh), the lower their power output is. This provides for an adjusted promotion of the different plant sizes and therefore allows also small installations to operate profitable, i.e. with more or less the same return on investment as large installations.

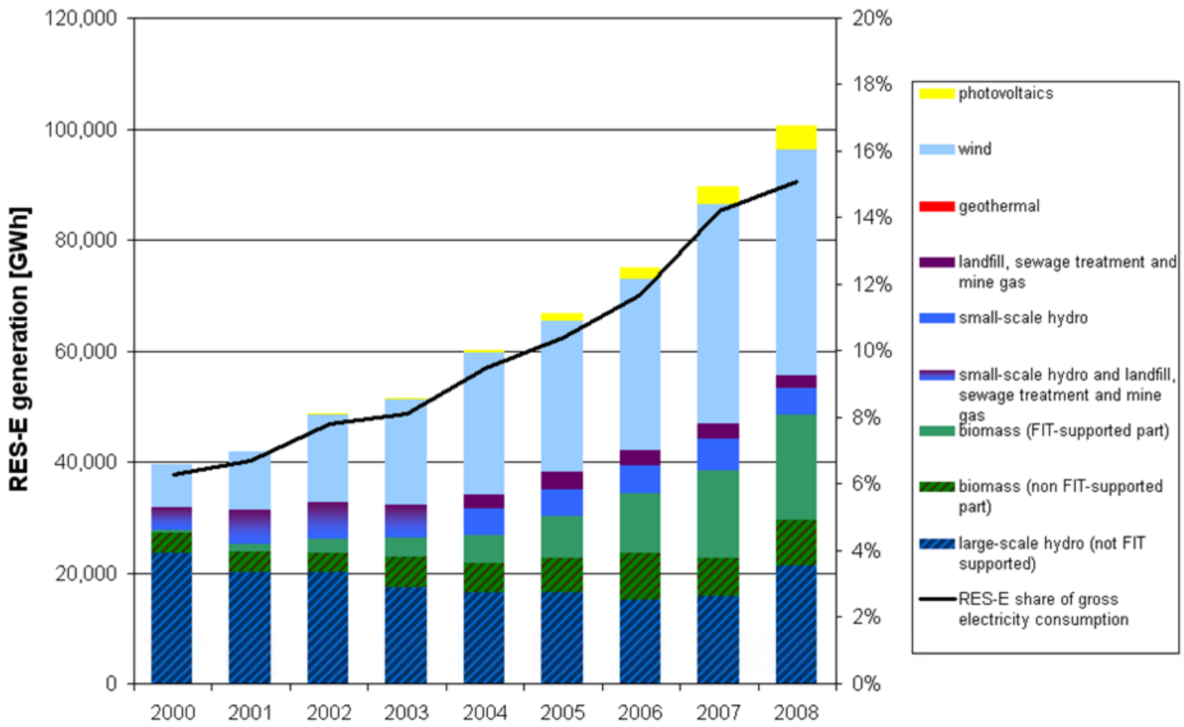
Another instrument to make the remuneration depend on the effective capacity is applied in the case of onshore wind energy which receives 9.2 €ct/kWh for at least five years and thereafter only 5.02 €ct/kWh: The worse the location of a wind turbine, the longer the high remuneration is paid to the operator. For the site assessment, the output of a respective turbine at a reference location is calculated and compared to the effective electricity output of the specific wind turbine in question. If the electricity generation is higher than 150% of the reference output, 9.2 €ct/kWh are paid only during the first five years, whereas a wind turbine with an electricity output inferior to 82.5% receives 9.2 €ct/kWh for twenty years. Graduations between these two poles can be calculated applying linear interpolation. In terms of a theoretical assessment of this regulation detail, the result depends on the aspired installed capacity: Supposing that the inferior locations´ exploitation is necessary to meet a certain target of installed wind turbine capacity and that the legislator is well informed about the electricity generation costs, the legislator reduces the costs for the consumers of electricity in comparison to a uniform tariff for wind turbines by reducing the total subsidies and consequently also the distribution effect. However, this may not be confounded with a higher static efficiency compared to a uniform tariff. It solely reduces the producer surplus and thereby the total remuneration volume.

A further interesting item can be found in the field of offshore wind turbines. There, a similar distinction in the runtime as in the case of onshore wind turbines is made: The basic remuneration period during which a tariff amounting to 15 €ct/kWh is paid lasts twelve years. Afterwards, the tariff drops to 3.5 €ct/kWh for the remaining eight years. But if an offshore turbine is erected at least 12 sea miles off the coast and in a water depth of at least 20 meters, this duration elongates by 0.5 months for every sea mile additional to 12 and by 1.7 months for every meter water depth additional to 20.

This regulation is actually very similar to the technology premium which is paid on top of the feed-in tariff in order to foster the use of particularly progressive technology components, especially in the field of electricity generation from biomass. Both intend to promote the development of the respective technologies by allowing for additional payments if a certain technology is applied. Viewed in this light, the technology premium as well as the adjusted term of high remunerations represents a further technology specification.

The performance of the German FIT system in terms of RES-E stimulation can be seen in Figure B-8. From 2000 to 2008 RES-E increased from roughly 40 TWh to more than 100 TWh. These figures also include RES-E generated by power plants which are not supported by the FIT system, namely large-scale hydro power plants and a part of the biomass plants. The FIT supported RES-E increased from approximately 12 TWh in 2000 to 71 TWh in 2008. Figure B-8 further shows the increase of the RES-E share of gross electricity consumption from 6.3% in 2000 to 15.1% in 2008. As far as the RES-E generation mix is concerned, wind and biomass contributed most to the rising RES-E share.

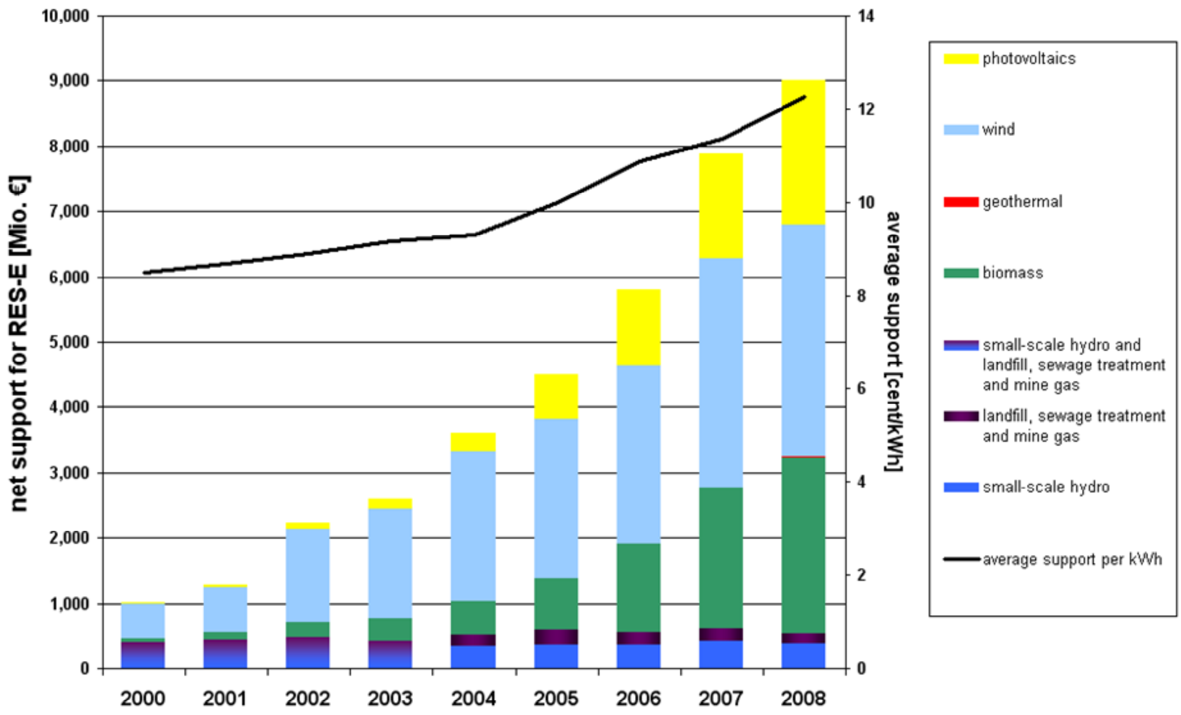
Figure B-8: Development of RES-E generation in Germany



Source: EWI based on data from BMU (2007), BMU (2009) and BDEW (2000-2008).

When comparing the RES-E generation mix to the technology mix in the support cost figures in Figure B-9, one has to keep in mind the schemes´ intentions. The technology specification directly clarifies that pure static efficiency is not the primary goal of the arrangement. Having in mind that certain technologies receive a by far higher remuneration than others and are therefore obviously intended to be expanded, the remuneration structure has to differ from the generation structure. In other words, if (the relatively expensive) photovoltaics-generated electricity accounts for 1% of the total generation of RES-E, this does not mean that it receives only 1% of the remuneration volume, but rather a much higher fraction. In a technology neutral scheme, there would be hardly a difference between the generation share and the remuneration share (See case study Sweden).

Figure B-9: Development of total RES-E net support in Germany



Source: EWI based on data from BMU (2007), BMU (2009) and BDEW (2000-2008).

Figure B-9 also shows the average support per kWh of RES-E which increased from 8.5 cent in 2000 to 12.253 cent in 2008, despite the degression of the tariffs. This increase reflects the growing share of expensive technologies, especially photovoltaics power.

B.4 Case Study Spain

The Spanish RES-E promotion system is often cited because it is one of the few countries that have implemented the premium system for the promotion of RES-E. In fact, Spain uses a combination of a FIT and a premium system. Each producer of RES-E can choose between a fixed tariff and a premium which is paid on top of the market price for electricity. The level of the remuneration differs depending on the technology and on the capacity of the facility. The decision between the two remuneration systems is taken for one year and afterwards the producer can decide again if he stays in the one system or switches to the other. In the so called market option, under which a premium is paid, producers of RES-E receive a statutorily regulated premium for each unit (kWh) of electricity produced.
The premium is paid in order to reduce the uncertainty of the profitability of a RES-E project. As in Spain the support of RES-E technologies began quite early with the Law for Energy Conservation (*Ley 82/80 de Conservación de la Energía*) in 1980, the current legislation is the result of a series of changes in legislative measures and financial support of RES-E production. [69]

The basis of the current system has been implemented in 1997 with the Electric Power Act (*Ley 54/97 del Sector Eléctrico*), which also formed a major step in the liberalisation of the electricity sector in Spain.[70] The law makes a differentiation between electricity production under the "ordinary system" i.e. on the spot market and the "special system" (*régimen especial*) for electricity production out of the following primary energy sources: non-consumable and non-hydro energy sources (solar, wind, geothermal, etc.) and biomass or other biofuels if the installed capacity of the facility does not exceed 50 MW. Producers which fall under the "special system" get a purchase guarantee for their electricity and a premium which is paid on top of the market price. The indicative target for the percentage of RES-E in the Spanish electricity mix was set by the government in the "Plan for the Promotion of

[69] Feed in Cooperation (2007).
[70] Free access to the electricity generation is granted and the remuneration is being realised through a competitively organised whole sale market.

Renewable Energies" (*PFER* in its Spanish acronym). This target was taken into account when fixing the level of the premium.
Since 1998 ("*Royal Decree" RD 2818/1998*) producers have the right to feed in the total amount of produced electricity into the grid and a formula for the (technology specific) final price has been established.[71] Additionally it has been decided to adjust the premium every four years.

In 2004 the framework for the "special system" was modified in order to make it more stable and predictable for RES-E producers (*RD 4367/2004*). According to the new regulation the producer has the choice between selling his electricity to the distributor at a regulated tariff or to sell it on the open market and then receive the negotiated price plus an incentive. The intention of the new framework was to grant the producers of the "special system" an adequate payment for their investments, irrespective of whether they choose the FIT or the premium. One of the positive effects of this system is that it encourages market participation through the market option and thus prepares producers of RES-E for competitive market participation better than a simple fixed tariff. Both, fixed tariffs and premiums were calculated by a formula that was linked indirectly to the annual average electricity market price.

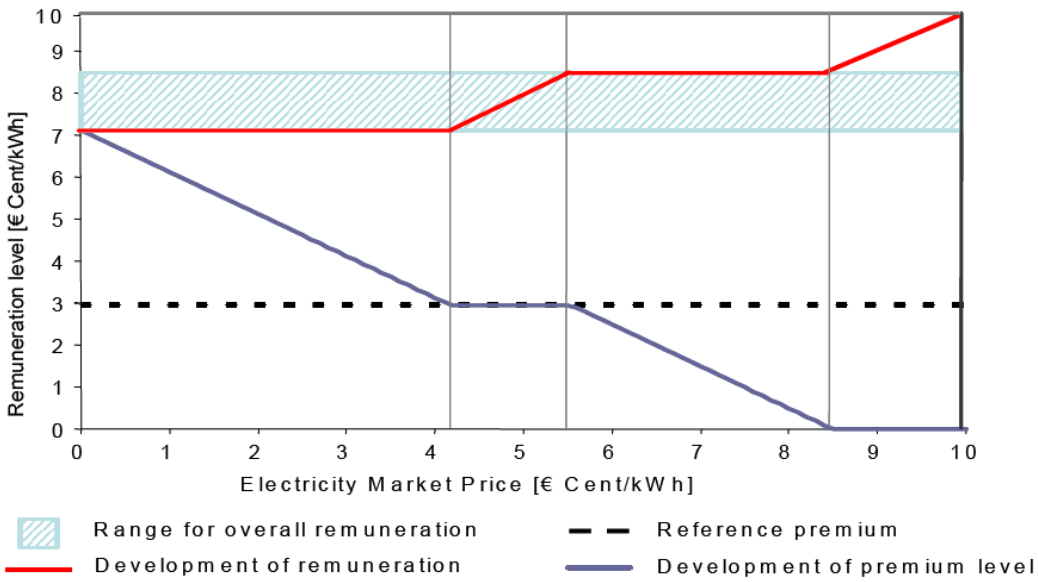
Despite these modifications and the resulting stable conditions, the expansion of the RES-E production in Spain stayed far behind the targets of the *PFER*. Less than 30% of the target was reached until 2005, mainly due to an unexpectedly high growth in electricity consumption. As a consequence, a new "Plan for Renewable Energies" for the period from 2005-2010 (*PER para el período 2005-2010*) was formulated with a new target of 12.1% of the primary energy consumption in Spain in 2010. Also higher premiums for solar power plants and biomass power plants as well as for biomass cofiring were introduced in 2005 (*Ley 24/2005*). In addition to the lag in RES-E expansion, consumer costs had risen and windfall profits were realized under the market option which then was chosen by more than 72% of all the RES-E producers until July 2006. The reason for this was the indirect linkage of the tariffs and

[71] The formular is the following: P= Pm + Pr ± RE, with P= Payment of the kWh, Pm= Market price, PR= premium, RE= a supplement for reactive energy.

premiums to the market price for electricity which had risen considerably. Therefore, in 2006 (*RD 7/2006*) the linkage of the FITs and the premiums was abolished.[72]

In 2007 a new law (*RD 661/2007*) was introduced which replaced the *RD 436/2004*. The major modification concerning the payment system was the introduction of cap and floor prices for the overall remuneration level. In this way the flexibility of the system is reduced by setting a corridor for the sum of the electricity price and the premium. Figure B-10 shows the correlation between the development of the remuneration level and the premium level in order to maintain a constant range of the overall remuneration.

Figure B-10: Development of remuneration level and premium level in Spain



Source: Feed in Cooperation (2007).

The overall remuneration within the market option is calculated in the following way:

1) The minimum level of the overall remuneration is paid as long as the sum of the electricity market price and the reference premium is less than the minimum level. This means that the real premium is calculated as the difference between the market price and the minimum level and that it is higher than the reference premium. As the market price rises, the real premium declines until the sum of the market price and

[72] CNE (2007).

the reference level reaches the minimum remuneration. Meanwhile the overall remuneration level is constant.
2) The reference premium is paid on top of the market price if the sum of the electricity market price and the reference premium ranges between the minimum and the maximum limit. Thus, the overall remuneration level increases, whereas the real premium is constant.
3) If the sum of the electricity market price and the reference premium passes the upper limit the overall remuneration level corresponds to the cap until electricity market price exceeds the cap price. The real premium that is paid to the producer is the difference between the cap and the electricity price. The overall remuneration remains constant and the real premium declines as the electricity price rises.
4) If the market electricity price exceeds the cap, no premium is paid and the overall remuneration is equal to the electricity market price.[73]

In so doing, the upper and lower limit for the premiums bring the market option closer to a FIT system, as they guarantee a minimum overall price to each RES-E producer but also reduce windfall profits through the upper limit.

The Spanish system also includes a technology specific support, as well in the regulated tariff option as in the market option. The intention is to have better control over the stimulation of the different technologies. Therefore the PER for the period 2005-2010 also includes specific targets for each technology. Tariffs and premiums are defined in a way in which the government hopes to meet these targets as effectively as possible.
Table B-2 gives a detailed overview of the remunerations for the different RES-E technologies. It is striking that photovoltaics can only receive a regulated tariff but not a premium. In addition to that the remuneration level is very high. The specific support level for this technology was set in order to foster its expansion, after it had lagged behind the PER targets at the beginning of the century. And it seems to have been quite effective in the sense of stimulation. Thus, the current system in Spain is

[73] Feed in Cooperation (2007).

still based on the Royal Decree *RD 661/2007* but it has been modified in 2008 concerning the regulation for photovoltaics.[74]

Because of the phasing out of the old FIT and risen costs, due to an extremely high expansion of the installed photovoltaics capacity, the new decree brings up further restrictions for the remuneration of electricity produced from photovoltaics (the target of the PER for the Period 2005-2010 was almost reached by middle of 2007, and in May 2008 the total installation of photovoltaics in Spain reached 1000 MW). Some important points of the changes that have been made are:[75]

A new distinction between the different photovoltaics technologies has been introduced. It differs now between roof- and building projects with a rated power of up to 20 kW and those above that level on the one hand, and on the other hand other projects (mainly free range plants) are treated as another category.

A new register has been created, in which fully developed projects can be inscribed and receive a FIT in advance, i.e. before their realisation (the so-called "Register on the in-advance-allocation of the compensation", *Registro de Preasignación de Retribución – RPR*). From September 2008 onwards, only those new installed projects that are in this register can receive the regulated tariff. But there are limits for the inscription to the RPR. The upper limit for 2009 has been set at 133 MW of free range plants and 267 MW of roof- and building-plants. Above the limit an exceptional amount of 100 MW for free-range plants in 2009 and another 60 MW in 2010 can be inscribed.[76]

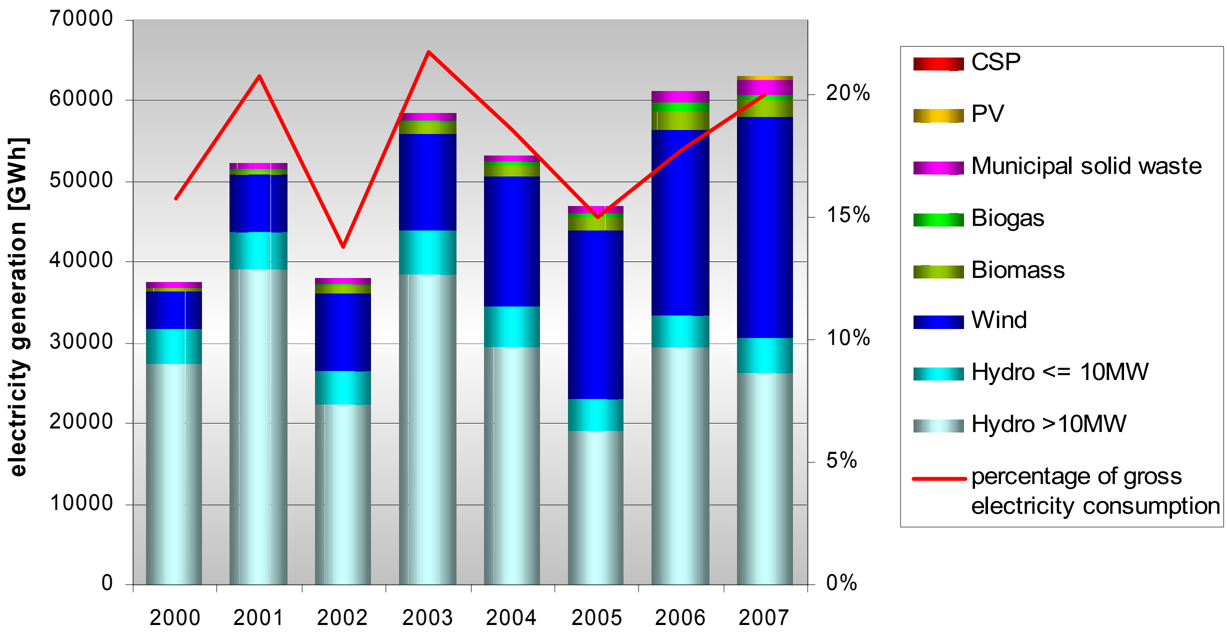
The introductory tariff for 2009 is reduced to 34 Cents/kWh for small roof- and building-plants up to 20 kW, to 31 Cents/kWh for those bigger than 20 kW and to 32 Cents/kWh for free-range plants up to 10 MW.

The case study of Spain shows how the premium system can be elaborated. The uncertainty for an investor is a little higher than in a pure FIT system. But the example also shows that the stimulation effect of the system is mainly dependent on the level of the remuneration. The approximation to the FIT system and the cuts in the system flexibility that have been made were only implemented after the

[74] *RD 1578/2008* (2008).
[75] DIKEOS Abogados (2008).
[76] In 2009 additionally an annual 500 MW cap for CSP was introduced.

expansion of some RES-E technologies had exceeded the set targets and after measures to ensure the accuracy in achieving the target had become necessary. The history of constant adaptations shows that the premium system as well as the FIT system needs adjustments from time to time to assure the achievement of the set targets. Figure B-11 shows that the production of RES-E underlied considerable fluctuations according to the production level of hydro energy, but it also becomes obvious that the adjustments of the regulatory framework had a strong influence on the electricity production of the different technologies. The share of wind energy for example is constantly rising since the “special system” was introduced and also the increases in tariffs for biomass and solar energy had some visible effect on the produced electricity. The share of electricity production from biomass has significantly risen, and the extreme jump of the PV production 2007 also becomes visible (in terms that the amount becomes visible in relation to the RES-E production from other sources).

Figure B-11: Electricity generation from RES and share of gross electricity consumption in Spain



Source: EWI based on data from IDAE (2006) and Eurostat (2009).

Table B-2: Tariffs and premiums in the Spanish RES-E promotion system [as modified in RD 661/2007]

Technology category		Installed Power	Period [years]	Fixed price: Fixed Tariff [€ Cent/kWh]	Market option: Reference premium [€ Cent/kWh]	Market option: Cap [€ Cent/kWh]	Market option: Floor [€ Cent/kWh]
b.1 Solar	b.1.1 Photovoltaic	≤ 0.1MW	1 - 25	44.0381			
			> 25	35.2305			
		0.1MW – 10MW	1 - 25	41.7500			
			> 25	33.4000			
		10MW – 50MW	1 - 25	22.9375			
			> 25	18.3811			
	b.1.2 Solar Thermal		1 - 25	26.9375	25.4000	34.3976	25.4038
			> 25	21.5498	20.3200		
b.2 Wind	b.2.1 Onshore		1 - 20	7.3228	2.9291	8.4944	7.1275
			> 20	6.1200			
b.3 Geothermal and Ocean			1 - 20	6.8900	3.8444		
			> 20	6.5100	3.0600		
b.4 Small-scale Hydro		< 10MW	1 - 25	7.8000	2.5044	8.5200	6.5200
			> 25	7.0200	1.3444		
b.5 Large-scale Hydro		10MW – 50 MW	1 - 25	$6.60+1.20\times\frac{50-P}{40}$	2.1044	8.0000	6.1200
			> 25	$5.94+1.08\times\frac{50-P}{40}$	1.3444		
b.6 Biomass	b.6.1 Energy crops	≤ 2MW	1 - 15	15.8890	11.5294	16.6300	15.4100
			> 15	11.7931	0		
		> 2MW	1 - 15	14.6590	10.0964	15.0900	14.2700
			> 15	12.3470	0		
	b.6.2 Agricultural wastes	≤ 2MW	1 - 15	12.5710	8.2114	13.3100	12.0900
			> 15	8.4752	0		
		> 2MW	1 - 15	10.7540	6.1914	11.1900	10.3790
			> 15	8.0660	0		
	b.6.3 Forestry wastes	≤ 2MW	1 - 15	12.5710	8.2114	13.3100	12.0900
			> 15	8.4752	0		
		> 2MW	1 - 15	11.8294	7.2674	12.2600	11.4400
			> 15	8.0660	0		
b.7 Biomass	b.7.1 Landfill gas		1 - 15	7.9920	3.7784	8.9600	7.4400
			> 15	6.5100	0		
	b.7.2 Gas from anaerobic digestion	≤ 0.5MW	1 - 15	13.0690	9.7696	15.3300	12.3500
			> 15	6.5100	0		
		> 0.5MW	1 - 15	9.6800	5.7774	11.0300	9.5500
			> 15	6.5100	0		
	b.7.3 Liquid bio-fuels, Manure		1 - 15	5.3600	3.0844	8.3300	5.1000
			> 15	5.3600	0		
b.8 Biomass from industrial processes	b.8.1 Agricultural wastes	≤ 2MW	1 - 15	12.5710	8.2114	13.3100	12.0900
			> 15	8.4752	0		
		> 2MW	1 - 15	10.7540	6.1914	11.1900	10.3790
			> 15	8.0660	0		
	b.8.2 Forestry wastes	≤ 2MW	1 - 15	9.2800	4.9214	10.0200	8.7900
			> 15	6.5100	0		
		> 2MW	1 - 15	6.5080	1.9454	6.9400	6.1200
			> 15	6.5080	0		
	b.8.3 Black liquor	≤ 2MW	1 - 15	9.2800	5.1696	10.0200	8.7900
			> 15	6.5100	0		
		> 2MW	1 - 15	8.0000	3.2199	9.0000	7.5000
			> 15	6.5080	0		

Source: Feed in Cooperation (2007).

C. Model Description of DIME
(Dispatch and Investment Model for Electricity Markets in Europe)

C.1 Basic properties

DIME was developed to combine the advantages of earlier simulation tools of the Institute of Energy Economics, namely GEMS (German Electricity Market Simulation) and CEEM (Cogeneration in European Electricity Markets). At the same time, regional coverage was extended. DIME was designed especially for long term simulations.

DIME is formulated as a linear optimization model for the European electricity generation market. It is applied to simulate dispatch as well as investment decisions regarding the supply side of the electricity sector. The objective function minimizes total discounted costs based on the assumption of a competitive generation market.

In DIME, all EU27 Memberstates, as well as Switzerland and Norway are represented and modelled in 29 regions.

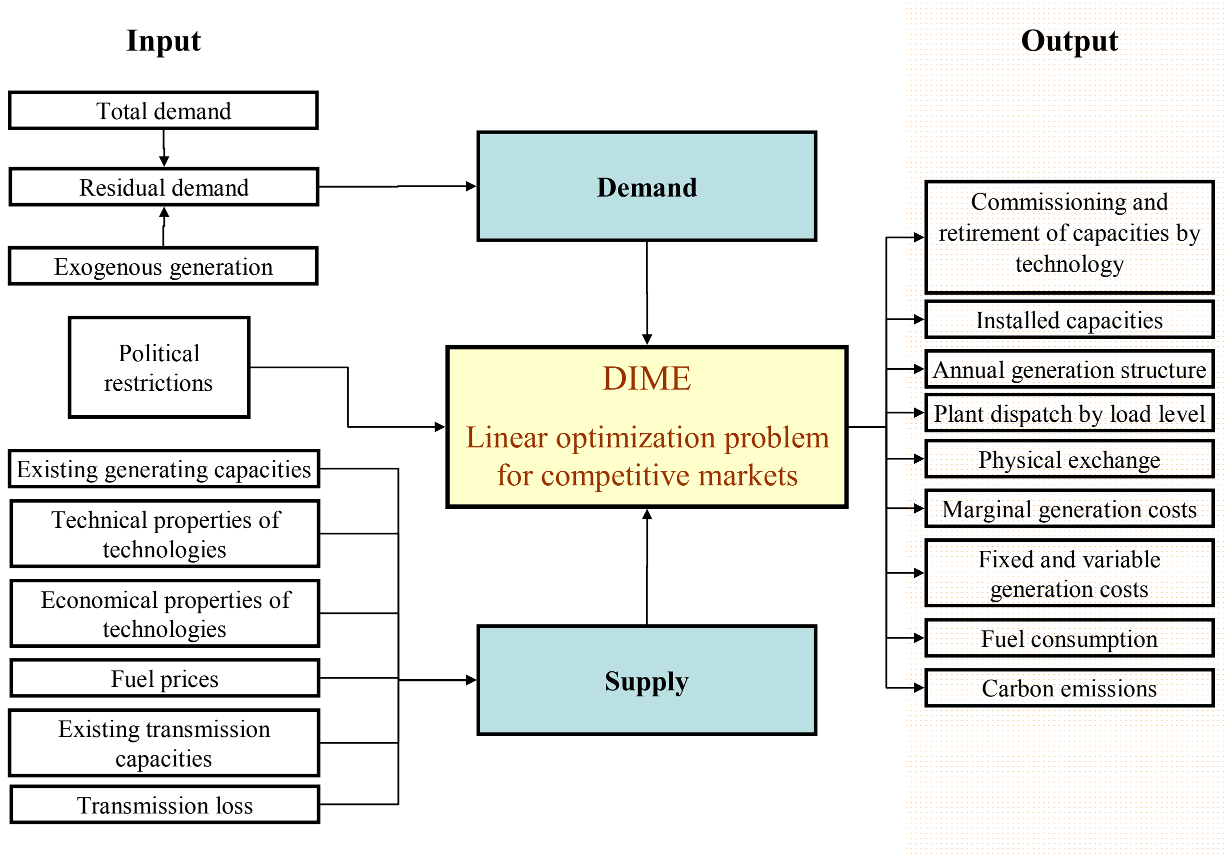
DIME uses a technology based bottom-up approach. It provides for 11 technologies for electricity generation comprising fossil, nuclear, hydro storage, and pumped storage plants. Technologies are further distinguished into representative vintage classes. Each class comprises all installations of the same technology being built during a certain period in the past. There are additional classes for future investments. This allows for attributing classes with different properties such as electric efficiency according to the age of the average installation within each class. The vintage structure in each region requires the model to commission new installations. Existing installations can be retired for economical reasons before their technical life time expires.

Simulations can be conducted for representative periods up to the years 2030 using steps of five years. Valid periods are 2008, 2010, 2015, 2020, 2025, and 2030. For each period retirement and commissioning of installations by technology and region is calculated. Within each period generation has to meet demand for electricity while accounting for physical exchange with neighbouring regions. Load structures are defined for four seasons, with each season having three representative days (working day, Saturday, Sunday). Each day can be subdivided into up to 24 hours. Thus, a period can at most consist of 288 typical load levels. At each time electricity load must be met by adequate generation at home or abroad. Transfer capacities limit physical electricity exchange.

C.2 Structure of the model

Figure C-1 illustrates the basic structure of DIME and depicts its main inputs and outputs.

Figure C-1: Input-output structure of DIME



Supply side input is based on detailed databases containing information on installed capacities in the different model regions and information on technical and economical parameters. Demand side input data comprises residual load structures and annual demand. Further, assumptions on future values for all factors are made. Political restrictions such as the use of nuclear power and objectives on climate protection are defined.

For each forecast period up to 2030 output is produced on retirement and commissioning of installations by technology, fuel use, carbon emissions, and costs related to production. For each load level within every forecast period output is produced on plant dispatch by technology, use of storage plants, marginal costs for electricity generation, electricity exchange. Weighted marginal costs for electricity generation can be used as price indicator in competitive markets.

The next two sections provide additional information on input and output data.

C.2.1 Input data

C.2.1.1 Supply side data

DIME accounts for round about 75 % of existing net generating capacity of the regions under consideration. Table C-1 summarizes technologies incorporated in DIME and those treated exogenously.

Table C-1: Technologies treated endogenously and exogenously

Technologies incorporated in DIME	Technologies treated exogenously
- Nuclear power stations - Lignite power stations - Hard coal power stations - Oil power stations - Gas-fired combined-cycle power stations (CCGT) - Open cycle gas turbines (OCGT) - Pumped-storage power stations - Hydro storage power stations - Backstop flexibility technology - Large-scale CHP technologies in Germany	- Run-of-river - Other renewable energies - Waste - Large-scale CHP technologies (except for Germany) - Small-scale CHP technologies

Information on installed capacity is obtained from EWI's power plant database. Net capacity for each installation is assigned to several vintage classes per technology. Thus, age specific properties such as efficiency are accounted. Existing installations will be decommissioned when their technical life time expires. Also, a certain date for retirement can be set. Furthermore, installations will be decommissioned if their production costs exceed sales revenues. Investment costs of existing installations do not influence the decision as these are considered to be sunk costs.

Figure C-2 shows, which regions are considered in DIME. Blue regions are explicitly modelled, green ones are satellite regions with electricity exchange only.

Figure C-2: Representation of European countries in DIME

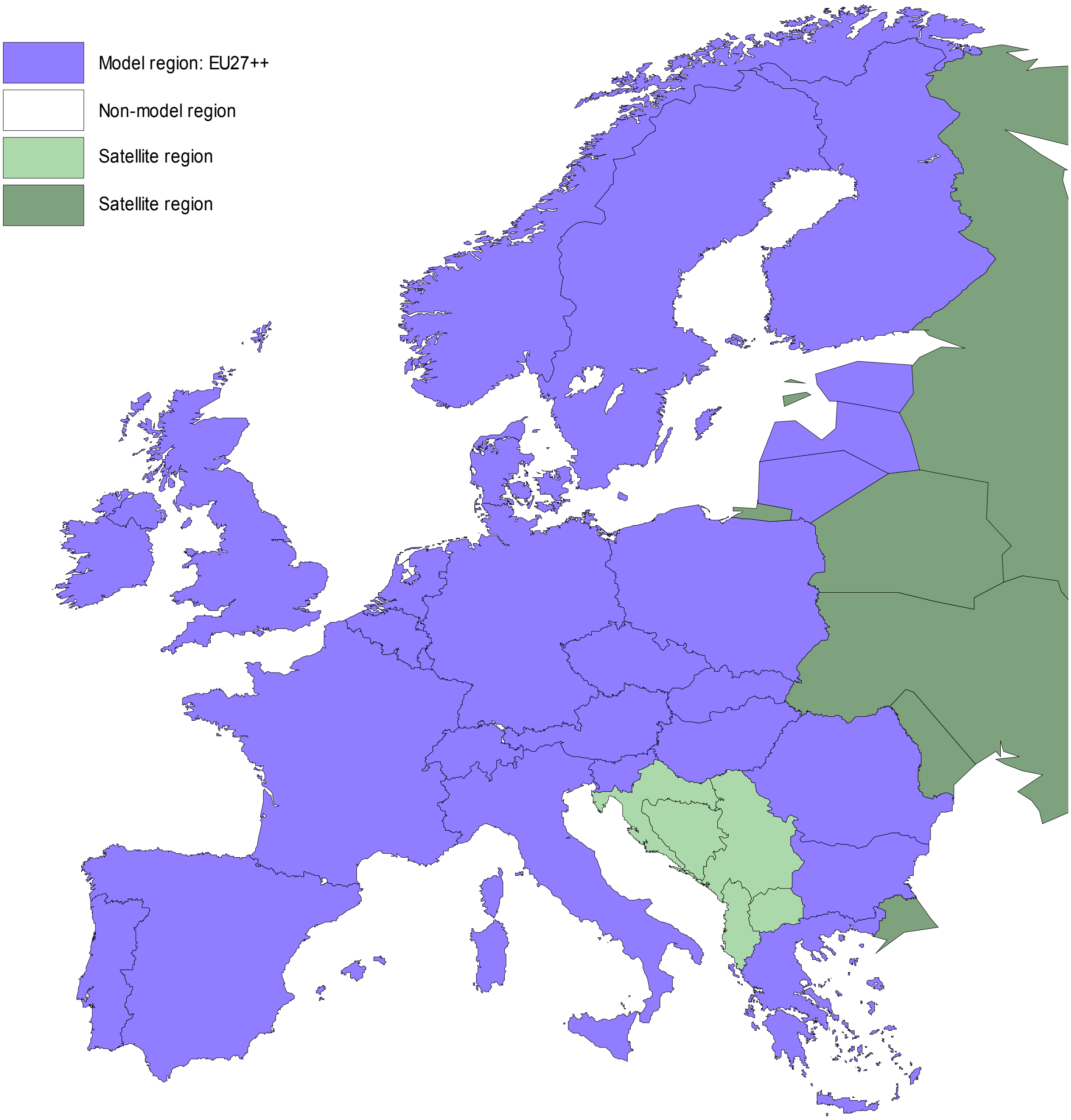


Table C-2 summarizes economical and technical properties being assigned to each technology.

Table C-2: Properties of technologies

Cost components	Technical properties
- Investment cost	- Installed capacity
- Depreciation time	- Availability
- Real interest rate	- Net efficiency
- Fixed operating cost	- Minimum load condition
- Fuel cost	- Rate of cooling down during idle time
- Other variable cost	- Start-up time
- Start-up cost	- Average seasonal availability
- Opportunity cost for carbon emissions	- Technical life time
	- Maximum capacity of hydro reservoirs
	- Natural inflow into hydro reservoirs

Investment costs are being annualized according to predefined depreciation time and interest rate. Fixed operating costs comprise costs for maintenance and personnel. Fixed costs are considered on an annual basis. They do not depend on actual production decisions. On the other hand, fuel costs, start-up costs, other variable costs, and opportunity costs for carbon emissions are related to production decisions. Fuel prices and electric efficiencies influence fuel costs. Start-up costs depend on several factors, namely specific costs for additional attrition from cold start and the duration of cold start. A cooling function links start-up costs for cold start and actual duration of standing idle.

In addition, lignite power stations are bound to local deposits. The operation of nuclear power stations is subject to political restrictions. These can be country specific limitations, phase-out plans or a complete ban.

DIME provides for two types of hydro stations: hydro storage and pumped-storage. Hydro storage plants can store natural inflow to their reservoirs subject to initial reservoir level and maximum reservoir size. Natural inflow depends on the season and region. The duration of a storage cycle can span up to one year. In contrast to that, cycle duration for pumped-storage plants is limited to one week. Decommissioning of hydro stations is not allowed, due to their long life time and favourable retrofitting measures.

C.2.1.2 Demand side data

The general approach to derive demand inputs comprises two steps. First, total annual demand and its structure are defined. Second, the model's residual demand is calculated from annual demand and electricity generation of technologies not being considered in the model.

Total demand

Annual electricity demand is specified for each region and future period. It consists of final electricity consumption and transmission losses. In contrast, consumption for storage operation is treated endogenously. As already mentioned a period's time resolution comprises four seasons having three representative days with up to 24 hours per day. In several steps annual demand is therefore broken down to hourly load structures. This calculation is based on historical data published by UCTE and national sources. The seasons are defined as follows:

Winter consisting of November, December, January, and February,

Spring consisting of March and April,

Summer consisting of May, June, July, and August,

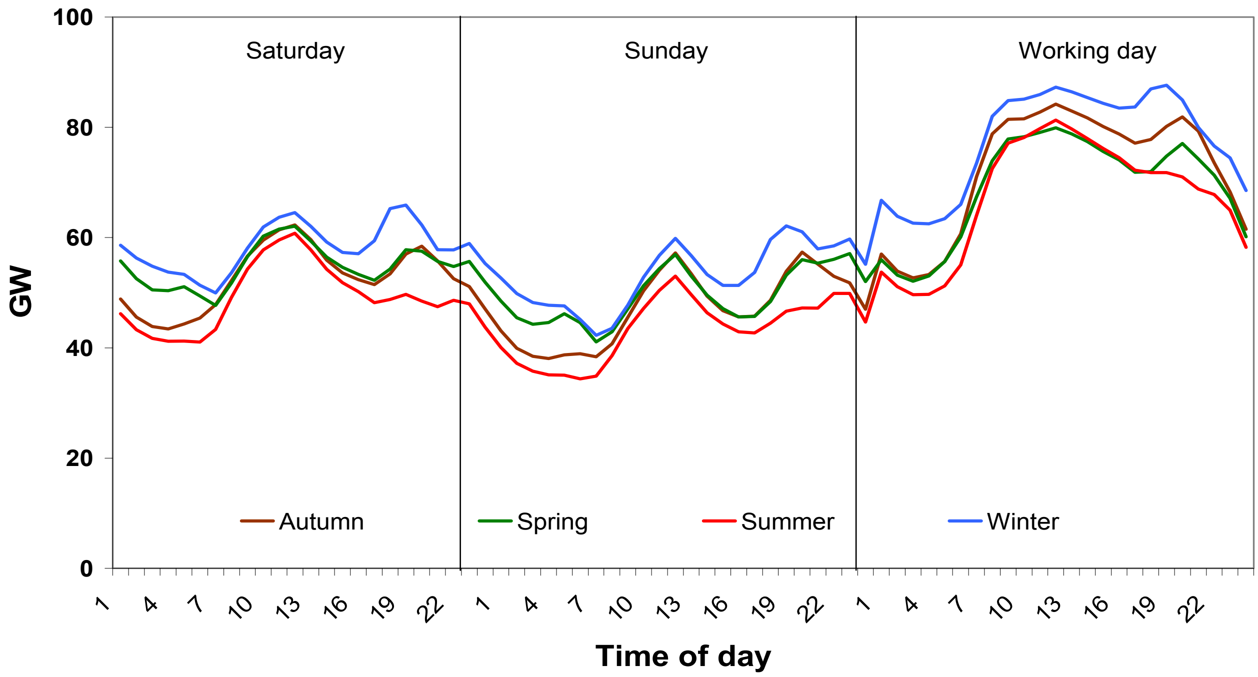
Autumn consisting of September and October.

Every season is represented by a typical week which repeats several times depending on a seasons duration. Each week consists of one Saturday, 1.2 Sundays and holidays, and 4.8 working days. Table C-3 illustrates the total occurrence for each day type and season. Figure C-3shows an example for a load structure in the model.

Table C-3: Total occurrence of day types per season

Day type	Spring	Summer	Autumn	Winter
Working days	41.8	84.3	41.8	82.3
Saturdays	8.7	17.6	8.7	17.1
Sundays	10.5	21.1	10.5	20.6
Total days	61	123	61	120

Figure C-3: Example of hourly, daily, and seasonal load fluctuations



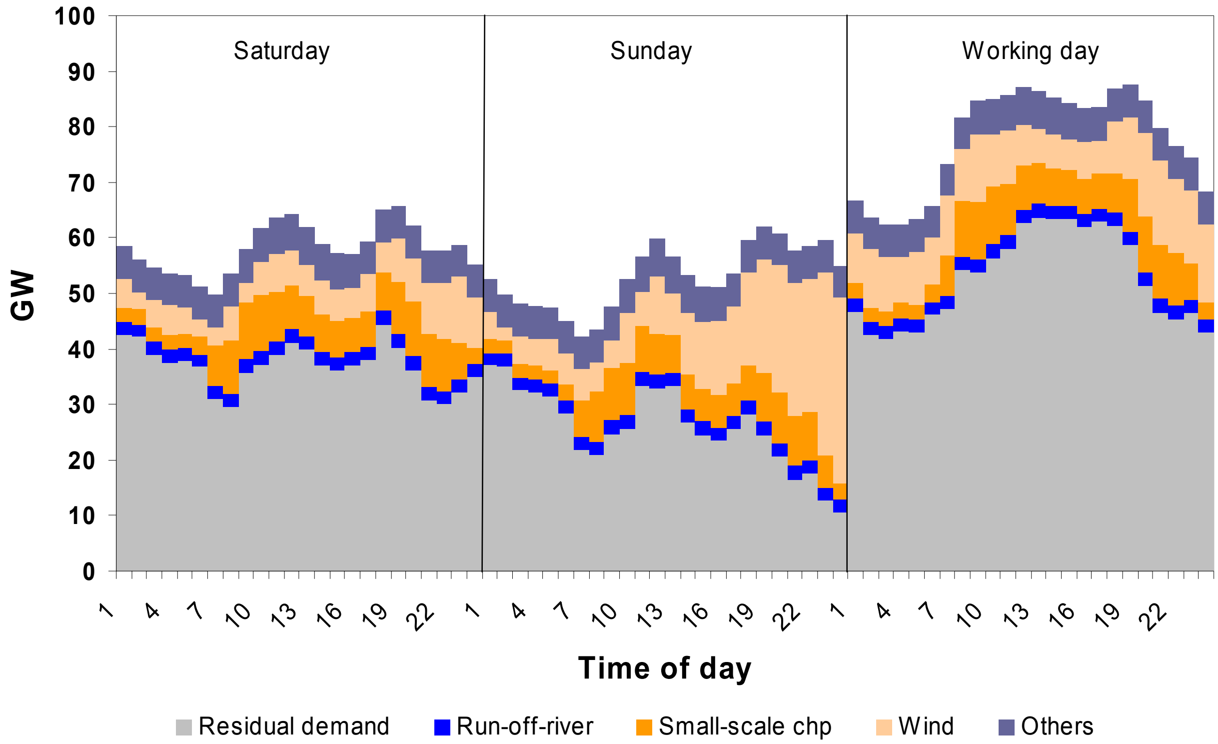
Each year starts with a spring season and ends with a winter season. Each week starts at Saturday followed by Sunday and then working days. Load sequencing is of utmost importance especially for start-up decisions and the operation of storage plants.

Residual demand

In order to derive residual demand, first of all the RES-E generation computed in LORELEI is deducted from total demand. In addition, assumptions on generation from other exogenously treated technologies are made (right-hand side of Table C-2). Again, for each technology annual values are combined with an hourly generation structure. For wind energy a more detailed approach is chosen to reflect its intermittent character. Generation is processed from typical historic feed-in structure and a random component, causing deviations from expected values. This allows feed-in to randomly fluctuate throughout the year.

Finally, generation of all exogenous generation is deducted from total demand. The result is the model's residual demand as depicted in Figure C-4.

Figure C-4: Example of deriving residual demand



C.2.1.3 Restrictions on electricity exchange

Transmission capacities between the regions limit physical exchange. By default net transfer capacities provided by ETSO are specified. Future grid extensions are also provided for. Within a region there are no bottlenecks assumed. Electricity exchange between regions is subject to a transmission loss of 10 % per 1000 kilometres. Average distances between the regions main production and consumption points are defined.

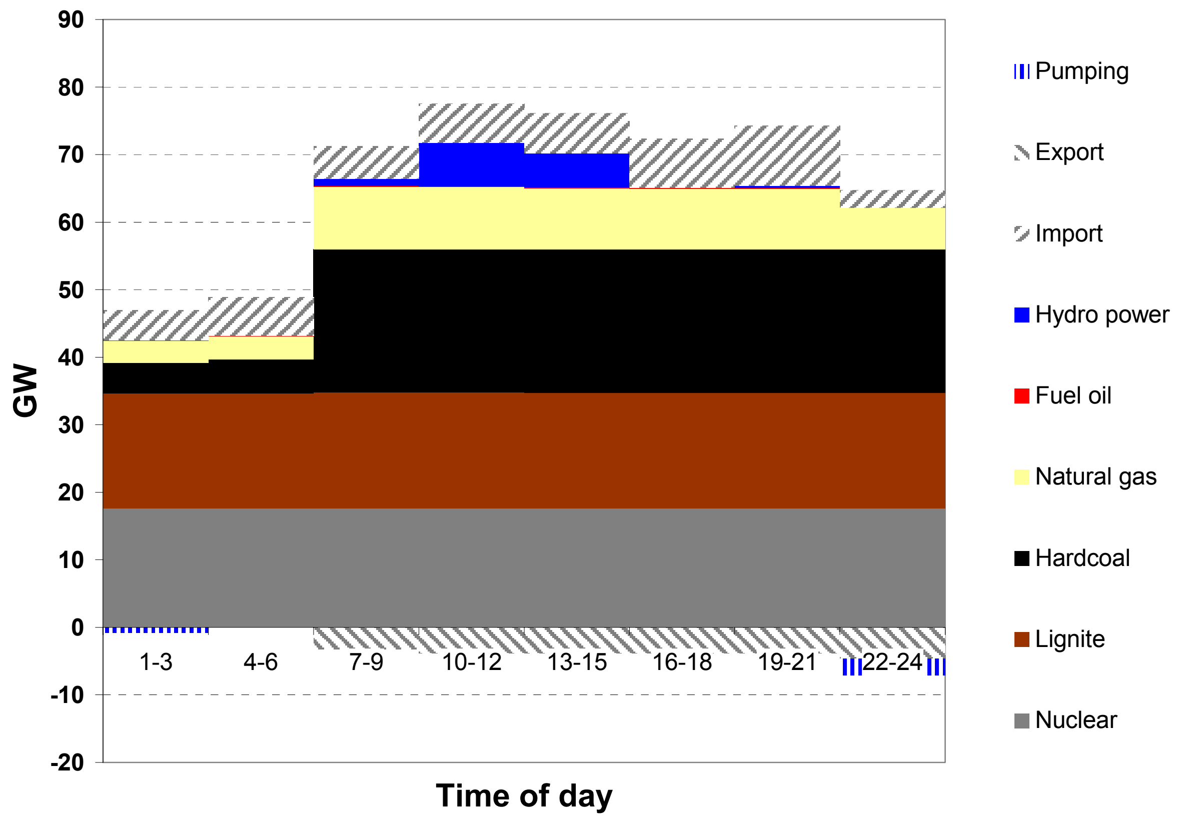
C.2.2 Output

Results are obtained regarding capacities, generation, physical exchange, costs, fuel consumption and carbon emissions.

For each forecast period installed capacity by region and technology is determined from installed capacity in the preceding period as well as from retirement and commissioning in the current period. A minor part of installed capacity is seasonally not available due to planned and unplanned outages.

At no time production may exceed available capacity. In addition, thermal power stations must be started up in order to become ready-to-operate. Figure C-5 contains plants dispatch for a working day in autumn. In the example time resolution was set to eight intervals per day each lasting for three hours. Import and export values have been aggregated for all transmissions lines to neighbouring countries. A region as a whole may import and export at the same time, albeit between two regions electricity can only flow into one direction.

Figure C-5: Sample of hourly dispatch in Germany for a working day in autumn



Also annual production and electricity exchange can be obtained for each region. Marginal cost of electricity production can be used as indicator for regional base load prices. They reflect sustainable-industry prices, accounting for short-run and long-run costs. However, in a situation of excess supply they will approach short-run marginal costs.

Literature

Agnolucci, P. (2006): *The importance and the policy impacts of post-contractual opportunism and competition in the English and Welsh non-fossil fuel obligation*, Energy Policy, Volume 35, Issue 1, January 2007, pp. 475-486.

Battle, C./ Pérez-Arriaga, I. J. (2007): *Design criteria for implementing a capacity mechanism in deregulated electricity markets*, Utilities Policy (2008), pp. 184-193.

BERR - Department for Business, Enterprise and Regulatory Reform (2007): *Special feature – Renewable Energy in 2006*, Press release of June 2007, [URL: http://www.berr.gov.uk/files/file43842.pdf] retrieved at 24/03/2009.

BERR - Department for Business Enterprise & Regulatory Reform (2008): *Atlas of UK Marine Renewable Energy Resources: Atlas Pages - A Strategic* Environmental Assessment Report, March 2008.

BDEW (2000-2008): EEG-Jahresabrechnungen 2000-2008, Bundesverband der Energie und Wasserwirtschaft [URL: http://www.bdew.de/bdew.nsf/id/DE_EEG-Jahresabrechnungen].

BMU (2007): *EEG-Erfahrungsbericht 2007*, Bundesministerium für Umwelt, Naturschutz und Reaktorsicherheit, November 2007.

BMU (2009): *Erneuerbare Energie in Zahlen – Nationale und Internationale Entwicklung,* Bundesministerium für Umwelt, Naturschutz und Reaktorsicherheit, Juni 2009.

California Energy Commission (2008): *Summary of PIER-Funded Wave Energy Research*, March 2008.

Carbon Trust (2006): *Future Marine Energy*, Results of the Marine Energy Challenge: Cost competitiveness and growth of wave and tidal stream energy, January 2006.

CIA (2007): *The World Factbook*, [URL: https://www.cia.gov/library/publications/the-world-factbook/].

CNE (2007): *RÉGIMEN ESPECIAL DE PRODUCCIÓN DE ENERGÍA ELÉCTRICA EN ESPAÑA*, Informe mensual de ventas de energía del régimen especial, 31st July 2007., [URL: www.cne.es/cne/doc/publicaciones/IAP_ventas_RE_julio07.pdf] retrieved at 25/02/2009.

Commission of the European Communities (2001): *COM(2001) 2001/77/EC*, *Directive on Electricity Production from Renewable Energy Sources*, July 2001.

Commission of the European Communities (2008): *COM(2008) 19 final*, *Proposal for a Directive of the European Parliament and of the Council on the Promotion of the Use of Energy from Renewable Sources*, Article 4, January 2008.

Commission of the European Communities (2009): *COM(2009) 192 final*, *The Renewable Energy Progress Report*, April 2009.

Directive 2009/28/EG (2009): *Directive 2009/28/EG of the European Parliament and of the Council of April 23 2009 on the promotion of the use of energy from renewable sources, June 2009.*

DECC - Department of Energy and Climate Change (2008): *Reform of the Renewables Obligation – Government Response to the Statutory Consultation on the Renewables Obligation Order 2009*, [URL: http://www.berr.gov.uk/files/file49342.pdf] retrieved at 24/03/2009.

Dena (2005): *Energiewirtschaftliche Planung für die Netzintegration von Windenergie in Deutschland an Land und Offshore bis zum Jahr 2020*, Februar 2005.

DG Env (2008): *Model-based Analysis of the 2008 EU Policy Package on Climate Change and Renewables.* By Capros, P.; L. Mantzos; V. Papandreou and N.Tasios., June 2008

DIKEOS Abogados (2008): *Photovoltaic in Spain: The first round of inscription for the new feed-in tariff is open!*, Press release of 31st October 2008, [URL: http://www.renewable-energy-industry.com/business/press-releases/newsdetail.php?changeLang=en_GB&newsid=2946], retrieved at 26/02/2009.

Drillisch, J. (2001): *Quotenmodell für regenerative Stromerzeugung*, Oldenbourg 2001.

EEG (2000): *BGBl. Teil I S. 305*, 29/03/2000,
[URL: http://bundesrecht.juris.de/bundesrecht/eeg/gesamt.pdf], retrieved at 18/05/2009.

EEG (2004): *BGBl. Teil I Nr. 40, S.1918 ff.,* 31/07/2004,
[URL: http://217.160.60.235/BGBL/bgbl1f/bgbl104s1918.pdf], retrieved at 18/05/2009.

EEG (2008): *§§ 8-12*, BGB1. Teil I Nr. 49, S. 2074, 31/10/2008,
[URL: http://www.bgblportal.de/BGBL/bgbl1f/bgbl108s2074.pdf].

ESHA: European Small Hydropower Association, Publications, [URL: http://www.esha.be/index.php?id=39].

ETSO - ETSOVista: Electricity Market Data Platform, [URL: http://www.etsovista.org].

EurObserv´ER (2008): *The State of Renewable Energies in Europe*, 8th EurObser´ER Report, Edition 2008.

Eurostat (2008): European Statistics, [URL: http://epp.eurostat.ec.europa.eu/portal/page/portal/eurostat/home/], retrieved at 12/06/2009.

EWI/Prognos (2007): *Energieszenarien für den Energiegipfel 2007.* Studie im Auftrag des BMWi

Feed-In Cooperation (2007): International Feed-In Cooperation, [URL: http://www.feed-in-cooperation.org/content/view/24/36/].

Geyer, M. et al. (2002): *Parabolrinnensysteme, in Solarthermische Kraftwerke -- Technologie und Perspektiven*, FVS Themen 2002.

Horlacher, H.-B. (2003): *Globale Potenziale der Wasserkraft*, Wissenschaftlicher Beirat der Bundesregierung, Berlin, Heidelberg 2003.

IE Leipzig (2006): *Biomassepellets im Kraftwerkssektor – Eine Marktanalyse (unveröffentlicht)*.

IEA - International Energy Agency (2000): *Experience Curves for Energy Technology Policy*, 2000.

IEA - International Energy Agency (2008): *Electricity Information*, 2008.

IEA - International Energy Agency - BioenergyTask 32: Biomass Combustion and Co-firing (2008): [URL: http://www.ieabcc.nl].

Jamasb, T./ Köhler, J. (2007): *Learning Curves for Energy Technology: A Critical Assessment*, Cambridge Working Papers in Economics 0752, Faculty of Economics, University of Cambridge, October 2007.

Junginger, M./ Faaij, A./ Turkenburg, W.C. (2005): *Global experience curves for wind farms*, Energy Policy 33 (2005), pp. 133-150.

Kahouli-Brahmi, S. (2008): *Technological learning in energy-environment-economy modelling: A survey*, Energy Policy 36 (2008), pp.138-162.

Kaltschmitt, M./ Streicher, W./ Wiese, A. (2006): *Erneuerbare Energien: Systemtechnik, Wirtschaftlichkeit, Umweltaspekte*, Springer, Berlin Heidelberg (2006)

Karytsas, C./ Mendrinos, D. (2006): *The LOW-BIN project of DG-TREN (efficient low temperature geothermal binary power) aiming in improving EGS exploitation costs*, 2006.

Lauber, V. (2003): *REFIT and RPS: options for a harmonised Community framework*, Energy Policy 32 (2004), pp. 1405-1414.

Menanteau, P./ Finon, D./ Marie-Laure Lamy (2003): *Prices versus quantities: choosing policies for promoting the development of renewable energy*, Energy Policy 31 (2003), pp. 799-812.

Mendoça, M. (2007): *Feed-in Tariffs: Accelerating the Deployment of Renewable Energy*, Gateshead, UK 2007.

Myslil, V./ Stibitz, M./ Frydrych, V. (2005): *Geothermal Energy Potential of Czech Republic*, Proceedings World Geothermal Congress 2005, Antalya, April 2005.

Nabe, C. (2006): *Effiziente Integration erneuerbarer Energien in den deutschen Elektrizitätsmarkt*, Dissertation, TU Berlin [URL: http://deposit.ddb.de/cgi-bin/dokserv?idn=979002052].

Neij, L./ Andersen, P.D./ Durstewitz, M./ Helby, P./ Hoppe-Kilpper, M./ Morthorst, P.E. (2003): *Experience Curves: A Tool for Energy Policy Assessment*, Environmental and Energy Systems Studies, Lund 2003.

NIRO - The Renewables Obligation Order 2005 (Northern Ireland) - Statutory Rule 2005 No. 38 (2005): *[URL: http://www.opsi.gov.uk/Sr/sr2005/20050038.htm]* retrieved at 24/03/2009.

Nitsch, J. (2007): *Lead Study Renewable Energy (Summary): Update and reassessment of the "Strategy to increase the use of renewable energies" up until the years 2020 and 2030, plus an outlook to 2050,* February 2007.

OFGEM - Office of the Gas and Electricity Markets (2008): *The Renewables Obligation Buy-Out Price and Mutualisation Ceiling*, Press release of January 28th 2008, [URL: http://www.ofgem.gov.uk/sustainability/environment/renewablobl/Documents1/Buy-out_and_mutualisation_press_release1.pdf] retrieved at 24/03/2009.

OFGEM - Office of the Gas and Electricity Markets (2009): *The Renewables Obligation Buy-Out Price and Mutualisation Ceiling*, Press release of February 9th 2009, [URL: http://www.ofgem.gov.uk/Sustainability/Environment/RenewablObl/Documents1/Press%20Release%20buy%20out.pdf] retrieved at 24/03/2009.

OFGEM – Office of the Gas and Electricity Markets (2009): *Renewables Obligation Annual Report 2007-2008*, [URL: http://www.ofgem.gov.uk/Pages/MoreInformation.aspx?file=Annual%20report%202007-08_Version%204.pdf&refer=Sustainability/Environment/RenewablObl] retrieved at 26/02/2009.

RO (2006) - The Renewables Obligation Order 2006 (No. 1004) (2006): [URL: http://www.statutelaw.gov.uk/legResults.aspx?LegType=All+Legislation&Year=2006&number=1004&searchEnacted=0&extentMatchOnly=0&confersPower=0&blanketAmendment=0&sortAlpha=0&TYPE=QS&PageNumber=1&NavFrom=0&activeTextDocId=2494094] retrieved at 24/03/2009.

RO (2009) – The Renewables Obligation Order 2009 (No.785) (2009): [URL: www.berr.gov.uk/files/file49197.pdf].

Royal Decree RD 1578/2008 of Saturday, 28th of September 2008, BOE núm. 234, Madrid.

Sawin, J.L. (2004): National Policy Instruments: Policy Lessons for the Advancement & Diffusion of Renewable Energy Technologies Around the World, January 2004.

Schaeffer, G.J./ Seebregts, A.J./ Beurskens, L.W.M./ de Moor, H.H.C./ Alsema, E.A./ van Sark, W.G.J.H.M./ Durstewitz, M./ Perrin, M./ Boulanger, P./ Laukamp, H./ Zuccaro, C. (2004): *Learning from the sun; Analysis of the use of experience curves for* *energy policy purpose: the case of photovoltaic power*, Final report of the Photex project, Report ECN-C-4-035, August 2004.

Scottisch Government (2006): *Progress on wave power development,* Press Release, [URL: http://www.scotland.gov.uk/News/Releases/2006/08/30103302].

Solarbuzz (2008): Portal to the World of Solar Energy, [URL: http://www.solarbuzz.com/].

Springmann, J.P. (2005): *Förderung erneuerbarer Energieträger in der Stromerzeugung: Ein Vergleich ordnungspolitischer Instrumente,* Deutscher Universitäts-Verlag, Wiesbaden, Juni 2005.

Staffhorst, M. (2006): *The Way to Competitiveness of PV - An Experience Curve and Break-even Analysis*, Renewable Energies and Energie Efficiency, Vol. 2, November 2006.

Stoft (2002): *Power System Economics: Designing Markets for Electricity,* 1st Edition, Wiley & Sons, July 2002.

Sustainable Development Commission (2007): *Tidal Power in the UK*, Research Report 5 – UK case studies, October 2007.

SEI - Sustainable Energy Ireland (2006): *Tidal & Current energy resources in Ireland*, 2006.

StromEinspG (1990): *BGBl. Teil I S. 2633*, 07/12/1990, [URL: http://www.umwelt-online.de/recht/energie/einspei.htm].

Swedish Energy Agency (2008): *The electricity certificate system,* 2008, [URL: http://www.swedishenergyagency.se/web/stemex01eng.nsf/ebb380ecedee7d1bc12570a4002d686d/7d45e23c528160b9c125728b00470d40/F_ART_RT00/0.84!OpenElement&FieldElemFormat=jpg:] retrieved at 03/03/2009.

Swedish Energy Agency (2009): *Policy making and Energy Scenarios,22/10 2009,* [URL: http://www.nog.se/files/Swedish%20Energy%20Agency.pdf] retrieved at 20/11/2009.

Tichler, R./ Kollmann, A. (2005): *Volkswirtschaftliche Aspekte der Nutzung von Kleinwasserkraft in Österreich*, Energie Institut der Johann Kepler Universität Linz, August 2005.

Trieb, F. (2005): *Potential and economy of renewable energies in MENA-Results from a study for German BMU*, Concentrating Solar Power for the Mediterranean Region, BMU, 2005.

UCTE - Union for the Co-ordination of Transmission of Electricity: European Energy Statistics, [URL: http://www.ucte.org].

UCTE - Union for the Co-ordination of Transmission of Electricity (2008): *UCTE Transmission Development Plan,* Edition 2008.

van der Linden, N.H./ Uyterlinde, M.A./ Vrolijk, C./ Nilsson, L.J./ Khan, J./ Astrand, K./ Ericsson, K./ Wiser, R. (2005): *Review of International Experience with Renewable Energy Obligation Support Mechanisms*, May 2005.

Weitzman, M. (1974): *Prices vs. Quantities*, The Review of Economic Studies, Vol. 41, (No. 4), pp. 477-491.

Wissen, R./Nicolosi, M. (2008): *Ist der Merit-Order-Effekt der erneuerbaren Energien richtig bewertet?* In: Energiewirtschaftliche Tagesfragen, (58) 1/2, S. 110-115.

Wissen, R. (Forthcomming): Dissertation, University of Cologne.

Institute of Energy Economics
at the University of Cologne

Alte Wagenfabrik
Vogelsanger Straße 321
50827 Köln

Tel.: +49 (0)221 277 29-100
Fax: +49 (0)221 277 29-400