EWEA
THE EUROPEAN WIND ENERGY ASSOCIATION

Pure Power

Wind energy targets for 2020 and 2030

A report by the European Wind Energy Association - 2011

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Foreword

At a time when fossil fuel prices are spiralling, the threat of irreversible climate change is on everyone's minds and serious questions are being raised over the cost and safety of nuclear, wind energy is considered more widely than ever a key part of the answer.

This updated edition of *Pure Power* once again shows the huge contribution wind energy already makes – and will increasingly make – to meeting Europe's electricity demand and strengthening its economy, and to avoiding polluting and costly fuel and carbon.

Wind energy currently meets 5.3% of the EU's electricity consumption from an installed capacity of 84.3 GW.

The European Wind Energy Association's scenarios show that wind energy in 2020 should meet 15.7% of EU electricity demand from 230 GW, and by 2030, 28.5% from 400 GW. Indeed, EWEA believes wind energy can provide half of Europe's power by 2050, with the remainder from other renewable sources.

To ensure the continued buoyancy of the wind energy sector and the path to 100% renewables in 2050, EU renewables legislation is needed now for the period after 2020. This should follow the successful legislation so far by setting an ambitious, binding renewables target for 2030. Such a target would take the EU from 19% renewable electricity today, to an expected 34% in 2020, and to 100% renewable electricity by 2050.

In addition to post-2020 legislation, investment is urgently needed in electricity infrastructure in order to transport large amounts of wind energy from where it is produced to where it is consumed and to create a single electricity market in the EU. Issues such as funding for research must also be tackled.

As wind energy grows year on year, so do its benefits for the EU. Jobs are created, a world-leading European industry is strengthened, carbon emissions and fuel imports are avoided. *Pure Power* is a detailed and encouraging picture of how the sector is likely to evolve and the positive impact it will have.

We wish you informative reading of what is, we hope, an essential reference book for anyone interested in the world of wind energy.

Christian Kjaer, Chief Executive Officer
European Wind Energy Association

Arthouros Zervos, President
European Wind Energy Association

Contents

Photo: Eon

1 NATIONAL WIND ENERGY SCENARIOS FOR 2020

The 2009 Renewable Energy Directive[1] requires all Member States to submit National Renewable Energy Action Plans (NREAPs) to the European Commission by 30 June 2010. By 4 January 2011, all 27 NREAPs had been submitted.

The NREAPs, which follow a template prepared by the European Commission, indicate estimates of gross final energy consumption of all types of energy (both renewable and non-renewable), for each year between 2010 and 2020. They also contain the expected contributions of the different types of energy for the three energy sectors: heating/cooling, electricity and transport. Furthermore they indicate a target for each renewable energy technology, including both onshore and offshore wind energy, and specify both total installed capacity (MW) and electricity production (MWh), for each year.

Adding up the 27 NREAPs, with 213 GW of installed capacity, wind power is forecast to produce 495 TWh of electricity in 2020. Taking the 27 NREAPs' additional energy efficiency scenario, EU gross electricity demand is scheduled to grow to 3,529 TWh in 2020. Wind energy would, therefore, meet 14% of the EU's demand.

The European Commission's reference scenario, using the PRIMES energy model by the E3M Lab at the National Technical University of Athens in 2009, assumes 222 GW of installed wind capacity in 2020 producing 525 TWh of electricity. The same model estimates that the EU's total electricity demand in 2020 will be 3,690 TWh. Hence, wind energy would meet 14.2% of total consumption, according to the European Commission.

In addition to the NREAPs and the European Commission's reference scenario, during 2009 EWEA analysed the wind energy markets in the 27 EU Member States in consultation with its member companies and national wind energy associations. This chapter provides the results of this analysis in the form of two 2020 EWEA scenarios for each national market: a "baseline" scenario and a "high" scenario. The "baseline" scenario is based on EWEA's traditionally conservative approach to setting targets for wind energy. It assumes a total installed capacity of wind power in the EU of 230 GW, producing 581 TWh of electricity, meeting 15.7% of electricity consumption.

EWEA's "high" scenario acknowledges that wind power – as the most affordable of the renewable electricity technologies in most EU Member States – could meet a higher share than the 14% of electricity demand by 2020 indicated by the NREAPs or the 14.2% assumed by the European Commission in its PRIMES model, if EU policy certainty beyond 2020 is achieved before 2014, additional R&D efforts are made, and if the necessary infrastructure investments and power market reforms are undertaken. Under such conditions, EWEA assumes in its "high scenario" that total installed wind power capacity will reach 265 GW by 2020, producing 682 TWh of electricity, meeting 18.4% of electricity consumption.

[1] Directive 2009/28/EC of the European Parliament and of the Council of 23 April 2009 on the promotion of the use of energy from renewable sources and amending and subsequently repealing Directives 2001/77/EC and 2003/30/EC.

AUSTRIA
MW
2010: **1,011 MW**
2020 (B/H): **3,500/4,000 MW**
Average annual 2011-2020: **249/299 MW**

TWh
2010 TWh: **2.1 (3%)**
2020 TWh (B/H): **7.7/8.6 TWh (10.3/11.8%)**

BELGIUM
MW
2010: **911 MW**
2020 (B/H): **3,900/4,500 MW**
Average annual 2011-2020: **299/359 MW**

TWh
2010 TWh: **2.2 (2.3%)**
2020 TWh (B/H): **10.8/12.9 TWh (10.2/12.3%)**

BULGARIA
MW
2010: **375 MW**
2020 (B/H): **3,000/3,500 MW**
Average annual 2011-2020: **263/313 MW**

TWh
2010 TWh: **0.8 (2%)**
2020 TWh (B/H): **7/8.2 TWh (18.4/21.5%)**

CYPRUS
MW
2010: **82 MW**
2020 (B/H): **300/500 MW**
Average annual 2011-2020: **22/42 MW**

TWh
2010 TWh: **0.2 (n/a)**
2020 TWh (B/H): **0.7/1.2 TWh (12.28/20.46%)**

CZECH REPUBLIC
MW
2010: **215 MW**
2020 (B/H): **1,600/1,800 MW**
Average annual 2011-2020: **139/159 MW**

TWh
2010 TWh: **0.5 (0.6%)**
2020 TWh (B/H): **3.5/3.9 TWh (4.1/4.6%)**

DENMARK
MW
2010: **3,752 MW**
2020 (B/H): **6,000/6,500 MW**
Average annual 2011-2020: **225/275 MW**

TWh
2010 TWh: **9.7 (25.6%)**
2020 TWh (B/H): **14.7/18.3 TWh (37.9/47.4%)**

ESTONIA
MW
2010: **149 MW**
2020 (B/H): **500/600 MW**
Average annual 2011-2020: **35/45 MW**

TWh
2010 TWh: **0.3 (3.5%)**
2020 TWh (B/H): **1.2/1.6 TWh (11.3/14.8%)**

FINLAND
MW
2010: **197 MW**
2020 (B/H): **1,900/3,000 MW**
Average annual 2011-2020: **170/280 MW**

TWh
2010 TWh: **0.5 (0.5%)**
2020 TWh (B/H): **5.1/8.6 TWh (5.1/8.7%)**

FRANCE
MW
2010: **5,660 MW**
2020 (B/H): **23,000/26,000 MW**
Average annual 2011-2020: **1,734/2,034 MW**

TWh
2010 TWh: **11.9 (2.3%)**
2020 TWh (B/H): **60.5/70.4 TWh (10.8/12.5%)**

GERMANY
MW
2010: **27,214 MW**
2020 (B/H): **49,000/52,000 MW**
Average annual 2011-2020: **2,179/2,479 MW**

TWh
2010 TWh: **49.5 (8%)**
2020 TWh (B/H): **106.3/115.9 TWh (16.6/18.1%)**

GREECE
MW
2010: **1,208 MW**
2020 (B/H): **6,500/8,500 MW**
Average annual 2011-2020: **529/729 MW**

TWh
2010 TWh: **3 (4.3%)**
2020 TWh (B/H): **17.4/23 TWh (22.6/29.5%)**

HUNGARY
MW
2010: **295 MW**
2020 (B/H): **900/1,200 MW**
Average annual 2011-2020: **60/90 MW**

TWh
2010 TWh: **0.6 (1.4%)**
2020 TWh (B/H): **2.1/2.8 TWh (4.3/5.8%)**

IRELAND
MW
2010: **1,428 MW**
2020 (B/H): **6,000/7,000 MW**
Average annual 2011-2020: **457/557 MW**

TWh
2010 TWh: **3.9 (12.9%)**
2020 TWh (B/H): **17.5/20.4 TWh (51.9/60.4%)**

ITALY
MW
2010: **5,797 MW**
2020 (B/H): **15,500/18,000 MW**
Average annual 2011-2020: **970/1,220 MW**

TWh
2010 TWh: **11.5 (3.2%)**
2020 TWh (B/H): **34.3/40.8 TWh (8.7/10.3%)**

LATVIA
MW
2010: **31 MW**
2020 (B/H): **200/300 MW**
Average annual 2011-2020: **17/27 MW**

TWh
2010 TWh: **0.1 (0.8%)**
2020 TWh (B/H): **0.5/0.8 TWh (5.2/9.2%)**

LITHUANIA
MW
2010: **154 MW**
2020 (B/H): **1,000/1,100 MW**
Average annual 2011-2020: **85/95 MW**

TWh
2010 TWh: **0.3 (2.7%)**
2020 TWh (B/H): **2.4/2.7 TWh (17.7/20.5%)**

LUXEMBOURG
MW
2010: **42 MW**
2020 (B/H): **300/700 MW**
Average annual 2011-2020: **26/66 MW**

TWh
2010 TWh: **0.1 (1.1%)**
2020 TWh (B/H): **0.6/1.5 TWh (7.2/16.9%)**

MALTA
MW
2010: **0 MW**
2020 (B/H): **100/200 MW**
Average annual 2011-2020: **10/20 MW**

TWh
2010 TWh: **0 (0%)**
2020 TWh (B/H): **0.2/0.4 TWh (8.4/16.8%)**

NETHERLANDS
MW
2010: **2,237 MW**
2020 (B/H): **9,500/11,400 MW**
Average annual 2011-2020: **726/916 MW**

TWh
2010 TWh: **5 (4.1%)**
2020 TWh (B/H): **26.93/34.0 TWh (19.9/25.1%)**

POLAND
MW
2010: **1,107 MW**
2020 (B/H): **10,500/12,500 MW**
Average annual 2011-2020: **939/1,139 MW**

TWh
2010 TWh: **2.4 (1.5%)**
2020 TWh (B/H): **25.3/30.0 TWh (13.8/16.3%)**

PORTUGAL
MW
2010: **3,898 MW**
2020 (B/H): **7,500/9,000 MW**
Average annual 2011-2020: **360/510 MW**

TWh
2010 TWh: **8.5 (15.4%)**
2020 TWh (B/H): **16.8/20.2 TWh (28.1/33.8%)**

ROMANIA
MW
2010: **462 MW**
2020 (B/H): **3,000/3,500 MW**
Average annual 2011-2020: **254/304 MW**

TWh
2010 TWh: **1 (1.6%)**
2020 TWh (B/H): **7.0/8.2 TWh (10.1/11.9%)**

SLOVAKIA
MW
2010: **3 MW**
2020 (B/H): **800/1,000 MW**
Average annual 2011-2020: **80/100 MW**

TWh
2010 TWh: **0 (0%)**
2020 TWh (B/H): **1.8/2.3 TWh (4.7/5.9%)**

EWEA Baseline scenario for the EU[1]

For the EU as a whole, the "baseline" scenario requires installed capacity to increase from 84.3 GW at end 2010 to 230 GW in 2020. That would require an average annual increase in capacity of 14.6 GW between 2011 and 2020. Wind energy production would increase from 181.7 TWh (2010) to 581 TWh (2020) and wind energy's share of total electricity demand would increase from 5.3% in 2010 to 15.7% in 2020.

EWEA High scenario for the EU[1]

For the EU as a whole, the "high" scenario requires installed capacity to increase from 84.3 GW at end 2010 to 265 GW in 2020. That would require an average annual increase in capacity of 18.1 GW between 2011 and 2020. Wind energy production would increase from 181.7 TWh (2010) to 680 TWh (2020) and wind energy's share of total electricity demand would increase from 5.3% in 2010 to 18.4% in 2020.

This overview illustrates, for each of the 27 Member States a) current installed wind capacity (MW) and electricity production in a normal wind year (TWh), b) EWEA's "baseline" and "high" targets for both capacity and electricity production and the corresponding share of national demand (for 2020 this is based on the European Commission's PRIMES model) – c) the amount of average annual capacity increases needed to meet the 2020 "baseline" and "high" targets. The map's colour code also refers to average annual capacity increases needed to meet each Member States' targets.

[1] Please note that the calculation of total EU electricity production in this chapter differs slightly from the EU totals calculated in subsequent chapters of this report, due to a different methodology. For more details, including a breakdown of the national scenarios on onshore and offshore wind, see Table 1.1

SLOVENIA

MW
2010: **0 MW**
2020 (B/H): **500/700 MW**
Average annual 2011-2020: **50/70 MW**

TWh
2010 TWh: **0 (0%)**
2020 TWh (B/H): **1.1/1.6 TWh (6.3/8.8%)**

SWEDEN

MW
2010: **2,163 MW**
2020 (B/H): **9,000/11,000 MW**
Average annual 2011-2020: **684/884 MW**

TWh
2010 TWh: **4.8 (3.2%)**
2020 TWh (B/H): **23.9/28.9 TWh (15.1/18.2%)**

EU-27

MW
2010: **84,324 MW**
2020 (B/H): **230,000/265,000 MW**
Average annual 2011-2020: **14,568/18,068 MW**

TWh
2010 TWh: **181.7 (5.3%)**
2020 TWh (B/H): **581/680 TWh (15.7/18.4%)**

SPAIN

MW
2010: **20,676 MW**
2020 (B/H): **40,000/42,500 MW**
Average annual 2011-2020: **1,932/2,182 MW**

TWh
2010 TWh: **45.4 (15.0%)**
2020 TWh (B/H): **94.1/100.8 TWh (26.8/28.8%)**

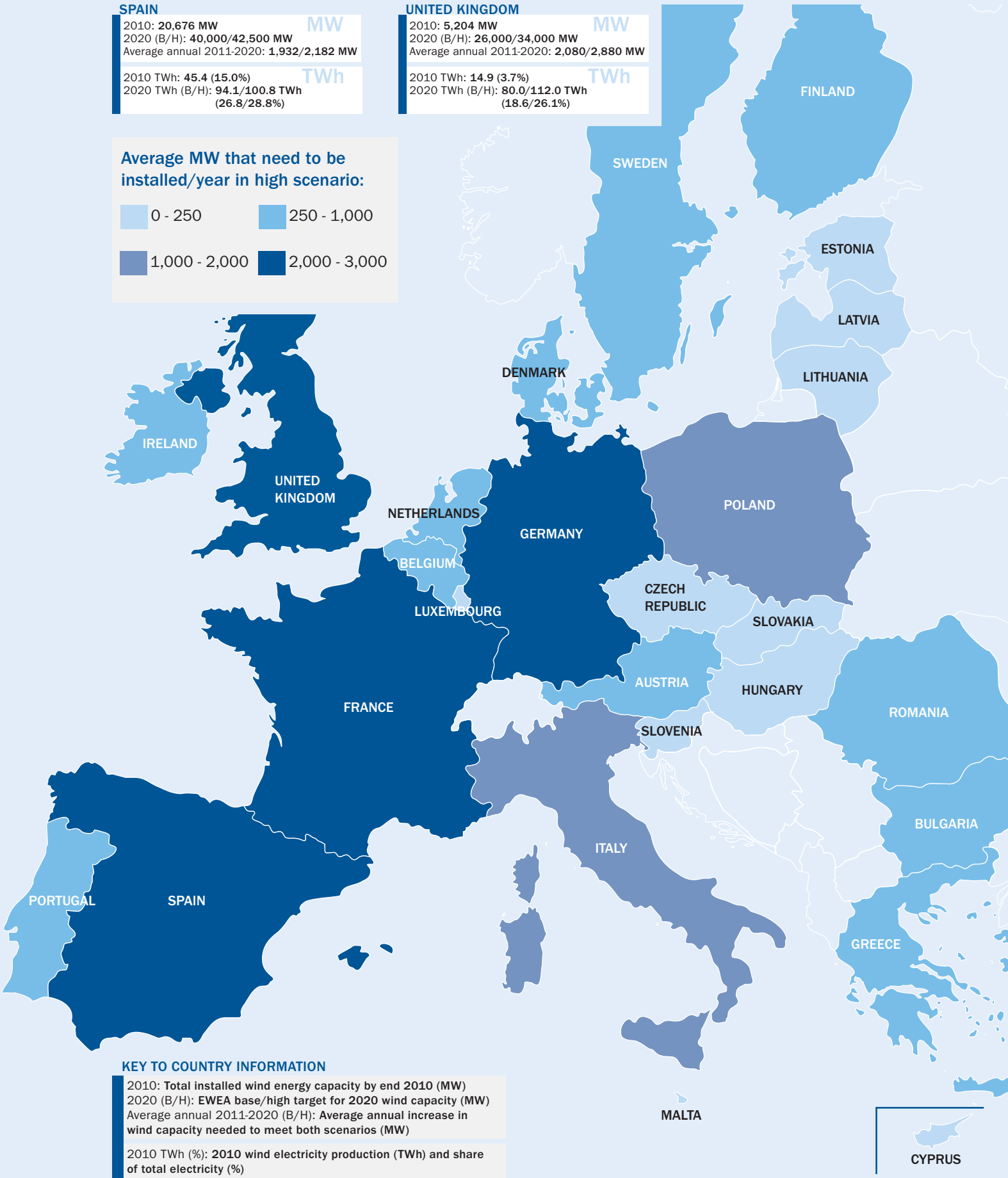
UNITED KINGDOM

MW
2010: **5,204 MW**
2020 (B/H): **26,000/34,000 MW**
Average annual 2011-2020: **2,080/2,880 MW**

TWh
2010 TWh: **14.9 (3.7%)**
2020 TWh (B/H): **80.0/112.0 TWh (18.6/26.1%)**

Average MW that need to be installed/year in high scenario:

- 0 - 250
- 250 - 1,000
- 1,000 - 2,000
- 2,000 - 3,000



KEY TO COUNTRY INFORMATION

2010: **Total installed wind energy capacity by end 2010 (MW)**
2020 (B/H): **EWEA base/high target for 2020 wind capacity (MW)**
Average annual 2011-2020 (B/H): **Average annual increase in wind capacity needed to meet both scenarios (MW)**

2010 TWh (%): **2010 wind electricity production (TWh) and share of total electricity (%)**
2020 TWh (B/H): **base/high target for electricity production from wind in 2020 (TWh) and as share of total 2020 electricity consumption (%)**

TABLE 1.1

Country	MW installed end 2010			MW installed end 2020: Baseline			MW installed end 2020: High			Average annual MW Baseline (2011-2020)	Average annual MW High (2011-2020)
	Onshore	Offshore	Total	Onshore	Offshore	Total	Onshore	Offshore	Total		
Austria	1,011	0	1,011	3,500	0	3,500	4,000	0	4,000	249	299
Belgium	716	195	911	2,100	1,800	3,900	2,500	2,000	4,500	299	359
Bulgaria	375	0	375	3,000	0	3,000	3,500	0	3,500	263	313
Cyprus	82	0	82	300	0	300	500	0	500	22	42
Czech Republic	215	0	215	1,600	0	1,600	1,800	0	1,800	139	159
Denmark	2,944	854	3,798	3,700	2,300	6,000	4,000	2,500	6,500	220	270
Estonia	149	0	149	500	0	500	500	100	600	35	45
Finland	171	26	197	1,500	400	1,900	2,000	1,000	3,000	170	280
France	5,660	0	5,660	19,000	4,000	23,000	20,000	6,000	26,000	1,734	2,034
Germany	27,122	92	27,214	41,000	8,000	49,000	42,000	10,000	52,000	2,179	2,479
Greece	1,208	0	1,208	6,500	0	6,500	8,300	200	8,500	529	729
Hungary	295	0	295	900	0	900	1,200	0	1,200	60	90
Ireland	1,403	25	1,428	5,000	1,000	6,000	6,000	1,000	7,000	457	557
Italy	5,797	0	5,797	15,000	500	15,500	17,000	1,000	18,000	970	1,220
Latvia	31	0	31	200	0	200	200	100	300	17	27
Lithuania	154	0	154	1,000	0	1,000	1,000	100	1,100	85	95
Luxembourg	42	0	42	300	0	300	700	0	700	26	66
Malta	0	0	0	100	0	100	200	0	200	10	20
Netherlands	1,998	247	2,245	5,000	4,500	9,500	5,400	6,000	11,400	726	916
Poland	1,107	0	1,107	10,000	500	10,500	12,000	500	12,500	939	1,139
Portugal	3,898	0	3,898	7,500	0	7,500	9,000	0	9,000	360	510
Romania	462	0	462	3,000	0	3,000	3,500	0	3,500	254	304
Slovakia	3	0	3	800	0	800	1,000	0	1,000	80	100
Slovenia	0.03	0	0.03	500	0	500	700	0	700	50	70
Spain	20,676	0	20,676	39,000	1,000	40,000	41,000	1,500	42,500	1,932	2,182
Sweden	1,999	164	2,163	6,000	3,000	9,000	8,000	3,000	11,000	684	884
UK	3,863	1,341	5,204	13,000	13,000	26,000	14,000	20,000	34,000	2,080	2,880
EU-27	81,380	2,944	84,324	190,000	40,000	230,000	210,000	55,000	265,000	14,568	18,068

Country	Electricity production end 2010 (TWh)			Electricity production end 2020: Baseline			Electricity production end 2020: High			Final electricity consumption 2008 (TWh)	Final electricity consumption 2020 (TWh)	Wind share 2010	Wind share 2020 Baseline	Wind share 2020 High
	Onshore	Offshore	Total	Onshore	Offshore	Total	Onshore	Offshore	Total					
Austria	2.0	0.0	2.0	7.5	0.0	7.5	8.6	0.0	8.6	72	72.9	2.8%	10.3%	11.8%
Belgium	1.5	0.7	2.2	4.7	6.1	10.8	5.6	7.3	12.9	95.5	105.3	2.3%	10.2%	12.3%
Bulgaria	0.8	0.0	0.8	7.0	0.0	7.0	8.2	0.0	8.2	39.7	38.2	2.1%	18.4%	21.5%
Cyprus	0.2	0.0	0.2	0.7	0.0	0.7	1.2	0.0	1.2	n/a	6.1	n/a	12.3%	20.5%
Czech Republic	0.5	0.0	0.5	3.5	0.0	3.5	3.9	0.0	3.9	72	85.0	0.6%	4.1%	4.6%
Denmark	6.6	3.1	9.7	8.5	6.2	14.7	9.2	9.1	18.3	37.8	38.7	25.6%	37.9%	47.4%
Estonia	0.3	0.0	0.3	1.2	0.0	1.2	1.2	0.4	1.6	9.6	10.6	3.5%	11.3%	14.8%
Finland	0.4	0.1	0.5	3.6	1.4	5.1	4.9	3.7	8.6	90.2	98.8	0.5%	5.1%	8.7%
France	11.9	0.0	11.9	45.8	14.7	60.5	48.3	22.1	70.4	528.0	562.7	2.3%	10.8%	12.5%
Germany	49.2	0.3	49.5	77.1	29.2	106.3	79.2	36.8	115.9	617.1	639.6	8%	16.6%	18.1%
Greece	3.0	0.0	3.0	17.4	0.0	17.4	22.3	0.7	23.0	69.4	78.1	4.4%	22.3%	29.5%
Hungary	0.6	0.0	0.6	2.1	0.0	2.1	2.8	0.0	2.8	43.9	48.0	1.5%	4.3%	5.8%
Ireland	3.8	0.1	3.9	13.9	3.6	17.5	16.7	3.7	20.4	30.1	33.7	12.9%	51.9%	60.5%
Italy	11.6	0.0	11.6	32.5	1.8	34.4	37.1	3.7	40.8	359.2	394.9	3.2%	8.7%	10.3%
Latvia	0.1	0.0	0.1	0.5	0.0	0.5	0.5	0.4	0.8	7.8	9.1	0.9%	5.2%	9.2%
Lithuania	0.4	0.0	0.4	2.4	0.0	2.4	2.4	0.4	2.7	13.0	13.3	2.7%	17.7%	20.5%
Luxembourg	0.1	0.0	0.1	0.6	0.0	0.6	1.5	0.0	1.5	7.9	8.7	1.1%	7.2%	16.9%
Malta	0.0	0.0	0.0	0.2	0.0	0.2	0.4	0.0	0.4	n/a	2.3	n/a	8.4%	16.8%
Netherlands	4.2	0.9	5.1	11.0	15.9	26.9	11.9	22.1	34.0	123.5	135.4	4.1%	19.9%	25.1%
Poland	2.4	0.0	2.4	23.5	1.8	25.3	28.2	1.8	30.0	155.0	183.9	1.6%	13.8%	16.3%
Portugal	8.6	0.0	8.6	16.8	0.0	16.8	20.2	0.0	20.2	55.4	59.7	15.5%	28.1%	33.8%
Romania	1.0	0.0	1.0	7.0	0.0	7.0	8.2	0.0	8.2	60.7	69.2	1.7%	10.1%	11.9%
Slovakia	0.0	0.0	0.0	1.8	0.0	1.8	2.3	0.0	2.3	29.5	38.8	0%	4.7%	5.9%
Slovenia	0.0	0.0	0.0	1.1	0.0	1.1	1.6	0.0	1.6	14.8	18.1	0%	6.3%	8.8%
Spain	45.5	0.0	45.5	90.4	3.7	94.1	95.3	5.5	100.8	302.7	350.4	15%	26.9%	28.8%
Sweden	4.2	0.6	4.8	13.3	10.6	23.9	17.9	11.0	28.9	148.1	158.6	3.2%	15.1%	18.2%
UK	10.2	4.8	15.0	35.8	44.2	80.0	38.6	73.5	112.0	400.4	429.4	3.7%	18.6%	26.1%
EU-27	171.1	10.6	181.7	432.7	148.2	581.0	478.3	203.8	682.1	3,390.7	3,689.5	5.3%	15.7%	18.4%

Photo: Enercon

2 THE CURRENT STATUS OF WIND POWER

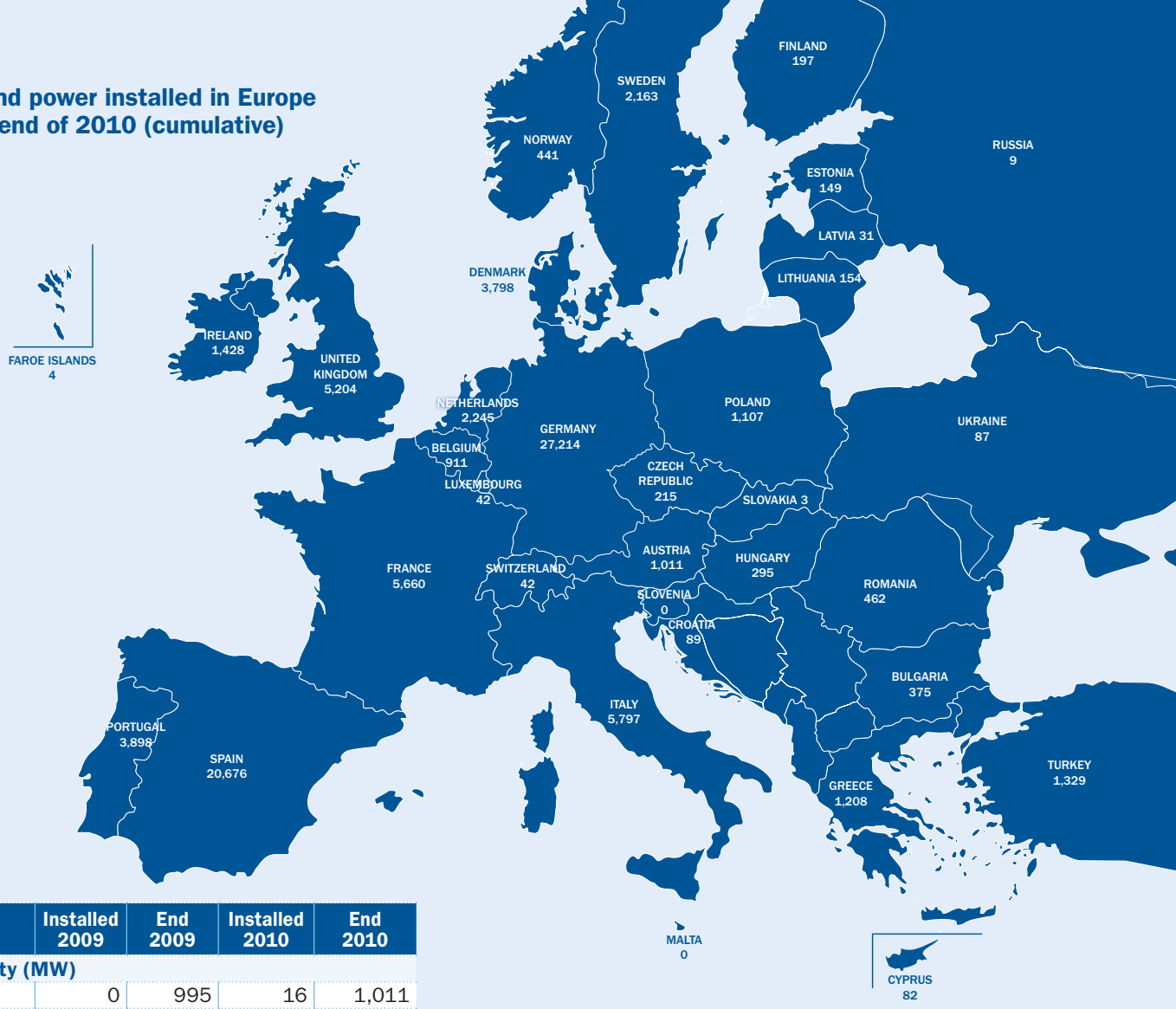
a. Global cumulative and annual installations to 2010

b. Wind energy and the EU Member States

c. The growth of offshore wind power

d. Wind power capacity compared to country size and population

Wind power installed in Europe by end of 2010 (cumulative)



	Installed 2009	End 2009	Installed 2010	End 2010
EU Capacity (MW)				
Austria	0	995	16	1,011
Belgium	149	563	350	911
Bulgaria	57	177	198	375
Cyprus	0	0	82	82
Czech Republic	44	192	23	215
Denmark	334	3,465	364	3,798
Estonia	64	142	7	149
Finland	4	147	52	197
France	1,088	4,574	1,086	5,660
Germany	1,917	25,777	1,493	27,214
Greece	102	1,087	123	1,208
Hungary	74	201	94	295
Ireland	233	1,310	118	1,428
Italy	1,114	4,849	948	5,797
Latvia	2	28	2	31
Lithuania	37	91	63	154
Luxembourg	0	35	7	42
Malta	0	0	0	0
Netherlands	39	2,215	32	2,245
Poland	180	725	382	1,107
Portugal	673	3,535	363	3,898
Romania	3	14	448	462
Slovakia	0	3	0	3
Slovenia	0.02	0,03	0	0,03
Spain	2,459	19,160	1,516	20,676
Sweden	512	1,560	604	2,163
United Kingdom	1,271	4,245	962	5,204
Total EU-27	**10,499**	**75,103**	**9,332**	**84,324**
Total EU-15	**10,038**	**73,530**	**8,033**	**81,452**
Total EU-12	**461**	**1,574**	**1,298**	**2,872**
Of which offshore and near shore	582	2,061	883	2,944

Note: Due to differences in methodology, some figures in this table may differ from figures communicated by national wind energy associations

European Union: 84,324 MW
Candidate Countries: 1,418 MW
EFTA: 478 MW
Total Europe: 86,321 MW

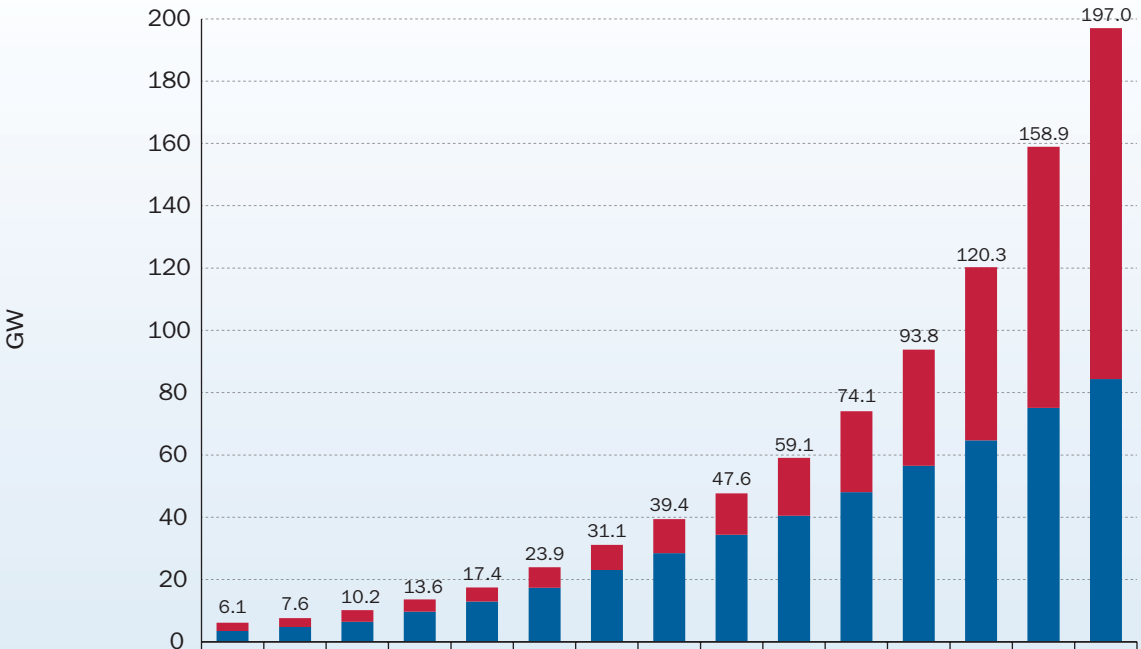
	Installed 2009	End 2009	Installed 2010	End 2010
Candidate Countries (MW)				
Croatia	10	28	61	89
FYROM*	0	0	0	0
Turkey	343	801	528	1,329
Total	**353**	**829**	**461**	**1,290**
EFTA (MW)				
Iceland	0	0	0	0
Liechtenstein	0	0	0	0
Norway	2	431	9	441
Switzerland	4	18	25	42
Total	**6**	**449**	**34**	**483**
Of which offshore and near shore	2	2	0	2
Other (MW)				
Faroe Islands	0	4	0	4
Ukraine	4	90	1	87
Russia	0	9	0	9
Total	**4**	**99**	**1**	**101**
Total Europe	**10,845**	**76,471**	**9,918**	**86,279**

*FYROM = Former Yugoslav Republic of Macedonia
Note: Due to previous-year adjustments, 127.8 MW of project de-commissioning, re-powering and rounding of figures, the total 2010 end-of-year cumulative capacity is not exactly equivalent to the sum of the 2009 end-of-year total plus the 2010 additions.

a. Global cumulative and annual installations to 2010

According to the Global Wind Energy Council (GWEC), 38.3 GW of wind power capacity was installed globally during 2010, reaching a total of 197 GW by the end of the year (Figure 2.1). The global annual market for wind turbines decreased by 1.3% in 2010, following growth of 46% in 2009, 37% in 2008 and 31% in 2007 (Figure 2.2). Over the past five years, the annual market for wind turbines has grown by 151% from 15.2 GW in 2006 to 38.3 GW in 2010. The total installed wind power capacity increased from 74 GW to 197 GW over the same period.

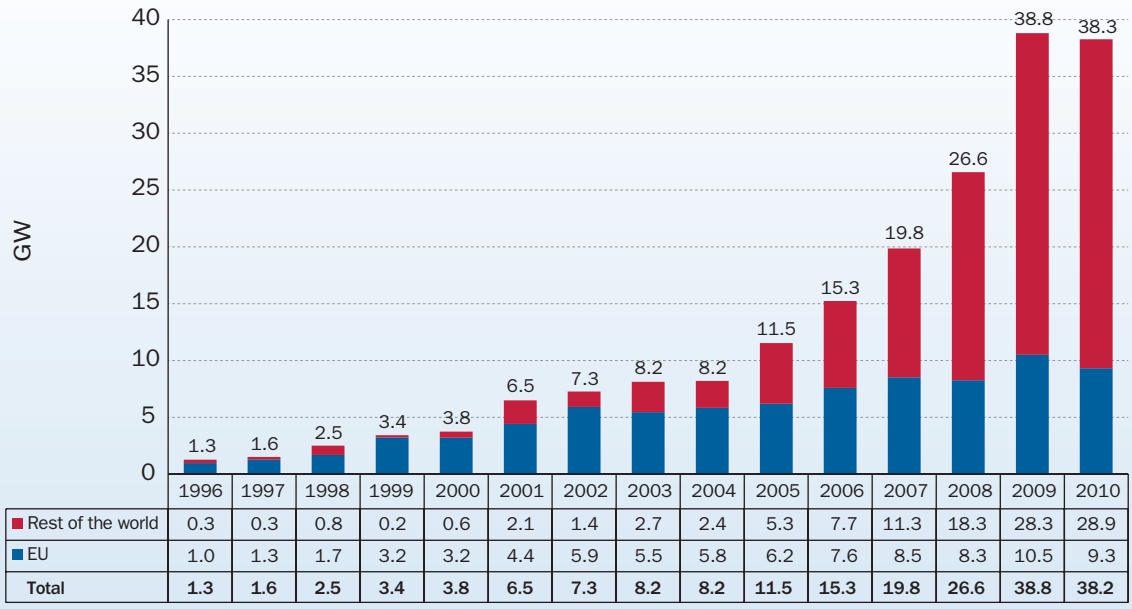
FIGURE 2.1 GLOBAL CUMULATIVE WIND POWER CAPACITY (1996 – 2010)



	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
Rest of the world	2.6	2.8	3.7	3.9	4.5	6.6	8.0	10.9	13.2	18.6	26.0	37.3	55.6	83.8	112.7
EU	3.5	4.8	6.5	9.7	12.9	17.3	23.1	28.5	34.4	40.5	48.0	56.5	64.7	75.1	84.3
Total	**6.1**	**7.6**	**10.2**	**13.6**	**17.4**	**23.9**	**31.1**	**39.4**	**47.6**	**59.1**	**74.1**	**93.8**	**120.3**	**158.9**	**197**

Source: "Global wind report – annual market update 2010" – GWEC 2011; EWEA 2011

FIGURE 2.2 GLOBAL ANNUAL WIND POWER CAPACITY (1996 – 2010)

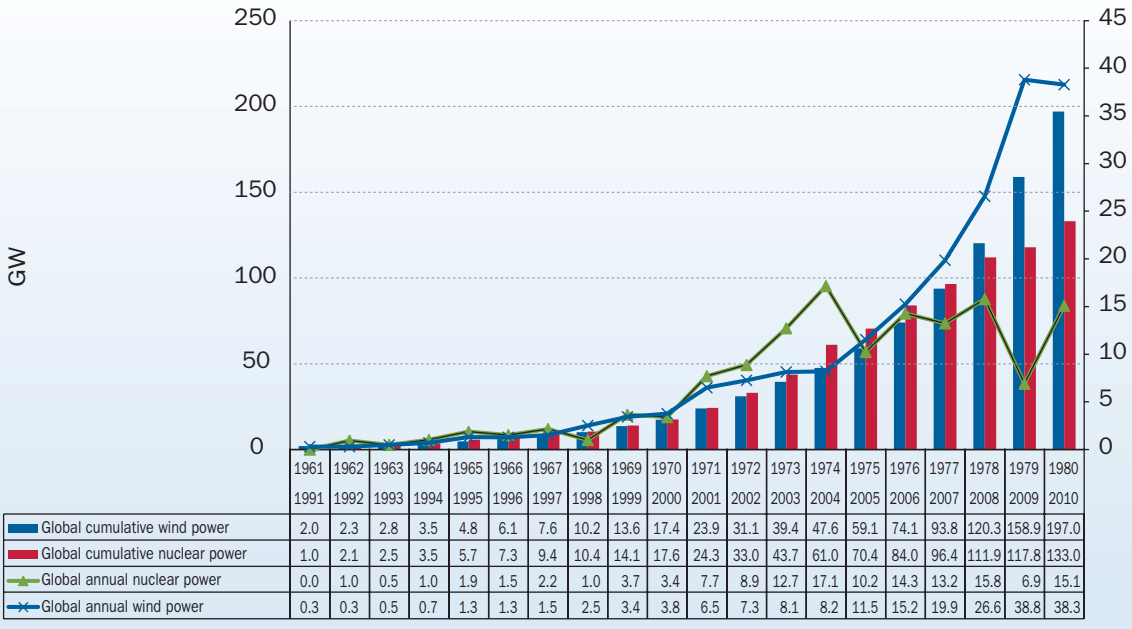


	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
Rest of the world	0.3	0.3	0.8	0.2	0.6	2.1	1.4	2.7	2.4	5.3	7.7	11.3	18.3	28.3	28.9
EU	1.0	1.3	1.7	3.2	3.2	4.4	5.9	5.5	5.8	6.2	7.6	8.5	8.3	10.5	9.3
Total	**1.3**	**1.6**	**2.5**	**3.4**	**3.8**	**6.5**	**7.3**	**8.2**	**8.2**	**11.5**	**15.3**	**19.8**	**26.6**	**38.8**	**38.2**

Source: "Global wind report – annual market update 2010" – GWEC 2011; EWEA 2011

Around the world, wind energy continues to expand rapidly, and follows a similar development path to other power sources that are now mainstream. Figure 2.3 compares the global development of wind energy over the 20 years from 1991 to 2010 with the development of nuclear power capacity – another large-scale technology with relatively low carbon emissions – from a similar stage of development over the 20 years from 1961 to 1980.

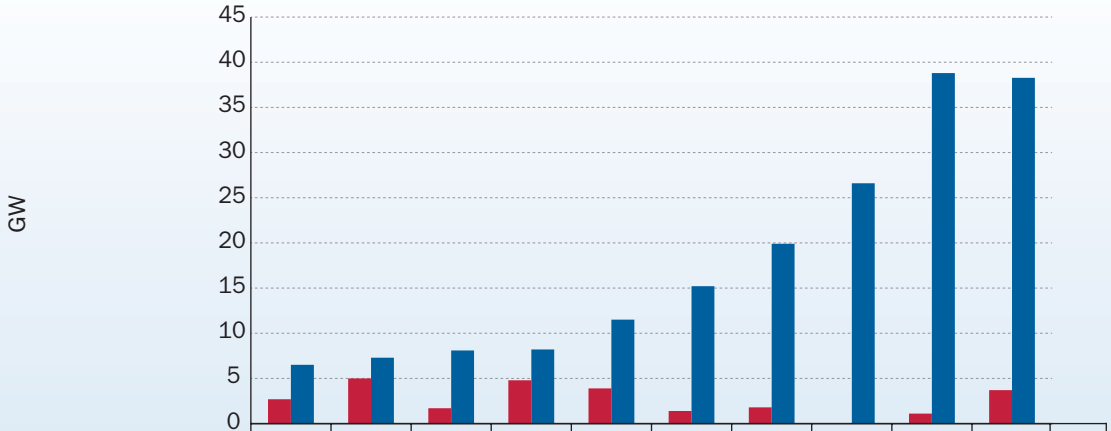
FIGURE 2.3 GLOBAL WIND POWER DEVELOPMENT (1991 – 2010) COMPARED TO NUCLEAR DEVELOPMENT (1961-1980)



	1961	1962	1963	1964	1965	1966	1967	1968	1969	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980
	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
Global cumulative wind power	2.0	2.3	2.8	3.5	4.8	6.1	7.6	10.2	13.6	17.4	23.9	31.1	39.4	47.6	59.1	74.1	93.8	120.3	158.9	197.0
Global cumulative nuclear power	1.0	2.1	2.5	3.5	5.7	7.3	9.4	10.4	14.1	17.6	24.3	33.0	43.7	61.0	70.4	84.0	96.4	111.9	117.8	133.0
Global annual nuclear power	0.0	1.0	0.5	1.0	1.9	1.5	2.2	1.0	3.7	3.4	7.7	8.9	12.7	17.1	10.2	14.3	13.2	15.8	6.9	15.1
Global annual wind power	0.3	0.3	0.5	0.7	1.3	1.3	1.5	2.5	3.4	3.8	6.5	7.3	8.1	8.2	11.5	15.2	19.9	26.6	38.8	38.3

Source: EWEA, GWEC and International Atomic Energy Agency (IAEA)

FIGURE 2.4 NEW ANNUAL GLOBAL WIND POWER AND NUCLEAR CAPACITY (GW) 2001-2010



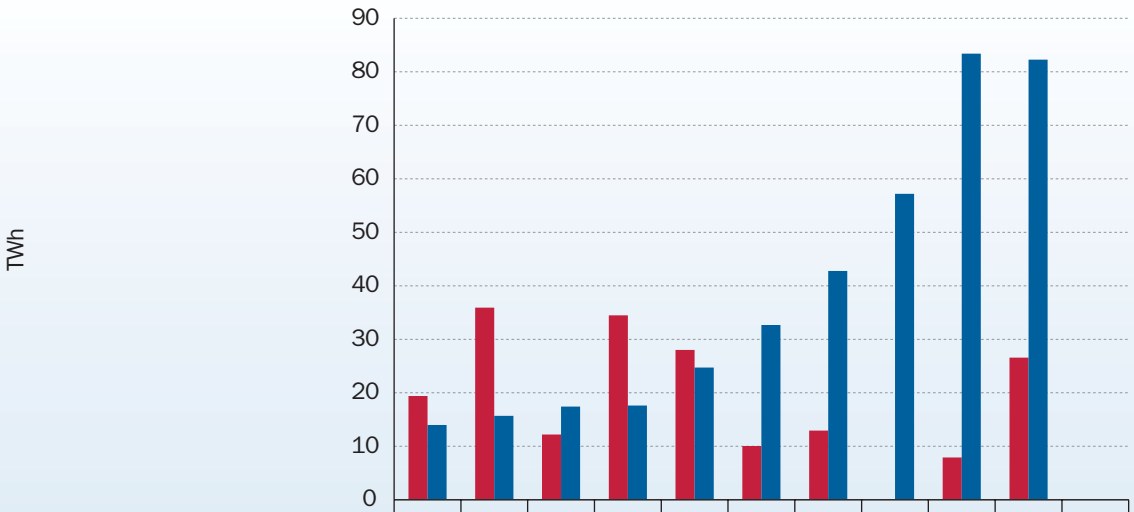
	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	Total
New global nuclear capacity	2.7	5.0	1.7	4.8	3.9	1.4	1.8	0.0	1.1	3.7	**26.1**
New global wind power capacity	6.5	7.3	8.1	8.2	11.5	15.2	19.9	26.6	38.8	38.3	**180.4**

Source: EWEA, GWEC and International Atomic Energy Agency (IAEA)

Looking at the last decade, global new wind power capacity has by far exceeded new nuclear capacity. The world installed almost 50% more new wind power capacity in 2010 alone (38.3 GW) than it installed new nuclear capacity in the last decade (26.1 GW) as shown in Figure 2.4.

Although annual capacity additions (Figure 2.4) is a good indication of economic activity, manufacturing, jobs creation and investments, capacity is a poor indicator for electricity production because 1 GW wind power capacity, for example, does not produce the same amount of electricity as 1 GW of nuclear capacity.

FIGURE 2.5 POWER PRODUCTION FROM NEW GLOBAL WIND POWER AND NUCLEAR CAPACITY 2001-2010 (TWh)



	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	Total
Power production of new nuclear capacity (TWh)	19	36	12	34	28	10	13	0	8	27	**187**
Power production of new wind capacity (TWh)	14	16	17	18	25	33	43	57	83	82	**388**

Source: EWEA, GWEC and International Atomic Energy Agency (IAEA)

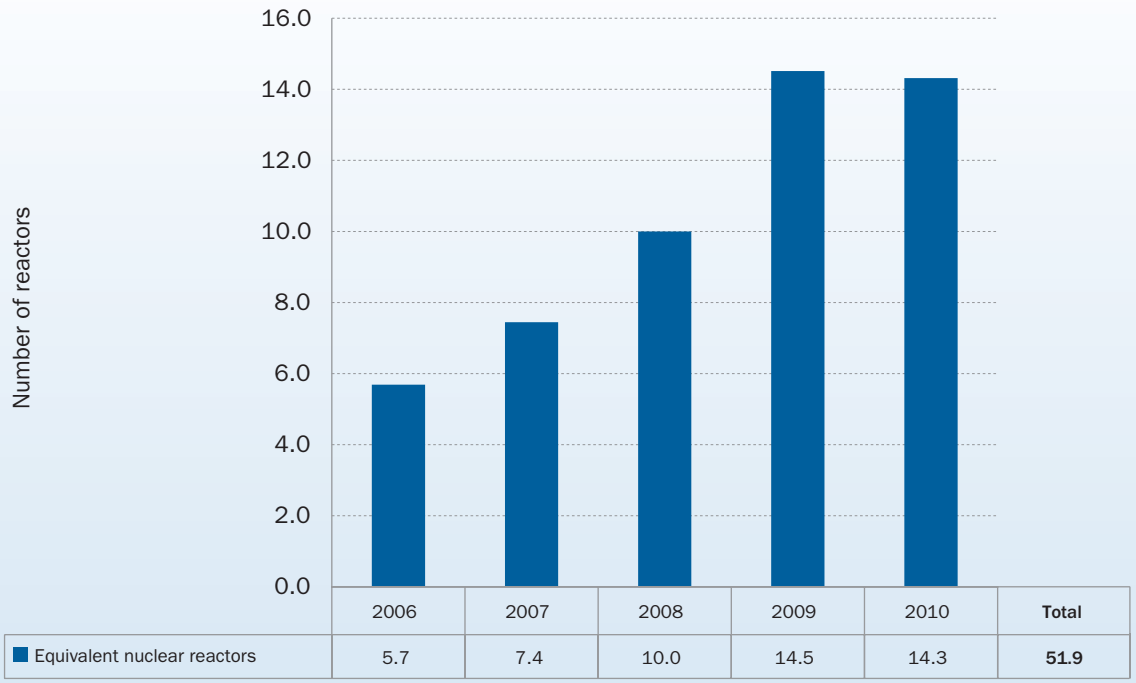
Figure 2.5 shows how much electricity the global annual capacity additions of wind and nuclear energy can produce[3].

In the past five years – from 2006 to 2010 – 139 GW of new wind power capacity was built globally compared to 8 GW of new nuclear capacity.

139 GW of new wind power capacity produces electricity equivalent to 52 nuclear power reactors, or 41.5 GW of nuclear capacity[4]. Hence, on average, the wind power industry – in electricity terms – has constructed the equivalent of more than 10 new nuclear power plants per year in the past five years.

The wind power capacity installed globally in 2009 and 2010 (77 GW), produces electricity equivalent to 29 nuclear power plants. Therefore, in electricity production terms, the wind power industry installed the equivalent of 1.2 nuclear power plants per month over the past two years.

FIGURE 2.6 POWER PRODUCTION FROM ANNUAL GLOBAL WIND CAPACITY ADDITIONS 2006-2010 IN NUCLEAR REACTOR ELECTRICITY EQUIVALENTS



	2006	2007	2008	2009	2010	Total
Equivalent nuclear reactors	5.7	7.4	10.0	14.5	14.3	**51.9**

Source: EWEA 2011

[3] The capacity factors for wind power and nuclear are assumed to be 24.5% and 82% respectively, i.e. 3.34 GW of wind energy is assumed to produce the same amount of electricity as 1 GW of nuclear energy.
[4] The average size of a nuclear reactor is assumed to be 800 MW.

b. Wind energy and the EU Member States

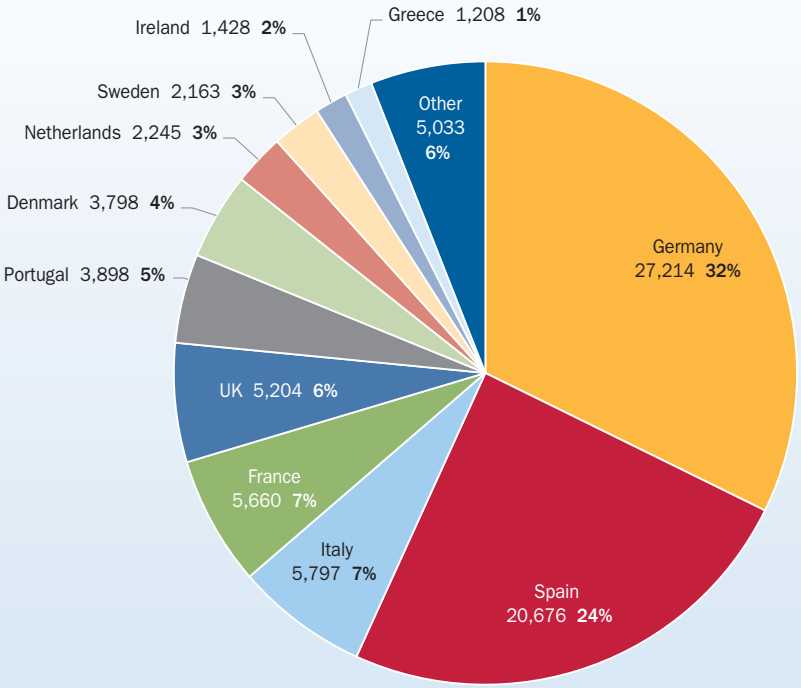
Germany (27.2 GW) and Spain (20.7 GW) continue to be Europe's undisputed leaders in terms of total installed wind energy capacity (Table 2.1). 57% of the EU's installed capacity is located in the two countries. By end 2010, five countries – Germany, Spain, Italy (5.8 GW), France (5.7 GW) and the UK (5.2 GW) – had passed 5 GW of total capacity. 25 of the 27 EU Member States utilise wind power.

TABLE 2.1 TOTAL INSTALLED WIND POWER CAPACITY IN THE EU-27 (ULTIMO 2007 – 2010, MW)

Country	2007	2008	2009	2010
Austria	982	995	995	1,011
Belgium	287	415	563	911
Bulgaria	57	120	177	375
Cyprus	0	0	0	82
Czech Republic	116	150	192	215
Denmark	3,125	3,163	3,478	3,798
Estonia	59	78	142	149
Finland	110	143	147	197
France	2,454	3,404	4,574	5,660
Germany	22,247	23,897	25,777	27,214
Greece	871	985	1,087	1,208
Hungary	65	127	201	295
Ireland	795	1,027	1,310	1,428
Italy	2,726	3,736	4,849	5,797
Latvia	27	27	28	31
Lithuania	51	54	91	154
Luxembourg	35	35	35	42
Malta	0	0	0	0
Netherlands	1,747	2,225	2,215	2,245
Poland	276	544	724	1,107
Portugal	2,150	2,862	3,535	3,898
Romania	8	11	14	462
Slovakia	5	3	3	3
Slovenia	0	0	0	0
Spain	15,131	16,689	19,160	20,676
Sweden	788	1,048	1,560	2,163
UK	2,406	2,974	4,245	5,204
EU Total	56,517	64,713	75,103	84,324

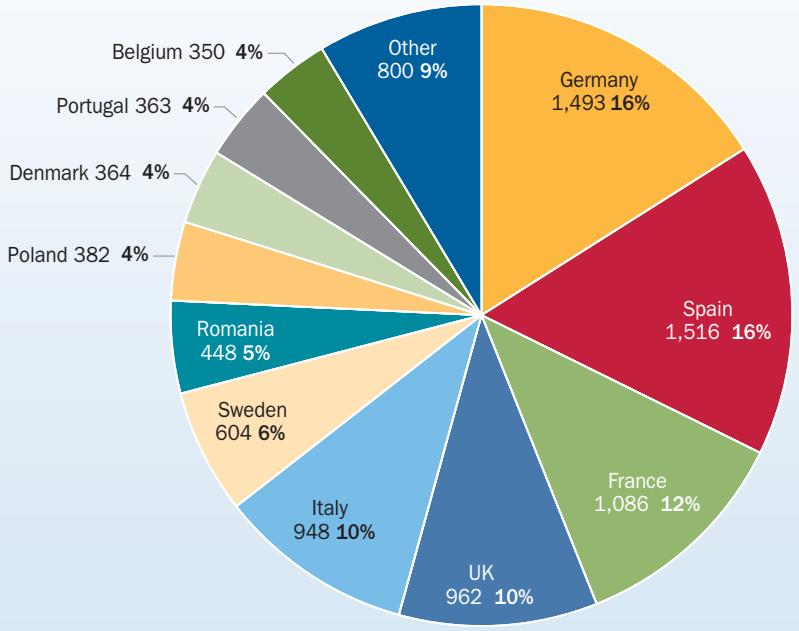
In 2010, Spain (1,516 MW) installed the most wind power, followed by Germany (1,493 MW). They were followed by France (1,086 MW), the UK (962 MW) and Italy (948 MW). Thirteen EU Member States – Germany, Spain, Italy, France, the UK, Portugal, Denmark, the Netherlands, Sweden, Ireland, Greece, Poland and Austria – now have more than 1 GW installed each.

FIGURE 2.7 MEMBER STATE WIND POWER CAPACITY (MW) AND SHARE (%) OF TOTAL EU CAPACITY AT END 2010 (TOTAL 84,324)



Other	
Poland	1,107
Austria	1,011
Belgium	911
Romania	462
Bulgaria	375
Hungary	295
Czech Republic	215
Finland	197
Lithuania	154
Estonia	149
Cyprus	82
Luxembourg	42
Latvia	31
Slovakia	3
Malta	0
Slovenia	0

FIGURE 2.8 MEMBER STATE MARKET SHARES FOR NEW CAPACITY IN 2010 (TOTAL 9,332 MW)

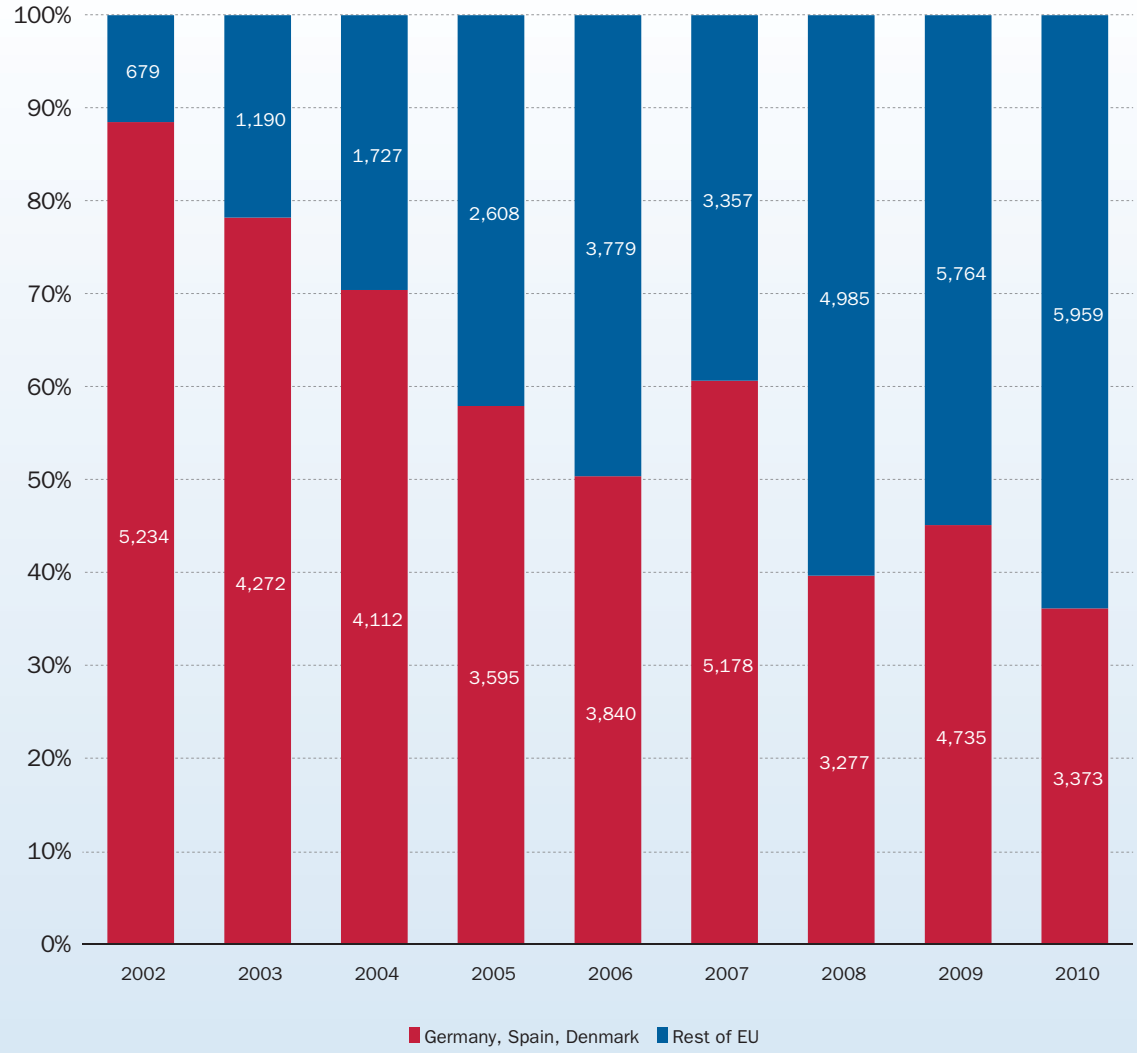


Other	
Bulgaria	198
Greece	123
Ireland	118
Hungary	94
Cyprus	82
Lithuania	63
Finland	52
Netherlands	32
Czech Republic	23
Austria	16
Luxembourg	7
Estonia	7
Latvia	2
Malta	0
Slovenia	0
Slovakia	0

Germany, Spain and Denmark, the three pioneering countries of wind power, are home to 61.3% of the installed wind power capacity in the EU. However, their share of new annual installations has dropped from 85% in 2000 to 36% in 2010. Germany and Spain continue to attract the majority of investments, but strong market growth is taking place in other European countries. In 2000, 469 MW were installed outside of the three pioneering countries. In 2010 the figure was 5,959 MW – more than a twelve-fold increase. All EU Member States except for Malta are now investing in wind power, partly as a result of the EU Renewable Electricity Directive passed in 2001 and its "successor", the EU Renewable Energy Directive passed in 2009.

It is now possible to distinguish an important second wave of wind markets in Europe, led by Portugal, the UK, France and Italy, and significant growth in emerging markets amongst the EU's new Member States such as Poland and Romania.

FIGURE 2.9 GERMANY, SPAIN AND DENMARK'S SHARE OF THE EU MARKET (2002 - 2010) IN MW



Source: EWEA 2011

c. The growth of offshore wind power

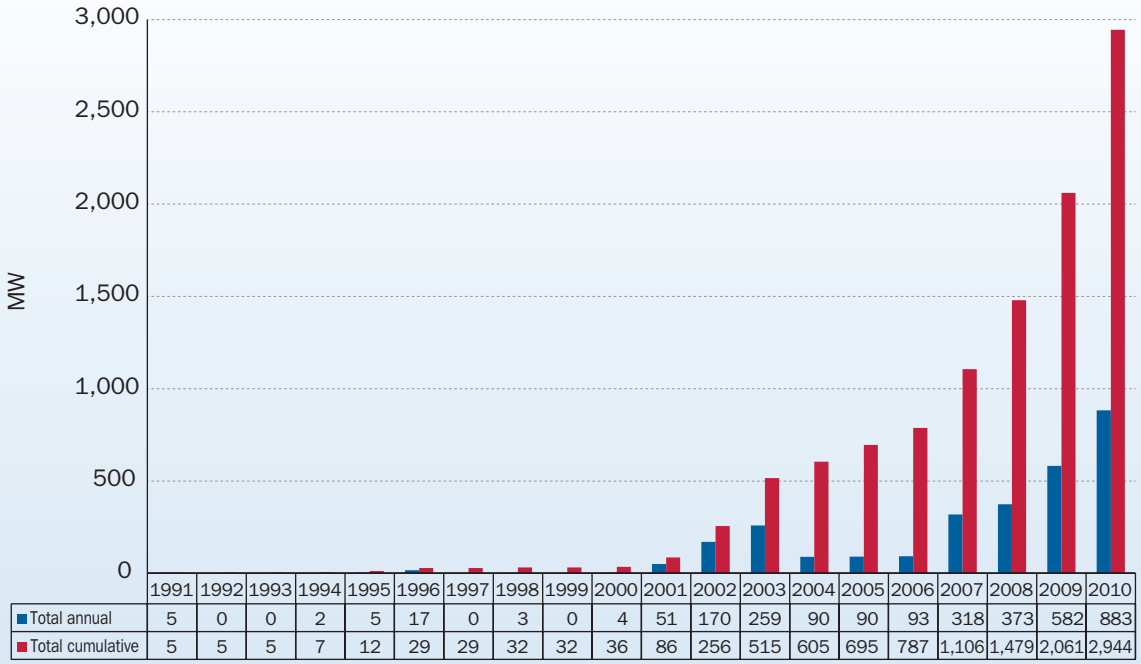
With 2.9 GW installed at end 2010, offshore wind accounted for 3.5% of installed EU wind energy capacity (up from 2.7% in 2009) and 9.5% of new annual capacity. In 2010, offshore wind accounted for 20.5% (€2.6 bn) of the 2010 total EU investments (€12.7 bn). 883 MW of offshore wind were installed in 2010, beating the previous year's record of 582 MW.

Historically, the front-runner in offshore wind was Denmark. But by the end of 2010, with 458 MW of new offshore installations, the UK became the first country to total more than 1 GW of offshore capacity. In Europe, there are now eight EU Member States, and Norway, with installed offshore capacity.

TABLE 2.2 OFFSHORE WIND POWER (2010)

	Installed in 2010	Total at end 2010
United Kingdom	458	1,341
Denmark	207	854
Netherlands	0	247
Belgium	165	195
Sweden	0	164
Germany	50	92
Finland	2	26
Ireland	0	25
Total EU	883	2,944
Norway	0	2.3
China	102	102
Total World	985	3,048

FIGURE 2.10 ANNUAL AND CUMULATIVE INSTALLED EU OFFSHORE CAPACITY 1991-2010 (MW)



	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
Total annual	5	0	0	2	5	17	0	3	0	4	51	170	259	90	90	93	318	373	582	883
Total cumulative	5	5	5	7	12	29	29	32	32	36	86	256	515	605	695	787	1,106	1,479	2,061	2,944

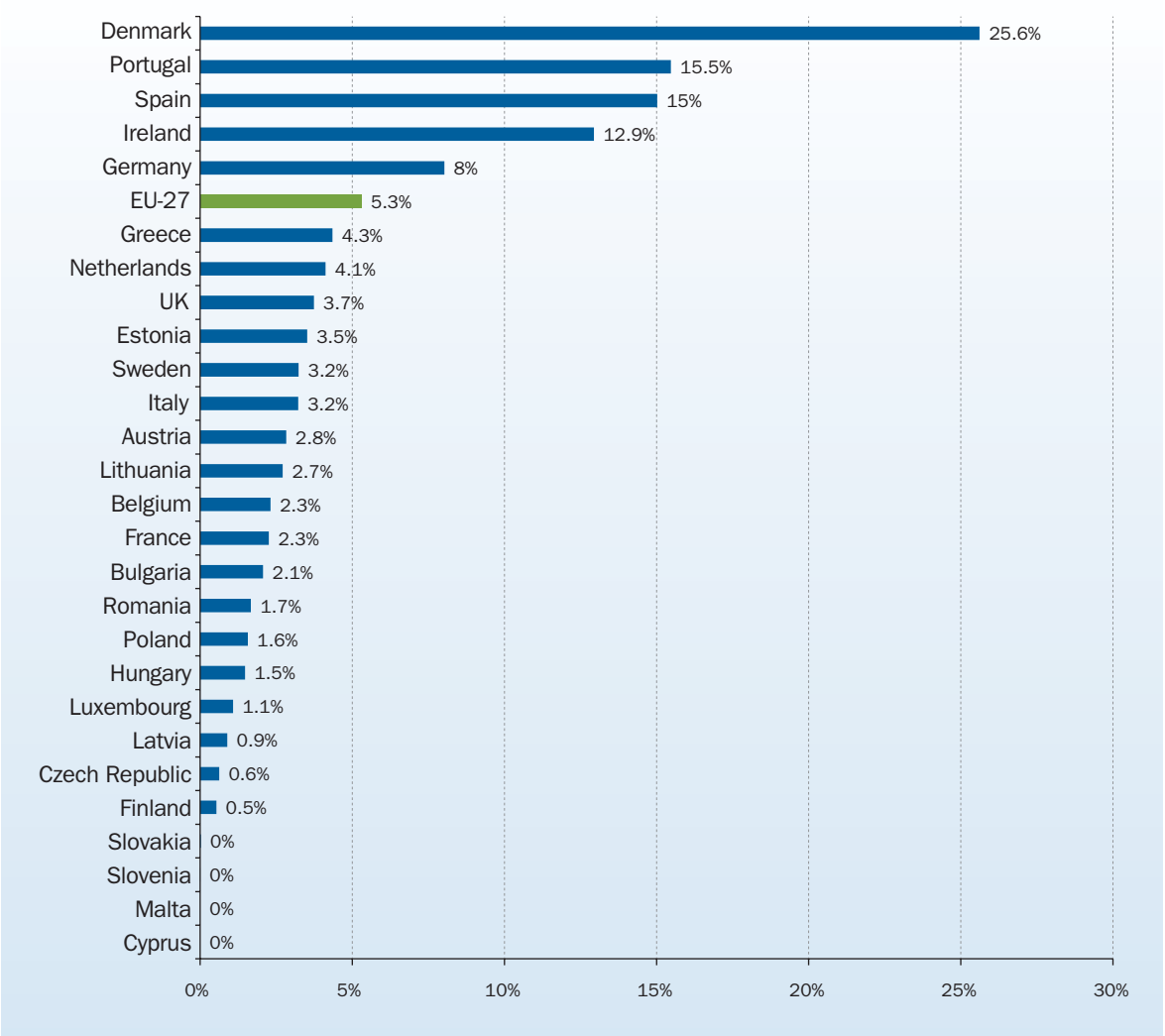
Source: EWEA 2011

d. Wind power capacity compared to country size and population

I. Wind energy share of electricity demand

The total wind power capacity installed at the end of 2010 would cover 5.3% of the EU-27's electricity demand in a normal wind year. Wind power in Denmark covers 26% of its total electricity consumption, by far the largest share of any country in the world. Portugal and Spain get 15% of electricity from wind power, Ireland 13% and Germany 8%[5] (Figure 2.11).

FIGURE 2.11 WIND ENERGY'S SHARE OF NATIONAL ELECTRICITY DEMAND AT END 2010

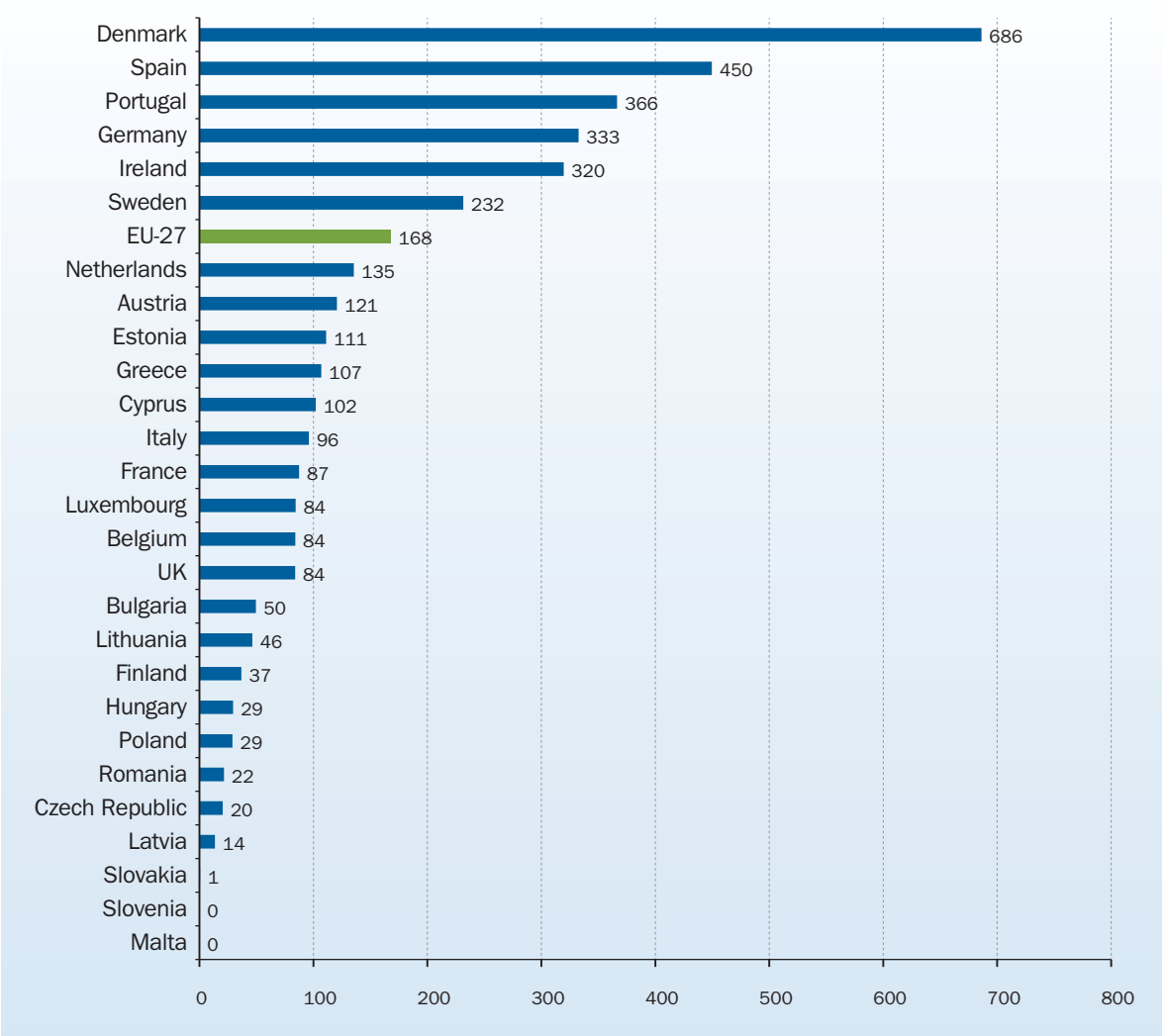


[5] Source: Eurostat and EWEA. The national wind power shares are calculated by taking the electricity that the capacity installed by the end of 2010 will produce in a normal wind year and dividing it by the 2008 electricity demand, which is the latest available figure from Eurostat. Average capacity factors are assumed by EWEA for each country. The statistical methodology used differs from the methodology otherwise used throughout this report. The figures may differ from the shares reported by national wind energy associations due to differences in methodology.

II. Installed capacity per inhabitant

By the end of 2010, 168 kW (0.168 MW) of wind energy capacity was installed for every 1,000 people in the EU – up from 133 kW at the end of 2008 (Figure 2.7). Denmark tops the list with 686 kW per 1,000 people, followed by Spain (450 kW) and Portugal (366 kW). If all EU countries had the same amount of installed wind power capacity per capita as Spain, the EU total would be 226 GW instead of the end 2010 figure of 84 GW. If all EU countries had the same amount of capacity per capita as Denmark, total EU installations would be 340 GW.

FIGURE 2.12 kW OF WIND ENERGY CAPACITY PER 1,000 PEOPLE AT END 2010



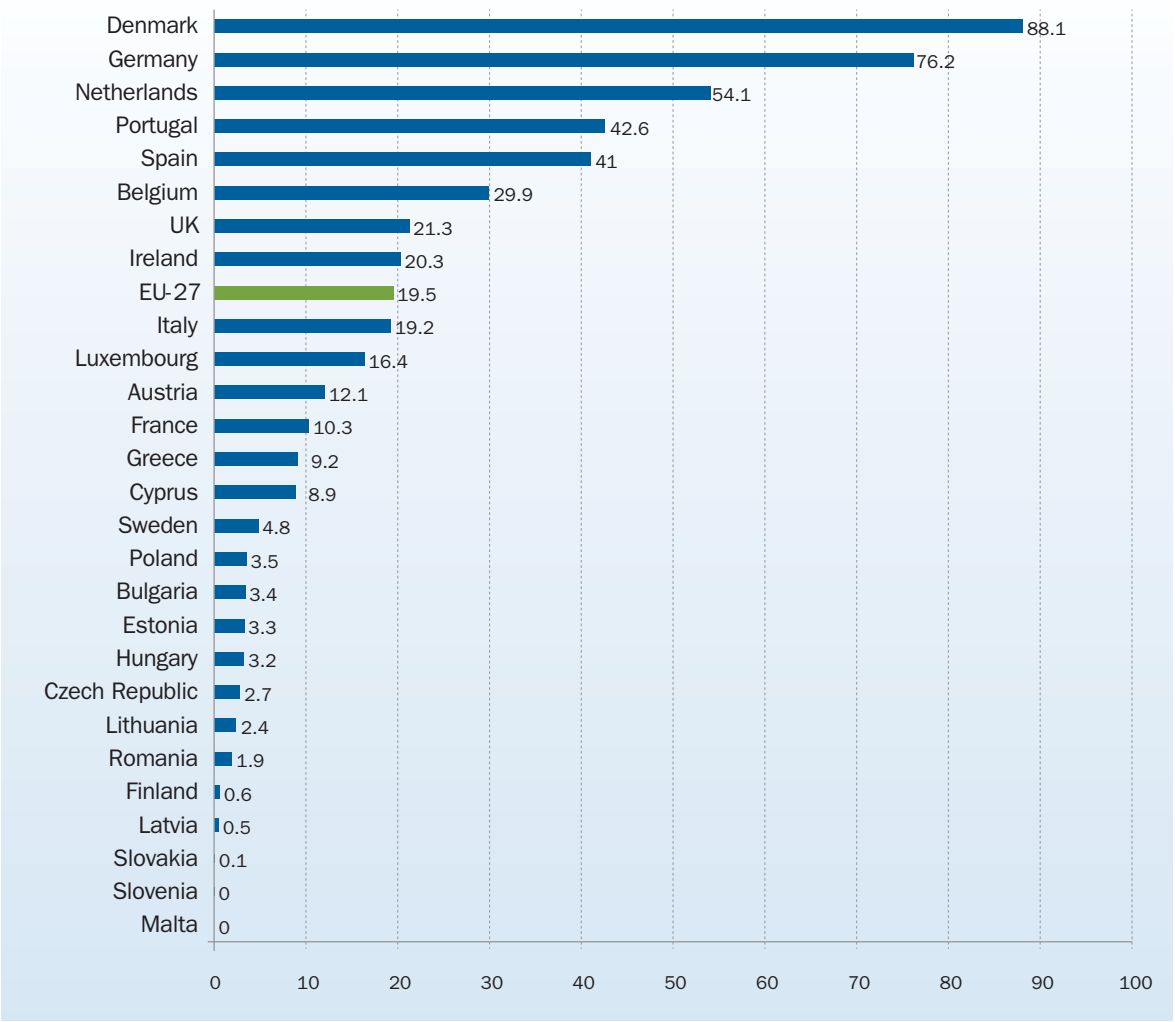
III. Installed capacity per land mass

There are 19.5 MW of wind power capacity installed per 1,000 km² of land area in the EU (Figure 2.13). Wind power density is highest in Denmark, but Germany comes a close second. The Netherlands has the third highest density of MW per km² in the EU. Portugal, Spain, Belgium, the UK and Ireland are all above the EU average. It is interesting that Spain's wind power density is just over half that of Germany, indicating a large remaining potential – at least from a land availability perspective.

Many geographically large Member States, such as France, the UK, Italy, Sweden, Finland, Poland and Romania, still have very low wind power densities compared to the leading countries. If France had the same wind power density as Denmark, it would have 48 GW of wind power capacity operating (5.7 GW were operating at end 2010); Sweden 39 GW (2.2 GW at end 2010), Finland 29 GW (0.2 GW at end 2010), Poland 27 GW (1.1 GW at end 2010), Italy 26 GW (5.8 GW at end 2010), the UK 21 GW (5.2 GW at end 2010).

If the eight geographically largest Member States had a "capacity-density" equivalent to that of Denmark, they would have a combined installed capacity of 266 GW. This is above EWEA's target for onshore wind energy capacity in the EU by 2030. If all the EU Member States had the same capacity density as Denmark, it would make a total of 377 GW, compared with 84 GW at the end of 2010.

FIGURE 2.13 MW OF WIND POWER CAPACITY PER 1,000 KM² AT END 2010

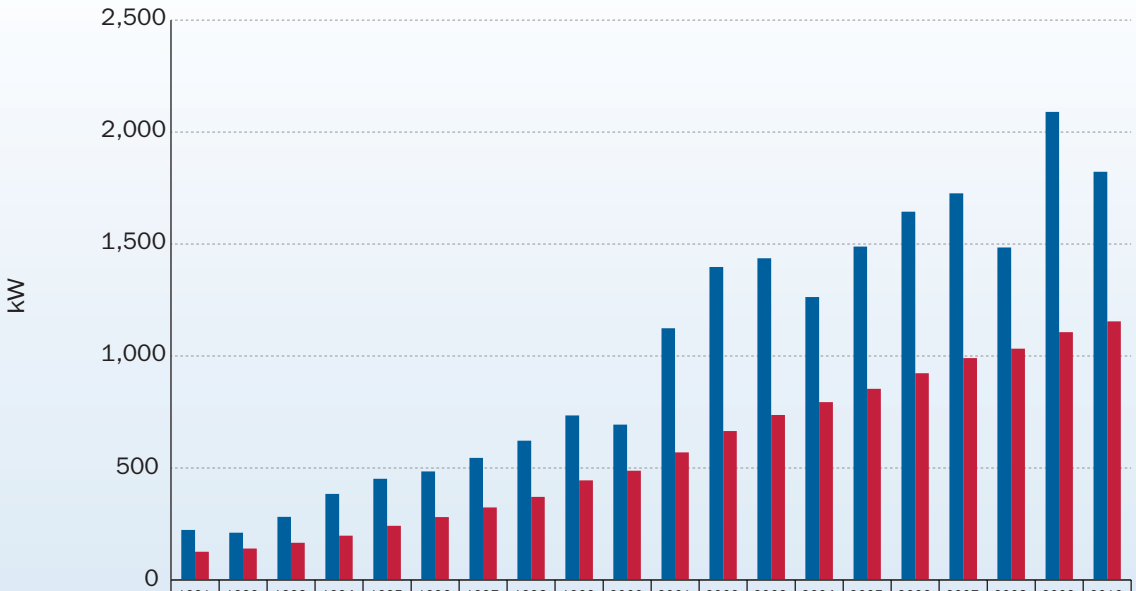


IV. Number of wind turbines

The development of wind power in Europe consists of the installation of wind turbines in the most suitable locations across the continent. Since its first developments in the early 1980s, the wind energy industry has installed increasingly sophisticated and larger wind turbines. Based on data from the consultancy BTM Consult, the following figures present the average size (capacity) and the number of wind turbines in Europe since 1991.

There is a clear increase in the number of turbines installed up to 2000. Subsequently, the number of turbines becomes more dependent on the machines' size. Since technology development resulted in substantially larger machines, the number of installations is within a narrower range of approximately 4,000-5,500 units onshore annually since 2001. Looking at the average size and taking into account the development of onshore wind energy cumulatively (Figure 2.14), a smoother transition to bigger machines is apparent. In the total number of wind turbines in operation, there is still a significant amount of older and considerably smaller machines. For the offshore sector, in Figure 2.15, the average size of a wind turbine has increased nearly every year since 2000 where for the first time the average annual size reached 2 MW. Subsequently, in 2005, the offshore wind turbines installed were of an average capacity of 3 MW and in 2010 the average capacity was 2.9 MW. At the same time, looking at the average capacity of offshore wind turbines, the industry has moved from the small 500 kW machines deployed during the 1990s to 2 MW-plus machines after 2005 showing a tendency to increase to over 3 MW in the near future.

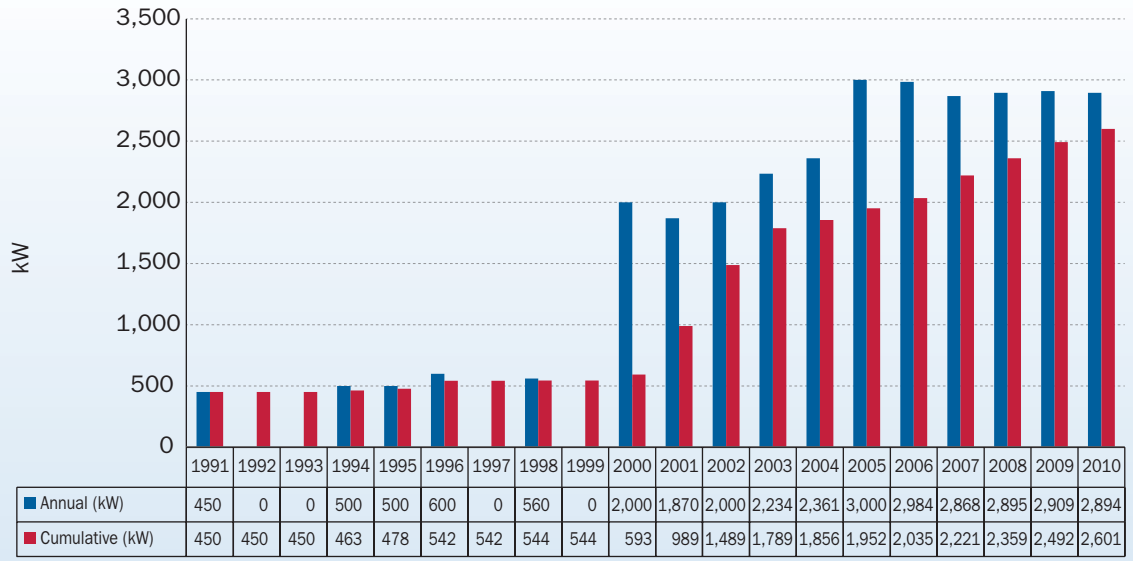
FIGURE 2.14 AVERAGE CAPACITY OF EUROPEAN ONSHORE WIND TURBINES, ANNUAL AND CUMULATIVE



	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
Annual (kW)	224	211	282	384	452	485	545	622	735	693	1,124	1,398	1,436	1,263	1,489	1,645	1,726	1,484	2,090	1,822
Cumulative (kW)	127	141	166	198	242	281	324	371	444	488	570	665	737	794	854	923	991	1,032	1,107	1,155

Source: EWEA 2011 and BTM Consult 2011

FIGURE 2.15 AVERAGE CAPACITY OF EUROPEAN OFFSHORE WIND TURBINES, ANNUAL AND CUMULATIVE



	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
Annual (kW)	450	0	0	500	500	600	0	560	0	2,000	1,870	2,000	2,234	2,361	3,000	2,984	2,868	2,895	2,909	2,894
Cumulative (kW)	450	450	450	463	478	542	542	544	544	593	989	1,489	1,789	1,856	1,952	2,035	2,221	2,359	2,492	2,601

Source: EWEA 2011

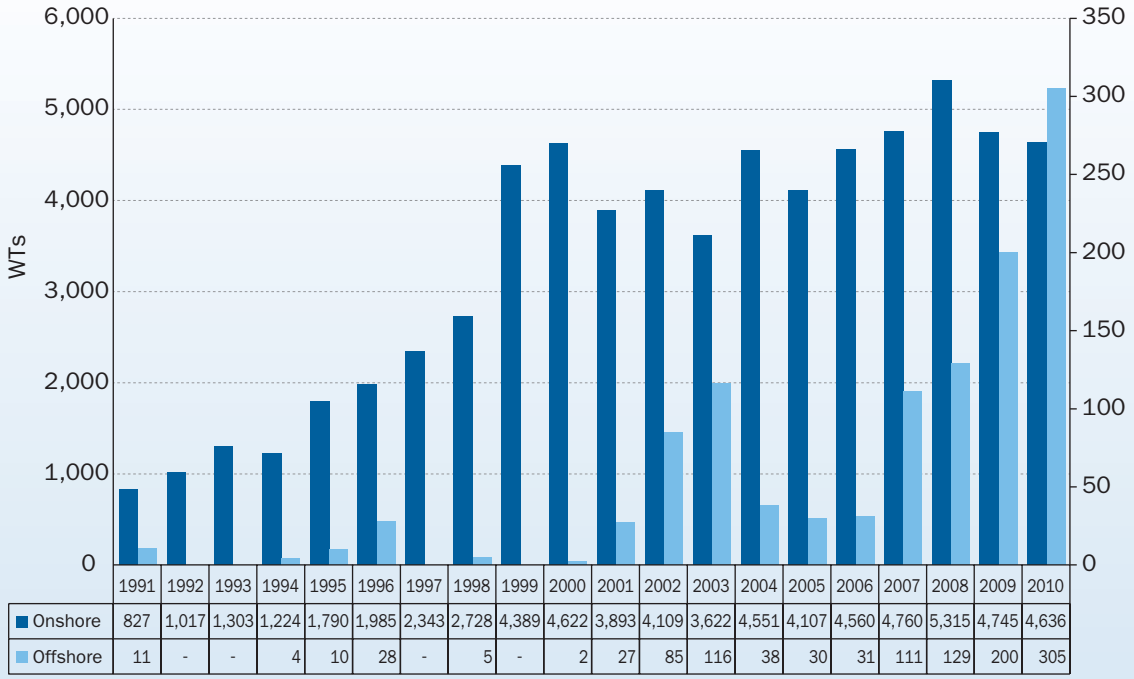
There has been a significant increase in average turbine capacity from some 200 kW onshore and 450 kW offshore in 1991 to over 1,700 kW onshore and 2,800 offshore in 2010. The increase in average generator capacity of wind turbines is a direct result of the continuous technological development over the last two decades; incorporating larger generators and up-scaling the wind turbines' rotors and other components.

Wind industry R&D is now gearing up to deliver even larger wind turbines including potentially up to 20 MW of rated power capacity[6].

The number of wind turbines installed annually and cumulatively is shown in the next two figures.

[6] UpWind – Design limits and solutions for very large wind turbines – www.upwind.eu

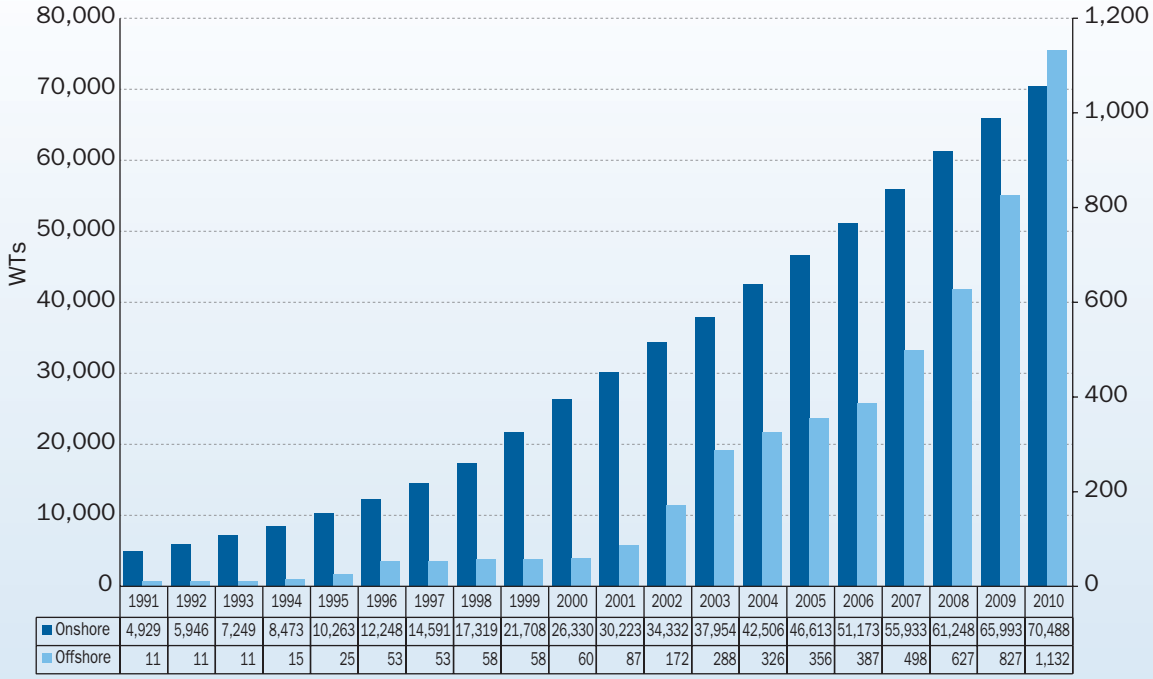
FIGURE 2.16 ANNUAL INSTALLATIONS OF WIND TURBINES ONSHORE (LEFT AXIS) AND OFFSHORE (RIGHT AXIS) IN EU



	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
Onshore	827	1,017	1,303	1,224	1,790	1,985	2,343	2,728	4,389	4,622	3,893	4,109	3,622	4,551	4,107	4,560	4,760	5,315	4,745	4,636
Offshore	11	-	-	4	10	28	-	5	-	2	27	85	116	38	30	31	111	129	200	305

Source: EWEA 2011 and BTM Consult 2011

FIGURE 2.17 CUMULATIVE NUMBER OF WIND TURBINES ONSHORE (LEFT AXIS) AND OFFSHORE (RIGHT AXIS) IN EU



	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
Onshore	4,929	5,946	7,249	8,473	10,263	12,248	14,591	17,319	21,708	26,330	30,223	34,332	37,954	42,506	46,613	51,173	55,933	61,248	65,993	70,488
Offshore	11	11	11	15	25	53	53	58	58	60	87	172	288	326	356	387	498	627	827	1,132

Source: EWEA 2011 and BTM Consult 2011

The development of wind energy in the last 20 years has been significant. A total of 81,380 MW of onshore wind have been brought online via the installation of 70,488 turbines. In addition, a further 1,132 wind turbines, totalling 2,944 MW have been installed in European offshore locations.

The construction of new, larger and more sophisticated wind turbines, both for use on land and offshore is an ongoing trend. As turbines get bigger in capacity, the generation of the same amount of energy can be achieved with fewer machines. In 2010 the average capacity of onshore wind turbines installed reached 1.8 MW. Even if we assume that this will remain the average size of new wind turbine installations for the rest of the decade, Europe will need 60,344 more turbines in order to achieve the 190 GW target by 2020. During this period, the installed power will increase 2.3-fold while the number of additional wind turbines will be 14% less than the number of turbines installed so far. Should the average size of wind turbines carry on increasing, as the trend identified in Figure 2.12 suggests, even less turbines will be required to more than double the EU's installed wind power capacity. If average wind turbine size reaches 2.5 MW over this decade, 43,448 new wind turbines need to be installed: representing 38% less turbines than were installed up to end 2010 for the same 2.3-fold increase in capacity. Similarly, a 3 MW average turbine size would require just over 36,000 new installations.

Moreover, offshore, assuming that the average 2010 turbine capacity of 2.9 MW will remain constant for the next ten years, the number of additional turbines needed to achieve the 40 GW target by 2020 is approximately 12,700. This represents an 11-fold increase in the number of wind turbines for an almost 14-fold increase in installed capacity. Should the average size of wind turbines increase as trends and wind turbine manufacturer new model announcements suggest, the 11-fold increase in installed capacity could be achieved with significantly fewer turbines. An average offshore wind turbine size of 4 MW would require 9,264 new installations to reach 40 GW of total capacity in 2020. If average offshore turbine size were to reach 5 MW, only 7,411 turbines would be required.

V. Wind energy and avoided CO_2 emissions

In February 2005 the Kyoto Protocol entered into force and with it, the EU's commitment to reduce emissions by 8% for the EU-15 as a whole. For the new Member States (EU-12), the target was between 6% and 8% – for an average of 7.8% from 1990 emission levels for the EU-27. The Kyoto commitment is the same each year so the reduction target is valid for the whole 2008-2012 period.

Comparing the reduction ambition from both the Kyoto Protocol ('KP' in Table 2.3) and the EU Climate and Energy Package with CO_2 avoided by wind energy shows (Table 2) that CO_2 avoided by wind energy was already equivalent to 28% of the EU's Kyoto commitment in 2010. By 2012, EWEA estimates EU installed wind power capacity will avoid 35% of the Kyoto target. By 2020 wind should represent 31% of the EU's current target of 20% reductions[7].

TABLE 2.3 PERCENTAGE OF REDUCTION EFFORT MET BY WIND ENERGY

	2010 (KP)	2012 (KP)	2020 (20%)
Yearly reduction effort (Mt)	446	446	1,113
Wind avoided CO_2 (Mt)	126	156	342
% of effort met by wind	28%	35%	31%

[7] EU Commission submissions to UNFCCC – 1990 emissions excluding LULUCF and international bunkers

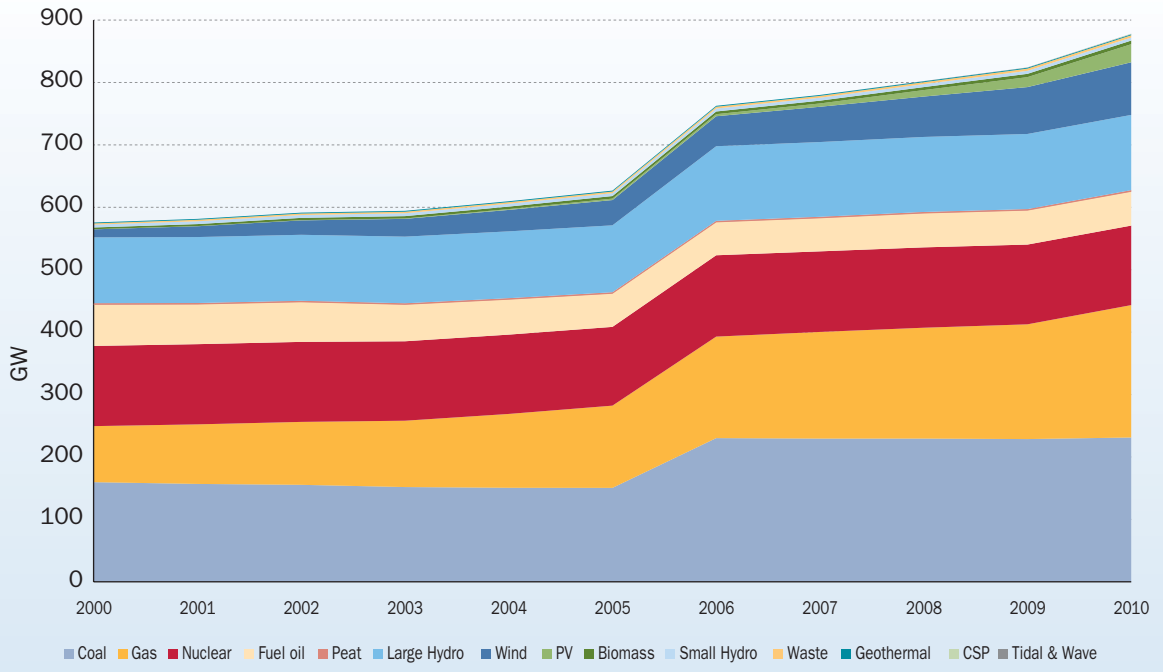
Photo: Enercon

3 HISTORICAL DEVELOPMENT OF THE EU'S ENERGY MIX

Between 2000 and 2010, the EU's total installed power capacity increased by 302.4 GW, reaching 877.9 GW by end 2010 (see Figure 3.1 and also Table 3.1 and Table 3.2). The most notable change in the energy mix over this period is the 58% increase in gas capacity to 212 GW, and the fact that wind energy has increased almost seven-fold over the same period – from 13 GW to 84.3 GW.

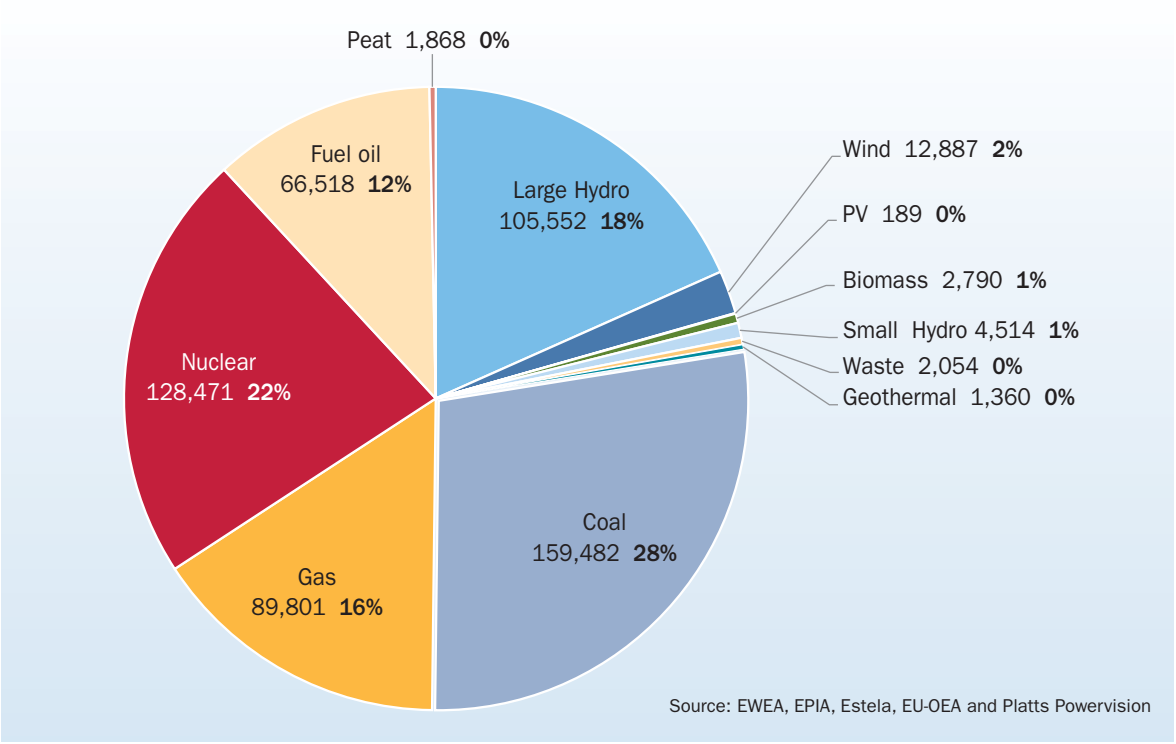
Natural gas' share of total EU capacity has increased by 62% since 2000, reaching 24.2% by the end of 2010. Coal's share has decreased marginally, while oil (down 5.3 percentage points), large hydro (down 4.5 percentage points) and nuclear (down almost eight percentage points) have all decreased their share. Wind energy's share has increased from 2.2% in 2000 to almost 10% in 2010.

FIGURE 3.1 INSTALLED POWER CAPACITY (GW) IN THE EU (2000 – 2010)



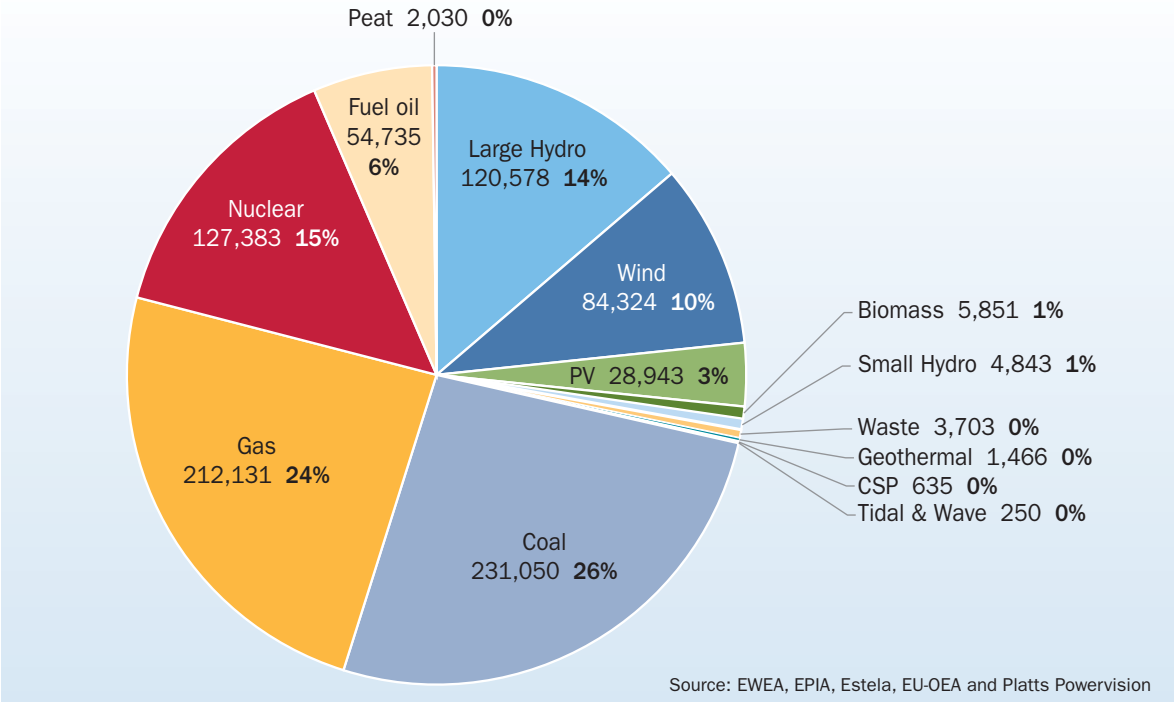
Source: EWEA, EPIA, Estela, EU-OEA and Platts Powervision

FIGURE 3.2 EU POWER CAPACITY MIX (2000) – TOTAL 575.5 GW



Source: EWEA, EPIA, Estela, EU-OEA and Platts Powervision

FIGURE 3.3 EU POWER CAPACITY MIX (2010) – TOTAL 877.9 GW



Source: EWEA, EPIA, Estela, EU-OEA and Platts Powervision

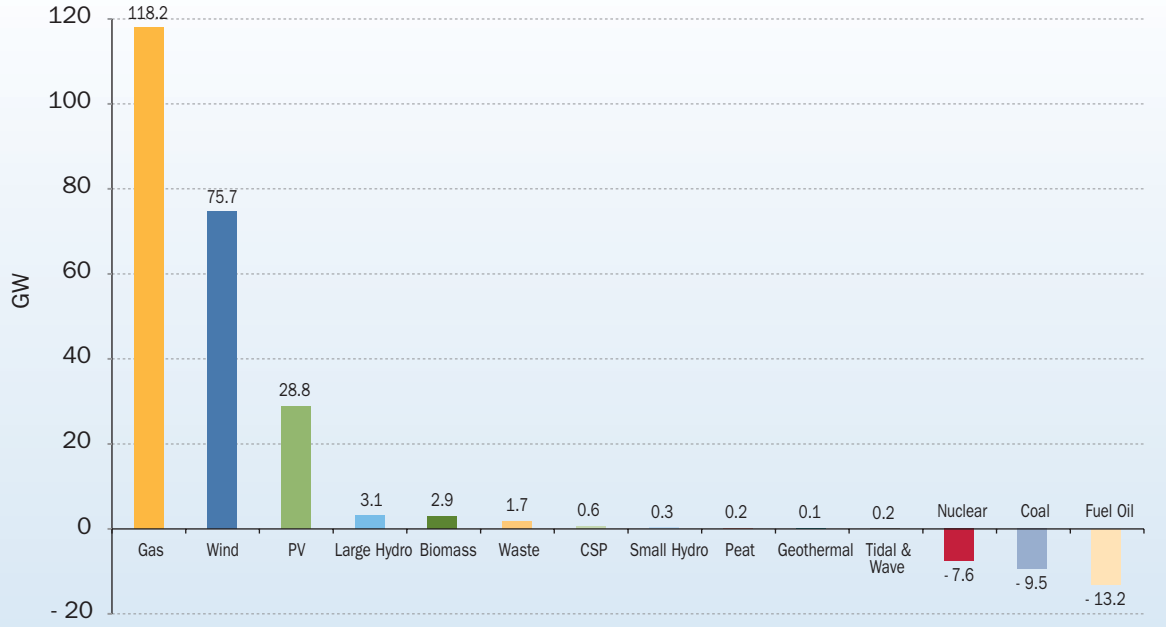
Changes in EU net installed capacity for the various electricity generating technologies from 2000 to 2010 are shown in Figure 3.4. Over the 10 year period, net capacity increased by 200.3 GW. The growth of gas (118.2 GW) and wind power (74.7 GW) came about at the expense of fuel oil (down 13.2 GW), coal (down 9.5 GW) and nuclear power (down 7.6 GW). In 2010, 56.4 GW of new capacity was installed in the EU-27. Most of this capacity (28.3 GW – 50.1%) was gas, making 2010 an exceptional year for gas installations. Furthermore 13 GW[8] (23%) of solar PV capacity was installed and 9.3 GW (16.5%) of wind.

Wind energy increased its share of total power capacity in the EU to 9.6% in 2010. However, it is wind's contribution to new generation capacity that is even more striking; 27.7% of all power capacity installed since 2000 has been wind energy, making it the second largest contributor to new EU capacity over the last ten years after natural gas (48.3%). 10.6% of all new capacity over the ten year period was solar PV, 6.2% was coal, 2.7% was fuel oil, 1.5% large hydro, 1.2% biomass and 0.7% nuclear power (Figure 3.6).

During 2010, the fuel oil and nuclear power sectors decommissioned more MW than they installed: the fuel oil sector decommissioned 245 MW and the nuclear sector 390 MW. For only the second time since 1998, the coal power sector installed more new capacity (4,056 MW) than it decommissioned (1,550 MW).

Moreover, in 2010, more renewable generating capacity was installed in the EU than ever before. With 23,719 MW of new generating capacity, renewables represented 42% of total new installed capacity. Although renewables' share of newly installed capacity decreased in 2010 due to the exceptional year for gas, it was the fourth year running that renewables had represented more than 40% of total new electricity generating installations (Figure 3.7).

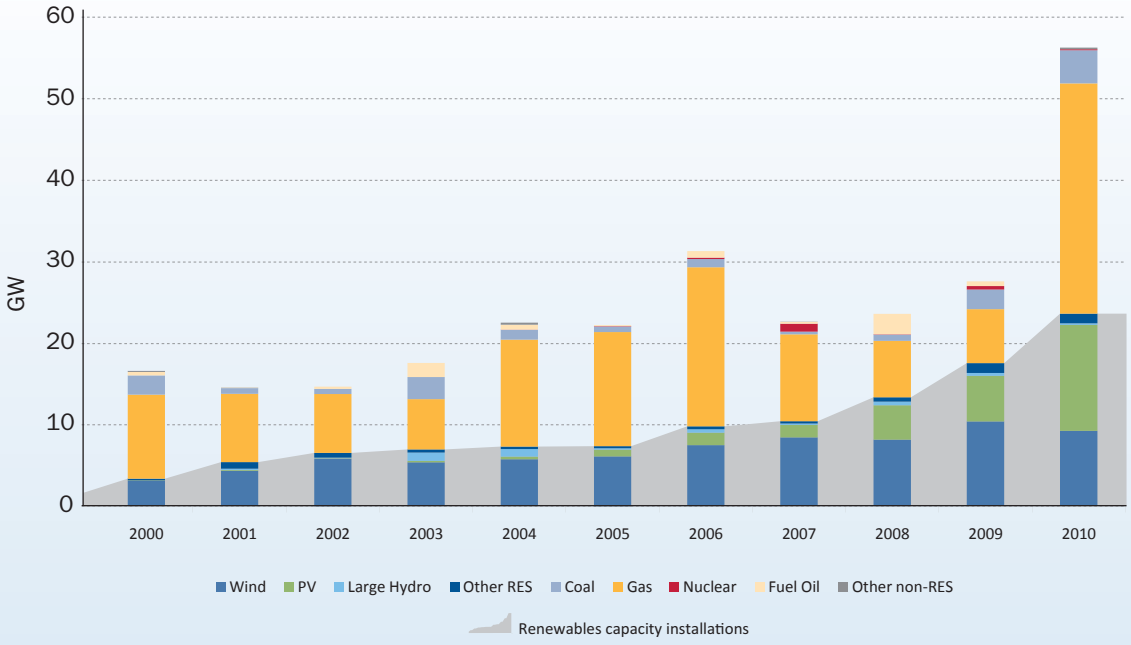
FIGURE 3.4 NET INCREASE/DECREASE IN POWER GENERATING TECHNOLOGIES (2000 – 2010) – TOTAL INCREASE: 200,275 GW



Source: EWEA, EPIA, Estela, EU-OEA and Platts Powervision

[8] Estimate provided by the European Photovoltaic industry Association (EPIA).

FIGURE 3.5 NEW EU POWER GENERATING CAPACITY (2000 – 2010) – TOTAL 272 GW

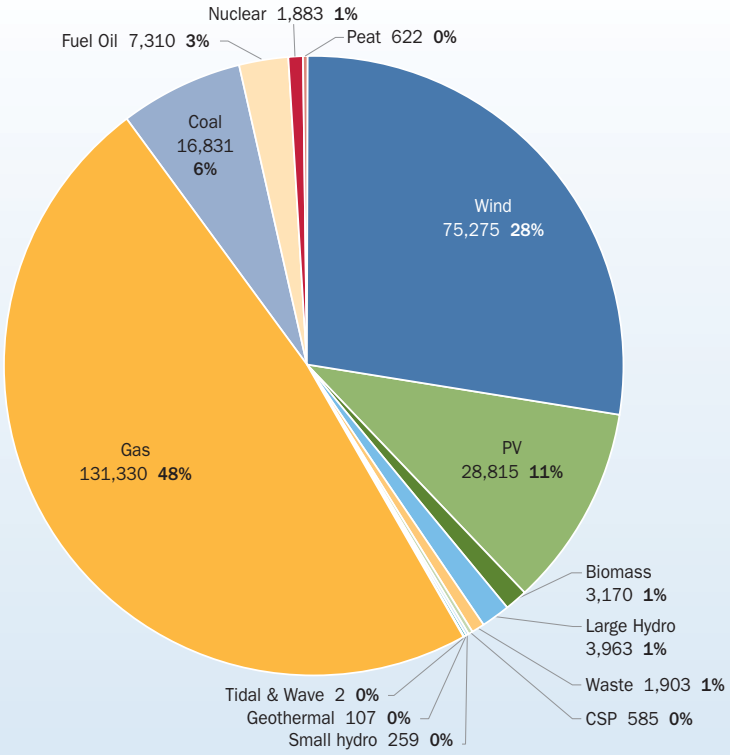


Share of RES in new power capacity additions:

2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
21%	38%	45%	40%	34%	34%	30%	47%	58%	64%	42%

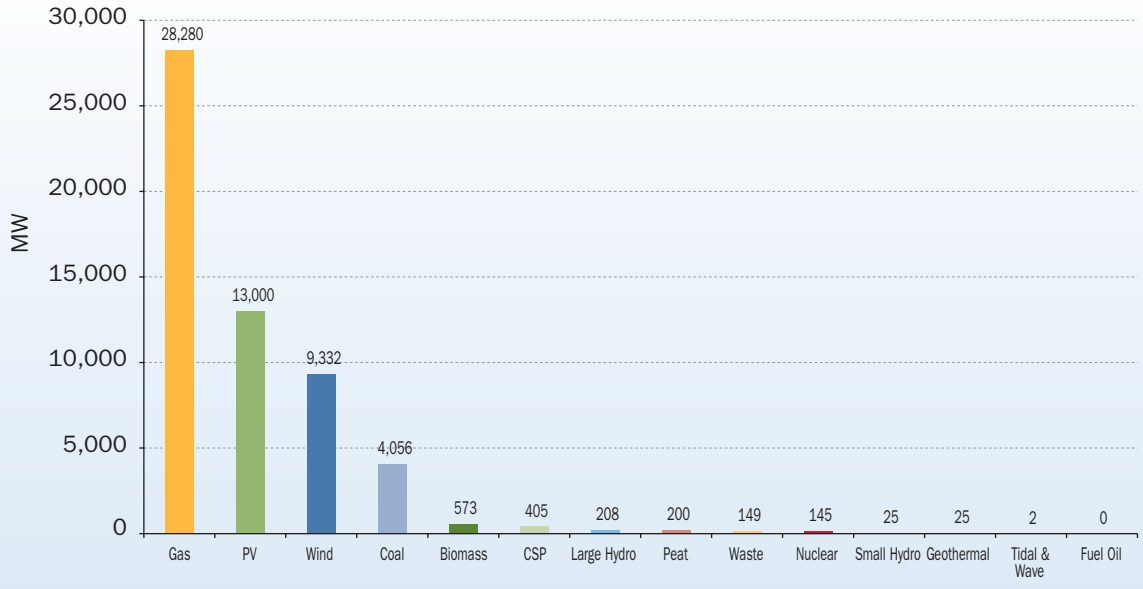
Source: EWEA, EPIA, Estela, EU-OEA and Platts Powervision

FIGURE 3.6 SHARE OF NEW EU POWER CAPACITY (2000 – 2010)



Source: EWEA, EPIA, Estela, EU-OEA and Platts Powervision

FIGURE 3.7 NEW INSTALLED POWER CAPACITY 2010 – TOTAL 56,400 MW



Gas	PV	Wind	Coal	Biomass	CSP	Large Hydro	Peat	Waste	Nuclear	Small Hydro	Geothermal	Tide & Wave
50%	23%	17%	7%	1%	1%	1%	0%	0%	0%	0%	0%	0%

Source: EWEA, EPIA, Estela, EU-OEA and Platts Powervision

TABLE 3.1 NEW ANNUAL POWER CAPACITY IN THE EU 1995-2010 (MW)*

Year	Gas	Wind	Coal	Fuel oil	Large hydro	Biomass	PV	Nuclear	Other non-RES	Other RES	Total
1995	4,661	814	847	1,273	352	0	-	1,258	171	136	9,511
1996	7,401	979	899	1,166	109	569	14	0	120	98	11,354
1997	9,130	1,277	2,792	964	461	82	18	1,516	0	163	16,403
1998	4,836	1,700	2,783	898	391	126	16	0	63	110	10,923
1999	4,855	3,225	62	269	327	9	31	4,548	0	69	13,396
2000	10,320	3,209	2,352	438	0	117	61	0	118	78	16,693
2001	8,391	4,428	703	52	168	383	97	0	9	425	14,656
2002	7,231	5,913	606	283	67	412	143	0	0	177	14,832
2003	6,166	5,462	2,725	1,718	1,035	244	199	0	0	131	17,680
2004	13,130	5,838	1,204	603	922	235	706	40	250	54	22,983
2005	14,025	6,204	677	118	195	101	1,007	50	0	135	22,511
2006	19,543	7,592	1,010	819	404	32	968	163	0	319	30,851
2007	10,670	8,535	332	212	175	196	1,970	987	45	77	23,196
2008	6,932	8,263	762	2,495	450	296	5,059	60	0	233	24,549
2009	6,642	10,499	2,406	573	338	581	5,605	439	0	621	27,693
2010	28,280	9,332	4,056	0	208	573	13,000	145	200	606	55,363

*EU-25 before January 2007; EU-15 before May 2005

Source: EWEA, EPIA, Estela, EU-OEA and Platts Powervision

TABLE 3.2 TOTAL INSTALLED POWER CAPACITY IN THE EU 1995-2010 (MW)*

Year	Gas	Wind	Coal	Fuel oil	Large hydro	Biomass	PV	Nuclear	Other non-RES	Other RES	Total
1995	58,482	2,497	160,926	69,723	104,411	1,928	47	125,065	1,722	7,411	532,213
1996	65,055	3,476	161,001	69,694	104,474	2,497	61	125,065	1,842	7,509	540,674
1997	72,981	4,753	163,095	69,019	104,934	2,579	79	126,522	1,842	7,672	553,476
1998	77,797	6,453	162,051	68,937	105,245	2,705	90	125,322	1,905	7,782	558,288
1999	82,192	9,678	160,686	66,490	105,552	2,673	128	128,471	1,865	7,851	565,585
2000	89,801	12,887	159,482	66,518	105,552	2,790	189	128,474	1,868	7,928	575,486
2001	95,457	17,315	156,671	64,119	105,695	3,173	286	128,471	1,797	8,354	581,337
2002	100,825	23,098	155,235	64,024	105,762	3,585	429	128,179	1,797	8,360	591,294
2003	106,312	28,491	151,644	59,039	106,797	3,760	628	127,267	1,797	8,491	594,224
2004	118,321	34,372	150,493	56,540	107,062	3,995	1,334	127,067	1,837	8,542	609,563
2005	131,797	40,500	150,333	53,650	107,247	4,096	2,341	126,160	1,797	8,672	626,593
2006	162,651	48,031	230,072	53,303	119,600	4,329	3,309	130,309	1,797	9,087	762,487
2007	170,877	56,517	229,322	53,515	119,775	4,498	5,279	129,107	1,842	9,163	779,895
2008	177,613	64,719	229,339	54,879	120,225	4,780	10,338	128,727	1,830	9,644	802,087
2009	183,851	75,103	228,544	54,980	120,397	5,323	15,943	127,773	1,830	10,240	823,972
2010	212,131	84,324	231,050	54,735	120,579	5,851	28,943	127,383	2,030	10,896	876,875

*EU-25 before January 2007; EU-15 before May 2005

Source: EWEA, EPIA, Estela, EU-OEA and Platts Powervision

Summary of wind energy in the EU-27 in 2010

- 84.3 GW installed capacity: 81.4 GW onshore and 2.9 GW offshore
- Annual installations of 9.3 GW: 8.4 GW (90.5%) onshore and 0.9 GW (9.5%) offshore
- Annual investments of €12.7 billion: €10.1 bn onshore and €2.6 bn offshore
- Meeting 5.3% of EU electricity demand
- 17% of all new generating capacity installed in the EU (total 2010: 55.4 GW)
- 10% of total electricity generating capacity in the EU (total: 876.9 GW)
- Producing 181.7 TWh: 171.1 TWh onshore and 10.6 TWh offshore, equivalent to the consumption of 48.3 million[9] average EU households
- Avoiding 126.4 Mt CO_2 annually, equal to 35% of the EU-15's Kyoto obligation
- Avoiding €3.2 bn[10] of CO_2 costs annually
- Avoided fuel costs of €6.5 bn (assuming fuel costs equivalent to the average price of oil in 2010 of $79.52[11] per bbl)

[9] According to the EC PRIMES model, an average EU household's consumption is 3.76 MWh in 2010.
[10] Assuming €25 per tonne of CO_2.
[11] New York Stock Exchange – www.nyse.tv

Photo: Luis Marinho

4 THE EVOLUTION OF WIND ENERGY TARGETS

a. Baseline scenarios from the European Commission, the EU Member States and the International Energy Agency

b. Three short-term predictions for the development of the EU wind power market (2011 – 2015)

c. Can wind energy deliver?

The 1997 European Commission White Paper on Renewable Sources of Energy set the goal of doubling the share of renewable energy in the EU's energy mix from 6% to 12% by 2010. According to Eurostat figures[12], the renewable energy consumption in the EU in 2008 was 10.3%, 1.7 percentage points below the White Paper's 2010 objective.

The White Paper also included a specific, non-binding 2010 target of 40 GW for wind power (2.5 GW in 1995), which would produce 80 TWh (4 TWh in 1995) of power and save 72 Mt of CO_2. By the end of 2010 there were 84.3 GW of wind power capacity installed in the EU producing 181.7 TWh of electricity. The 40 GW target was reached in 2005 and the White Paper target for wind power production in 2010 was exceeded by over 100 TWh. Another target set out in the White Paper was to increase the total production of electricity from renewable energy sources from 337 TWh in 1995 to 675 TWh in 2010. The White Paper expected wind power to contribute 22% of the increase in renewable electricity. In reality, wind power contributed 53% of the increase (178 TWh).

The European Commission's White Paper was followed by Directive 2001/77/EC on the promotion of electricity from Renewable Energy Sources. When adopted in 2001, it was the most important piece of legislation ever introduced for renewables and led the (at the time) 15 Member States to develop political frameworks and financial instruments to encourage investment in renewables and tackle administrative barriers and grid access barriers.

The directive set national indicative targets for the contribution of electricity from renewables as a percentage of gross electricity consumption by 2010. The overall goal was to increase the share coming from renewables from 14% in 1997 to 22.1% in 2010. With enlargement, the 2010 objective was reduced to 21%. In their National Renewable Energy Action Plans, the 27 EU Member States estimate that renewable electricity production would reach 640 TWh by 2010 or 19% of consumption, narrowly missing the Directive's electricity objective.

The 40 GW goal from the European Commission's White Paper naturally formed EWEA's target for 2010 in 1997, but three years later, due to strong development in the German, Spanish and Danish wind energy markets, EWEA increased its target by 50% to 60 GW by 2010 and 150 GW by 2020 (Table 4.1). In 2003, EWEA once again increased its target, this time by 25% to 75 GW by 2010 and 180 GW in 2020.

In 2007, due to the expansion of the EU with ten new Member States, EWEA increased its target for 2010 to 80 GW, while maintaining its 2020 target of 180 GW and setting a target of 300 GW by 2030.

In March 2007, the 27 EU Heads of State unanimously agreed a binding target for 20% renewable energy in 2020. Subsequent to the adoption of the EU's 2009 Renewable Energy Directive, which, for electricity, aims to increase the share of electricity from renewables from 15% in 2005 to 34% in 2020, EWEA in March 2009 again raised its 2020 target for wind energy to 230 GW, including 40 GW offshore and its 2030 target to 400 GW, including 150 GW offshore. These continue to form EWEA's latest targets for 2020 and 2030.

At end 2010, 84.3 GW of wind energy capacity was operating in the EU, of which 81.5 GW in the EU-15. Hence, EWEA underestimated the wind power market by 6.5 GW back in 2003 when it last set a 2010 target.

In the scenario that EWEA published in November 2009[13], we expected installations to reach 82.5 GW by end 2010. Thus the total capacity was underestimated by almost 2 GW. EWEA expected total annual installations in 2009 to be 8.6 GW and 9.2 GW in 2010, whereas the actual market was higher, at 10.5 GW in 2009 and 9.3 GW in 2010.

In the EU, cumulative installed wind power capacity has increased by an average of 17% year on year over the past decade, from 17.3 GW in 2001 to 84.3 GW in 2010. In terms of annual installations, the EU market for wind turbines has grown by an average of 7% annually during the same period, from 4.4 GW in 2001 to 9.3 GW in 2010.

[12] Eurostat 13 July 2010.
[13] Pure Power, EWEA 2009.

a. Baseline scenarios from the European Commission, the EU Member States and the International Energy Agency

The European Commission publishes baseline scenarios for the development of various electricity generation technologies including wind energy using its energy model PRIMES (see Table 4.1). In 1996, before adopting its White Paper target of 40 GW of wind power by 2010, the European Commission estimated that 8 GW would be installed by 2010 in the EU. The 8 GW were reached eleven years early, in 1999 and actual installations reached ten times more, or 81.5 GW in 2010 (in EU-15). The Commission's target for 2020 was set at 12.3 GW and reached two decades ahead of schedule, in 2000.

Since 1996, the European Commission has changed its baseline scenario six times. Over the ten year period between 1996 and 2006, its targets for wind energy in 2010 and 2020 gradually increased tenfold – from 8 GW to 79 GW (for 2010) and from 12 GW to 129 GW (for 2020). Most recently, in 2009, the European Commission updated its scenarios based on the PRIMES model, to 2030[14]. In its new reference scenario, the Commission expects 222 GW of wind to be installed in 2020, 72% and almost 100 GW more than in its 2008 scenario. Its 2030 projection is of 280 GW of wind power capacity, an increase of 92% compared to its estimate just one year earlier.

In parallel to the European Commission's projections, the Member States in compliance with the 2009 Renewable Energy Directive were individually required to submit National Renewable Energy Action Plans (NREAPs) detailing targets for each renewable technology in 2020. Taking the 27 NREAPs together, installed wind power capacity in 2020 is forecast at 213 GW, 43 GW of which offshore[15].

The International Energy Agency (IEA) also publishes scenarios for the development of wind power. In 2002, the IEA estimated that 33 GW would be installed in Europe in 2010, 57 GW by 2020 and 71 GW by 2030. Two years later, in 2004, it doubled its forecast for wind to 66 GW in 2010 and more than doubled its 2020 and 2030 business as usual scenario for wind in the EU to 131 GW and 170 GW respectively. In 2006, the IEA again increased both its 2020 and 2030 targets for wind power in the EU. The IEA subsequently reviewed upwards its 2030 target in 2008 and 2009. In 2010, in its World Energy Outlook, the IEA again upped its wind power targets to 199 GW in 2010 and 263 GW in 2030[16].

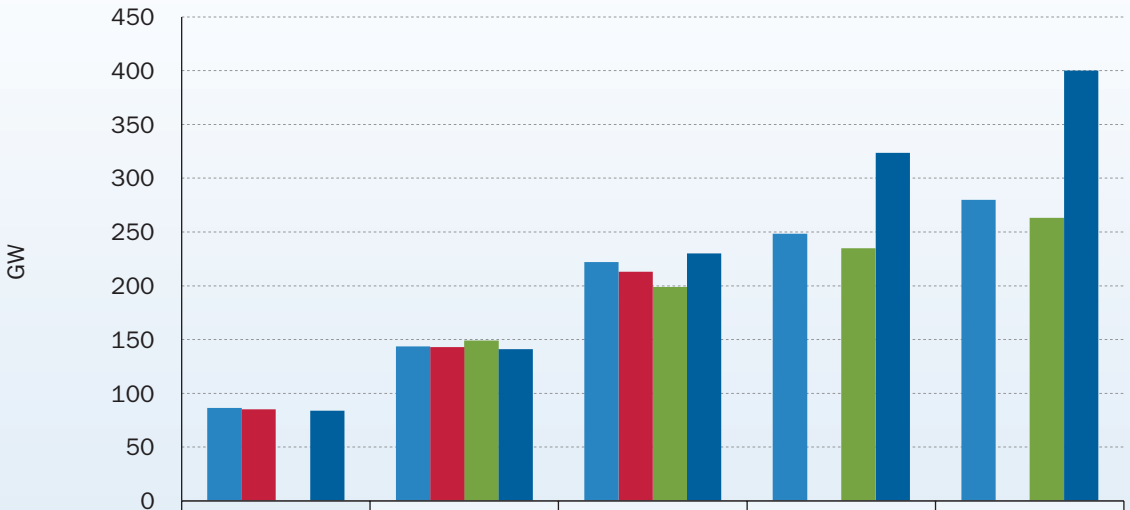
The latest wind energy scenarios from the IEA, European Commission and EWEA are compared in Figure 4.1.

[14] EC, EU energy trends to 2030 – update 2009.
[15] Belgium did not submit an onshore/offshore split, however information obtained by EWEA indicates that 2 GW of installed capacity by 2020 is the country's offshore wind target.
[16] IEA – World Energy Outlook 2010 – new policies scenario.

TABLE 4.1 WIND SCENARIOS FOR EU-27 FROM THE EUROPEAN COMMISSION (PRIMES), THE MEMBER STATES, THE IEA AND EWEA IN GW TOTAL CAPACITY

	1995	2000	2005	2008	2010	2015	2020	2025	2030
European Commission scenarios									
EC 1996		4,38	6,1		8	10	12		
EC 1999			15,3		23		47		
EC 2003					70		95		120
EC 2004					73		104		135
EC 2006					79	104	129	166	185
EC 2008					71	92	120	137	146
EC 2009					86	144	222	248	280
National Renewable Energy Action Plans									
NREAPs					85	143	213		
IEA scenarios									
IEA 2002					33		57		71
IEA 2004					66		131		170
IEA 2006					68	106	150		217
IEA 2008						140	183	211	232
IEA 2009						138	183	220	241
IEA 2010 new policies				65		149	199	235	263
IEA 2010 current policies						192		245	
EWEA scenarios									
EWEA 1997					40				
EWEA 2000					60		150		
EWEA 2003					75		180		
EWEA 2007					80	125	180	166	300
EWEA 2009					82.5	143	230	324	400
EWEA 2011						141	230	324	400
Real market figures									
	2.5	12.9	40.5	64.9	84.3				

FIGURE 4.1 LATEST WIND ENERGY SCENARIOS FOR EU-27 FROM THE EUROPEAN COMMISSION, THE MEMBER STATES, THE IEA AND EWEA (GW TOTAL INSTALLED CAPACITY)



	2010	2015	2020	2025	2030
EC 2009	86	144	222	248	280
NREAPs	85	143	213	-	-
IEA 2010		149	199	235	263
EWEA 2011	84	141	230	324	400

Source: EWEA, European Commission, International Energy Agency, National Renewable Energy Action Plans.

In 2008, one year after the 27 EU Heads of State unanimously agreed the mandatory 20% renewable energy target, the European Commission's PRIMES model – which is run by the E3M lab at the National Technical University of Athens – rather surprisingly reduced its wind energy targets for the first time ever. It lowered its 2010 target by 10% from 79 GW to 71 GW and its 2015 forecast by 12% from 104 GW to 92 GW.

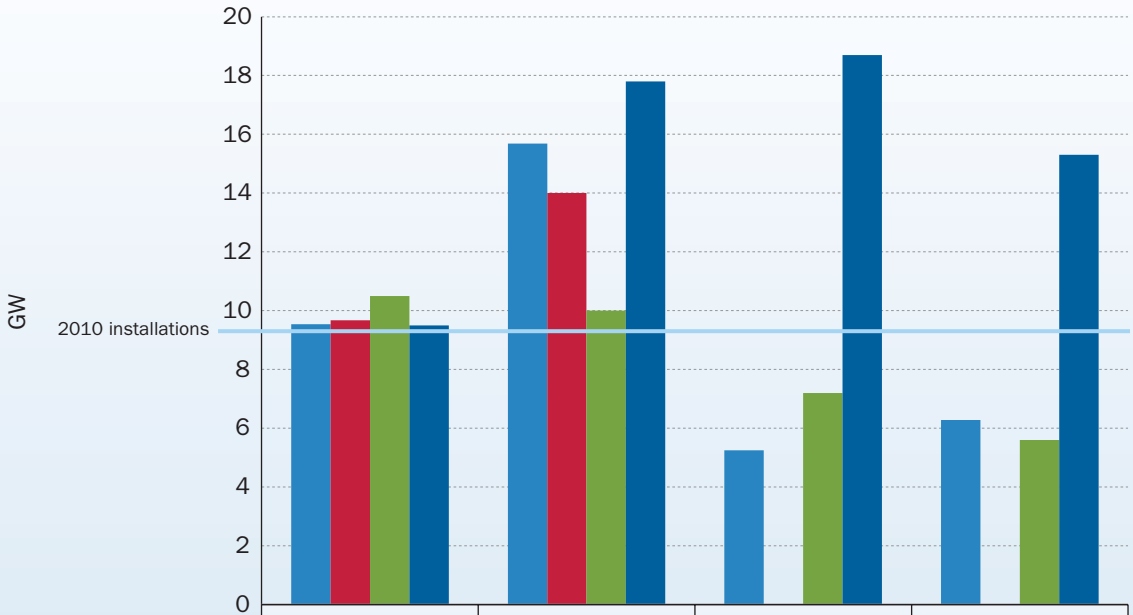
In the same year, the IEA dramatically increased its 2015 forecast by 24% from 106 GW to 140 GW, in line with EWEA's 2015 target of 143 GW.

Similarly in 2008, the European Commission's PRIMES model lowered its 2020 wind energy target from 129 GW to 120 GW, while the IEA increased its target from 150 GW to 183 GW (exceeding EWEA's then 2020 target of 180 GW). For 2030, the European Commission reduced its wind energy target by a massive 39 GW – reducing it by 21% from an already very low level of 185 GW to 146 GW – while the IEA raised its target 28% from 170 GW to 217 GW. These downward revisions have been inverted and the European Commission's latest PRIMES scenario now forecasts 222 GW of installed wind power capacity in 2020 and 280 GW in 2030, above the IEA's scenarios, but below EWEA's (see Figure 4.1).

After having forecast a significant decrease in average annual wind power installations beyond 2010, the latest PRIMES scenario suggests that average net annual installations will be 9.5 GW between 2010 and 2015 – a figure slightly above the 2010 annual market (9.3 GW). In contrast, the EU Member States via their NREAPs forecast a faster average annual increase than the Commission and EWEA over the coming years of 9.7 GW to 2015 (see Figure 4.2).

Importantly, expectations for wind energy in 2020 are converging. However, the IEA and the European Commission's PRIMES scenarios for the power sector in the EU continue to lack credibility for the period after 2020. For example, from 2021 to 2025, the European Commission expects the increase in wind power capacity to drop by an astonishing 67% to 5.2 GW per year, compared to the previous five-year period (Figure 4.2).

FIGURE 4.2 AVERAGE ANNUAL INCREASE IN WIND POWER CAPACITY IN THE EU-27 – THE EUROPEAN COMMISSION, EU MEMBER STATES, THE IEA AND EWEA



	2010 - 2015	2016 - 2020	2021 - 2025	2026 - 2030
EC 2009	9.5	15.7	5.2	6.3
NREAPs	9.7	14.0	-	-
IEA 2010	10.5	10.0	7.2	5.6
EWEA 2011	9.5	17.8	18.7	15.3

The European Commission's 2009 reference scenario takes into account the European Union's "climate and energy package" – including decreased CO_2 emissions (impacting on the price of carbon), increased energy efficiency and increased penetration of renewables through the policy framework of the Renewable Energy Directive 28/2009/EC.

In contrast to its 2008 scenario forecasting a reduction in investments in wind energy, in the Commission's 2009 scenario wind energy capacity is expected to increase to 222 GW by 2020 – 85% more than the 120 GW predicted in 2008. This forecast is above the sum of the 27 NREAPs (213 GW) and just short of EWEA's 230 GW target.

However, from 2021 to 2030, the European Commission's PRIMES scenario forecasts a drastic decrease in wind power and other renewables investments in the EU. From an average annual market of 13.6 GW of new wind installations between 2011 and 2020, the forecast drops to 5.8 GW annually from 2021 to 2030 to reach a cumulative capacity of just under 280 GW in 2030. EWEA expects annual wind energy installations to keep growing to 2025, driven by offshore wind, before stabilising at around 15 GW per year in the 2026 to 2030 period. In all, EWEA expects that there will be 400 GW of installed wind power capacity in the EU in 2030, 150 GW of which offshore.

Moreover, according to the European Commission's forecast, investments in biomass and energy from waste will follow a similar trend to investments in wind; a sharp increase between 2011 and 2015 followed by a slow-down between 2016 and 2020 and a significant drop in annual investments after 2020. The trend for other renewables – including solar technologies, geothermal, tidal and wave – is somewhat different: annual investments increase slowly between 2011 and 2015, more sharply during the subsequent five years, and then plunge post-2020.

Investments in renewable electricity capacity investments total 122 GW (76% of all new power capacity) between 2016 and 2020, according to PRIMES. For the subsequent five-year period (2021-2025), investments in renewable electricity capacity will drop 55% to 56 GW, according to the European Commission's energy model.

Contrary to recent market developments, the PRIMES model forecasts a dramatic increase in EU coal power investments. While new coal installations amounted to 4,320 MW from 2006 to 2010, this would increase more than six-fold to over 27,000 MW between 2011 and 2015, according to PRIMES. In the following five years new coal installations would drop to around 16,600 MW but pick up again beyond 2020.

Despite gas having been the leading technology for new power investments in the EU over the past decade, the PRIMES model expects new gas power investments to experience a dramatic drop of 80% already from 2016.

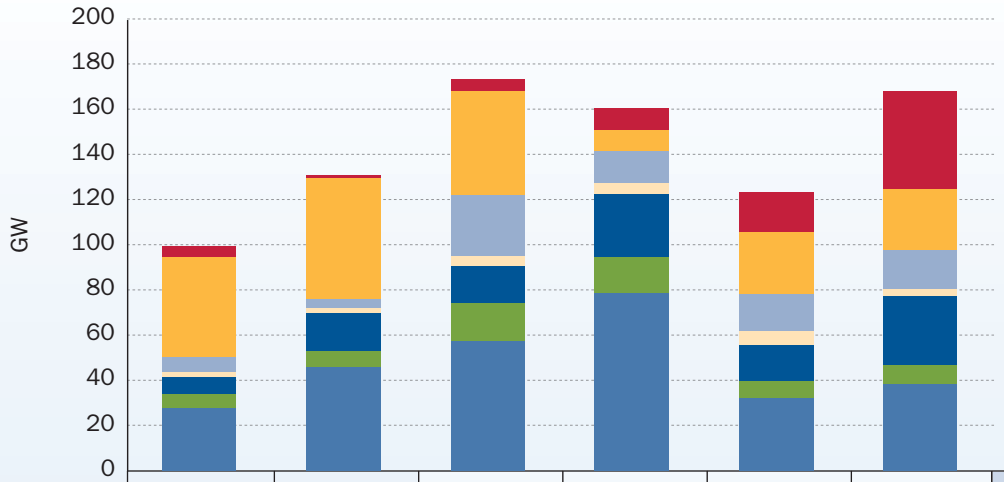
Even more surprisingly, the European Commission's PRIMES energy model expects 14.3 GW of new nuclear capacity to be connected to the EU grid in the current decade, or about two new nuclear reactors per year up to 2020. Three projects are currently under construction in Slovakia, France and Finland with a combined capacity of 4.2 GW. The model does not specify where the additional 10 nuclear reactors of 1 GW each are assumed to be constructed and grid connected over the next eight and a half years. For the decade 2020 to 2030, the Commission assumes that more than seven new nuclear power plants of 1 GW each will be build per year (71.3 GW in total) in the European Union.

The European Commission's energy model assumes the investment cost of new nuclear power in 2010 to be €2.8 billion per GW, "including extension of lifetime and refurbishment". Moody's, the credit rating agency, in 2009 estimated the capital cost of nuclear capacity to be 85% higher or $7.5 billion (€5.2 billion) per GW, while concluding that nuclear electricity – even under the credit agency's optimistic assumption of a 50 year reactor lifetime – cost 20% more to produce than new onshore wind electricity.

The European Commission's PRIMES model justifies its decrease in wind and other renewables investments post 2020 by the lack of an EU regulatory framework, whereas the increase up to 2020 is justified by Member States' efforts to reach their binding renewable energy targets. The Commission also notes that "between 2015 and 2020 renewable energies represent the bulk of overall investment in the capacity accounting for almost 80%, the largest amount of which being devoted to wind onshore followed by wind offshore and solar".

In total, PRIMES forecasts that 624 GW of new power generating capacity will be build in the EU in the two decades from 2011 to 2030, of which 345 GW (55%) will be renewable capacity. The model expects 206 GW of wind to be constructed, equal to 33% of all new power capacity in the period.

FIGURE 4.3 NEW CAPACITY ADDITIONS
EU 2000-2030 ACCORDING TO THE EUROPEAN COMMISSION'S PRIMES MODEL, 2009



	2000-2005	2006-2010	2011-2015	2016-2020	2021-2025	2026-2030	2011-2030
Nuclear	4,832	1,535	4,999	9,323	17,628	43,289	75,239
Gas	44,166	53,284	46,048	9,502	27,274	27,009	109,833
Coal	6,802	4,320	27,407	14,218	16,622	17,485	75,732
Oil	2,208	2,307	4,314	4,651	5,907	3,413	18,285
Other RES	7,445	16,486	16,497	28,052	16,318	30,135	91,002
Biomass*	5,921	7,027	16,524	15,920	7,222	8,344	48,010
Wind	27,791	45,821	57,238	78,443	32,096	38,345	206,122
Total new power capacity	99,165	130,780	173,027	160,109	123,067	168,020	624,223
All renewables	41,157	69,334	90,259	122,415	55,636	76,824	345,134
Renewables share	42%	53%	52%	76%	45%	46%	55%
Wind share	28%	35%	33%	49%	26%	23%	33%

*biomass and waste

Source: "EU Energy trends to 2030 – update 2009", European Commission 2010

The reader should note that, because the European Commission ran the PRIMES model during 2009, capacity figures for 2009 and 2010 are part of the 2006-2010 forecast rather than "real" data for the two years. Using real data for 2009 and 2010 would add 12.5 GW to other renewables and almost 20 GW to gas investments in the 2006-2010 period, indicating a dramatic underestimation of these technologies for 2009 and 2010 in the PRIMES model.

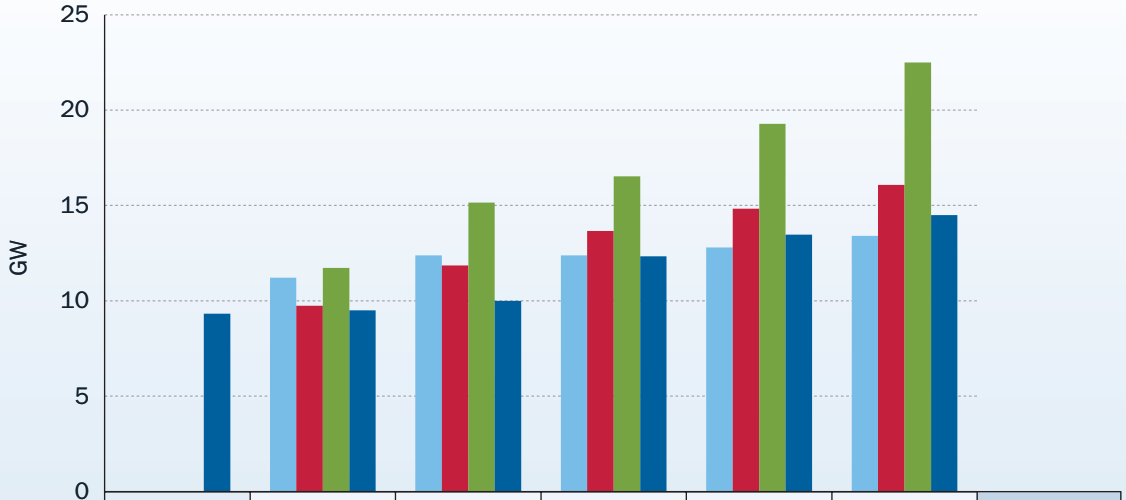
b. Three short-term predictions for the development of the EU wind power market (2011 – 2015)

As illustrated in the previous sections, the European Commission's PRIMES energy model has serious flaws. Furthermore, the public has no access to data or information about the model's underlying assumptions, e.g. its assumed breakdown of wind energy into onshore and offshore is not disclosed and it does not provide assumptions on capacity retirements. This lack of transparency makes it difficult to analyse the model's shortcomings.

For the first time, nevertheless, the 2009 update projects a growth of wind energy capacity diverging only by 3.5% from EWEA's 2020 forecast of 230 GW – the Commission forecasts 222 GW in 2020. Short-term, for the first time, the Commission's scenarios are similar to EWEA's. The Commission expects 144 MW of wind power capacity to be installed by 2015 – an average annual increase of 11.5 GW between 2011 and 2015. EWEA's forecast expects 141 GW to be installed in 2015 – an average annual increase of 11.4 GW.

As was also illustrated in the previous section, EWEA has always been rather conservative in setting targets and has, as a consequence, found it necessary to raise its targets four times since 2000. As depicted in Figure

FIGURE 4.4 ANNUAL MARKET FORECASTS (2011 – 2015) EWEA, EER, MAKE CONSULTING AND BTM CONSULT COMPARED



	2010 real	2011	2012	2013	2014	2015	2011 - 2015
EER	-	11.22	12.39	12.39	12.80	13.40	62.2
Make	-	9.74	11.86	13.66	14.83	16.08	66.2
BTM	-	11.73	15.15	16.53	19.28	22.50	85.2
EWEA	9.33	9.50	10.00	12.34	13.47	14.50	59.8

4.4, EWEA's target is significantly below those of market analysts BTM Consult[17] and MAKE Consulting[18] for every year up to 2015. EWEA's forecast is also below market analysts Emerging Energy Research's (EER)[19] for 2011, 2012 and 2013. For the subsequent two years, EWEA's forecast is slightly above EER's.

It is clear that EWEA – which expects a total of 59.8 GW to be installed in the European Union over the next five years – is more conservative than the three independent market analysts. Over the five year period, EER expects 62.2 GW to be installed, MAKE Consulting expects 66.2 GW and BTM Consult expects 85.2 GW.

c. Can wind energy deliver?

Following the Council's agreement to reduce EU greenhouse gas emissions by 80-95% by 2050, it has been widely debated whether we can reach our carbon targets without building new nuclear power stations. That question has already been answered. The European Union is already 16% below its 1990 level of greenhouse gas emissions and, thus, already close to meeting its 2020 reduction target of 20%, not least because of the rapid expansion of some renewables as documented elsewhere in this report. This reduction in EU CO_2 emissions has been achieved without building one single new nuclear power plant. Globally, the world installed almost 50% more new wind power capacity in 2010 alone (38.3 GW) than it installed new nuclear capacity in the last decade (26.1 GW).

New nuclear power plants are not needed to meet Europe's future demand for power. Whether they will be built is, in the end, a political question. Several more cost-effective renewable energy technologies such as onshore and offshore wind energy already exist and more are on their way.

However, another question is whether we can meet our climate and energy targets if we phase out Europe's existing nuclear power plants and whether or not renewables can fill the gap, as suggested by the German government in the aftermath of the Fukushima nuclear disaster. Germany, which gets 20% of its electricity from nuclear, would be able to do it in a decade, starting with the seven nuclear plants already idled, according to a report by the government's Ethics Commission. So would the UK (16% nuclear) and Spain (20% nuclear) probably, whereas one would expect it to take significantly longer in France, which gets 80% of its electricity from nuclear energy.

Removing any capacity from the power system is likely to increase power prices in the short-term. The German government estimates that domestic electricity prices would rise by €0.01/kWh , equivalent to €3 per month for an average German household if all the country's nuclear reactors were phased out in 2020.

[17] Source BTM, 2011.
[18] Source MAKE, 2011.
[19] Source EER, 2010.

Photo: ACCIONA

5 2020 TARGETS

a. Analysis of the National Renewable Energy Action Plans

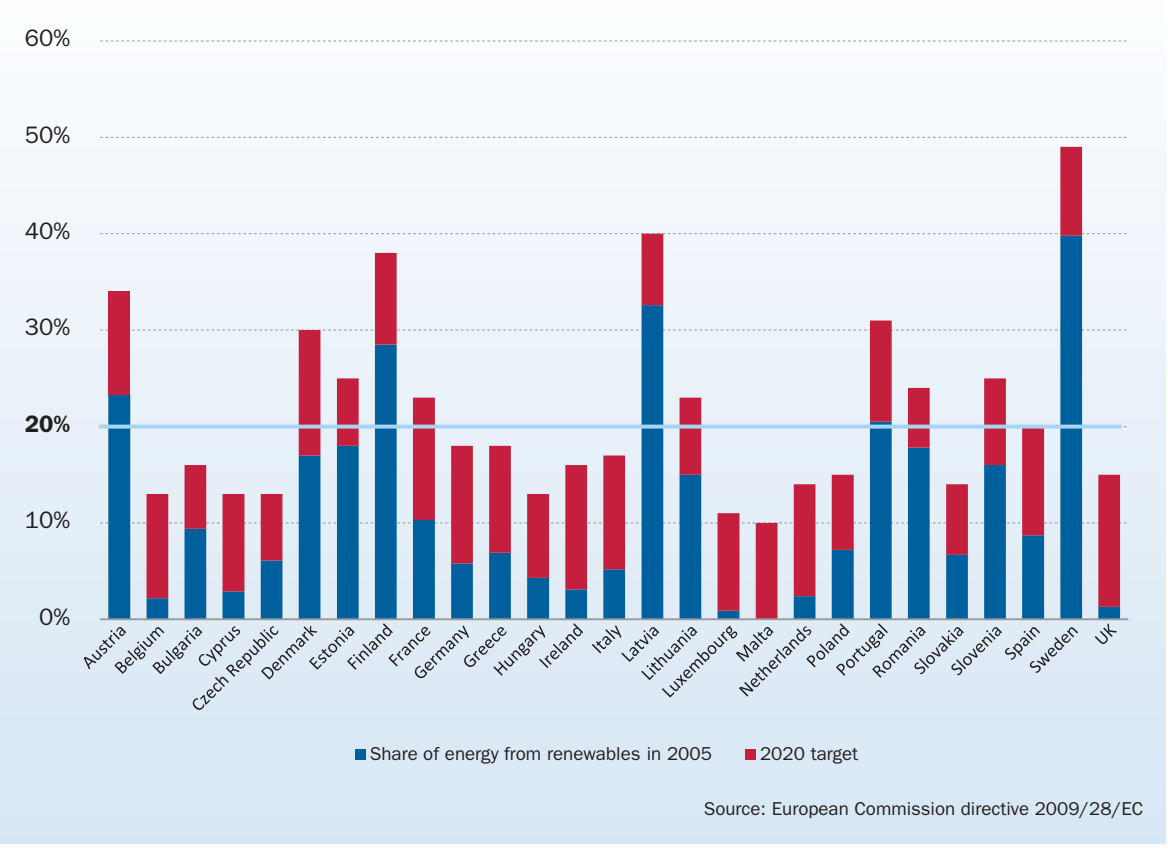
b. EWEA scenarios

a. Analysis of the National Renewable Energy Action Plans

The December 2008 agreement on the 2009 Renewable Energy Directive is the main reason EWEA increased its targets for 2020 in March 2009 from 180 GW to 230 GW and subsequently increased its 2030 target from 300 GW to 400 GW. The directive sets binding national targets for the share of renewable energy in each of the 27 EU Member States in 2020 (see Figure 5.1). It is by far the most significant legislative effort to promote renewable energy, including wind power, anywhere in the world.

The 2009 Renewable Energy Directive ("the directive") also sets out indicative trajectories for renewable energy in each Member State corresponding to average minimum renewables penetration for four two year periods (2011-2012, 2013-2014, 2015-2016 and 2017-2018). This is to ensure that countries do not put off making an effort to the end of the target period.

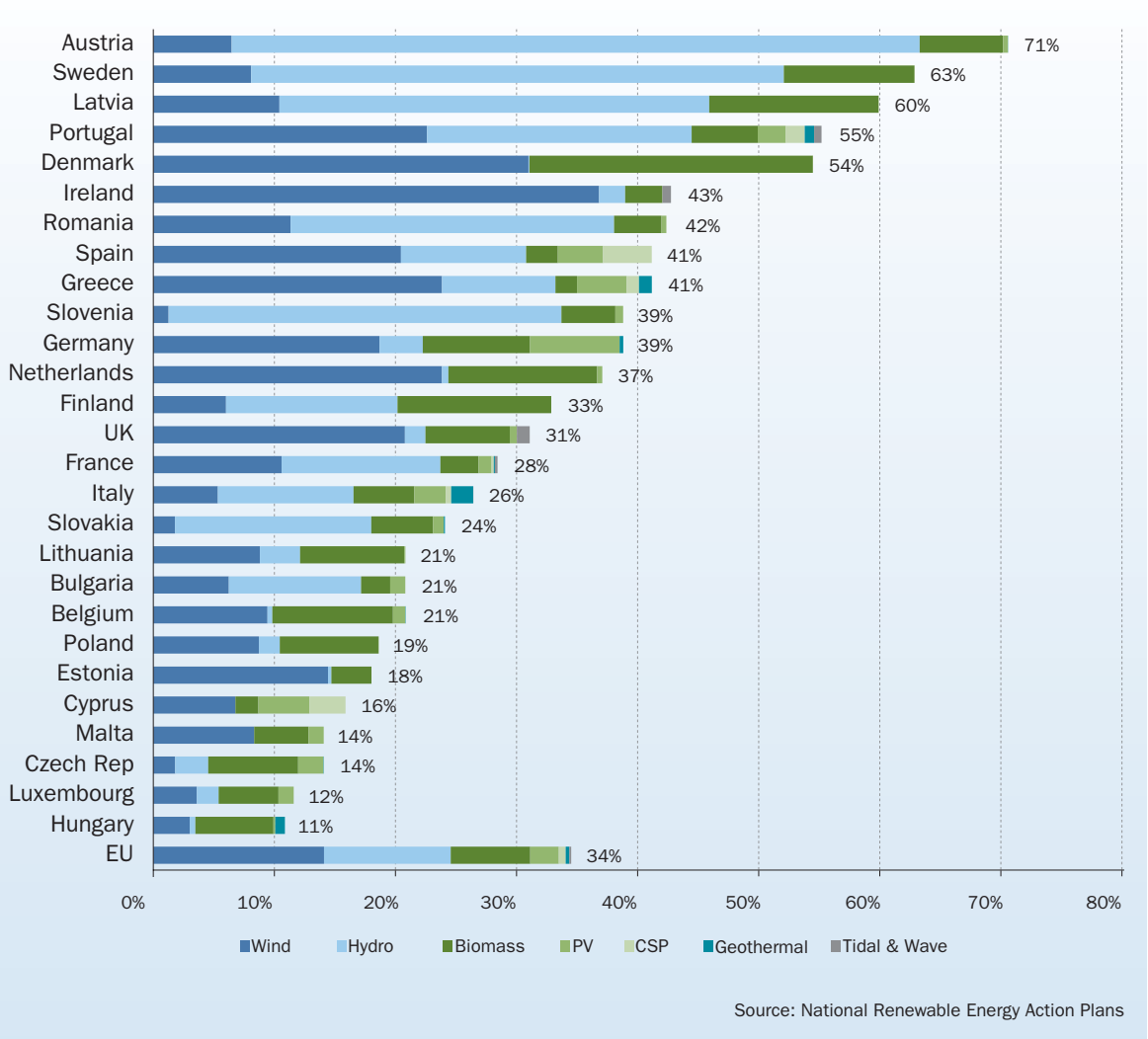
FIGURE 5.1 NATIONAL OVERALL TARGETS FOR THE SHARE OF ENERGY FROM RENEWABLES IN FINAL CONSUMPTION (2020)



Source: European Commission directive 2009/28/EC

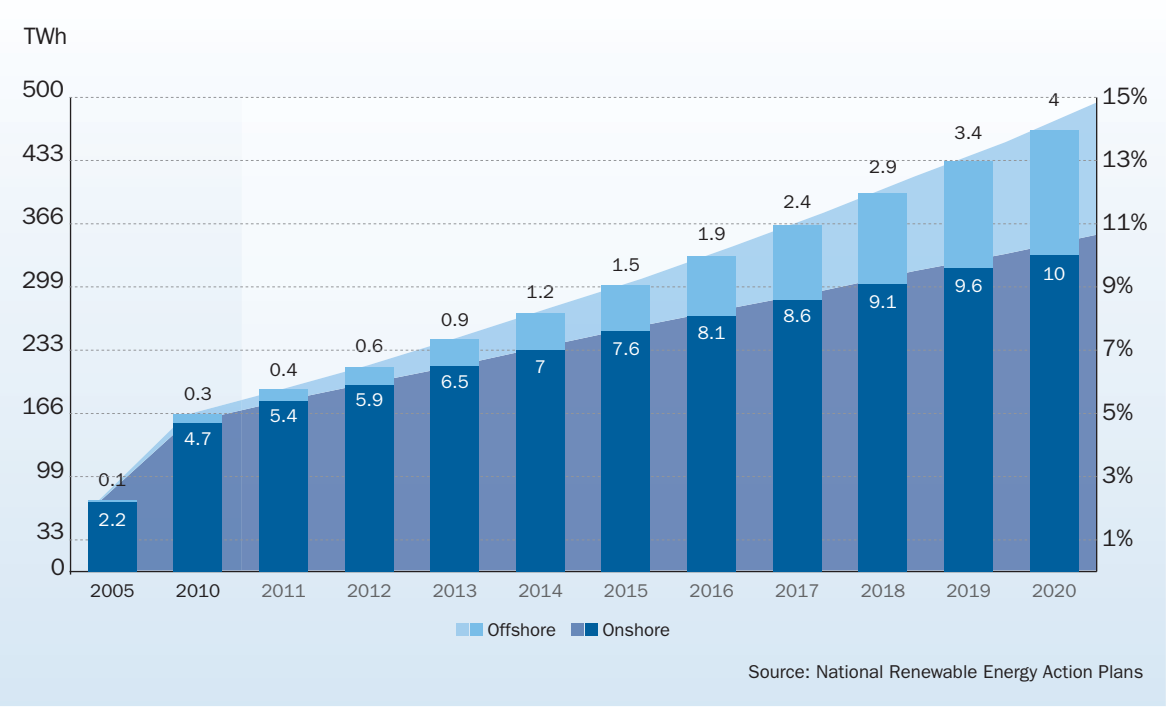
The directive sets out to increase the overall share of renewable energy from 8.6% in 2005 to 20% in 2020. For electricity, the European Commission, when drafting the directive, expected that the share of renewable energy would increase from 15% to 34% in 2020. Moreover, the European Commission expected wind energy (prior to the 2009 update mentioned above) to be supplying 12% of the EU's electricity demand by 2020, equivalent to around 180 GW of wind power capacity. This corresponds to EWEA's previous target of 180 GW, including 35 GW offshore. To reach the 180 GW, wind power capacity would need to increase by 9.6 GW per year over the next 10 years. Given the increase of 9.3 GW in 2010 and that wind energy is the most competitive of the renewable energy technologies in most Member States, 180 GW of wind power in the EU is likely to be achieved well before 2020.

FIGURE 5.2 RENEWABLES' SHARE OF ELECTRICITY CONSUMPTION PER MEMBER STATE (%) IN 2020 ACCORDING TO THE NREAPs
For full details see Annex 3.



Source: National Renewable Energy Action Plans

FIGURE 5.3 ELECTRICITY PRODUCTION FROM ONSHORE AND OFFSHORE WIND ENERGY ACCORDING TO THE NREAPs



Source: National Renewable Energy Action Plans

As mentioned in a previous chapter[20], the directive also required that every Member State produce a National Renewable Energy Action Plan (NREAP). The NREAPs include targets for wind power installations and wind energy production. The NREAPs show that the vast majority of Member States are taking their responsibilities seriously. According to the plans, the EU-27 will exceed its target of meeting 20% of its gross final energy consumption from renewable sources by 2020. Taken together, the NREAPs show that the EU-27 will meet 20.7% of its 2020 energy consumption from renewables. The target for renewables in electricity consumption is 34%[21], and the EU Member States have a 213 GW target for wind power, which will produce 495 TWh of electricity – enough to meet 14% of the EU's electricity consumption.

The remaining 20% of electricity consumption covered by renewable energy sources in 2020 consists of:

- Hydro – 10.5% (370 TWh from 136 GW of installed capacity);
- Biomass – 6.7% (232 TWh from 43 GW of installed capacity);
- Solar PV – 2.4% (83.3 TWh from 84 GW of installed capacity);
- Concentrated solar power – 0.5% (20 TWh from 7 GW of installed capacity);
- Geothermal – 0.3% (10.7 TWh from 1.6 GW of installed capacity);
- Tidal, wave and ocean – 0.2% (5.8 TWh from 2 GW of installed capacity).

[20] Chapter 1, National Wind Energy Scenarios.
[21] Together, the NREAPs forecast total electricity consumption for the 27 Member States in 2020 of 3,529 TWh.

b. EWEA scenarios

Assuming the European Commission's "EU Energy Trends to 2030"[22] projections for electricity demand in 2020, EWEA's 2020 target of 230 GW of wind power would meet 15.7% of EU electricity demand, including 4% of overall demand being met by offshore wind. If the electricity consumption scenario from the NREAPs is assumed, 230 GW of wind power would meet 19.3% of electricity demand (4.2% from offshore).

TABLE 5.1 RENEWABLES' AND WIND'S SHARE IN EU ENERGY MIX

	2005	2020
Renewable energy share EC*	8.6%	20%
Renewable energy share NREAPs**	8.7%	20.7%
Renewable electricity share EC***	14.3%	36.1%
Renewable electricity share NREAPs**	16%	34%
Wind share EC****	2.5%	15.7%
of which offshore	0.1%	4%
Wind share NREAPs*****	2.5%	19.3%
of which offshore	0.1%	4.2%

* 2009 Renewable Energy Directive / European Commission

** National Renewable Energy Action Plans / EU Member States

*** 2009 EU energy trends to 2030 / European Commission

**** EWEA, assuming European Commission "EU energy trends to 2030" demand

***** EWEA, assuming National Renewable Energy Action Plans demand

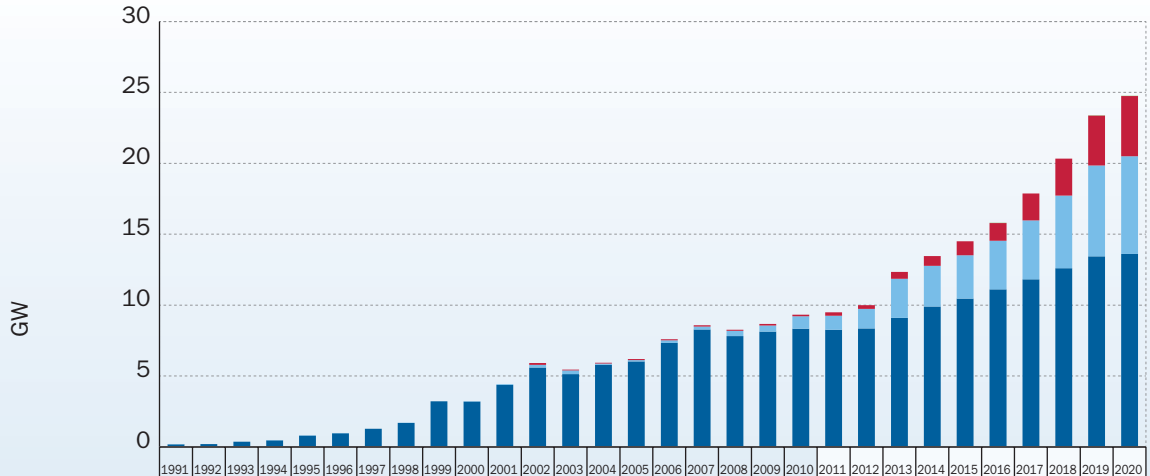
Figure 5.4 shows the annual market for wind power up to 2020 according to EWEA's targets. In 2011, the annual market for offshore wind is expected to reach 1 GW for the first time and exceed it in subsequent years. During the second half of this decade, an increasing amount of existing onshore wind power capacity will be decommissioned. The market for replacement (repowering) is expected to increase from 1 GW in 2015 to 4.2 GW in 2020. By 2020, 28% of the annual market for new wind power capacity will be offshore. Annual investment in wind power will increase from €12.7 billion in 2010 to €26.6 billion in 2020 (see Chapter 10). Annual investment in offshore wind will increase from €2.6 billion in 2010 to €10.4 billion in 2020, equal to 39.1% of total investment.

Figure 5.5 shows the development of total installed capacity in the EU according to EWEA's targets. At end 2010, there were 84.3 GW of wind power capacity installed in the EU, and EWEA expects 141 GW to be installed in 2015. Offshore wind energy's share of total wind power capacity will increase gradually from 3.5% in 2010 to 9.9% in 2015 and 17.4% in 2020.

The wind energy capacity installed at end 2010 will, in a normal wind year, produce 181.7 TWh of electricity. If EWEA's scenarios are met, wind energy will produce 330 TWh in 2015 and 581 TWh in 2020 – meeting, respectively 9.4% and 15.7% of the EU's total electricity consumption. Offshore wind energy's share of EU wind energy production will increase from 5.8% in 2010 to 25.5% in 2020.

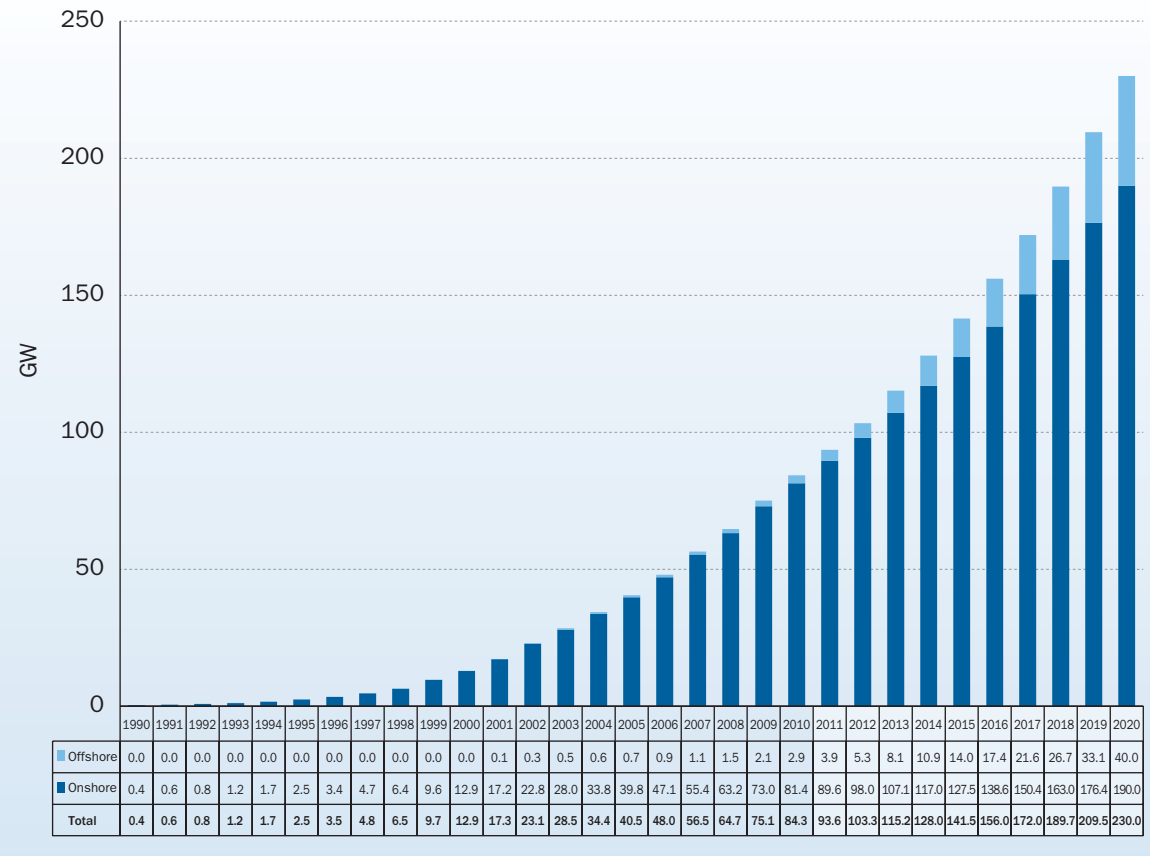
[22] Source: "EU energy trends to 2030 – 2009 update", European Commission 2010.

FIGURE 5.4 NEW ANNUAL EU WIND POWER CAPACITY ADDITIONS (1991-2020)



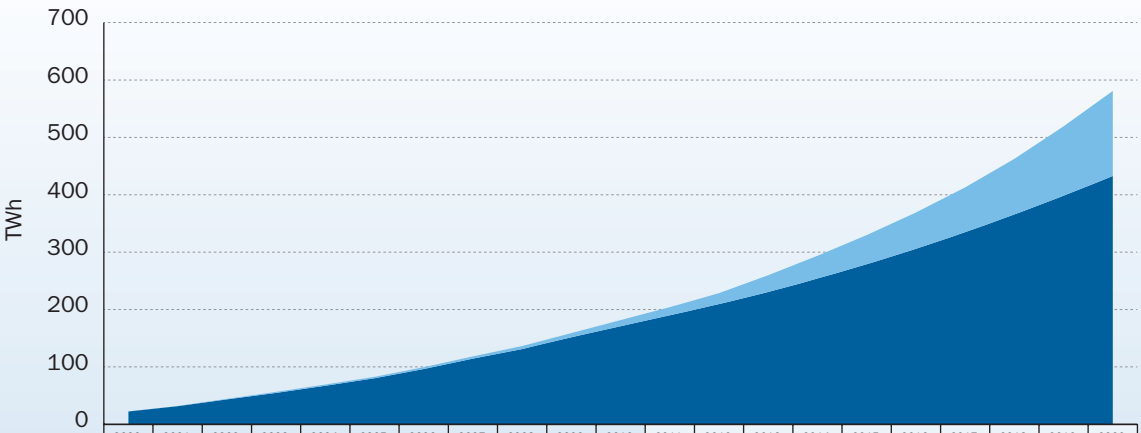
	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
Offshore repowering	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Onshore repowering	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.2	0.3	0.5	0.7	1.0	1.3	1.9	2.6	3.5	4.2
New offshore	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.2	0.3	0.1	0.1	0.2	0.2	0.4	0.4	0.9	1.0	1.4	2.8	2.9	3.1	3.4	4.1	5.1	6.4	6.9
New onshore	0.2	0.2	0.4	0.5	0.8	1.0	1.3	1.7	3.2	3.2	4.4	5.6	5.1	5.8	6.0	7.3	8.3	7.8	8.1	8.3	8.3	8.4	9.1	9.9	10.5	11.1	11.8	12.6	13.4	13.6
Total	**0.2**	**0.2**	**0.4**	**0.5**	**0.8**	**1.0**	**1.3**	**1.7**	**3.2**	**3.2**	**4.4**	**5.9**	**5.5**	**5.9**	**6.2**	**7.6**	**8.6**	**8.3**	**8.7**	**9.3**	**9.5**	**10.0**	**12.3**	**13.5**	**14.5**	**15.8**	**17.9**	**20.3**	**23.4**	**24.8**

FIGURE 5.5 CUMULATIVE EU WIND POWER CAPACITY (1990-2020)



	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
Offshore	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.3	0.5	0.6	0.7	0.9	1.1	1.5	2.1	2.9	3.9	5.3	8.1	10.9	14.0	17.4	21.6	26.7	33.1	40.0
Onshore	0.4	0.6	0.8	1.2	1.7	2.5	3.4	4.7	6.4	9.6	12.9	17.2	22.8	28.0	33.8	39.8	47.1	55.4	63.2	73.0	81.4	89.6	98.0	107.1	117.0	127.5	138.6	150.4	163.0	176.4	190.0
Total	**0.4**	**0.6**	**0.8**	**1.2**	**1.7**	**2.5**	**3.5**	**4.8**	**6.5**	**9.7**	**12.9**	**17.3**	**23.1**	**28.5**	**34.4**	**40.5**	**48.0**	**56.5**	**64.7**	**75.1**	**84.3**	**93.6**	**103.3**	**115.2**	**128.0**	**141.5**	**156.0**	**172.0**	**189.7**	**209.5**	**230.0**

FIGURE 5.6 WIND ENERGY PRODUCTION IN THE EU (2000 – 2020)

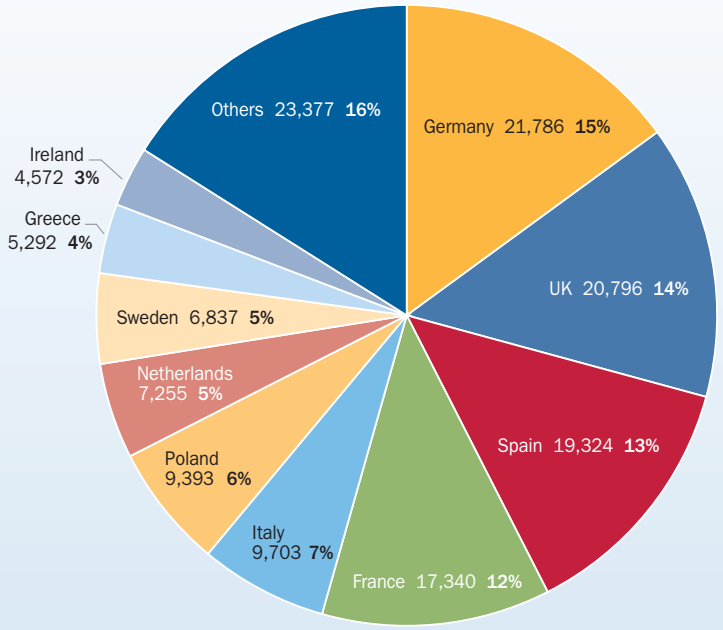


	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
Offshore	0.1	0.3	0.9	1.8	2.1	2.5	3.2	3.9	5.3	7.4	10.6	14.2	19.1	29.1	39.5	50.6	63.2	78.3	97.1	120.5	148.2
Onshore	22.5	31.7	43.5	54.8	67.3	80.3	96.4	114.5	131.2	151.6	171.1	190.0	209.5	230.8	254.2	279.2	305.9	334.7	365.6	398.8	432.7
Total	**22.6**	**32.0**	**44.4**	**56.6**	**69.4**	**82.8**	**99.6**	**118.5**	**136.4**	**159.0**	**181.7**	**204.2**	**228.6**	**259.9**	**293.7**	**329.8**	**369.1**	**412.9**	**462.6**	**519.3**	**581.0**

Figure 5.7 shows the national breakdown of the increase in wind power capacity according to EWEA's 230 GW scenario (see also Chapter 1). In total, wind energy capacity in the EU will increase by 146 GW by 2020. Germany will continue to be in the lead over the next 10 years, increasing its installed capacity by 21.8 GW. Spain, with a 19.3 GW increase would be overtaken by France (adding 20.8 GW) and the UK would come in fourth adding 17.3 GW. They are followed by Italy (9.7 GW), Poland (9.4 GW) and the Netherlands (7.3 GW). The group labelled "others" has 16% of the total increase in capacity (23.4 GW). Nevertheless, Germany and Spain together would still make up 28% of the total EU increase. Today, 25 EU Member States have wind power. All 27 Member States are expected to have operating wind farms by 2020.

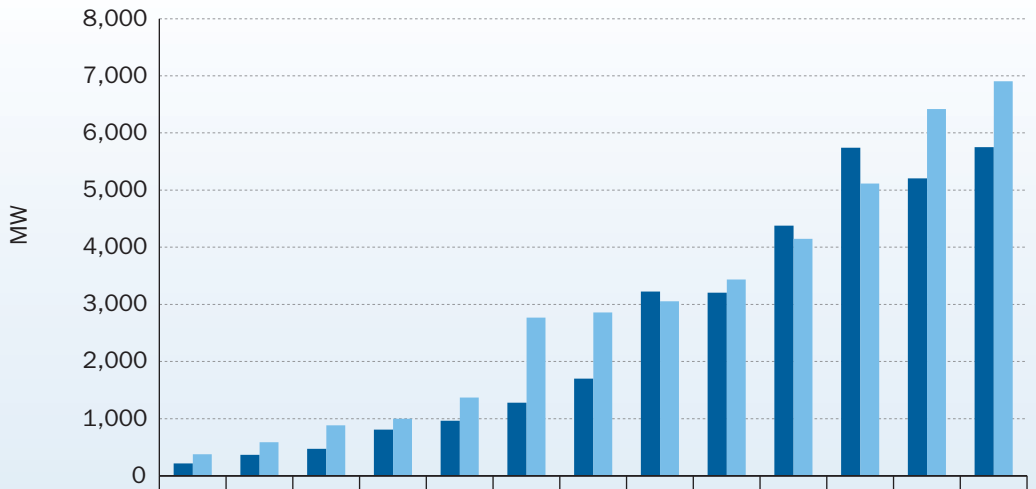
EWEA's 40 GW target for offshore wind energy by 2020 requires an annual average market growth of 21% – from 883 MW in 2010 to 6,902 MW in 2020 – over the next 10 years. For comparison, the onshore market grew by an annual average of 22% – from 809 MW in 1995 to 5,749 MW in 2004 (see Figure 5.6). EWEA is confident that the development of onshore can be replicated at sea, but it requires increased efforts, not least in terms of R&D and the construction of a European offshore power grid.

FIGURE 5.7 TOP 10 EU COUNTRIES FOR INCREASED WIND POWER CAPACITY IN GW (2011-2020)



Others	Increase in wind power capacity 2011-2020 (MW)	% of EU-27 increase in wind power capacity 2011-2020
Portugal	3,602	2.5%
Belgium	2,986	2.1%
Bulgaria	2,625	1.8%
Romania	2,538	1.7%
Austria	2,489	1.7%
Denmark	2,202	1.5%
Finland	1,703	1.2%
Czech Republic	1,385	1%
Lithuania	846	0.6%
Slovakia	797	0.5%
Hungary	605	0.4%
Slovenia	500	0.3%
Estonia	351	0.2%
Luxembourg	258	0.2%
Cyprus	218	0.1%
Latvia	169	0.1%
Malta	100	0.1%

FIGURE 5.8 ONSHORE HISTORICAL GROWTH 1994 – 2004 COMPARED TO EWEA'S OFFSHORE PROJECTION 2010 – 2020



	1992 - 2008	1993 - 2009	1994 - 2010	1995 - 2011	1996 - 2012	1997 - 2013	1998 - 2014	1999 - 2015	2000 - 2016	2001 - 2017	2002 - 2018	2003 - 2019	2004 - 2020
Onshore (1992-2004)	215	367	470	809	962	1,277	1,697	3,225	3,205	4,377	5,743	5,203	5,749
Offshore (2008-2020)	374	584	883	1,000	1,370	2,767	2,859	3,053	3,433	4,145	5,115	6,419	6,902

Source: EWEA 2011

Summary of wind energy in 2020, according to EWEA targets

- 230 GW installed capacity: 190 GW onshore and 40 GW offshore
- Annual installations of 24.8 GW: 17.8 GW (72%) onshore and 6.9 GW offshore (28%)
- Annual investments of €26.6 billion: €16.2 billion onshore and €10.4 billion offshore
- Meeting 15.7% to 16.5% of EU electricity demand depending on total demand
- 22.9% of total electricity generating capacity in the EU (Total end 2020: 1,003 GW)
- Producing 581 TWh of electricity: 433 TWh onshore and 148 TWh offshore, equivalent to the consumption of 140 million average EU households
- Avoiding 341.6 Mt CO_2 annually
- Avoided fuel costs of €23.9 billion (assuming IEA forecast, fuel cost equivalent to $97.4/bbl of oil, real 2010 value)
- Avoiding €8.5 billion of CO_2 costs annually (assuming €25/t CO_2).

Photo: ACCIONA

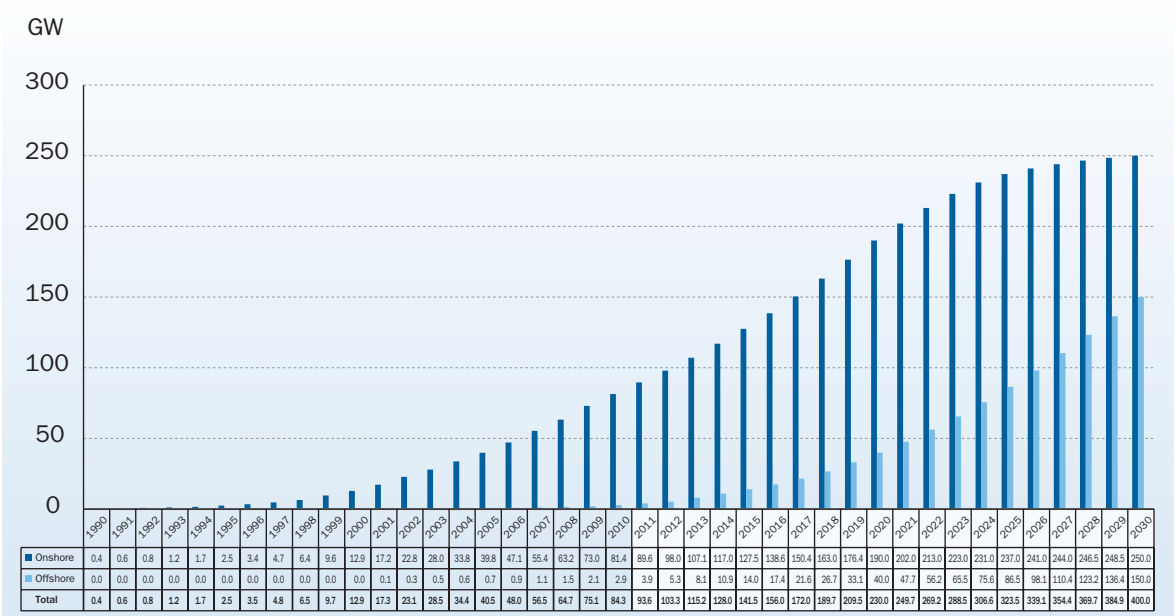
6 EWEA'S 2030 TARGET

By 2030, EWEA expects 400 GW of wind energy capacity to be operating in the EU – 250 GW on land and 150 GW offshore. Figure 6.1 shows the development in cumulative wind energy capacity according to this target. The onshore development forms a classic S-curve of early exponential growth being replaced by saturation towards 2030. In terms of total capacity, offshore is currently (end 2010) at the level of onshore wind in 1995. By 2025, offshore capacity is expected to exceed the 84.3 GW of wind that was operating onshore at the end of 2010. According to the target, offshore wind is following onshore wind in Europe with a 15 year time-lag. Given its larger potential, it can be expected that total offshore wind capacity will exceed onshore capacity at some point beyond 2030.

A comparison of EWEA's scenarios up to 2030 with those of independent analysts shows that EWEA's targets are conservative (see Chapter 5). As Figure 6.2 reveals, EWEA's scenario has 141 GW of installed capacity in 2015 compared with 148 GW for EER and 179 GW for BTM Consult, whilst the 27 EU Member States' NREAPs expect 143 GW of wind power capacity by 2015. By 2020, EWEA has 230 GW to BTM's 312 GW, although EER has a lower target of 223 GW. As seen in previous chapters, the European Commission expects 222 GW in 2020, whilst the NREAPs add up to 213 GW. In 2030, EWEA's 400 GW target is well exceeded by BTM's more ambitious 509 GW[23] (although it is important to note that BTM is looking at the whole of Europe, not just the EU-27). There is no available 2030 figure from EER.

By 2030, wind power in the EU will produce 1,154 TWh – 591.3 TWh onshore and 562.4 TWh offshore (Figure 6.3), meeting 28.5% of EU electricity demand, according to EWEA's calculations, depending on the level of demand (see the next chapter). Due to the higher capacity factor of offshore turbines, the 150 GW offshore wind capacity will produce almost as much power as the 250 GW of onshore capacity in 2030. By 2022, the production of offshore wind electricity (209 TWh) will exceed the current electricity production from onshore wind (182 TWh).

FIG 6.1 CUMULATIVE ONSHORE AND OFFSHORE WIND POWER IN THE EU (1990-2030)

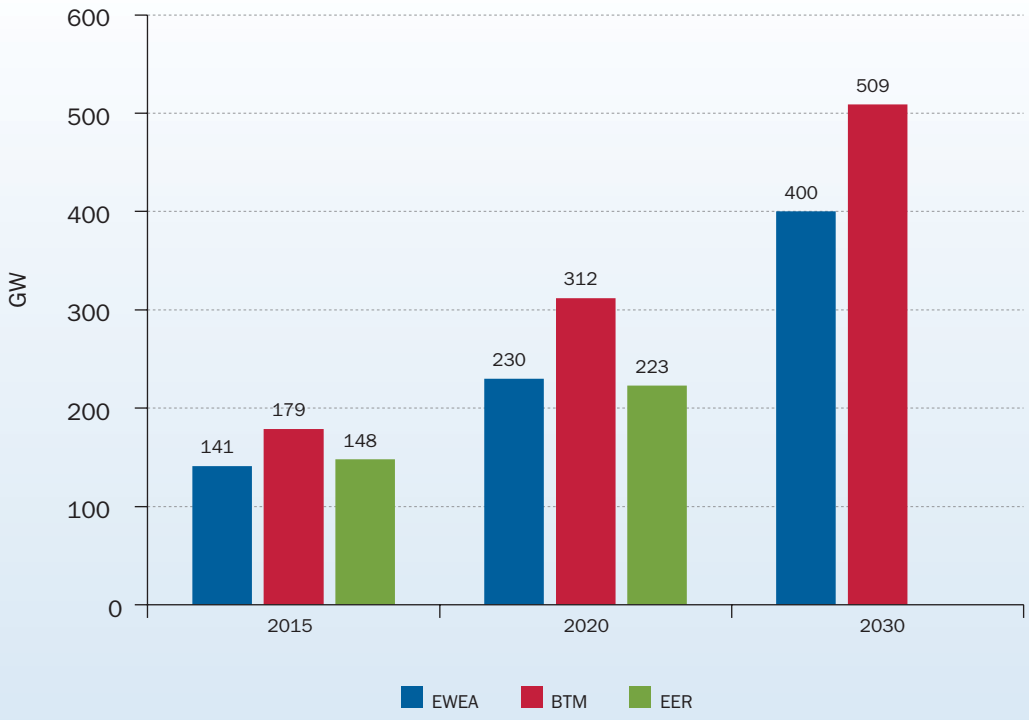


	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
Onshore	0.4	0.6	0.8	1.2	1.7	2.5	3.4	4.7	6.4	9.6	12.9	17.2	22.8	28.0	33.8	39.8	47.1	55.4	63.2	73.0	81.4	89.6	98.0	107.1	117.0	127.5	138.6	150.4	163.0	176.4	190.0	202.0	213.0	223.0	231.0	237.0	241.0	244.0	246.5	248.5	250.0
Offshore	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.3	0.5	0.6	0.7	0.9	1.1	1.5	2.1	2.9	3.9	5.3	8.1	10.9	14.0	17.4	21.6	26.7	33.1	40.0	47.7	56.2	65.5	75.6	86.5	98.1	110.4	123.2	136.4	150.0
Total	0.4	0.6	0.8	1.2	1.7	2.5	3.5	4.8	6.5	9.7	12.9	17.3	23.1	28.5	34.4	40.5	48.0	56.5	64.7	75.1	84.3	93.6	103.3	115.2	128.0	141.5	156.0	172.0	189.7	209.5	230.0	249.7	269.2	288.5	306.6	323.5	339.1	354.4	369.7	384.9	400.0

Source: EWEA 2011

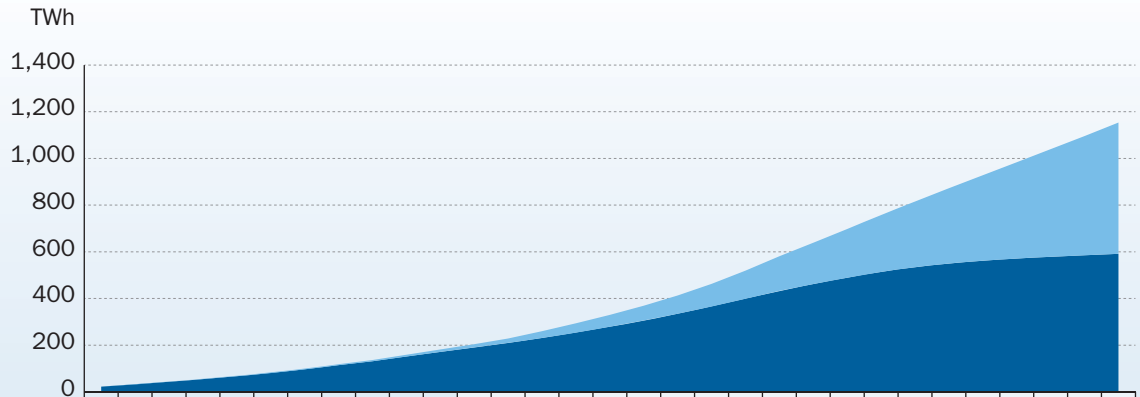
[23] BTM 2009

FIGURE 6.2 TOTAL INSTALLED WIND POWER CAPACITY IN EUROPE – EWEA, BTM AND EER SCENARIOS COMPARED



Source: EWEA 2011, BTM 2010, EER 2010

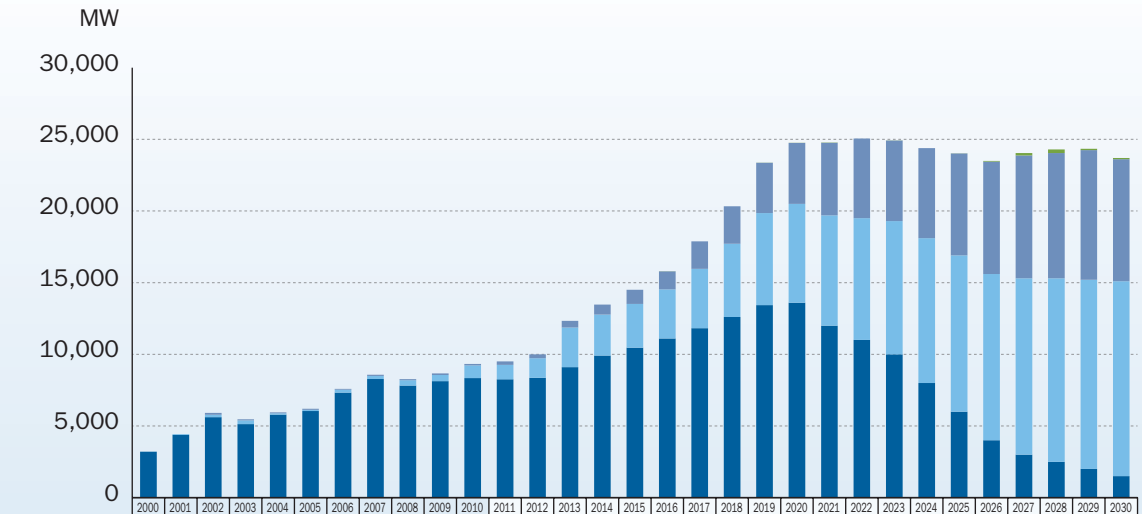
FIGURE 6.3 ELECTRICITY PRODUCTION FROM ONSHORE AND OFFSHORE WIND IN THE EU (2000-2030)



	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
Offshore	0	0	1	2	2	2	3	4	5	7	11	14	19	29	40	51	63	78	97	120	148	177	209	244	281	322	366	412	461	511	562
Onshore	22	32	44	55	67	80	96	115	131	152	171	190	209	231	254	279	306	335	366	399	433	462	489	514	534	550	562	571	579	586	591
Total	**23**	**32**	**44**	**57**	**69**	**83**	**100**	**118**	**136**	**159**	**182**	**204**	**229**	**260**	**294**	**330**	**369**	**413**	**463**	**519**	**581**	**639**	**698**	**757**	**816**	**873**	**928**	**983**	**1,040**	**1,096**	**1,154**

Source: EWEA 2011

FIGURE 6.4 ANNUAL WIND POWER INSTALLATIONS IN THE EU (2000-2030)



	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
Offshore repowering																	5	0	0	2	5	17	0	3	0	4	51	170	259	90	90
Onshore repowering			130	69	65	76	61	87	67	109	111	241	271	469	694	980	1,256	1,911	2,609	3,506	4,250	5,062	5,555	5,622	6,287	7,114	7,842	8,570	8,739	9,049	8,512
Offshore	4	51	170	259	90	90	201	210	374	430	883	1,000	1,370	2,768	2,859	3,054	3,429	4,145	5,116	6,418	6,897	7,700	8,500	9,300	10,100	10,900	11,600	12,300	12,800	13,200	13,600
Onshore	3,205	4,377	5,613	5,134	5,791	6,038	7,330	8,277	7,822	8,129	8,338	8,259	8,359	9,100	9,913	10,466	11,106	11,822	12,602	13,436	13,600	12,000	11,000	10,000	8,000	6,000	4,000	3,000	2,500	2,000	1,500
Total	**3,209**	**4,428**	**5,913**	**5,462**	**5,946**	**6,204**	**7,592**	**8,574**	**8,263**	**8,668**	**9,332**	**9,500**	**10,000**	**12,337**	**13,466**	**14,500**	**15,796**	**17,878**	**20,326**	**23,362**	**24,752**	**24,779**	**25,055**	**24,924**	**24,387**	**24,017**	**23,493**	**24,040**	**24,298**	**24,339**	**23,702**

Source: EWEA 2011

Figure 6.4 shows that the market for onshore wind power will increase up to 2020, then decline steadily in the decade up to 2030, while an increasing share of the onshore market will come from the replacement of existing capacity. No significant decommissioning of offshore wind turbines is envisaged until after 2030. Wind energy development after 2020 will to a large degree be determined by the price and availability of fuel and the price of emitting CO_2.

In total, EWEA's targets suggest that 162 GW of new capacity will be built in the 10 years from 2011 to 2020, and that an additional 241 GW will be constructed in the decade from 2021 to 2030 (see Table 6.1). The table also shows the historic and future growth rates in annual installations for the period 1991 to 2030.

As mentioned in the previous chapter, the annual market for offshore wind reached 0.9 GW in 2010 which translates into an average annual growth rate for offshore of 33% this decade – similar to the annual growth rate in onshore in the ten years from 1991 to 2000 (33%). To meet the 230 GW target in 2020 would require an average growth in annual installations of 10% from 2011 to 2020: 8% growth in the onshore market and 21% growth in the offshore market.

In total, average annual installations are assumed to more than double from 7.2 GW in the past decade (2001 to 2010) to 16.2 GW in the ten years between 2011 and 2020. In the ten years after that, (2021 to 2030) average annual installations will be some 40% higher (24.2 GW) than the decade before.

TABLE 6.1 NEW WIND CAPACITY (1991 – 2030)

New wind capacity			
	Onshore	Offshore	Total
1991-2000	12,413	35	12,448
2001-2010	69,157	2,908	72,065
2011-2020	124,850	37,067	161,916
2021-2030	132,352	109,083	241,435

Annual growth rates			
	Onshore	Offshore	Total
1991-2000	33%	-2.6%	32.7%
2001-2010	6.8%	33.1%	7.7%
2011-2020	7.7%	21.3%	10%
2021-2030	-5.2%	5.8%	-0.5%

Average MW/year			
	Onshore	Offshore	Total
1991-2000	1,241	6	1,245
2001-2010	6,916	291	7,206
2011-2020	12,485	3,707	16,192
2021-2030	13,235	10,908	24,143

Summary of wind energy in 2030, according to EWEA targets

- 400 GW installed capacity: 250 GW onshore and 150 GW offshore
- Annual installations of 23.7 GW: 10 GW (42%) onshore and 13.7 GW offshore (58%)
- Annual investments of €25.3 billion: €8.2 billion onshore and €17.1 billion offshore
- Meeting 28.5% of EU electricity demand depending on total demand
- 36% of total electricity generating capacity in the EU (Total end 2030: 1,111 GW)
- Producing 1,154 TWh of electricity: 591 TWh onshore and 562 TWh offshore, equivalent to the consumption of 252 million average EU households
- Avoiding 646 Mt CO_2 annually
- Avoided fuel costs of €51 billion (assuming IEA forecast: fuel cost equivalent to $108.2/bbl of oil)
- Avoiding €26 billion of CO_2 costs annually (assuming €40/t CO_2).

Photo: Imagine

7 WIND ENERGY IN ELECTRICITY GENERATION

a. Share of electricity produced by wind

b. Contribution of wind power to electricity generation capacity

c. Household demand

d. Electric cars

a. Share of electricity produced by wind

The 84.3 GW of installed capacity in the EU-27 at the end of 2010 will, in a normal wind year, produce 182 TWh of electricity, enough to meet 5.3% of EU electricity demand.

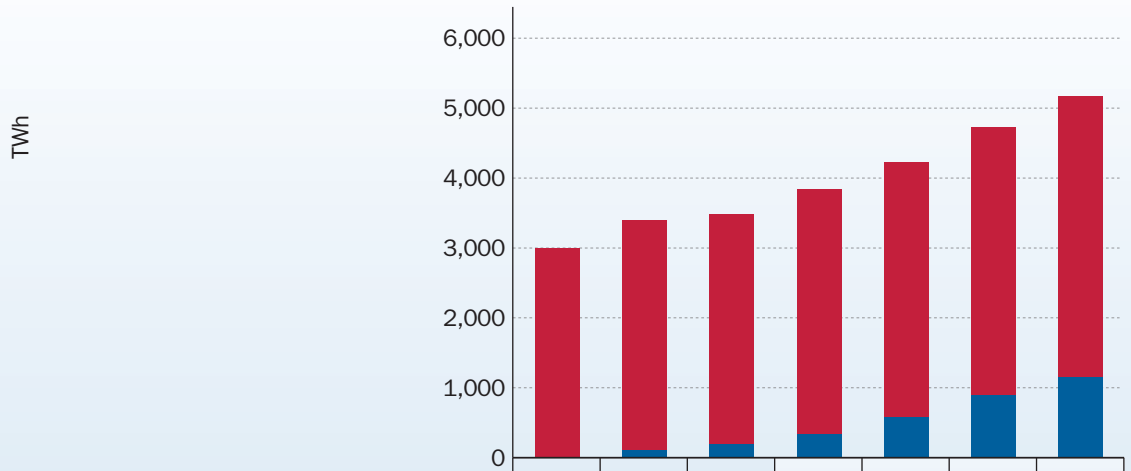
Wind power's share of total EU power demand depends on the evolution of electricity consumption in the EU. The European Commission, in its "Energy trends to 2030" forecast assumes that the EU's gross electricity consumption will grow by 11.6% over the next 10 years; from 3,307.2 TWh in 2010 to 3,689.7 in 2020. The forecast assumes an electricity consumption of 4,051.3 TWh in 2030, implying a further 9.8% increase in demand from 2020 and an overall 22.5% increase in demand in the 20 years from 2010 to 2030.

As can be seen from Table 7.1, wind power will produce 330 TWh in 2015, 581 TWh in 2020 and 1,154 TWh in 2030. Wind power will meet 9.4% of EU electricity demand in 2015 according to the European Commission's reference scenario, 15.7% in 2020 and 28.5% in 2030.

The calculations in the following chapters of this report are based on the European Commission's reference scenario for electricity demand, unless otherwise stated.

It is assumed that the average capacity factor of all wind turbines in the EU will increase from 24.6% in 2010 to 28.8% in 2020 and 32.9% in 2030. The increase will be due to better design, exploiting the resources in more windy areas of Europe, technology improvements and a larger share of offshore wind. In Germany, average capacity factors will start to increase as older turbines are replaced and offshore wind power takes off. It should be noted that for a technology that makes use of a free resource, a high capacity factor is not a goal in itself. It is not technically problematic to increase capacity factors, but doing so affects grid integration, modelling and generation costs.

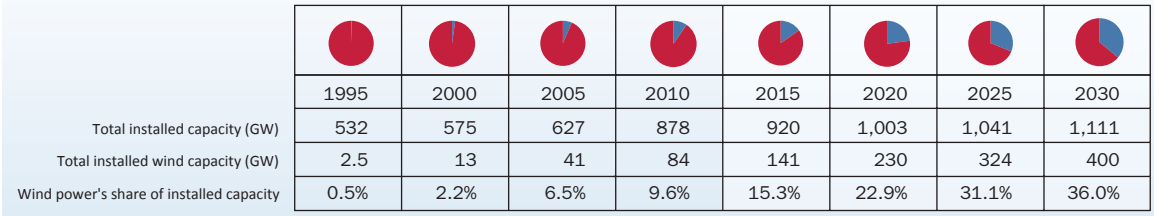
FIGURE 7.1 WIND ENERGY SHARE OF EU ELECTRICITY DEMAND (2000 – 2030)



	2000	2005	2010	2015	2020	2025	2030
EU reference (TWh)	2,994	3,320	3,307	3,524	3,690	3,910	4,051
Wind energy production (TWh)	23	83	182	330	581	873	1154

Source: EWEA and EC 2010

FIGURE 7.2 WIND POWER SHARE OF INSTALLED CAPACITY (2005 - 2030)



	1995	2000	2005	2010	2015	2020	2025	2030
Total installed capacity (GW)	532	575	627	878	920	1,003	1,041	1,111
Total installed wind capacity (GW)	2.5	13	41	84	141	230	324	400
Wind power's share of installed capacity	0.5%	2.2%	6.5%	9.6%	15.3%	22.9%	31.1%	36.0%

Source: EWEA and EC 2010

TABLE 7.1 ELECTRICITY PRODUCTION FROM WIND (TWh)

Year	Onshore	Offshore	Total	EU reference consumption
2000	22.5	0.1	22.6	2,993.7
2005	80.3	2.5	82.8	3,320.3
2010	171	10.6	181.6	3,307.2
2015	279.1	50.6	329.7	3,524.2
2020	432.7	148.2	580.9	3,689.7
2025	550.2	322.4	872.6	3,910.3
2030	591.3	562.4	1,153.7	4,051.3

Source: EWEA and EC 2010

TABLE 7.2 WIND SHARE OF ELECTRICITY CONSUMPTION (%)

Year	Onshore	Offshore	Total	EU reference consumption (TWh)
2000	0.8%	0%	0.8%	2,993.7
2005	2.4%	0.1%	2.5%	3,320.3
2010 EC reference scenario	5.2%	0.3%	5.5%	3,307.2
2015 EC reference scenario	7.9%	1.4%	9.4%	3,524.2
2020 EC reference scenario	11.7%	4%	15.7%	3,689.7
2025 EC reference scenario	14.1%	8.2%	22.3%	3,910.3
2030 EC reference scenario	14.6%	13.9%	28.5%	4,051.3

Source: EWEA and EC 2010

b. Contribution of wind power to electricity generation capacity

The IEA expects 5,900 GW of electricity generating capacity to be installed worldwide in the period 2009 - 2035, requiring investments of $9.6 trillion in generation, $2.2 trillion in transmission grids and $4.8 trillion in distribution grids. For OECD Europe, the IEA expects 337 GW to be built, requiring investments of $694 billion in new generation, $110 billion in transmission and $332 billion in distribution grids[24].

As already mentioned, wind power's contribution to new power capacity in the EU was exceeded only by gas in the last decade. 28% of all installed capacity was wind power from 2000 to 2010. 48% was gas, 6% was coal and 0.7% was nuclear. In 2010, the EU countries installed almost as much renewable power capacity than all capacity additions in previous year. 16.5% of all capacity additions were wind power. On average during the past decade, wind power has represented over 28% of total annual capacity additions in the EU.

Europe has to invest in new capacity to replace ageing plants and meet future demand. 878 GW of electricity generating capacity was operating in the EU by the end of 2010[25]. Total installed capacity will increase to 1,003 GW in 2020 and 1,111 GW in 2030, according to the European Commission (see Table 7.3).

The Commission expects new capacity worth 333 GW to be built between 2011 and 2020 and an additional 291 GW between 2021 and 2030. In total, 624 GW of new capacity will need to be constructed over the coming 20 years in the EU, equal to 71% of the total capacity installed by end 2010.

Consequently, 208 GW of existing capacity will be decommissioned up to 2020 and an additional 183 GW between 2021 and 2030.

TABLE 7.3 NEW CAPACITY, DECOMMISSIONING AND TOTAL CAPACITY (2011 – 2030) IN GW

	New capacity	Decommissioning	Total capacity ultimo
2011 – 2020	333	208	1,003
2021 – 2030	291	183	1,111

Source: EWEA based on EU energy trends to 2030 (update 2009), European Commission 2010

[24] IEA World Energy Outlook 2010.
[25] EWEA, Platts Powervision, EPIA, Estela, EU-OEA.

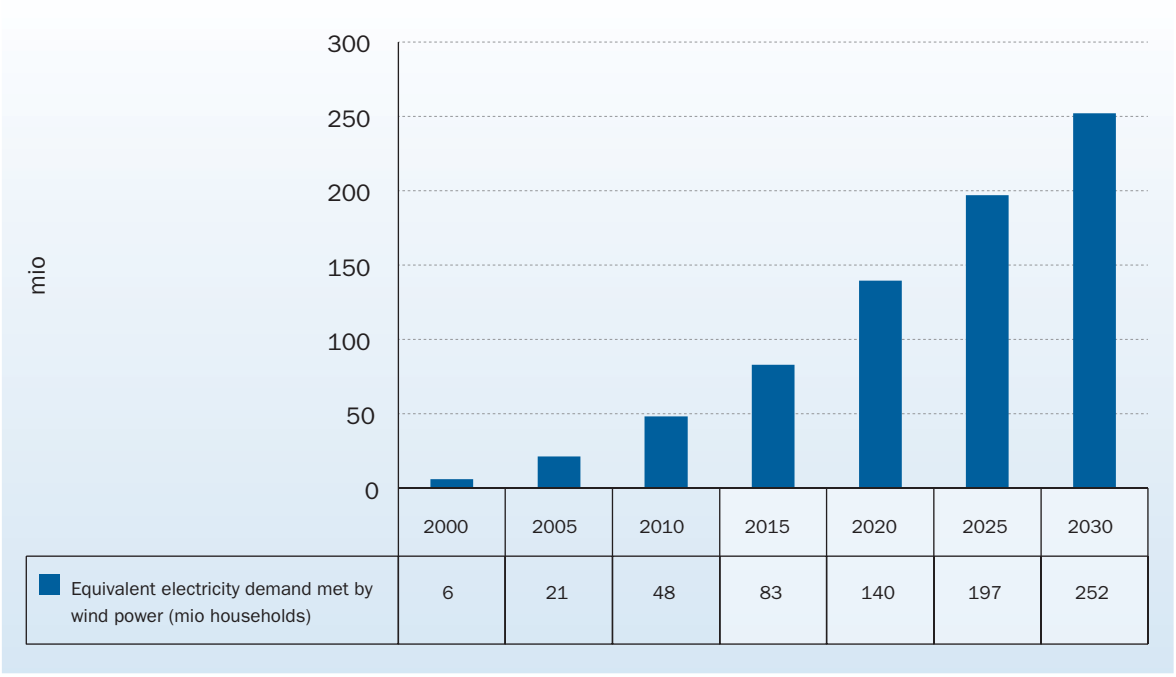
c. Household demand

The wind energy production derived from EWEA's scenarios can be expressed in terms of household electricity consumption. Household consumption is expected to increase from 815 TWh in 2010 to 1,102 TWh in 2030[26].

By 2020, some 27% of total electricity demand will be consumed by households. Other sectors that consume electricity include industry, agriculture, public and private services.

While the total EU population is estimated to remain relatively stable, the number of households will increase by approximately 25 million between 2010 and 2030, indicating a reduction in average household size from 2.3 people in 2010 to 2.15 in 2030. The average annual household consumption will increase by 21% from 3,759 kWh in 2010 to 4,579 kWh in 2030 (Figure 7.3).

FIGURE 7.3 WIND ENERGY AS SHARE OF EU HOUSEHOLD DEMAND



The wind power capacity installed by the end of 2010 will produce 181 TWh in an average wind year which is equivalent to the electricity needs of 48 million EU average households. If EWEA's targets are reached, wind power will produce electricity equivalent to the needs of 140 million households in 2020 and 252 million households in 2030. By 2030 wind power will produce more electricity than the combined consumption of the EU's 240 million households (Table 7.4).

[26] "EU energy trends to 2030 – 2009 update", European Commission, 2010.

TABLE 7.4 WIND ENERGY AND HOUSEHOLD DEMAND

Year	2000	2005	2010	2015	2020	2025	2030
Average household consumption (kWh)	3,644	3,862	3,760	3,977	4,162	4,427	4,580
Number of households (mio)	195	206	217	225	231	236	241
Wind energy production TWh	23	83	182	330	581	873	1154
Equivalent electricity demand met by wind power (mio households)	6	21	48	83	140	197	252
Equivalent electricity demand met by wind power (% of households)	3%	10%	22%	37%	60%	84%	105%

d. Electric cars

Car manufacturers have started to develop hybrid vehicles and pure electric vehicles (PEVs) in recent years. EWEA's scenarios to 2030 do not take into account any increase in the electricity demand from electric cars. It is generally recognised that electric motors are much more efficient than the combustion engine[27]. Consequently, a shift from the current petrol and diesel cars to electric cars could save a large amount of fossil fuels. An important note is that an electric vehicle is as "clean" as the technology used to produce the electricity needed to operate it. Consequently, the larger the share of renewable energy in Europe's power mix, the cleaner the electric vehicles of the future will be.

Conservatively assuming that an average electric car consumes 0.2 kWh per kilometre and has an average mileage of 10,000 km per car[28], an electric car will consume 2,000 kWh per year. As a result, the wind energy produced in Europe in 2010 could power 90.8 million electric cars (see Table 7.5).

TABLE 7.5 WIND ENERGY AND ELECTRIC CARS

Year	Wind energy production (TWh)	Average annual energy consumption per car (kWh)	Number of electric cars powered by wind (mio)
2010	181.7	2,000	91
2020	581.0	2,000	290
2030	1,153.7	2,000	577

If EWEA's targets are met, enough wind energy will be produced to power 291 million electric cars in 2020 and 577 million cars in 2030. In 2009, there were around 236 million cars in the EU 27[29].

[27] The European Association for Battery, Hybrid and Fuel Cell Electric Vehicles (AVERE – www.avere.org)

[28] The European Environment Agency (2009) estimates that electric vehicles (EV) will consume between 0.11 and 0.2 kWh/km – the lower estimate through likely technology developments in the future. The Brussels-based NGO "Transport & Environment" assumes that EVs have an annual mileage of 8,640 kilometres (80% of that of petrol cars).

[29] According to Eurostat, there were estimated 473 cars per 1,000 inhabitants in the EU-27 in 2009. In addition, the population of the EU-27 was estimated by Eurostat to be 499 million in 2009.

Photo: Thinkstock

8 WIND ENERGY AND CO_2

The commitment of EU-15 in 1997 in Kyoto was to reduce by 8% its greenhouse gas emissions (GHGs) compared to their 1990 levels by 2008-2012. According to the agreement each of the 15 Member States has a different target as a result of a burden sharing approach. The new Member States' targets are set individually at 8% except for Hungary and Poland who must reduce their GHGs by 6%.

Finally, the overall Kyoto reduction target for EU-25 (excluding Cyprus and Malta which have no obligation) is 7.8%, or 450 Mt of CO_2 equivalents. The EU-15 needs to reduce its emissions by 342 Mt of CO_2 equivalents.

In 2007 the GHG emissions of all the EU-27 decreased by 9.3% compared to 1990 levels[30].

CO_2 reductions from wind power

The most important greenhouse gas is CO_2. There are different methodologies for calculating the CO_2 avoided by wind energy and they all depend on the assumptions made about which fuels are displaced when electricity from wind energy is produced. The energy mix together with the base load is different between Member States. Ideally wind power avoided CO_2 should be calculated based on the energy mix and intermediate load in each Member State. In this report it is assumed that wind energy avoids CO_2 at the intermediate level but at the average EU-27 generation mix.

Nuclear power is inflexible and cannot easily be ramped up and down. Therefore wind power does not replace operating nuclear generation except during scheduled and unscheduled nuclear shutdowns and nuclear decommissioning. Wind power does not replace hydropower either, because hydropower serves as a storage technology for electricity. Electricity from hydro that is not used when wind power is operating will be saved for production later.

Consequently, for the EU as a whole it is assumed that each kWh of wind power displaces a kWh produced by the energy mix of coal, oil and gas at the time of production. This approach certainly underestimates wind energy's CO_2 avoidance because wind energy avoids the most expensive, inefficient and, hence, CO_2 intensive production rather than the average production mix.

The EU energy mix is expected to change during the period up to 2030. According to the European Commission, thermal power stations in the EU produced 1,871 TWh in 2010 and emitted 1,302 Mt of CO_2. Taking this into account, 1 TWh of wind energy saved 0.696 Mt of CO_2 in 2010. Following the same approach and the European Commission's data for 2015, 2020, 2025 and 2030 and applying a linear regression for the intermediate years, the avoided CO_2 emissions are calculated. As a result, it is assumed that in 2020 wind energy will avoid 0.588 Mt CO_2/TWh and 0.560 Mt CO_2/TWh in 2030. Taking into account the wind production of 2010, wind energy avoided 126 Mt of CO_2 in 2010. Following EWEA's base scenario, the annual CO_2 avoided from wind energy will increase to 342 Mt in 2020 and 646 Mt in 2030.

At a CO_2 price of €25/t, wind power avoided €3.1 billion in carbon costs in 2010. At the same price, wind power is estimated to avoid carbon costs of €8.5 billion in 2020 and €25.8 billion in 2030 assuming the price of CO_2 reaches €40/t. It is important to note that the total CO_2 reductions from wind power capacity in EWEA's 2030 base scenario greatly exceed the annual figures presented in Figure 8.1 because the turbines installed in a given year will deliver CO_2 reductions over their lifetime – that is, for 20 to 25 years from the year of their first installation – and therefore, far beyond 2030.

[30] EEA 2009: Greenhouse gas emission trends and projections in Europe 2009.

FIGURE 8.1 CO_2 AVOIDED ANNUALLY BY WIND ENERGY (LEFT AXIS) AND ANNUAL CO_2 COST AVOIDED BY WIND ENERGY (RIGHT AXIS) FOR VARIOUS CO_2 PRICES (2000 – 2030)

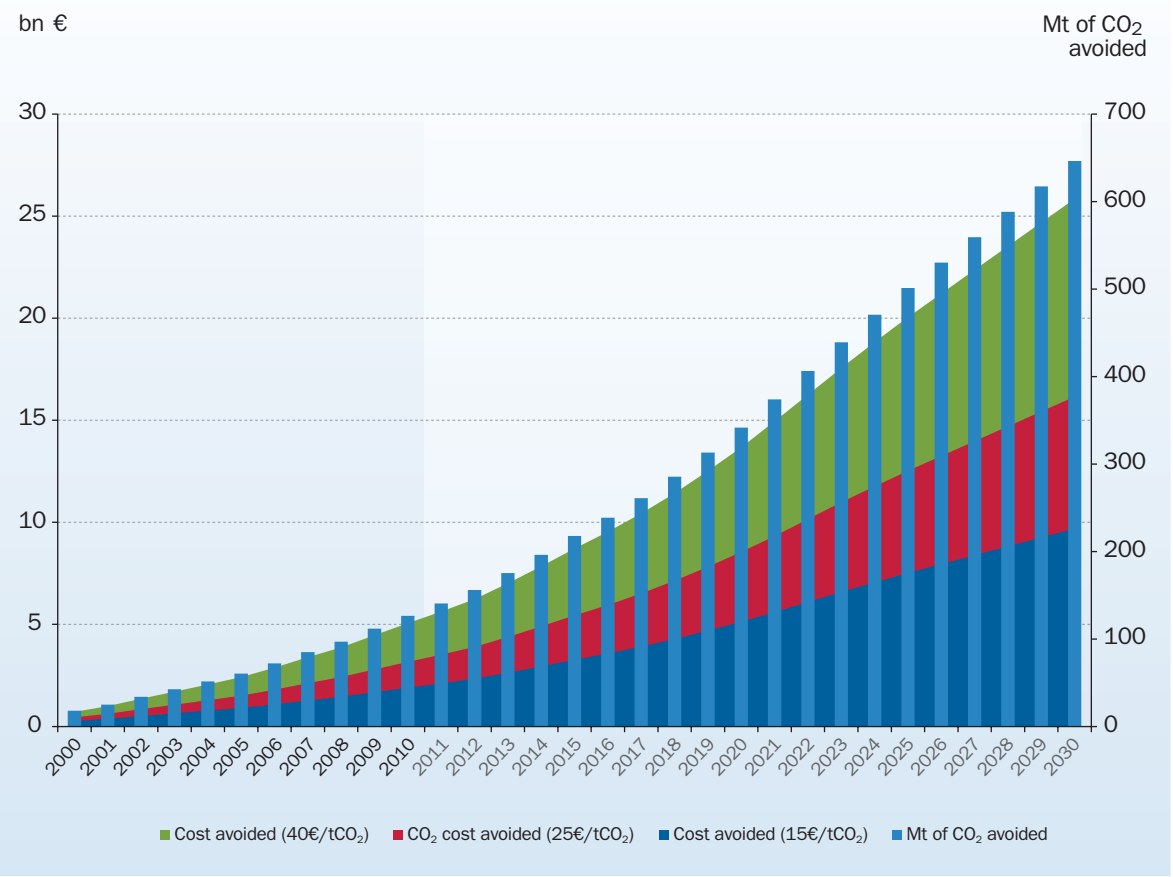


Photo: Luis Marinho

9 WIND ENERGY AND AVOIDED FUEL COSTS

Generating energy from wind requires no fuel. During the production of wind energy, a significant amount is saved on fuel costs – that is, on the coal, gas and oil that would otherwise have been used in energy production. At the same time, generating energy with wind power reduces the demand for imported fuel, bringing down the cost of fuel and reducing the rate of depletion of Europe's remaining fossil fuel reserves.

The estimates on avoided fuel cost of wind energy depend on the assumptions on the future fuel prices. Oil prices influence significantly gas prices as well as coal prices, albeit to a lesser extent. Both the IEA and the European Commission have for many years made predictions on future coal gas and oil prices, and most governments base their energy policies on the IEA's price scenarios. The European Commission's price predictions are lower than the IEA's (see Table 9.1).

In their most recent scenarios, both the European Commission and the IEA have lowered their oil price assumptions in comparison to their 2008 forecasts. On 11 July 2008, the oil price reached a historic high of $145/bbl[31]. Due to the financial crisis in 2008 and 2009, the price of a barrel of oil dropped significantly. However, on 4 March 2011, oil was trading at $115.7/bbl. Both the European Commission's and the IEA oil price forecasts for 2030 are below this current level.

TABLE 9.1 OIL PRICE ASSUMPTIONS

Oil price assumptions in $2010 per barrel	2010	2015	2020	2025	2030
European Commission	71.0	71.1	87.3	98.7	104.5
IEA	59.4	88.9	97.4	103.3	108.2
Average 2010 oil price	79.52				

[31] New York Stock Exchange, price at close: http://www.nyse.tv/crude-oil-price-history.htm

FIGURE 9.1 OIL PRICE ASSUMPTIONS

The fuel costs avoided due to wind energy production are calculated on the basis of three different fuel price assumptions: (a) the European Commission's fuel price assumptions, (b) the International Energy Agency price assumptions and (c) the historic peak price of oil on 11 July 2008 and related price assumptions.

In 2010 the average oil price was $79.52 per barrel. The existing price relations the avoided fuel costs from wind energy are summarised in Table 9.2:

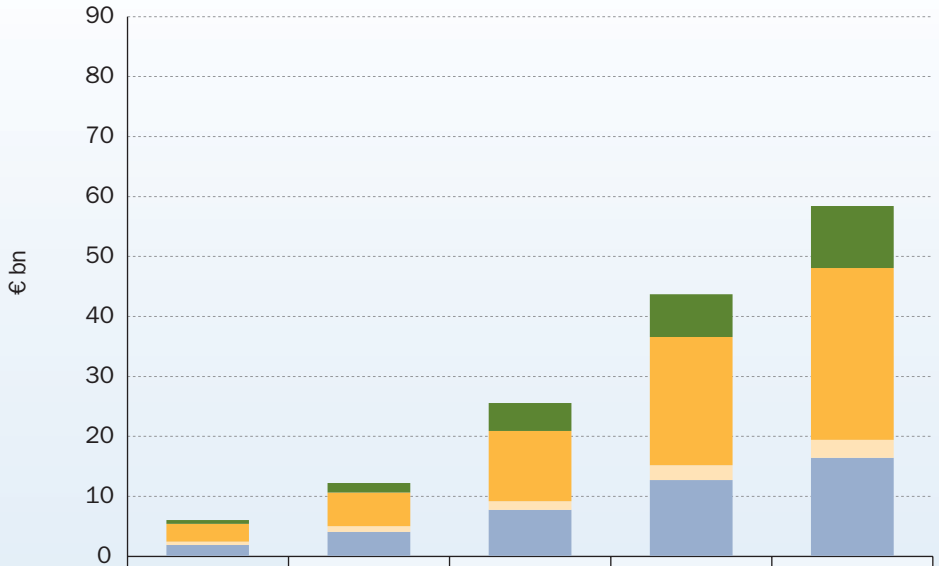
TABLE 9.2 AVOIDED FUEL COST FROM WIND ENERGY (AVERAGE 2010 OIL PRICE: $79.52 PER BARREL)

Avoided fuel cost	€ bn
Coal	2.00
Oil	0.61
Gas	3.25
Biomass and waste	0.69
Total	**6.54**
Avoided fuel cost (€) /TWh wind	**36,018,801**

Figure 9.2 shows that according to the European Commission's fuel price assumptions, the production of wind energy avoided €5.92 billion of fuel costs in total in 2010: €2.94 billion worth of gas, €1.81 billion worth of coal, €0.62 worth of biomass/waste and €0.55 billion worth of oil. According to EWEA's targets, wind energy is expected to avoid €25.3 billion of fuel costs in 2020 and almost €58 billion in 2030 based on the European Commission's future fuel price assumptions. Following the IEA's future fuel price assumptions, wind energy will avoid €51 billion in 2030 and, if fuel prices reach the historic $145/bbl, in 2030 wind energy will avoid €80 billion of fuel costs. The calculation is based on an exchange rate of $1.40/€1.

Figures 9.2 and 9.3 together with Table 9.2 show that both the European Commission and the IEA underestimated the oil price for 2010 and consequently underestimated the avoided fuel costs from wind energy.

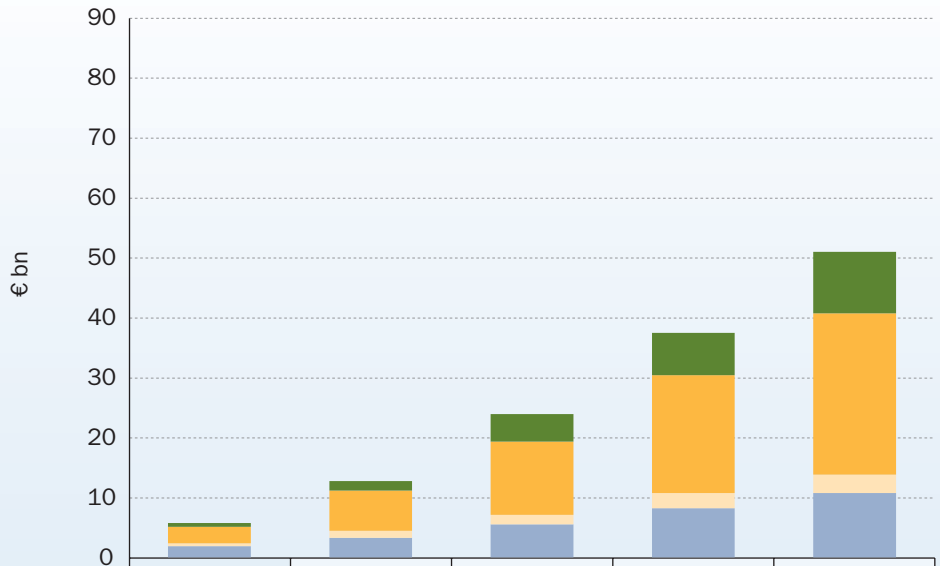
FIGURE 9.2 AVOIDED FUEL COSTS FROM WIND – EUROPEAN COMMISSION FUEL PRICES



	2010	2015	2020	2025	2030
Biomas and waste	0.62	1.60	4.60	7.06	10.29
Gas	2.94	5.56	11.66	21.22	28.43
Oil	0.55	0.94	1.42	2.48	2.98
Coal	1.81	3.97	7.62	12.54	16.25
Total (€ bn)	**5.91**	**12.07**	**25.30**	**43.31**	**57.95**
Avoided fuel cost (€) / TWh wind	**32,554,830**	**36,595,695**	**43,547,374**	**49,633,060**	**50,226,520**

Source: EWEA and European Commission 2010

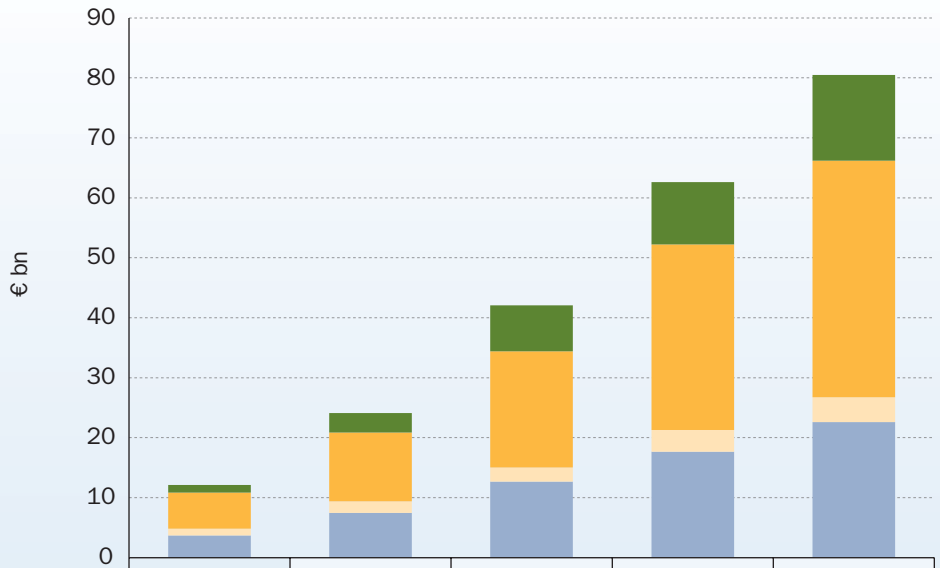
FIGURE 9.3 AVOIDED FUEL COSTS FROM WIND – INTERNATIONAL ENERGY AGENCY (IEA) FUEL PRICES



	2010	2015	2020	2025	2030
Biomas and waste	0.62	1.59	4.59	7.04	10.25
Gas	2.76	6.68	12.22	19.64	26.88
Oil	0.46	1.17	1.58	2.56	3.09
Coal	1.87	3.26	5.49	8.17	10.71
Total (€ bn)	**5.71**	**12.71**	**23.89**	**37.41**	**50.92**
Avoided fuel cost (€) / TWh wind	**31,419,182**	**38,549,829**	**41,113,605**	**42,875,471**	**44,136,650**

Source: EWEA and IEA 2010

FIGURE 9.4 AVOIDED FUEL COSTS FROM WIND – HISTORIC PRICE 11 JULY 2008 ($147/BARREL)



	2010	2015	2020	2025	2030
Biomas and waste	1.27	3.27	7.66	10.38	14.28
Gas	6.00	11.47	19.39	30.95	39.47
Oil	1.12	1.91	2.36	3.59	4.14
Coal	3.70	7.46	12.68	17.68	22.60
Total (€ bn)	**12.10**	**24.11**	**42.07**	**62.60**	**80.48**
Avoided fuel cost (€) / TWh wind	**66,584,051**	**73,092,523**	**72,420,845**	**71,738,974**	**69,760,923**

Source: EWEA

Photo: Luis Marinho

10 WIND POWER INVESTMENTS

a. Capital costs

b. Total investments

c. Employment

a. Capital costs

Generating wind power requires no fuel. Therefore, the total cost of producing wind energy during the 20 (onshore) to 25 years (offshore) of a wind turbine's design lifetime is highly predictable. The future price of coal, oil and gas as well as the future price of carbon do not affect the cost of wind energy production to any significant extent.

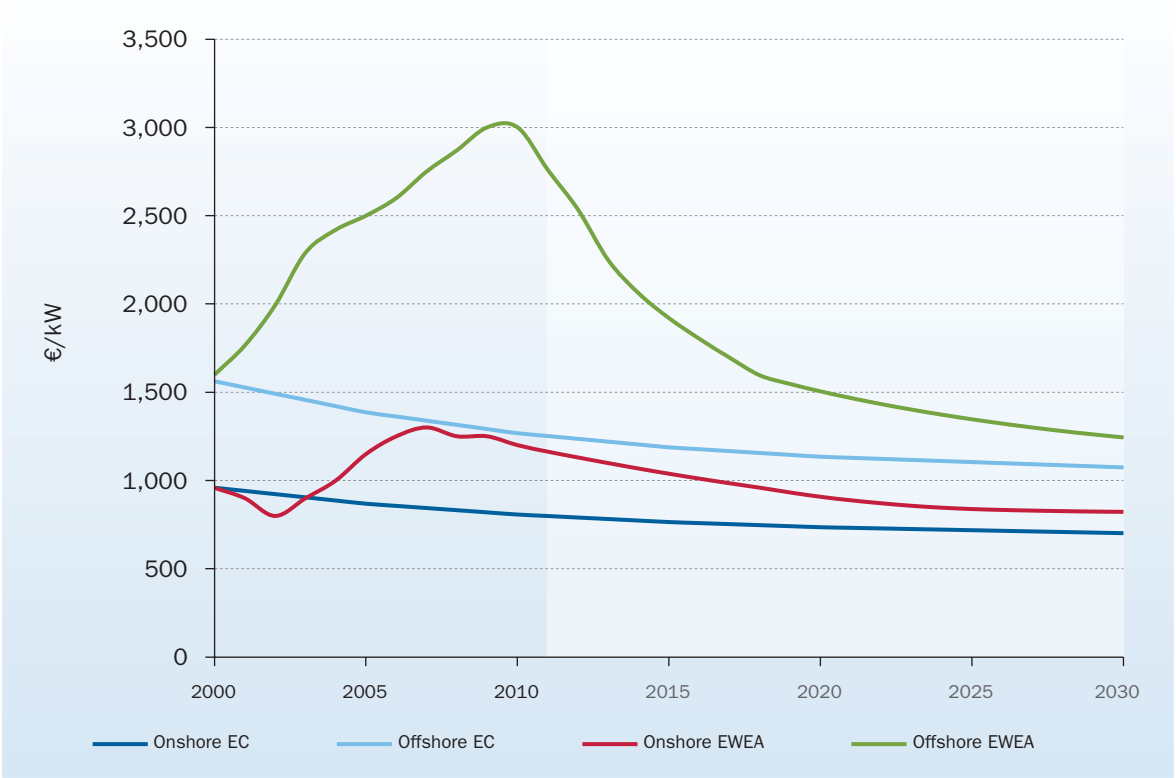
In order to calculate the wind power investments needed to reach EWEA's scenario up to 2030, it is necessary to make assumptions on the future cost of installed wind power capacity. For some years it was assumed that the cost of wind was about €1,000/kW of installed capacity. However, since 2000 there have been large variations in the price (not necessarily the cost) of installing wind power.

From 2001 to 2004 there was a surplus of wind turbines due to the slower than expected development of the global market for wind power. As an impact, the price of wind power capacity went down, reaching €700-800/kW for some projects. In the past six years, the global market for wind power increased annually and the demand for wind turbines surged, resulting in price increases. Remaining stable since 2008, from 2010 and onwards, turbine prices seem to follow their long-term decreasing trend.

The European Commission, in its Renewable Energy Roadmap in 2007 assumed that onshore wind power would cost €807/kW (in €2010) in 2010. In 2020 the price will drop to €735/kW and in 2030 it will reach €700/kW. The long term cost curve could still apply when balance between demand and supply of wind turbines stabilises.

Figure 10.1 shows the European Commission's assumptions on the price of wind energy up to 2030. In the same figure, EWEA provides two curves that represent the relation of demand and supply on wind turbine prices in recent years. EWEA assumes onshore wind power prices of €1,200/kW in 2010 (€2010 prices) and offshore prices of €3,000/kW. The increase in offshore costs up to now reflected the current absence of economies of scale as well as the low market development, bottlenecks in the supply chain and few offshore turbine suppliers. In the near future, prices are expected to decrease as a result of technology learning, economies of scale and a rapidly growing number of offshore wind turbine manufacturers and models.

FIGURE 10.1 CAPITAL COST OF ONSHORE AND OFFSHORE WIND



b. Total investments

Based on the EWEA targets for installed capacity up to 2030 and the wind farm cost assumptions shown in Figure 10.1, the expected investments from 2000 to 2030 are presented in Figure 10.2 both for onshore and offshore wind power.

FIGURE 10.2 WIND POWER INVESTMENTS 2000 - 2030

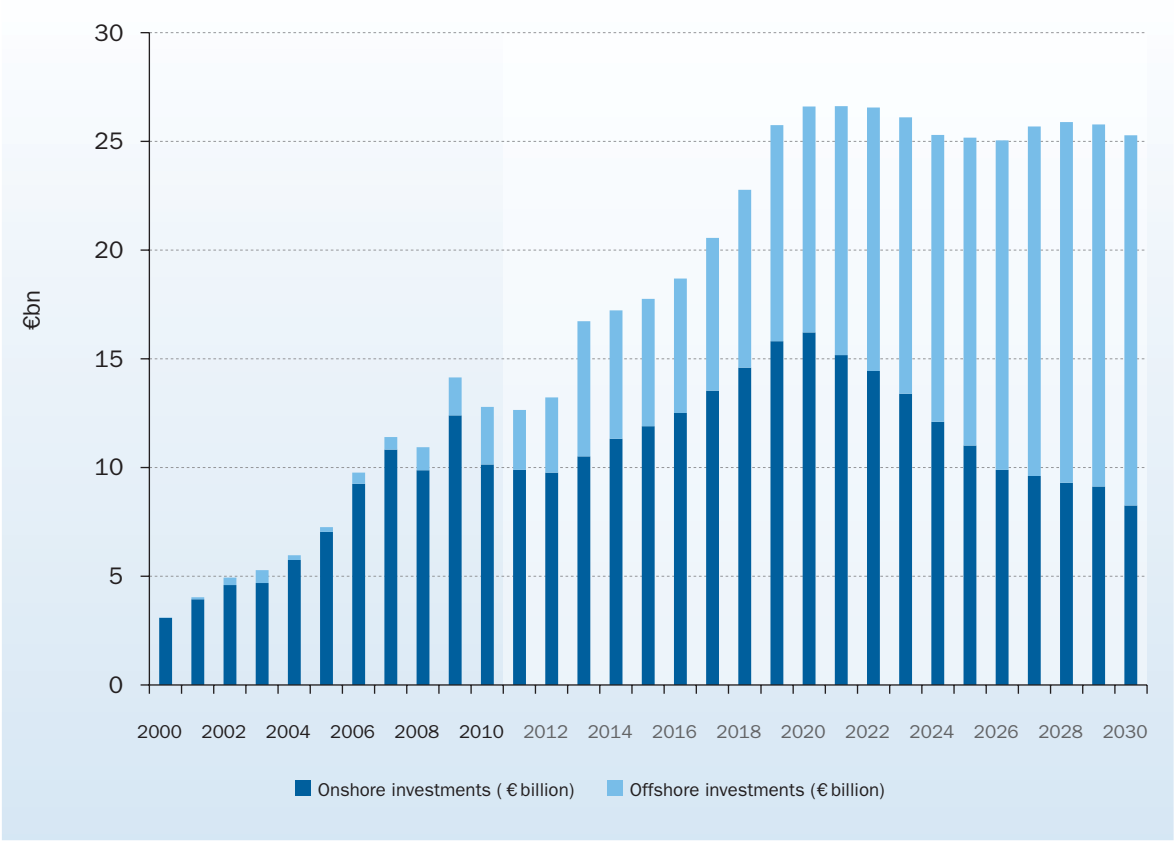


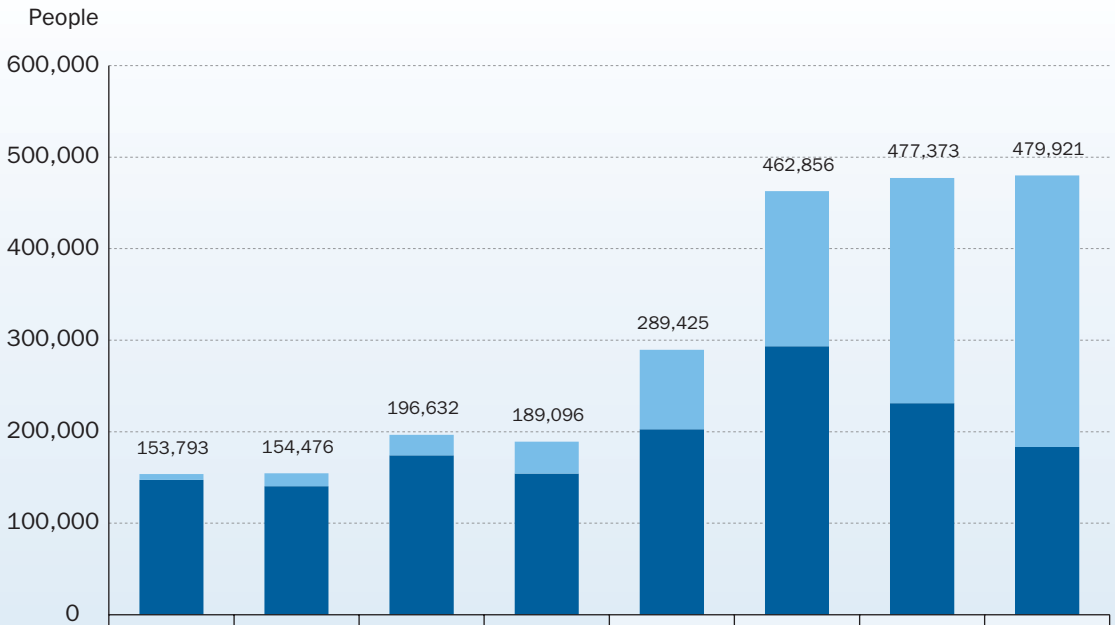
TABLE 10.1 WIND POWER INVESTMENTS 2000-2030

Year	Onshore investments (€2010 bn)	Offshore investments (€2010 bn)	Total investments (€2010 bn)
2000	3.07	0.01	3.08
2001	3.94	0.09	4.03
2002	4.59	0.34	4.93
2003	4.68	0.59	5.28
2004	5.75	0.22	5.97
2005	7.03	0.23	7.26
2006	9.24	0.52	9.76
2007	10.82	0.58	11.40
2008	9.86	1.07	10.93
2009	12.39	1.75	14.14
2010	10.09	2.65	12.74
2011	9.89	2.76	12.65
2012	9.75	3.47	13.23
2013	10.51	6.22	16.73
2014	11.32	5.89	17.21
2015	11.89	5.86	17.75
2016	12.50	6.19	18.69
2017	13.52	7.03	20.55
2018	14.59	8.17	22.76
2019	15.80	9.93	25.73
2020	16.21	10.39	26.60
2021	15.16	11.46	26.62
2022	14.43	12.13	26.56
2023	13.39	12.70	26.10
2024	12.10	13.20	25.30
2025	11.00	14.16	25.16
2026	9.88	15.16	25.04
2027	9.60	16.07	25.67
2028	9.29	16.59	25.87
2029	9.10	16.66	25.76
2030	8.23	17.04	25.27

c. Employment

In 2010, the wind energy industry employed 189,000 people directly and indirectly in Europe. Assuming that EWEA's targets are met in the future, more than 462,000 people will be employed in the wind energy business in 2020. By 2025, employment in the offshore wind energy sector is expected to exceed onshore as shown in Figure 10.3. By 2030, 479,000 people are expected to be employed in wind energy, 296,000 of whom in the offshore sector (almost 62% of the total).

FIGURE 10.3 WIND ENERGY SECTOR EMPLOYMENT (2007-2030)



	2007	2008	2009	2010	2015	2020	2025	2030
Offshore	6,374	13,931	22,458	34,945	86,731	169,550	246,175	296,548
Onshore	147,419	140,544	174,174	154,151	202,694	293,306	231,198	183,373
Total	**153,793**	**154,476**	**196,632**	**189,096**	**289,425**	**462,856**	**477,373**	**479,921**

Source: EWEA 2011

Photo: Eon

11 WIND ENERGY TO 2050

Since 1997, the European Union has had a successful renewable energy policy which has enabled significant progress to be made towards the EU's objectives of reducing greenhouse gas emissions, ensuring security of supply and improving EU competitiveness.

Ambitious targets are at the core of the EU's policies to promote energy from renewable sources. Due to the early adoption of ambitious national and EU targets, European companies are world leaders in wind power technology, and have a leading share of the world market. As a result, Europe today gets approximately 20% of its electricity from renewable energy sources, including 5.3% from wind energy.

In order to continue the development and deployment of renewable energy technologies, the EU adopted the 2009 Renewable Energy Directive, which included a 20% renewable energy target by 2020 for the EU. In 2020, according to the Renewable Energy Directive's 27 National Renewable Energy Action Plans, 34% of the EU's total electricity consumption will come from renewable energy sources, including 495 TWh from wind energy meeting 14% of consumption.

Importantly, expectations for wind energy and other renewables in 2020 are converging – as can be seen by comparing scenarios by EWEA, the European Commission's 'Trends to 2030', the European Commission's Joint Research Centre, ENTSO-E, and the National Renewable Energy Action Plans – with renewables meeting between 32.6% and 36% of electricity consumption.

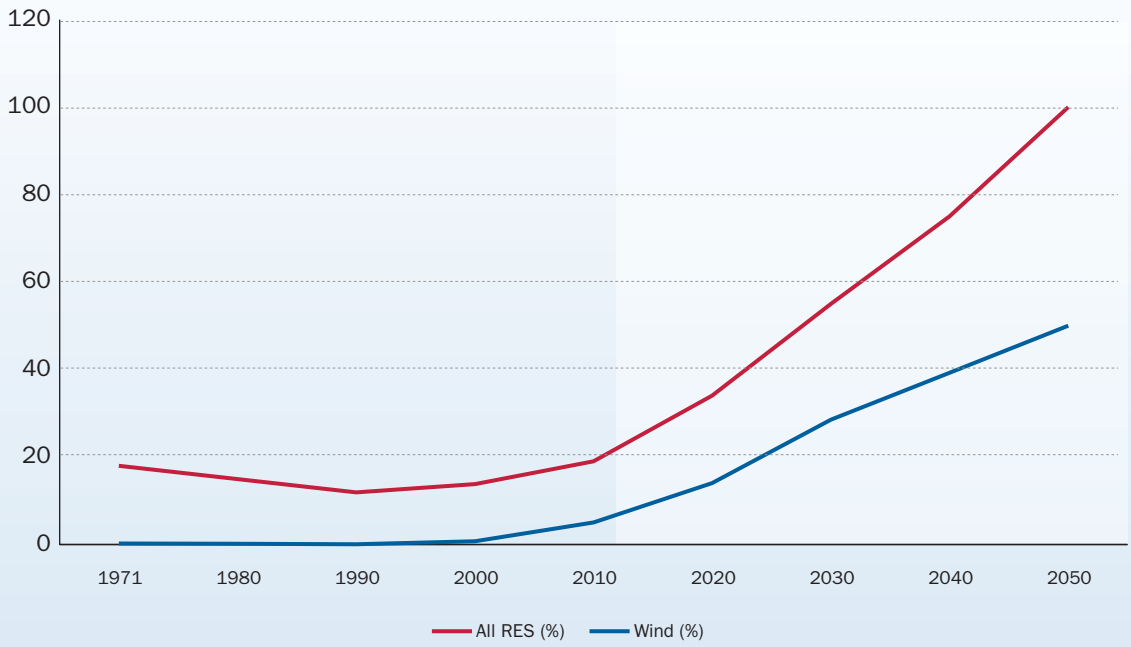
The EU has provided the power sector with a very clear trajectory over the next ten years. What is yet to be done is for the EU to provide the power sector with an equally clear trajectory for the period after 2020.

Currently, the agreed framework for post-2020 consists of the following elements:

- the Heads of States' commitment to reduce greenhouse gas emissions by 80-95% by 2050;
- the directive on the EU Emissions Trading System, which will continue to reduce the emissions cap for the ETS sectors by 1.74% each year beyond 2020;
- a post-2020 EU framework for renewable energy, consisting of a Renewable Energy Roadmap for the post-2020 period expected to be published in 2018.

Given the proven success of the EU regulatory framework for renewables since 1997, EWEA considers the most effective post-2020 regulatory framework to be a binding 2030 renewable energy target. This would give the power sector a vital stepping stone, taking it from 19% renewable electricity in 2010, to an expected 34% in 2020, and to 100% renewable electricity by 2050, with wind energy contributing 50%.

FIGURE 11.1 CONTRIBUTION OF ELECTRICITY FROM RENEWABLE ENERGY SOURCES AND WIND ENERGY 1970-2010 AND EXPECTED CONTRIBUTION 2011-2050 (% OF CONSUMPTION).



Sources: 1971-1989 3E/EWEA assumption: 1990-2008 Eurostat: 2009
EWEA assumption: 2010-2020 NREAPs: 2020-2030 EWEA (based on PRIMES consumption 2030: 2031-2050 EWEA).

The EU's renewable energy policy – the 2001 Renewable Electricity Directive and the 2009 Renewable Energy Directive – is successfully transforming Europe's power sector. Therefore, the most effective post-2020 framework would be to replicate the successful approach and set an ambitious, binding 2030 target for renewable energy that is compatible with the necessary carbon reductions in the power sector.

TABLE 11.1 INSTALLED CAPACITY, ELECTRICITY PRODUCTION AND SHARE OF EU DEMAND

	Onshore wind (GW)	Offshore wind (GW)	Total wind energy capacity (GW)	Average capacity factor onshore	Average capacity factor offshore	TWh onshore	TWh offshore	TWh total	EU-27 gross electricity consump-tion	Wind power's share of electricity demand
2020	190	40	230	26%	42.3%	433	148	581	3,690	16%
2030	250	150	400	27%	42.8%	591	562	1,154	4,051	29%
2050	275	460	735	29%	45%	699	1,813	2,512	5,000	50%

Source: EWEA based on PRIMES consumption to 2030 and EC Low Carbon Roadmap to 2050.

Table 11.1 shows wind power's share of electricity demand taking into account EWEA's 2020 and 2030 targets and the electricity the installed capacity would produce in a normal wind year. To calculate wind power's penetration, the European Commission's PRIMES calculations for electricity consumption have been used. By 2050, wind power could produce more than 2,500 TWh and there by meeting half of Europe's expected electricity demand.

Photo: De Visu

ANNEXES / REFERENCES

ANNEX 1 CUMULATIVE INSTALLATIONS OF WIND POWER IN THE EU (MW)

Country	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
Austria	77	94	140	415	606	819	965	982	995	995	1,011
Belgium	13	32	35	68	96	167	194	287	415	563	911
Bulgaria	0	0	0	0	10	10	36	57	120	177	375
Cyprus	0	0	0	0	0	0	0	0	0	0	82
Czech Republic	0	0	3	9	17	28	54	116	150	192	215
Denmark	2,417	2,489	2,889	3,116	3,118	3,128	3,136	3,125	3,163	3,478	3,798
Estonia	0	0	2	2	6	32	32	59	78	142	149
Finland	39	39	43	52	82	82	86	110	143	147	197
France	66	93	148	257	390	757	1,567	2,454	3,404	4,574	5,660
Germany	6,113	8,754	11,994	14,609	16,629	18,415	20,622	22,247	23,897	25,777	27,214
Greece	189	272	297	383	473	573	746	871	985	1,087	1,208
Hungary	0	0	3	3	3	17	61	65	127	201	295
Ireland	118	124	137	190	339	496	746	795	1,027	1,210	1,428
Italy	427	682	788	905	1,266	1,718	2,123	2,726	3,736	4,849	5,797
Latvia	0	0	24	27	27	27	27	27	27	28	31
Lithuania	0	0	0	0	6	6	48	51	54	91	154
Luxembourg	10	15	17	22	35	35	35	35	35	35	42
Malta	0	0	0	0	0	0	0	0	0	0	0
Netherlands	446	486	693	910	1,079	1,219	1,558	1,747	2,225	2,215	2,245
Poland	0	0	27	63	63	83	153	276	544	725	1,107
Portugal	100	131	195	296	522	1,022	1,716	2,150	2,862	3,535	3,898
Romania	0	0	1	1	1	2	3	8	11	14	462
Slovakia	0	0	0	3	5	5	5	5	3	3	3
Slovenia	0	0	0	0	0	0	0	0	0	0	0
Spain	2,235	3,337	4,825	6,203	8,264	10,028	11,623	15,131	16,689	19,160	20,676
Sweden	231	293	345	399	442	510	571	788	1,048	1,560	2,163
UK	406	474	552	667	904	1,332	1,962	2,406	2,974	4,245	5,204
EU Total	**12,887**	**17,315**	**23,157**	**28,598**	**34,372**	**40,500**	**48,031**	**56,517**	**64,713**	**75,103**	**84,324**

ANNEX 2 ANNUAL INSTALLATIONS OF WIND POWER IN THE EU (MW)

Country	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
Austria	43	17	46	276	192	218	146	19	14	0	16
Belgium	7	19	3	33	28	71	28	93	135	149	350
Bulgaria	0	0	0	0	10	0	26	21	63	57	198
Cyprus	0	0	0	0	0	0	0	0	0	0	82
Czech Republic	0	0	0	6	9	11	26	63	34	44	23
Denmark	646	72	506	249	9	22	12	3	60	347	364
Estonia	0	0	0	0	3	26	0	27	19	64	7
Finland	0	0	4	9	30	4	4	24	33	5	52
France	41	27	55	109	138	367	810	888	950	1,170	1,086
Germany	1,671	2,641	3,240	2,645	2,037	1,809	2,233	1,667	1,659	1,917	1,493
Greece	77	83	25	86	90	100	173	125	114	102	123
Hungary	0	0	0	0	0	14	43	4	62	74	94
Ireland	44	6	13	53	149	157	250	49	232	283	118
Italy	150	255	106	117	361	452	417	603	1,010	1,113	948
Latvia	0	0	0	3	0	0	0	0	0	2	2
Lithuania	0	0	0	0	6	0	42	8	3	37	63
Luxembourg	0	5	2	5	14	0	0	0	0	0	7
Malta	0	0	0	0	0	0	0	0	0	0	0
Netherlands	13	40	222	224	199	154	354	210	500	25	32
Poland	0	0	0	36	0	20	69	123	268	181	382
Portugal	39	31	64	104	226	500	694	434	712	673	363
Romania	0	0	0	0	0	1	1	5	3	3	448
Slovakia	0	0	0	3	2	0	0	0	0	0	0
Slovenia	0	0	0	0	0	0	0	0	0	0	0
Spain	423	1,102	1,488	1,378	2,065	1,764	1,595	3,508	1,558	2,471	1,516
Sweden	11	62	52	54	43	68	62	217	262	512	604
UK	44	68	87	121	237	445	634	443	569	1,271	962
EU Total	**3,209**	**4,428**	**5,973**	**5,510**	**5,838**	**6,204**	**7,592**	**8,535**	**8,262**	**10,498**	**9,332**

ANNEX 3 RENEWABLES' SHARE OF ELECTRICITY CONSUMPTION PER MEMBER STATE (%) IN 2020 ACCORDING TO THE NREAPs

	Wind	Hydro	Biomass	PV	CSP	Geothermal	Tidal & Wave
Austria	6%	57%	7%	0%	0%	0%	0%
Belgium	9%	0%	10%	1%	0%	0%	0%
Bulgaria	6%	11%	2%	1%	0%	0%	0%
Cyprus	7%	0%	2%	4%	3%	0%	0%
Czech Republic	2%	3%	7%	2%	0%	0%	0%
Denmark	31%	0%	23%	0%	0%	0%	0%
Estonia	14%	0%	3%	0%	0%	0%	0%
Finland	6%	14%	13%	0%	0%	0%	0%
France	11%	13%	3%	1%	0%	0%	0%
Germany	19%	4%	9%	7%	0%	0%	0%
Greece	24%	9%	2%	4%	1%	1%	0%
Hungary	3%	0%	6%	0%	0%	1%	0%
Ireland	37%	2%	3%	0%	0%	0%	1%
Italy	5%	11%	5%	3%	0%	2%	0%
Latvia	10%	35%	14%	0%	0%	0%	0%
Lithuania	9%	3%	9%	0%	0%	0%	0%
Luxembourg	4%	2%	5%	1%	0%	0%	0%
Malta	9%	0%	5%	1%	0%	0%	0%
Netherlands	24%	1%	12%	0%	0%	0%	0%
Poland	9%	2%	9%	0%	0%	0%	0%
Portugal	23%	22%	5%	2%	2%	1%	1%
Romania	11%	27%	4%	0%	0%	0%	0%
Slovakia	2%	16%	5%	1%	0%	0%	0%
Slovenia	1%	33%	4%	1%	0%	0%	0%
Spain	20%	10%	3%	4%	4%	0%	0%
Sweden	8%	44%	11%	0%	0%	0%	0%
UK	21%	2%	7%	1%	0%	0%	1%
EU	**14%**	**10%**	**7%**	**2%**	**1%**	**0%**	**0%**

ANNEX 4 WIND ENERGY INSTALLATIONS 2000-2030 (GW)

	Onshore annual	Onshore total	Onshore decommis-sioning	Offshore annual	Offshore total	Offshore decommis-sioning	Total net wind annual	Total installed wind capacity
2000	3.2	12.9	0.0	0.0	0.0	0.0	3.2	12.9
2001	4.4	17.2	0.0	0.1	0.1	0.0	4.4	17.3
2002	5.7	22.8	0.1	0.2	0.3	0.0	5.8	23.1
2003	5.2	28.0	0.1	0.3	0.5	0.0	5.4	28.5
2004	5.7	33.8	0.1	0.1	0.6	0.0	5.8	34.4
2005	6.1	39.8	0.1	0.1	0.7	0.0	6.1	40.5
2006	7.4	47.1	0.1	0.2	0.9	0.0	7.5	48.0
2007	8.3	55.4	0.1	0.2	1.1	0.0	8.4	56.5
2008	7.9	63.2	0.1	0.4	1.5	0.0	8.2	64.7
2009	9.9	73.0	0.1	0.6	2.1	0.0	10.4	75.1
2010	8.4	81.4	0.1	0.9	2.9	0.0	9.2	84.3
2011	8.5	89.6	0.2	1.0	3.9	0.0	9.3	93.6
2012	8.6	98.0	0.3	1.4	5.3	0.0	9.7	103.3
2013	9.6	107.1	0.5	2.8	8.1	0.0	11.9	115.2
2014	10.6	117.0	0.7	2.9	10.9	0.0	12.8	128.0
2015	11.4	127.5	1.0	3.1	14.0	0.0	13.5	141.5
2016	12.4	138.6	1.3	3.4	17.4	0.0	14.5	156.0
2017	13.7	150.4	1.9	4.1	21.6	0.0	16.0	172.0
2018	15.2	163.0	2.6	5.1	26.7	0.0	17.7	189.7
2019	16.9	176.4	3.5	6.4	33.1	0.0	19.9	209.5
2020	17.8	190.0	4.2	6.9	40.0	0.0	20.5	230.0
2021	17.1	202.0	5.1	7.8	47.7	0.0	19.8	249.7
2022	16.6	213.0	5.6	8.5	56.2	0.0	19.5	269.2
2023	15.6	223.0	5.6	9.1	65.5	0.0	19.1	288.5
2024	14.3	231.0	6.3	9.6	75.6	0.0	17.6	306.6
2025	13.1	237.0	7.1	10.5	86.5	0.0	16.5	323.5
2026	11.8	241.0	7.8	11.5	98.1	0.1	15.4	339.1
2027	11.6	244.0	8.6	12.4	110.4	0.2	15.2	354.4
2028	11.2	246.5	8.7	13.0	123.2	0.3	15.2	369.7
2029	11.0	248.5	9.0	13.2	136.4	0.1	15.1	384.9
2030	10.0	250.0	8.5	13.7	150.0	0.1	15.1	400.0

ANNEX 5 WIND ENERGY PRODUCTION AND SHARE OF ELECTRICITY CONSUMPTION 2000-2030

	Avg capacity factor onshore	Avg. capacity factor offshore	Avg. capacity factor	Onshore wind energy production (TWh)	Offshore wind energy production (TWh)	Total wind energy production (TWh)	Gross electricity consumption (PRIMES) TWh	Wind energy's share of electricity consumption (onshore)	Wind energy's share of electricity consumption (offshore)	Wind energy's share of electricity consumption (total)
2000	19.9%	40.0%	20.0%	22.5	0.1	22.6	2,993.7	0.8%	0.0%	0.8%
2001	21.0%	40.1%	21.1%	31.7	0.3	32.0	3,017.2	1.0%	0.0%	1.1%
2002	21.7%	40.2%	22.0%	43.5	0.9	44.4	3,040.6	1.4%	0.0%	1.5%
2003	22.4%	40.3%	22.7%	54.8	1.8	56.6	3,064.1	1.8%	0.1%	1.8%
2004	22.7%	40.4%	23.0%	67.3	2.1	69.4	3,087.5	2.2%	0.1%	2.2%
2005	23.0%	40.5%	23.3%	80.3	2.5	82.8	3,320.3	2.4%	0.1%	2.5%
2006	23.3%	40.6%	23.7%	96.4	3.2	99.6	3,357.4	2.9%	0.1%	3.0%
2007	23.6%	40.7%	23.9%	114.5	3.9	118.5	3,372.2	3.4%	0.1%	3.5%
2008	23.7%	40.8%	24.1%	131.2	5.3	136.4	3,390.7	3.9%	0.2%	4.0%
2009	23.7%	40.9%	24.2%	151.6	7.4	159.0	3,349.0	4.5%	0.2%	4.7%
2010	24.0%	41.0%	24.6%	171.1	10.6	181.7	3,307.2	5.2%	0.3%	5.5%
2011	24.2%	41.0%	24.9%	190.0	14.2	204.2	3,350.6	5.7%	0.4%	6.1%
2012	24.4%	41.1%	25.3%	209.5	19.1	228.6	3,394.0	6.2%	0.6%	6.7%
2013	24.6%	41.2%	25.8%	230.8	29.1	259.9	3,437.4	6.7%	0.8%	7.6%
2014	24.8%	41.3%	26.2%	254.2	39.5	293.7	3,480.8	7.3%	1.1%	8.4%
2015	25.0%	41.3%	26.6%	279.2	50.6	329.8	3,524.2	7.9%	1.4%	9.4%
2016	25.2%	41.4%	27.0%	305.9	63.2	369.1	3,557.3	8.6%	1.8%	10.4%
2017	25.4%	41.4%	27.4%	334.7	78.3	412.9	3,590.4	9.3%	2.2%	11.5%
2018	25.6%	41.5%	27.8%	365.6	97.1	462.6	3,623.5	10.1%	2.7%	12.8%
2019	25.8%	41.6%	28.3%	398.8	120.5	519.3	3,656.6	10.9%	3.3%	14.2%
2020	26.0%	42.3%	28.8%	432.7	148.2	581.0	3,689.7	11.7%	4.0%	15.7%
2021	26.1%	42.4%	29.2%	461.8	177.0	638.8	3,733.8	12.4%	4.7%	17.1%
2022	26.2%	42.4%	29.6%	488.9	208.7	697.6	3,777.9	12.9%	5.5%	18.5%
2023	26.3%	42.5%	30.0%	513.8	243.6	757.3	3,822.1	13.4%	6.4%	19.8%
2024	26.4%	42.5%	30.4%	534.2	281.5	815.7	3,866.2	13.8%	7.3%	21.1%
2025	26.5%	42.6%	30.8%	550.2	322.4	872.6	3,910.3	14.1%	8.2%	22.3%
2026	26.6%	42.6%	31.2%	561.6	366.1	927.7	3,938.5	14.3%	9.3%	23.6%
2027	26.7%	42.7%	31.7%	570.7	412.5	983.2	3,966.7	14.4%	10.4%	24.8%
2028	26.8%	42.7%	32.1%	578.7	460.8	1,039.5	3,994.9	14.5%	11.5%	26.0%
2029	26.9%	42.8%	32.5%	585.6	510.8	1,096.4	4,023.1	14.6%	12.7%	27.3%
2030	27.0%	42.8%	32.9%	591.3	562.4	1,153.7	4,051.3	14.6%	13.9%	28.5%

ANNEX 6 WIND ENERGY INVESTMENTS UP TO 2030

	Investment cost onshore (€2010/kW)	Investment cost offshore (€2010/kW)	Annual investment onshore (€2010 billion)	Annual investment offshore (€2010 billion)	Total wind power capital investments (€2010 billion)
2000	959	1,600	3	0	3
2001	900	1,766	4	0	4
2002	800	1,993	5	0	5
2003	900	2,290	5	1	5
2004	1,000	2,420	6	0	6
2005	1,150	2,500	7	0	7
2006	1,250	2,600	9	1	10
2007	1,300	2,750	11	1	11
2008	1,250	2,870	10	1	11
2009	1,250	3,000	12	2	14
2010	1,200	3,000	10	3	13
2011	1,163	2,759	10	3	13
2012	1,130	2,533	10	3	13
2013	1,098	2,247	11	6	17
2014	1,068	2,060	11	6	17
2015	1,039	1,920	12	6	18
2016	1,011	1,803	12	6	19
2017	985	1,696	14	7	21
2018	960	1,596	15	8	23
2019	933	1,547	16	10	26
2020	908	1,506	16	10	27
2021	889	1,468	15	11	27
2022	872	1,434	14	12	27
2023	858	1,402	13	13	26
2024	847	1,374	12	13	25
2025	839	1,347	11	14	25
2026	834	1,323	10	15	25
2027	830	1,301	10	16	26
2028	827	1,280	9	17	26
2029	825	1,262	9	17	26
2030	823	1,245	8	17	25

ANNEX 7 CO_2 AVOIDED FROM WIND

	Mt CO_2 avoided /TWh	CO_2 avoided from onshore wind (Mt)	CO_2 avoided from offshore wind (Mt)	Total CO_2 avoided from wind (Mt)	Oil price (in $2010 /barrel)	Annual avoided fuel cost €2010 billion
2000	0.793	18	0	18		
2001	0.779	25	0	25		
2002	0.766	33	1	34		
2003	0.753	41	1	43		
2004	0.741	50	2	51		
2005	0.730	59	2	60		
2006	0.723	70	2	72		
2007	0.716	82	3	85		
2008	0.710	93	4	97		
2009	0.703	107	5	112		
2010	0.696	119	7	126	80	6.5
2011	0.689	131	10	141		
2012	0.682	143	13	156		
2013	0.675	156	20	175		
2014	0.668	170	26	196		
2015	0.661	184	33	218	89	12.7
2016	0.646	198	41	239		
2017	0.632	211	49	261		
2018	0.617	226	60	286		
2019	0.603	240	73	313		
2020	0.588	255	87	342	97	23.9
2021	0.585	270	104	374		
2022	0.582	285	122	406		
2023	0.580	298	141	439		
2024	0.577	308	162	471		
2025	0.574	316	185	501	103	37.4
2026	0.571	321	209	530		
2027	0.569	325	235	559		
2028	0.566	327	261	588		
2029	0.563	330	288	617		
2030	0.560	331	315	646	108	50.9

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