WIND ENERGY - THE FACTS

APPENDICES

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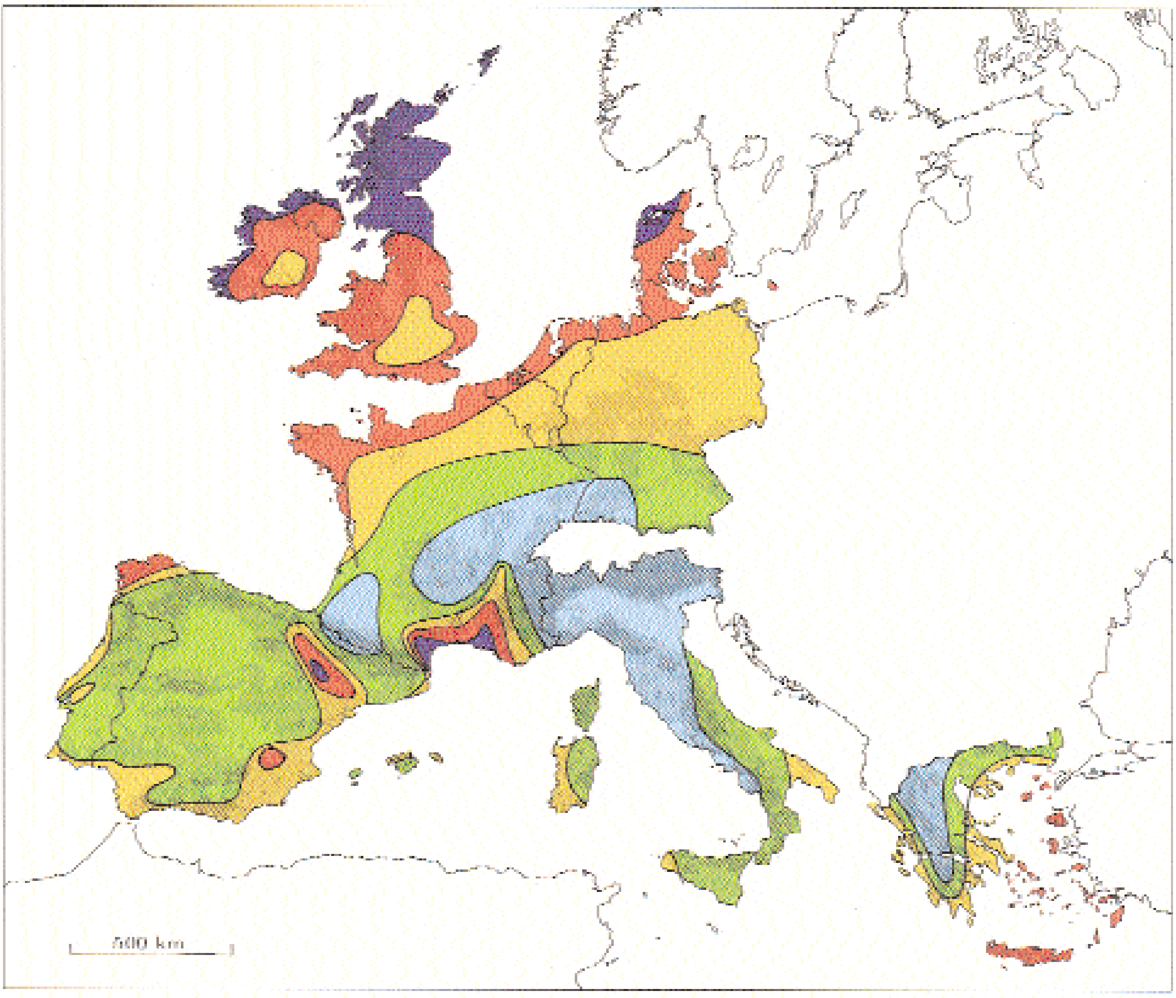
APPENDIX A: ONSHORE WIND MAPS

Figure A.1: European Wind Atlas, Onshore (EU-12). Source: Risø National Laboratory.



Wind resources at 50 metres above ground level for five different topographic conditions										
	Sheltered terrain		Open plain		At a sea coast		Open sea		Hills and ridges	
	$m s^{-1}$	Wm^{-2}	$m s^{-1}$	Wm^{-2}	$m s^{-1}$	Wm^{-2}	$m s^{-1}$	Wm^{-2}	$m s^{-1}$	Wm^{-2}
	> 6.0	> 250	> 7.5	> 500	> 8.5	> 700	> 9.0	> 800	> 11.5	> 1800
	5.0-6.0	150-250	6.5-7.5	300-500	7.0-8.5	400-700	8.0-9.0	600-800	10.0-11.5	1200-1800
	4.5-5.0	100-150	5.5-6.5	200-300	6.0-7.0	250-400	7.0-8.0	400-600	8.5-10.0	700-1200
	3.5-4.5	50-100	4.5-5.5	100-200	5.0-6.0	150-250	5.5-7.0	200-400	7.0- 8.5	400- 700
	< 3.5	< 50	< 4.5	< 100	< 5.0	< 150	< 5.5	< 200	< 7.0	< 400

Figure A.2: Denmark Wind Atlas. Source: Risø (1999).

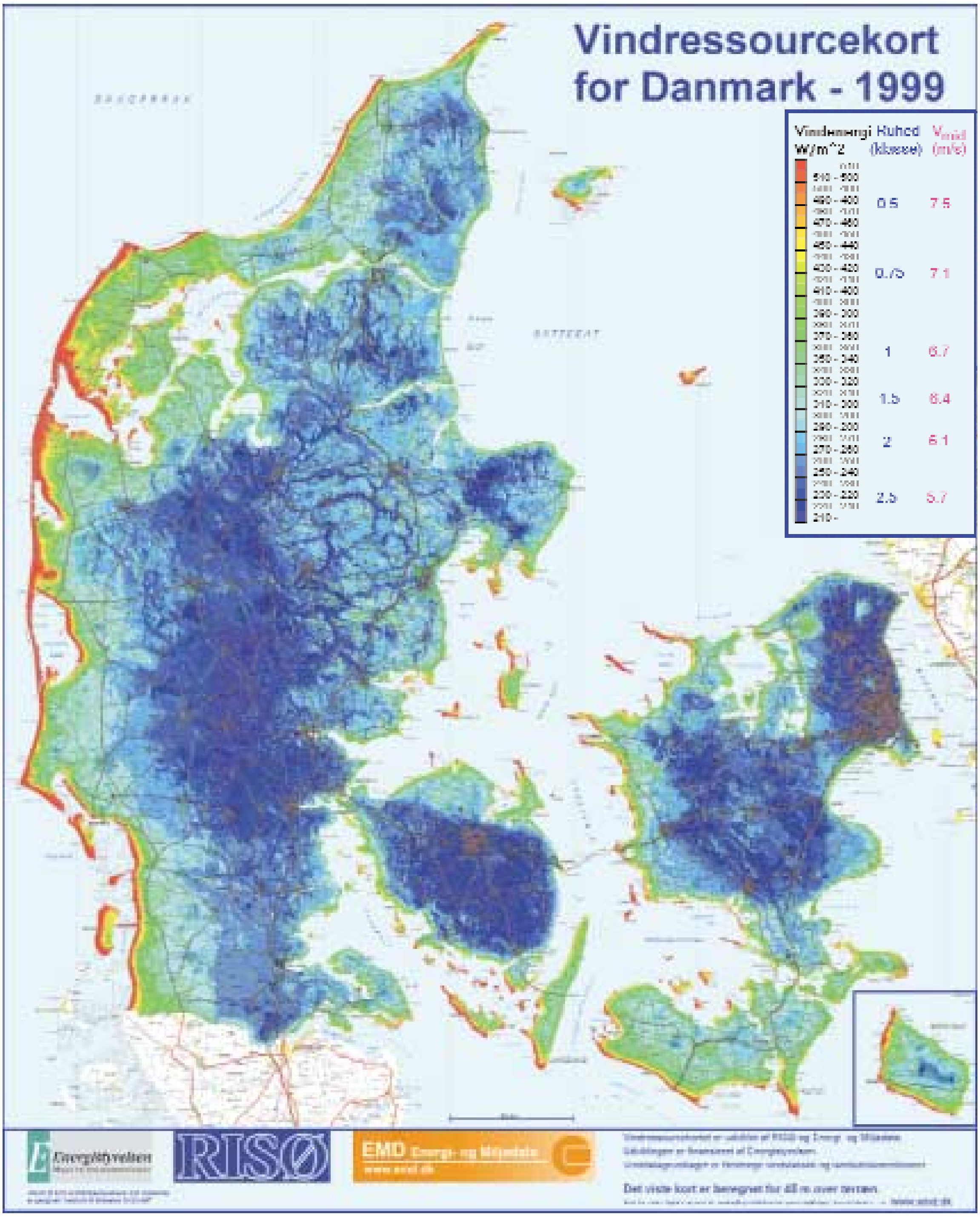


Figure A.3: German Wind Atlas. Source: Deutscher Wetterdienst.

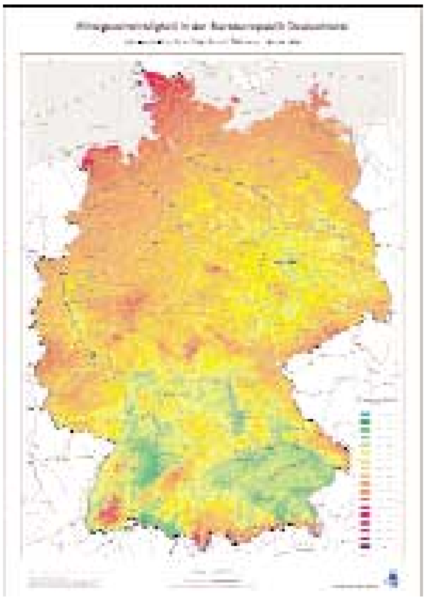
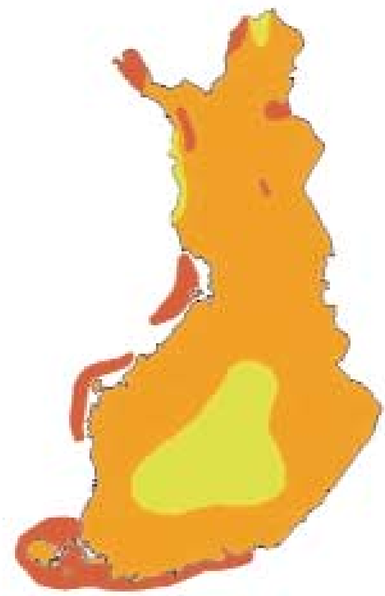


Figure A.4: Finland Wind Atlas. Source: FMI/Energy Group (1991).



	Sheltered Terrain m/s	Sheltered Terrain W/m²	Open Plain m/s	Open Plain W/m²	At a Sea Coast m/s	At a Sea Coast W/m²	Open Sea m/s	Open Sea W/m²	Hills and Ridges m/s	Hills and Ridges W/m²
	> 6.0	> 250	> 7.5	> 500	> 6.0	> 700	> 9.0	> 800	> 11,5	> 1800
	5.0-6.0	150-250	6.5-7.5	300-500	7.0-8.5	400-700	8.0-9.0	600-800	10.0-11.5	1200-1800
	4.5-5.0	100-150	5.5-6.5	200-300	6.0-7.0	250-400	7.0-8.0	400-600	8.5-10.0	700-1200
	3.5-4.5	50-100	4.5-5.5	100-200	5.0-6.0	150-250	5.5-7.0	200-400	7.0-8.5	400-700
	< 3.5	< 50	< 4.5	< 100	< 5.0	< 150	< 5.5	< 200	< 7.0	< 400

Wind resources at 50 meters above ground level for five different topographic conditions

Figure A.5: Greece Wind Atlas. Source: CRES (2001).

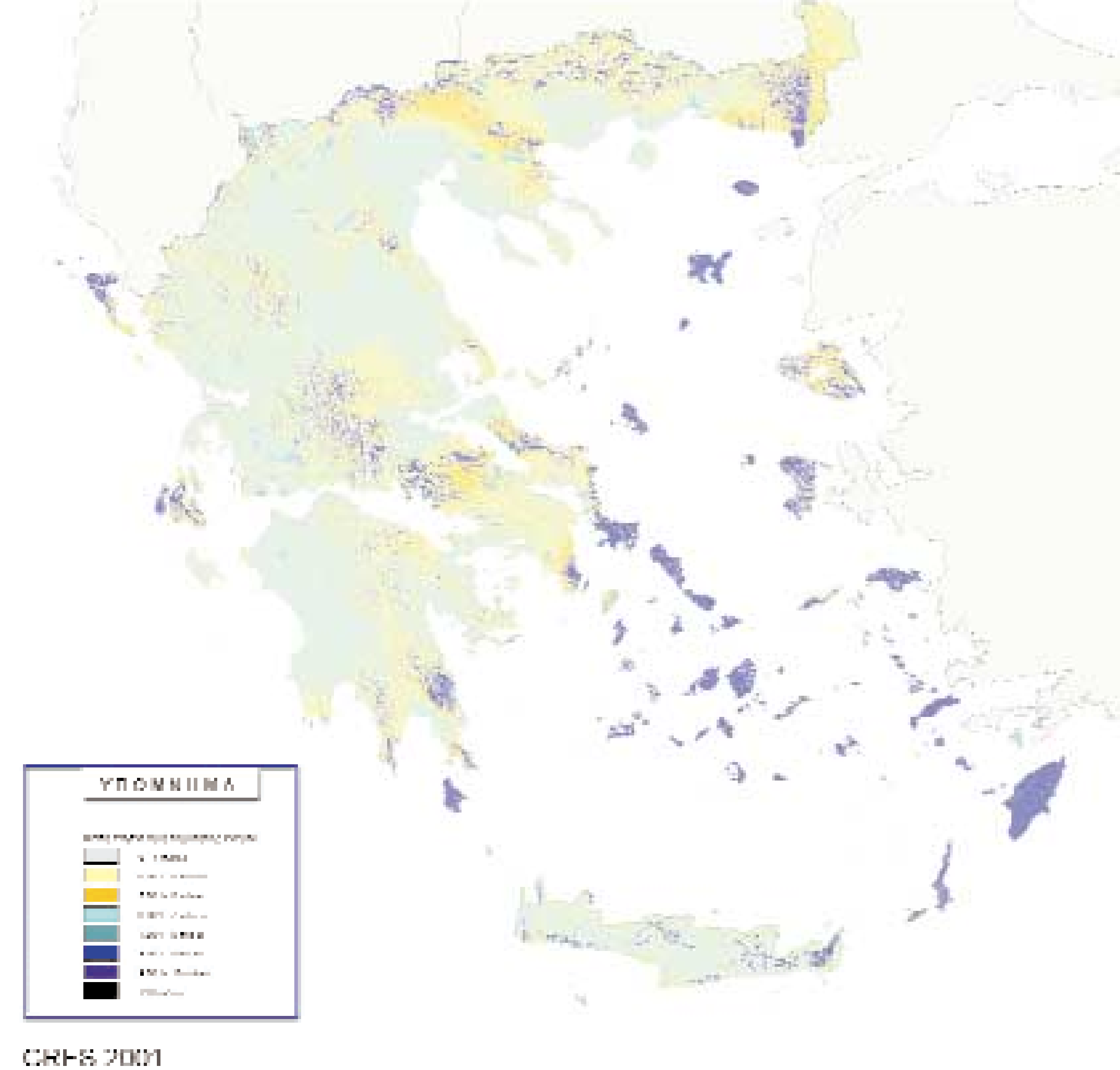


Figure A.6: Ireland Wind Atlas. Source: True Wind Solutions (2003).

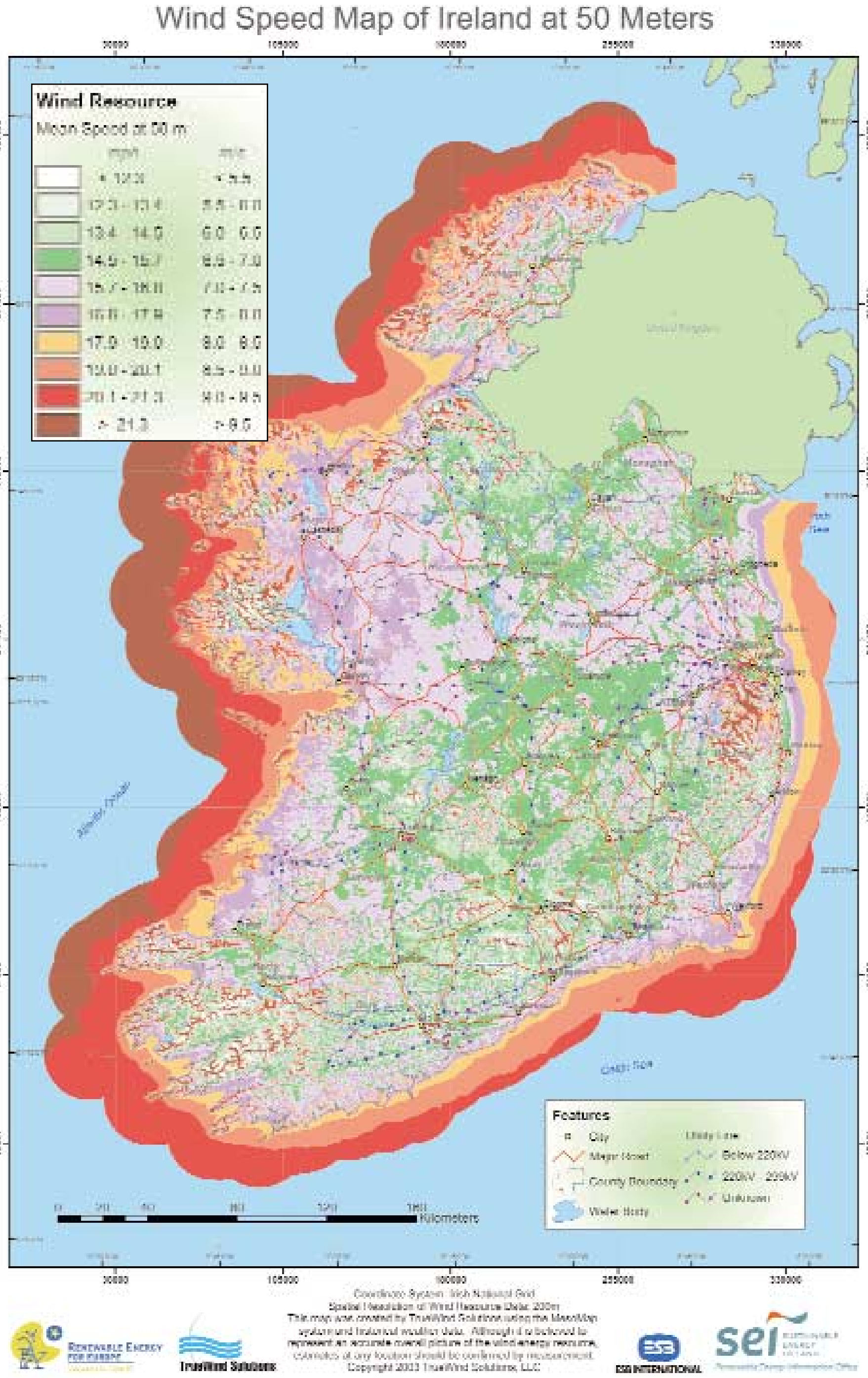


Figure A.7: Sweden Wind Atlas. Source: SMHI, *Vindatlas för Sverige* (1992).

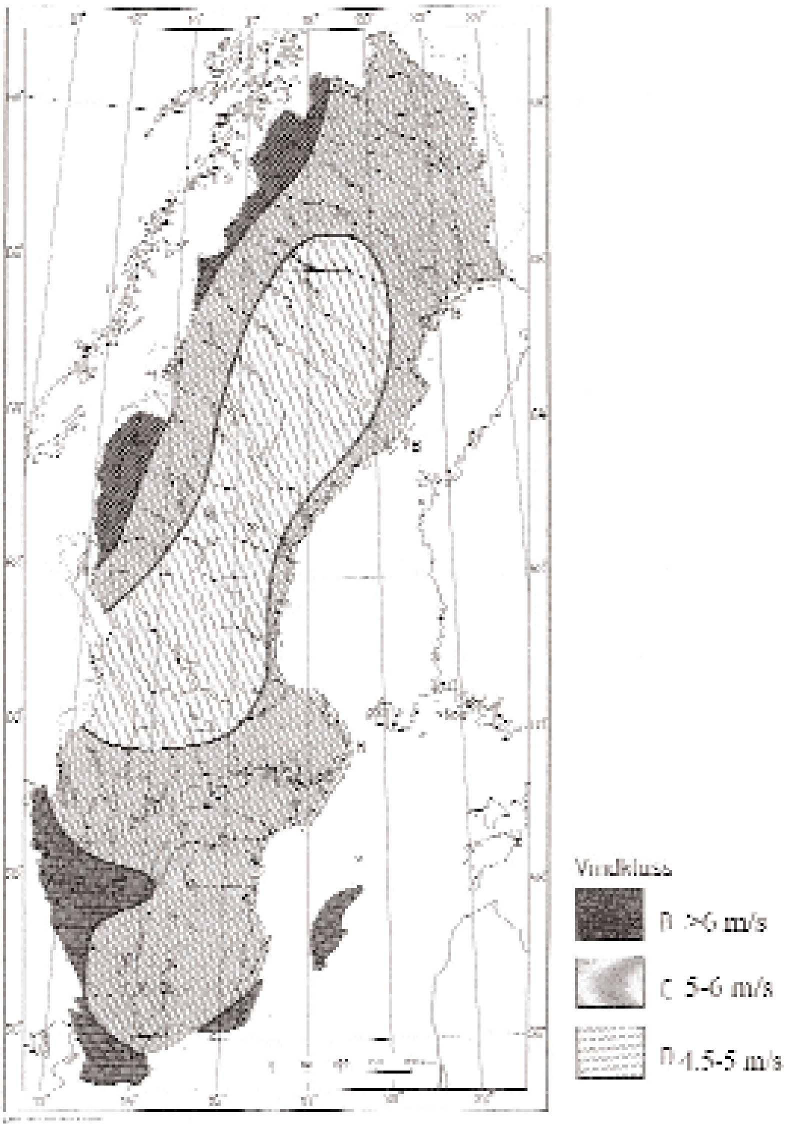


Figure A.8: UK Wind Atlas. Source: Burch & Ravenscroft (1992).

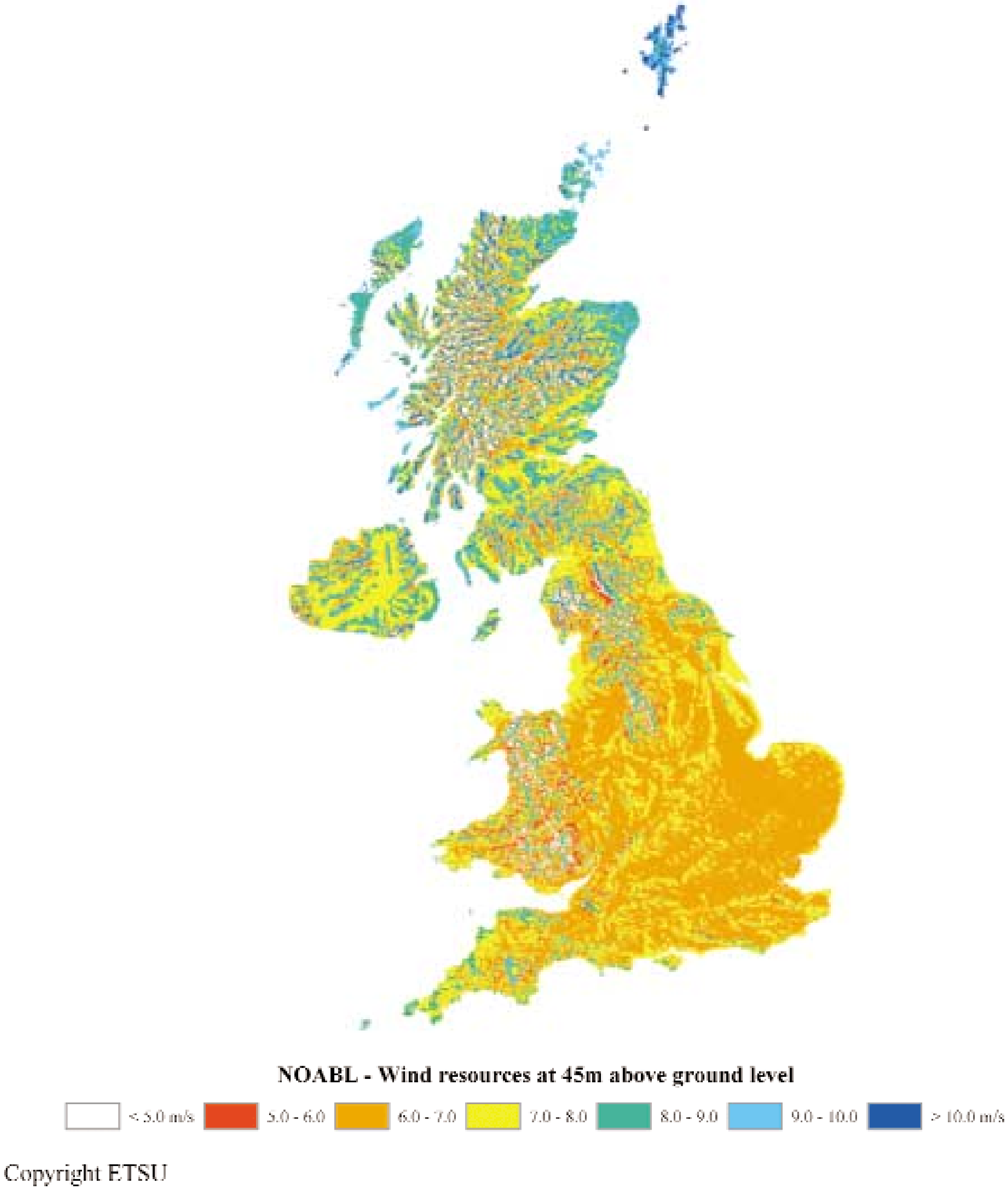


Figure A.9: Central European Wind Atlas. Source: Dobesch & Kury (1997).

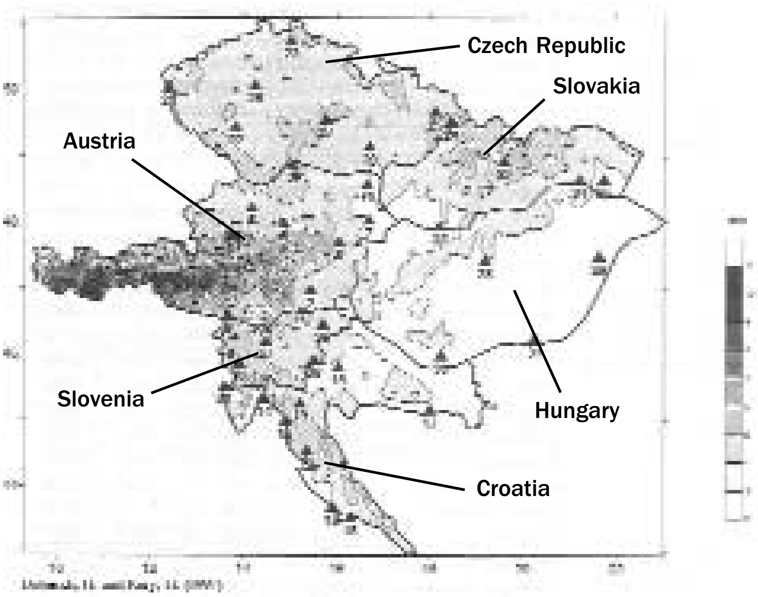
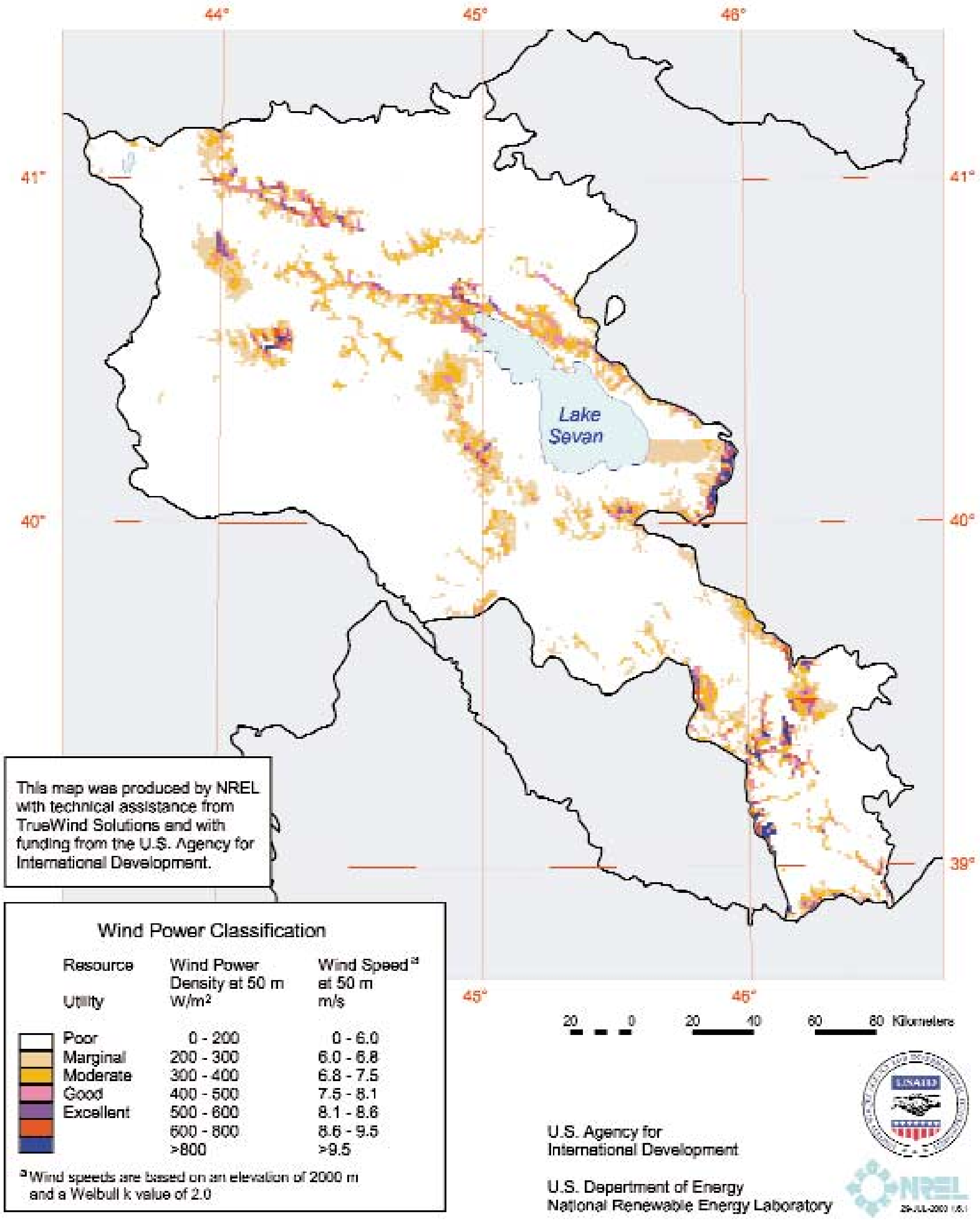
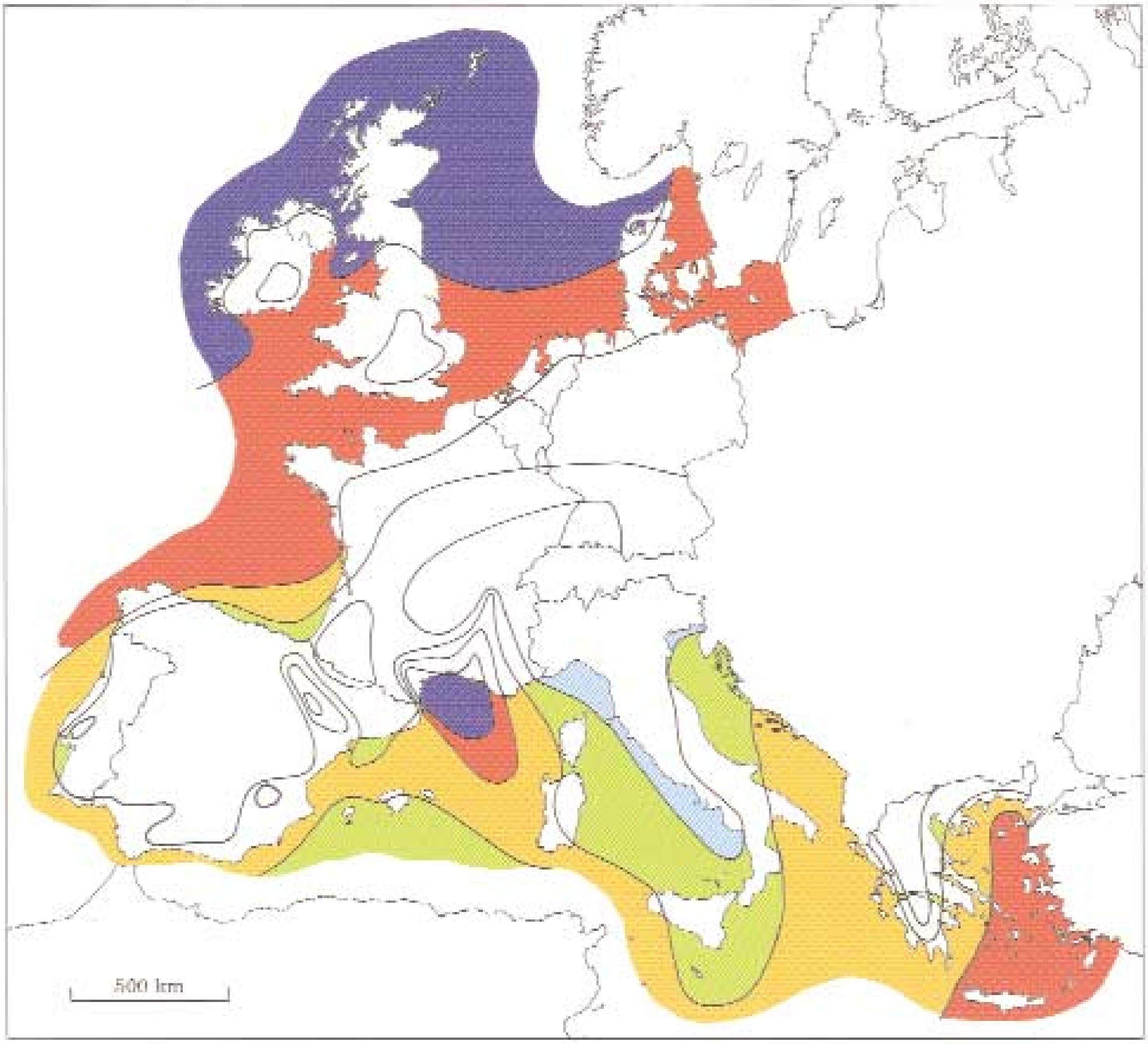


Figure A.10: Armenia Wind Atlas. Source: Elliott *et al.*, NREL (2003).



APPENDIX B: OFFSHORE WIND MAPS

Figure B.1: European Wind Atlas, Offshore. Source: Risø National Laboratory.



Wind resources over open sea (more than 10 km offshore) for five standard heights										
	10 m		25 m		50 m		100 m		200 m	
	ms^{-1}	Wm^{-2}	ms^{-1}	Wm^{-2}	ms^{-1}	Wm^{-2}	ms^{-1}	Wm^{-2}	ms^{-1}	Wm^{-2}
(purple)	> 8.0	> 600	> 8.5	> 700	> 9.0	> 800	> 10.0	> 1100	> 11.0	> 1500
(red)	7.0-8.0	350-600	7.5-8.5	450-700	8.0-9.0	600-800	8.5-10.0	650-1100	9.5-11.0	900-1500
(orange)	6.0-7.0	250-300	6.5-7.5	300-450	7.0-8.0	400-600	7.5- 8.5	450- 650	8.0- 9.5	600- 900
(green)	4.5-6.0	100-250	5.0-6.5	150-300	5.5-7.0	200-400	6.0- 7.5	250- 450	6.5- 8.0	300- 600
(light blue)	< 4.5	< 100	< 5.0	< 150	< 5.5	< 200	< 6.0	< 250	< 6.5	< 300

OFFSHORE WIND MAPS MODELLED IN "STUDY OF OFFSHORE WIND ENERGY IN THE EU" (GARRAD HASSAN *ET AL.*, 1995)

Figure B.2: Denmark - Germany

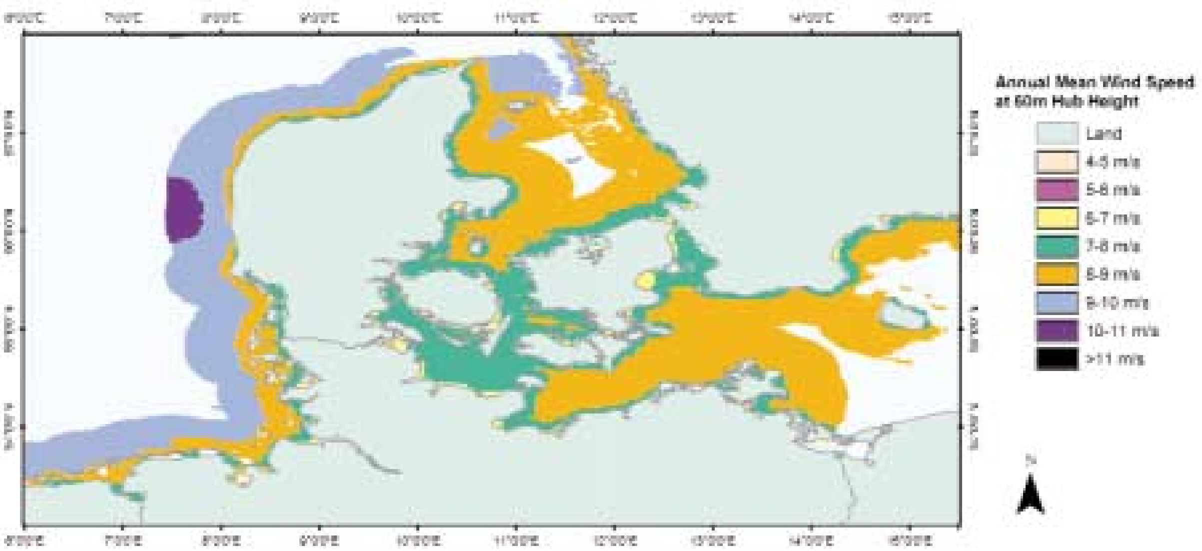


Figure B.3: France - Atlantic

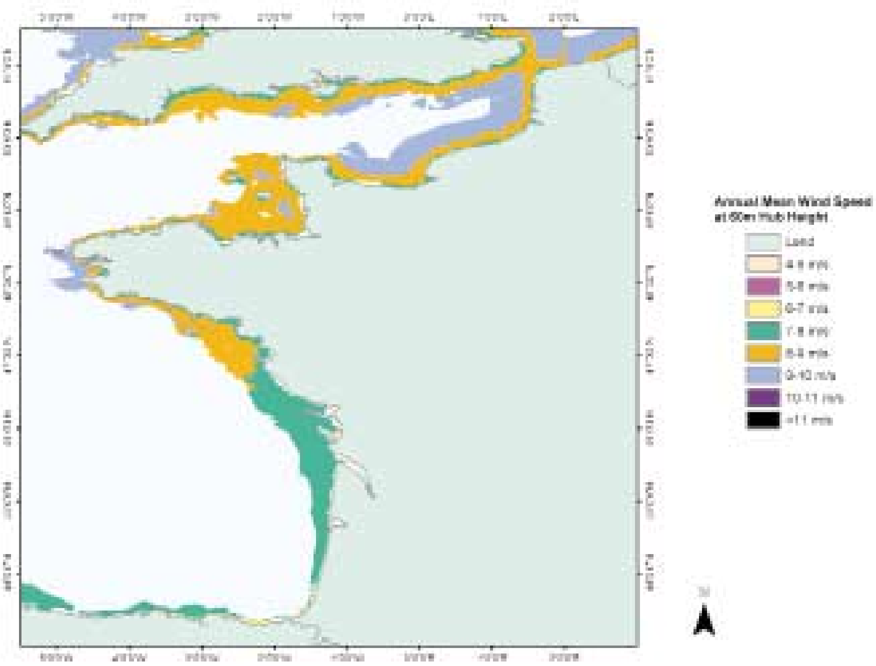


Figure B.4: France - Mediterranean

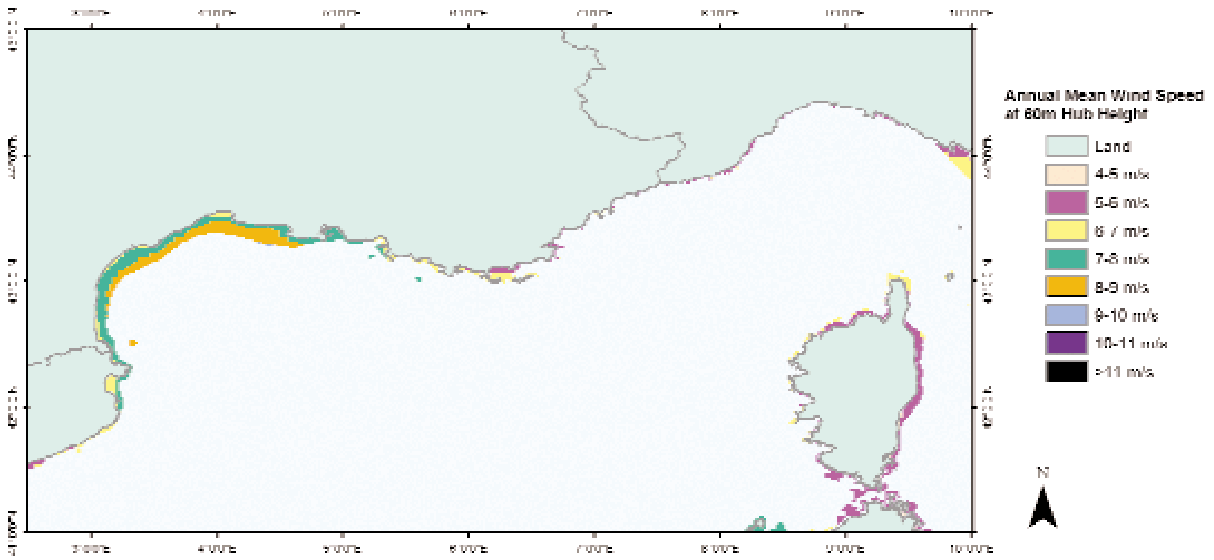


Figure B.5: Great Britain - North

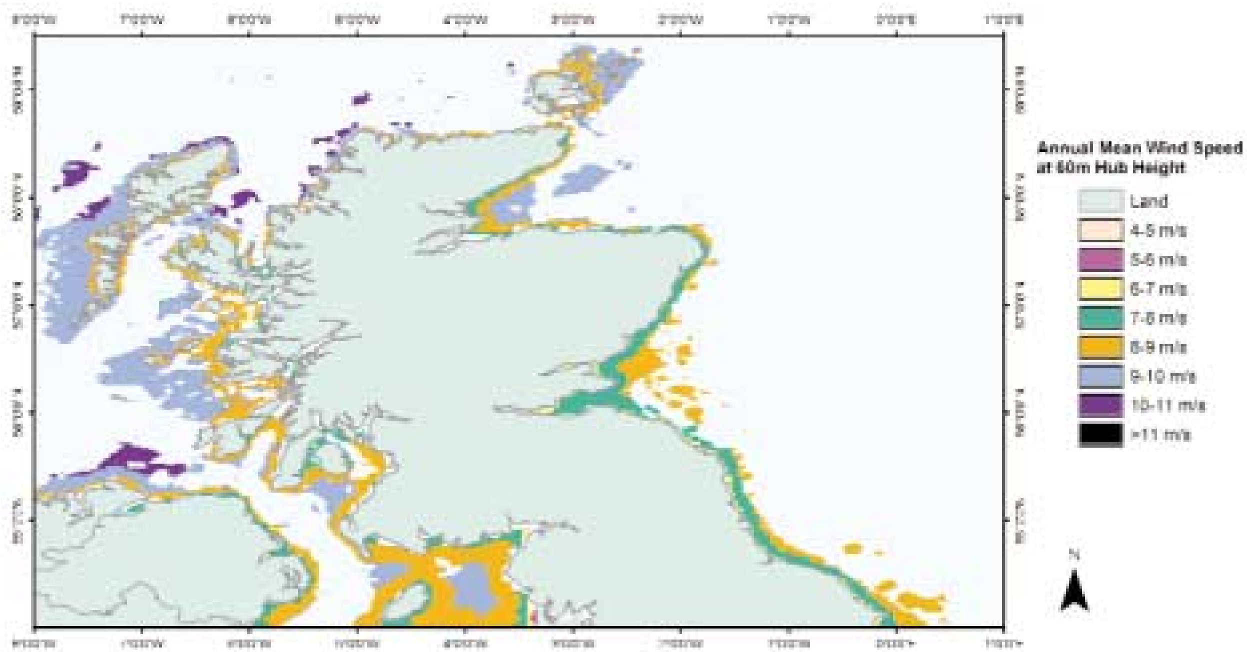


Figure B.6: Great Britain - South

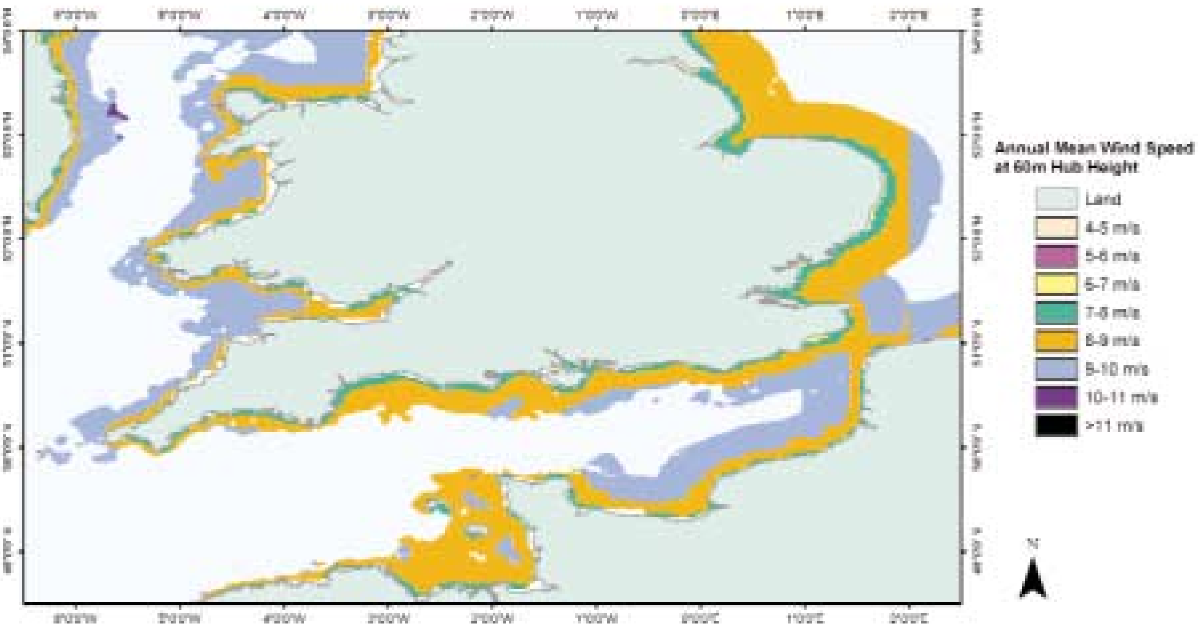


Figure B.7: Greece

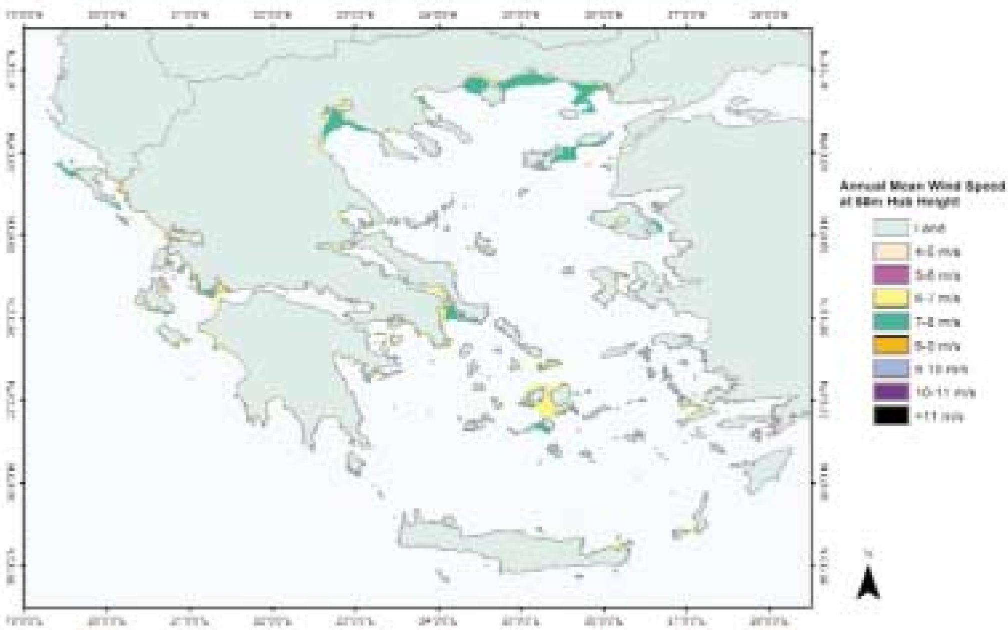


Figure B.8: Ireland

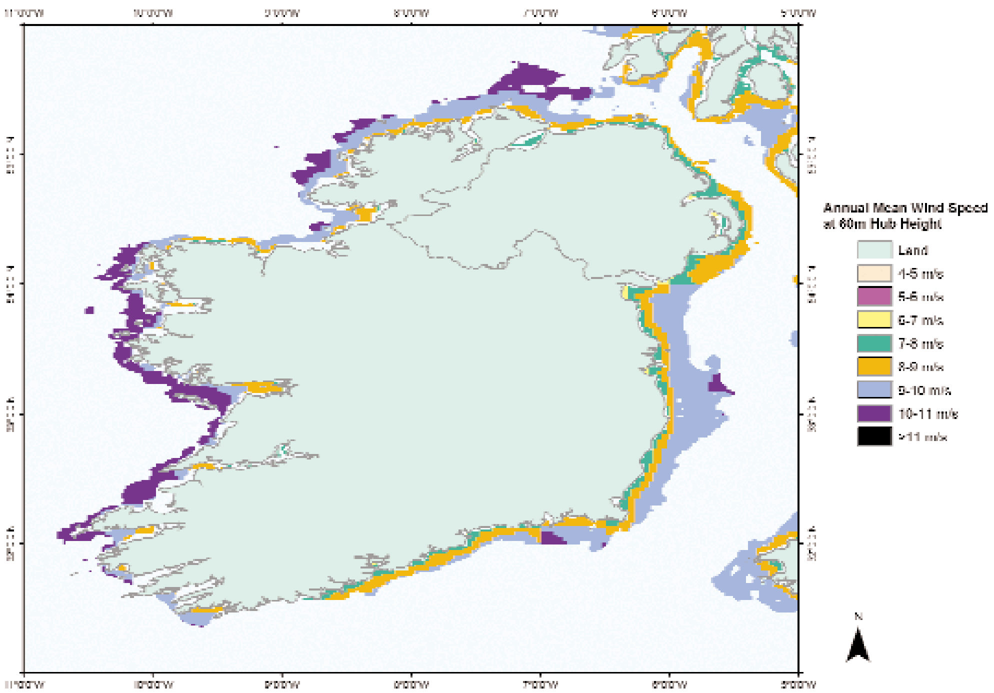


Figure B.9: Italy

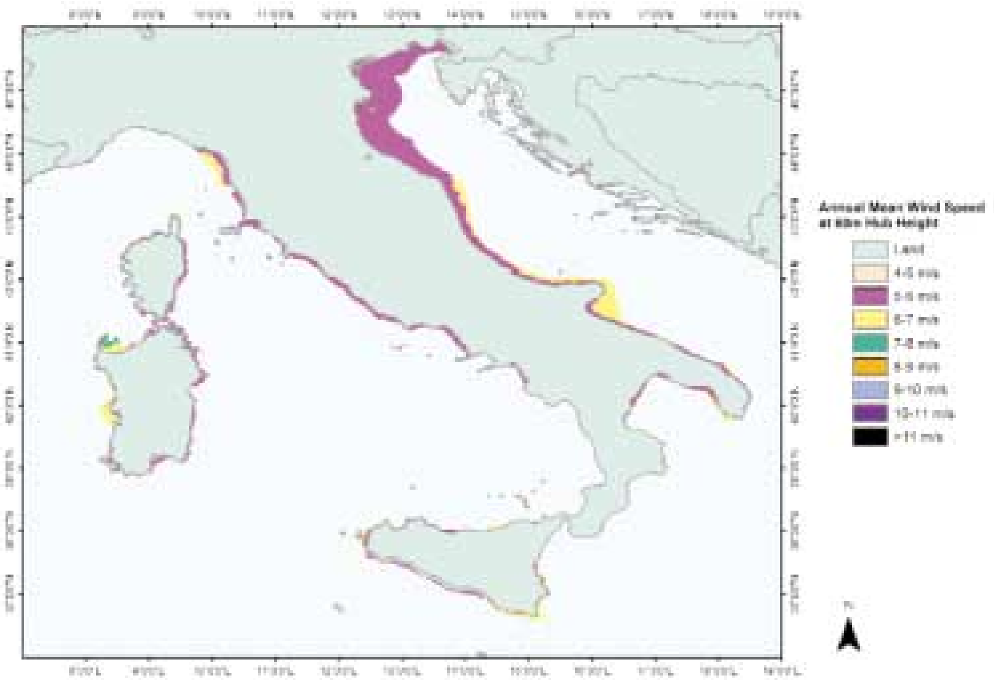


Figure B.10: Netherlands - Belgium

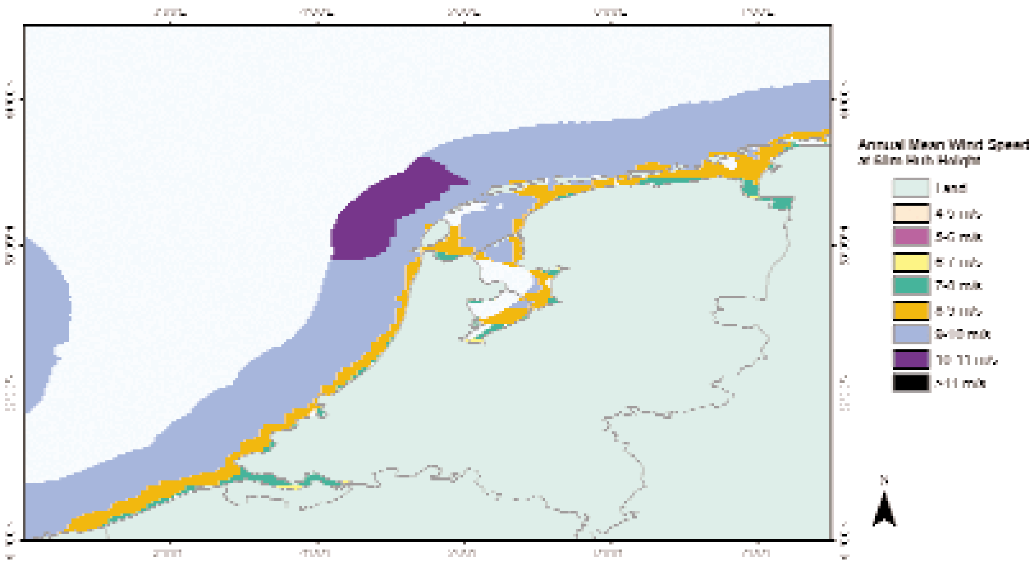
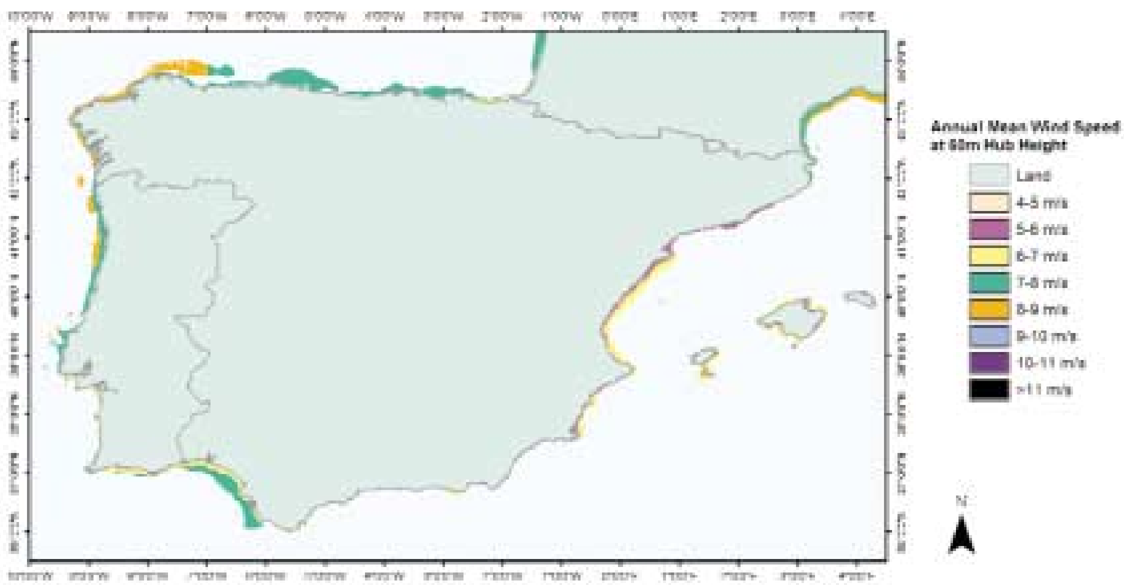


Figure B.11: Spain - Portugal



APPENDIX C: WORKED EXAMPLE FOR CUILLIAGH MOUNTAIN WIND FARM, IRELAND

C.1 Introduction

The main text has provided a general discussion of the assessment of the wind resource and energy production. This Appendix is included in order to provide a "worked example". It demonstrates all the different aspects of the process outlined in the main text. The project considered is the Cuilliagh Mountain wind farm in Ireland, which consists of 18 Vestas V47 WTs and was constructed in 2000. The following specific analyses are presented:

1 The results of the pre-construction projection of the expected energy production of the wind farm, including uncertainty analysis.
2 The review of the actual production of the wind farm over a 17-month period.
3 The results of a "wind in–energy out" validation test of the predictive methodologies employed in 1) above.

Airtricity, a leading international wind farm developer, owns the Cuilliagh Mountain Wind Farm and thanks are to be extended to Airtricity for allowing their proprietary data to be used for this example case.

C.2 Description of the Site and Monitoring Equipment

The site lies in central County Donegal approximately 14 km southwest of Letterkenny. The wind farm site lies on Cuilliagh Mountain with maximum elevation of approximately 360 m.

The site at Cuilliagh Mountain has had one 30 m and two 10 m temporary meteorological masts installed in the period since mid-1997. The 10 m data are not considered further within this report.

The wind data from the 30 m site mast have been recorded using NRG sensors with a Maximum 40 anemometer and wind vane at 10 m and 30 m. A NRG 9210 logger was programmed to record hourly mean wind speed, wind speed standard deviation, three-second gust and direction.

C.3 Malin Head Meteorological Station

The assessment of the wind climate at the site uses data recorded at a nearby meteorological station, Malin Head, which is situated on the coast approximately 65 km north-northeast of the Cuilliagh site. From discussions with Met Éireann (the Irish Meteorological Service) staff and consideration of other meteorological stations in the region, it was concluded that Malin Head was the most appropriate reference meteorological station for this analysis. Data from 1979 to 2000 have been used in the analysis reported here. Discussions with Met Éireann staff indicate that there has been no change during this period which will have a significant effect on the consistency of the measurements. This is important since the analysis method used here relies on long-term consistency of the measurements at the meteorological station.

C.4 Wind Data

The data sets from Malin Head and the Cuilliagh site, as used in the analyses described in the following sections, are summarised in Table C.1:

Table C.1: Data available from Cuilliagh and from Malin Head

Cuilliagh Mountain Mast 05 NRG (206940, 402500)	Hourly mean wind speed, standard deviation, gust and direction at 30 m	05 July 1997 - 24 Jan 1999
	Hourly mean wind speed, standard deviation, and direction at 10 m	
Malin Head Meteorological Station NRG (241950, 458550)	Hourly record of 10-minute mean wind speed and direction (time series data).	05 July 1997 - 24 January 1999
	Hourly record of 10-minute mean wind speed and direction (frequency table).	1979 - 1998

C.5 Description of the Proposed Wind Farm

The wind turbine model selected for the Cuilliagh Mountain Wind Farm was the Vestas V47 660 kW model with a hub height of 45 m. The basic parameters of the turbine are presented in Table C.2 below.

Table C.2: Main Parameters of the Vestas V47 660 kW Wind Turbine

Diameter	47.0	m
Hub height	45	m
Rotor speed	28.5	rpm
No. of blades	3	
Nominal rated power	660	kW

The power curve used in the analysis has been supplied for an air density of 1.225 kg/m^3 and is presented in Table C.3.

Table C.3: Performance Data for the Vestas V47 660 kW Wind Turbine

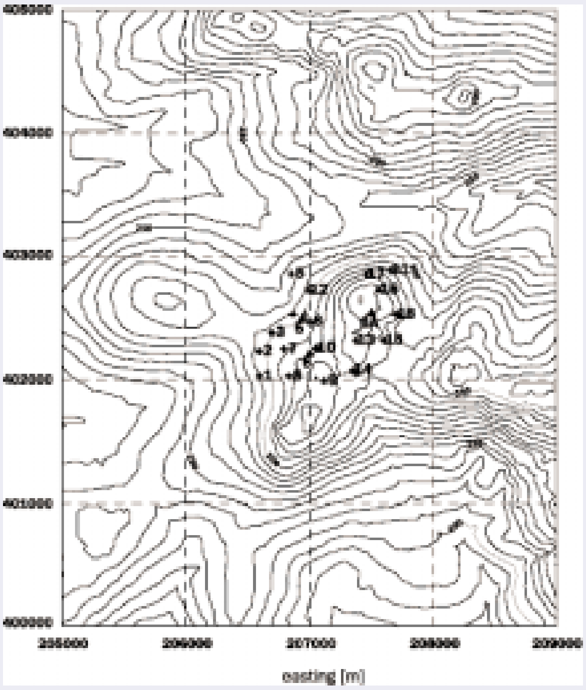
Wind Speed [m/s at hub height]	V47 Power Output [kW]
4	2.9
5	43.8
6	96.7
7	166
8	252
9	350
10	450
11	538
12	600
13	635
14	651
15	657
16	659
17	660
18	660
19	660
20	660
21	660
22	660
23	660
24	660
25	660

From data recorded at local meteorological stations and with standard lapse rate assumptions, the Cuilliagh Mountain site is predicted to have an air density of 1.205 kg/m^3. Since the predicted mean air density at the site differs from the air density for which the power curves were supplied, a small air density adjustment following the IEC 61400-12: 1998 standard was made to the power curves used in the analysis.

The power curve for the Vestas V47 660 kW turbine has been compared to a reference curve from an independent test of the performance of the turbine. It was found that the reference curve out-performed the supplied curve by 2% for the wind regime at the Cuilliagh site. This result indicates that the supplied curve is broadly in line with the performance that might be expected.

The Cuilliagh Mountain Wind Farm has a total nameplate capacity of just under 12 MW. It is located approximately 1.5 km south of the Cark wind farm. The effect of these turbines on the predicted energy production of the Cuilliagh development was estimated.

Figure C.1: Layout of the Cuilliagh Mountain Wind Farm



C.6 Results of the Analysis

The analysis to determine the wind regime and expected energy production of the proposed Cuilliagh Mountain wind farm involved several steps:

- The directional correlations between wind speeds recorded at Cuilliagh Mast 05 at 30 m and at Malin Head were established.
- The correlation relationships were applied to historical wind data recorded at Malin Head to produce a description of the long-term wind regime at Cuilliagh mast 05.
- Wind flow modelling was carried out to determine the hub height wind speed variations over the site relative to the 30 m anemometry mast.
- The energy production of the wind farm was calculated, taking account of array losses and topographic effects.
- The seasonal variation in the energy production of the wind farm was calculated.
- Sources of uncertainty in the wind speed and energy production estimates were identified and quantified.

C.7 Correlation of Wind Regime at Cuilliagh Mountain and Malin Head

The measured wind direction at Cuilliagh Mast 05 at 30 m is compared to the concurrent wind direction measured at Malin Head in Figure C.2. The directions recorded between the two locations show some scatter but are generally well correlated for the most frequent sectors.

The monitored wind speeds at 30 m height in each of 12 30˚ direction sectors are compared to the concurrent wind speed at Malin Head in Figure C.3. The quality of the correlation is considered to be reasonable for all direction sectors. The wind speed ratios for each direction sector are presented in Table C.4.

Table C.4: Wind Speed Ratios between Cuilliagh Mast 05 at 30 m and Malin Head

Direction Sector	Number of Hours Analysed	Wind Speed Ratio
345-15	278	0.701
15-45	194	0.767
45-75	229	0.800
75-105	461	0.718
105-135	795	0.957
135-165	1098	0.976
165-195	1622	0.879
195-225	1208	0.897
225-255	1210	0.894
255-285	1230	0.868
285-315	708	0.834
315-345	421	0.819
All	9454	0.861

Figure C.2: Correlation of Wind Direction at Malin Head and at Cuilliagh Mast 05 at 10 m

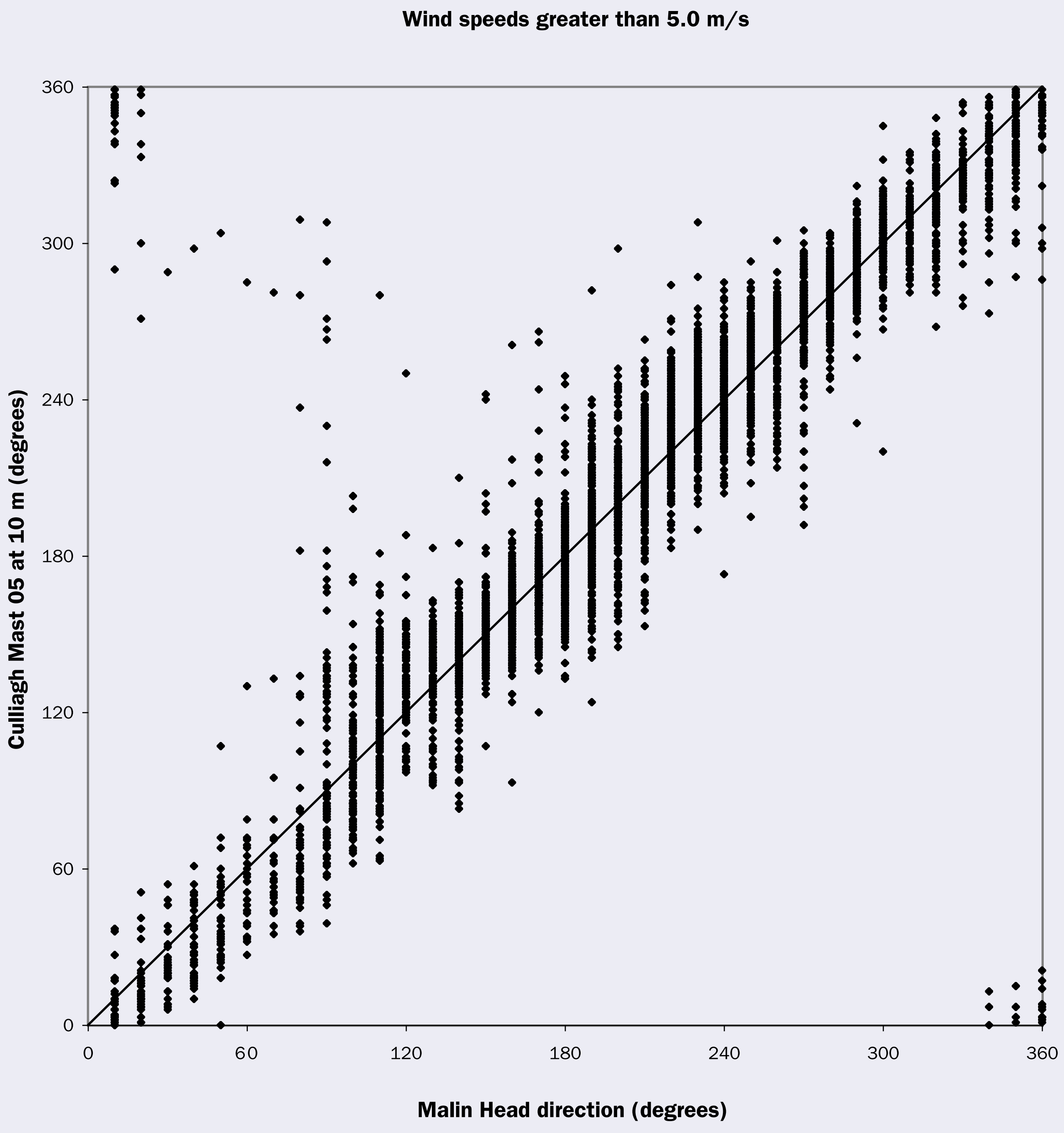


Figure C.3a: Correlation of Wind Speed at Malin Head and at Cuilliagh Mast 05 at 30 m – Continued

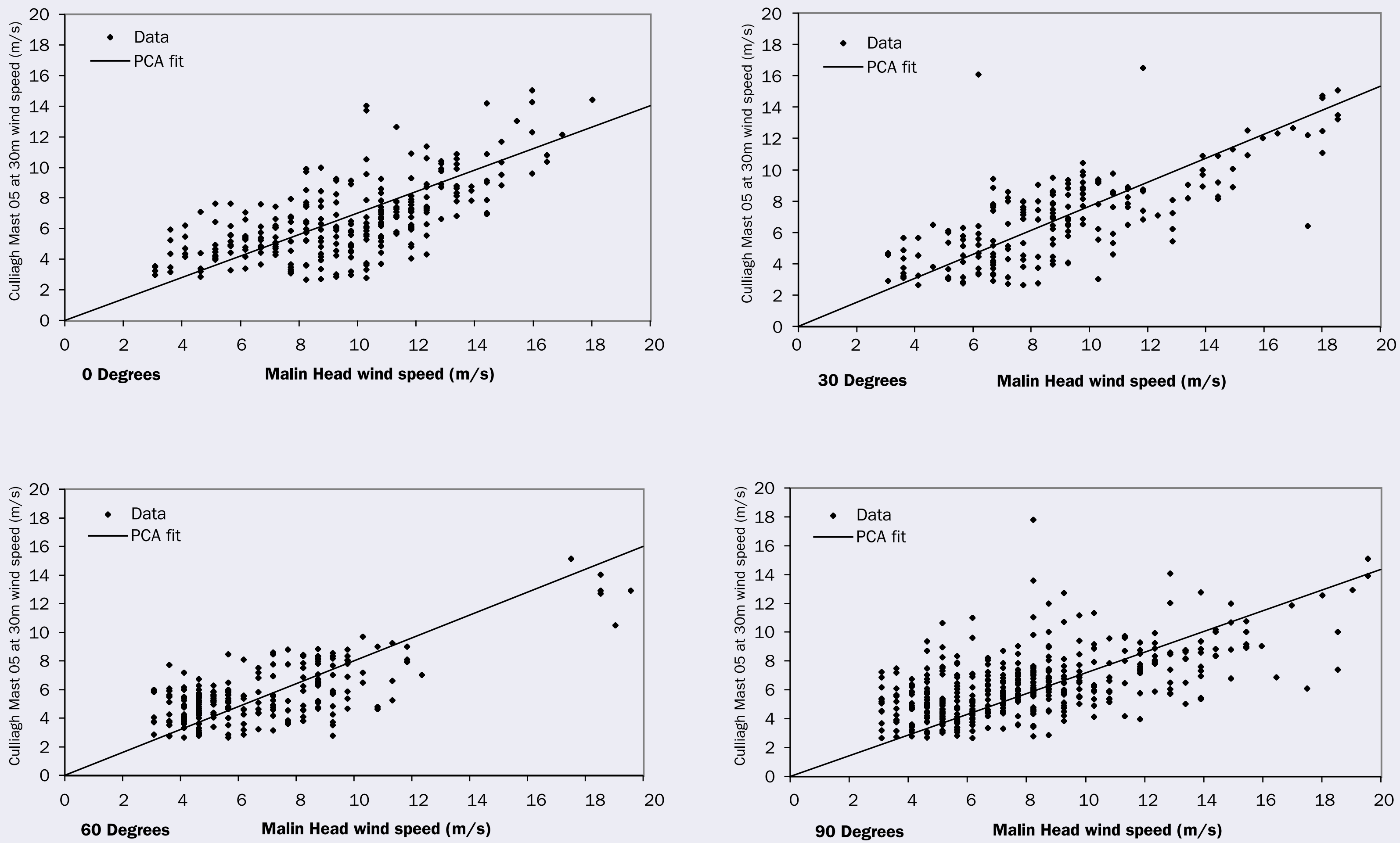


Figure C.3b: Correlation of Wind Speed at Malin Head and at Cuilliagh Mast 05 at 30 m – Continued

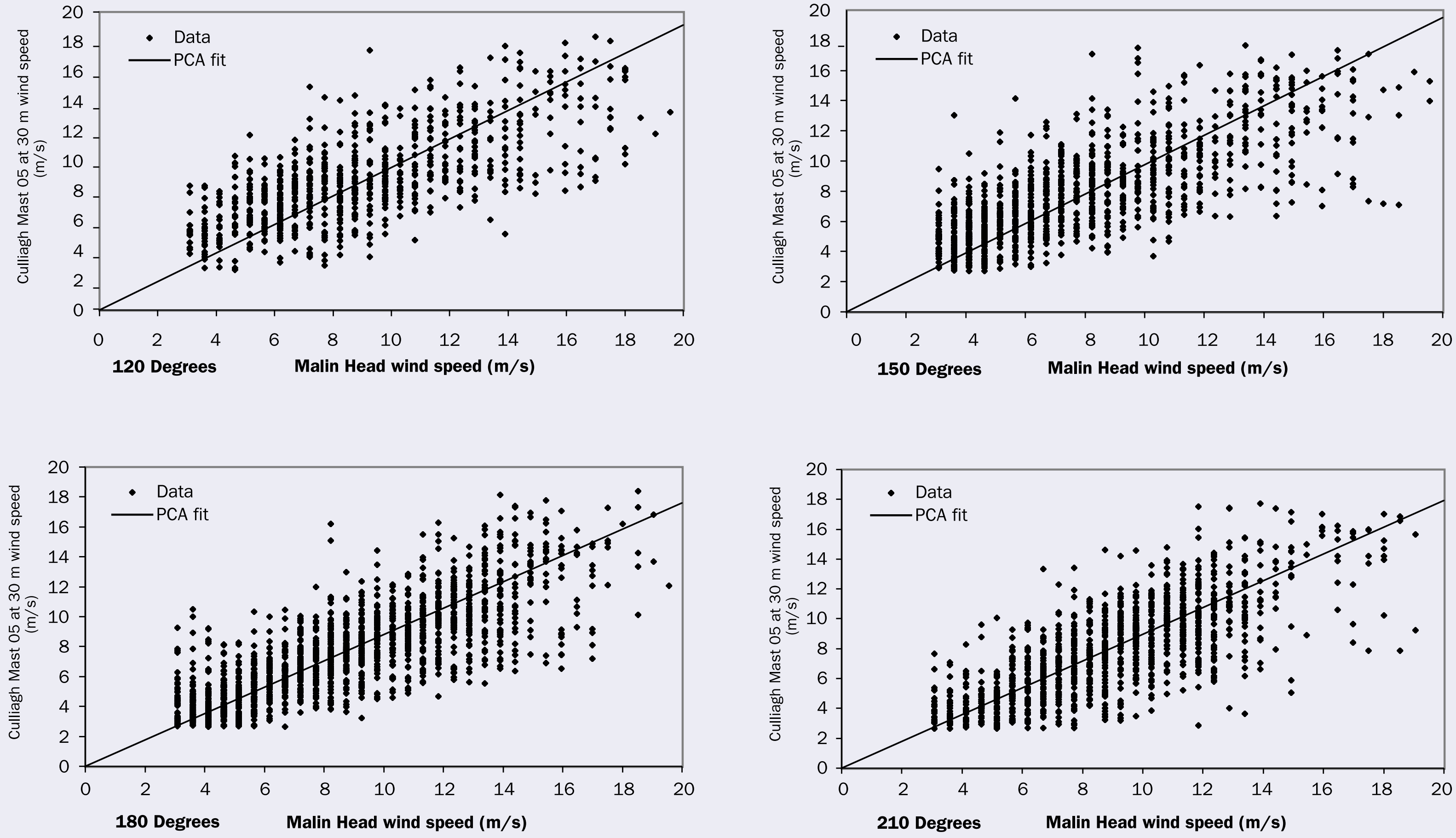
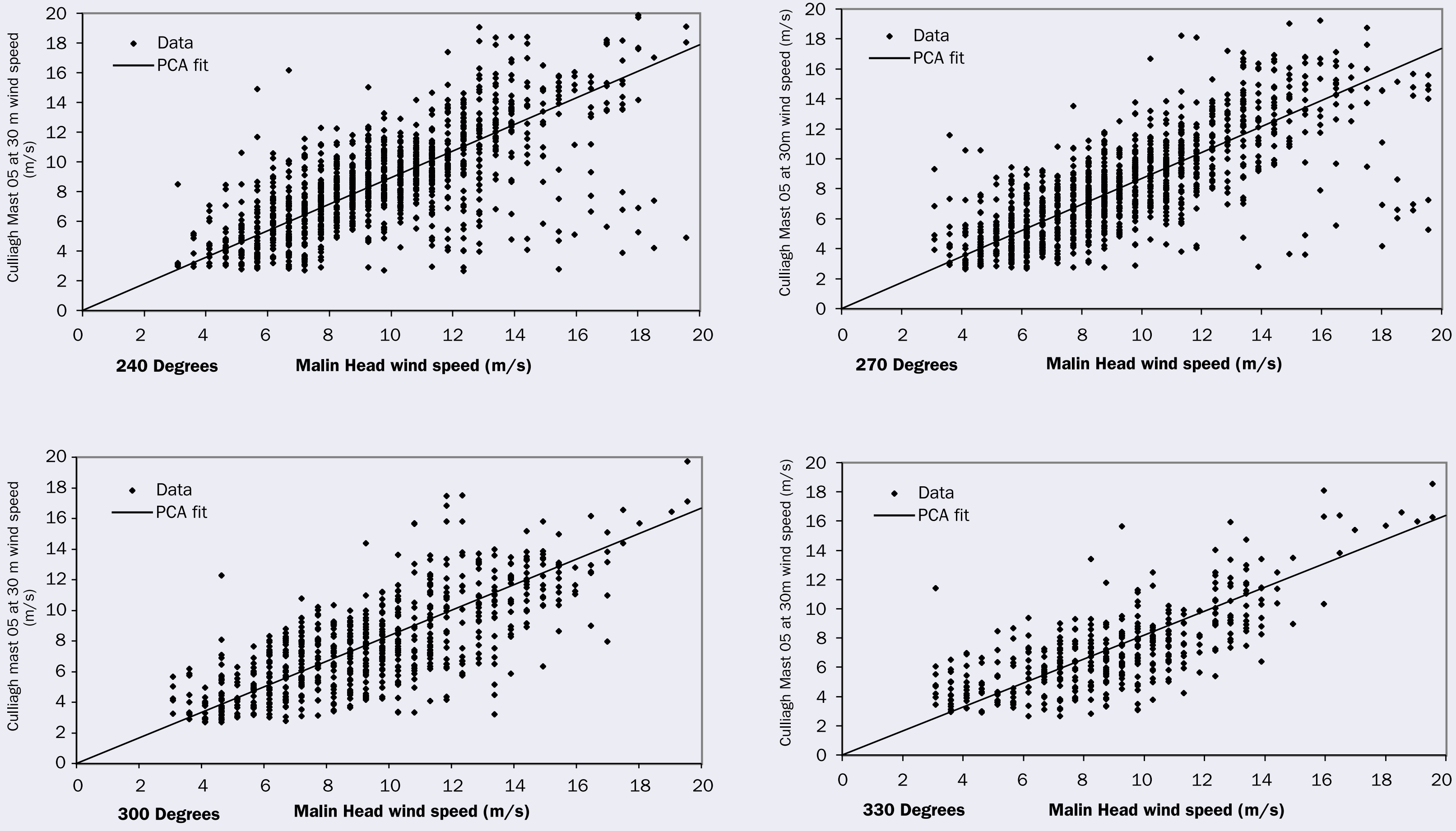


Figure C.3c: Correlation of Wind Speed at Malin Head and at Cuilliagh Mast 05 at 30 m – Concluded

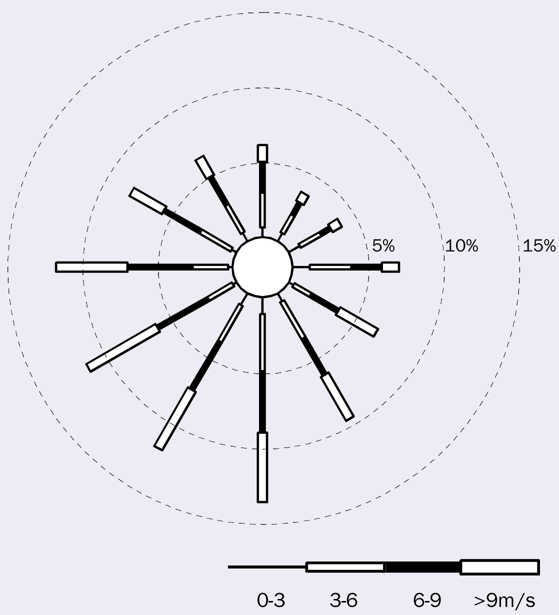


C.8 Long-term Mean Wind Speed at Cuilliagh Mountain

The wind speed ratios listed in Table C.4 were used to factor the long-term wind speeds at Malin Head for the period 1979 to 1998. By this method, the long-term mean wind speed at Cuilliagh Mast 05 at 30 m was calculated to be 7.2 m/s.

The corresponding joint wind speed and direction frequency distribution for Cuilliagh Mast 05 over the historical period 1979 to 1998 is presented in Figure C.4 in the form of a wind rose.

Figure C.4: Annual Wind Rose for Cuilliagh Mast 05 at 30 m.



C.9 Site Wind Speed Variations at Cuilliagh Mountain

The variation in wind speed over the Cuilliagh Mountain site has been predicted using the WAsP computational flow model. WAsP was used to model the wind flow over the site, being initiated from the long-term wind speed and direction frequency distribution derived for Mast 05 at 30 m.

Table C.5 shows the predicted long-term mean wind speed at each wind turbine location at hub height. The average long-term mean wind speed at a hub height of 45 m for the whole wind farm was found to be 8.1 m/s.

Table C.5: Mean Wind Speed and Projected Energy Output of Individual Wind Turbines

Turbine Number	Mean Hub Height Wind Speed[1] [m/s]	Energy Output[2] [GWh/Annum]
1	7.7	2.2
2	7.8	2.1
3	7.8	2.1
4	7.6	1.9
5	7.4	2.0
6	7.8	2.0
7	8.0	2.1
8	8.1	2.3
9	8.4	2.5
10	8.0	2.2
11	8.2	2.3
12	7.6	2.0
13	8.6	2.4
14	8.2	2.3
15	8.2	2.3
16	8.8	2.5
17	8.5	2.4
18	8.3	2.3
Overall	8.1	

[1] Wind speed at location of turbines at 45 m height, not including wake effects.
[2] Individual turbine output includes topographic and array effects only.

C.10 Projected Energy Production

The predicted energy production for the wind farm is detailed in Table C.6 below. The energy capture of individual turbines is given in Table C.5.

Table C.6: Predicted Energy Production of Cuilliagh Mountain Wind Farm

Ideal energy production	40.2	GWh/annum
Topographic effect	*107.0 %*	*Calculated*
Array effect	*92.7 %*	*Calculated*
Electrical transmission efficiency	*97.0 %*	*Estimate*
Availability	*97.0 %*	*Estimate*
Icing and Blade fouling	*99.0 %*	*Estimate*
High wind hysteresis	*99.6 %*	*Estimate*
Substation maintenance	*100.0 %*	*Not considered*
Utility downtime	*100.0 %*	*Not considered*
Power curve adjustment	*100.0 %*	*Not considered*
Columnar control losses	*100.0 %*	*Not considered*
Wake effect of existing wind farms	*99.8 %*	*Estimate*
Net energy production	36.9	GWh/annum

The energy production predictions include calculation of the array and topographic effects, an estimate of availability and electrical loss and factors to account for WT icing, high wind hysteresis and the wake effect of existing turbines. Other potential sources of energy loss are also listed. It is recommended that the client carefully consider these issues since at the time of this energy assessment there was insufficient information to estimate the effect on the predicted energy production.

C.11 Seasonal Variations

The monthly energy production of the wind farm is presented in Table C.7. There is a large seasonal variation of the predicted long-term monthly energy production, with winter and summer months producing approximately 140% and 60%, respectively of the long-term mean monthly energy production.

Table C.7: Monthly Variation of the Projected Energy Output[1] of the Wind Farm

January	4.27
February	3.87
March	3.84
April	2.53
May	2.16
June	1.86
July	2.05
August	2.21
September	2.85
October	3.60
November	3.67
December	3.99

[1] Energy output includes all losses.

C.12 Uncertainty Analysis

The main sources of deviation from the central estimate have been quantified and are shown in Tables C.8a and C.8b which consider future periods of 10 years and one year respectively.

Table C.8a: Uncertainty in Projected Energy Output[1] of the Proposed Wind Farm – 10 Year Future Period

Source of Uncertainty	Wind Speed [%]	Wind Speed [m/s]	Energy Output[1] [%]	Energy Output[1] GWh/Annum
Anemometer accuracy	2.0	0.14		
Correlation accuracy		0.19		
Period representative of long-term	1.3	0.10		
Total wind		**0.26**		**2.22**
Wake and topographic calculation	-	-	3.0	1.11
Wind variability (10 years)	1.9	0.14		1.19
Overall (10 years)				**2.75**

[1] Sensitivity of net production to wind speed is calculated to be 8.68 GWh/annum/(m/s)

Table C.8b: Uncertainty in Projected Energy Output[1] of the Proposed Wind Farm – One Year Future Period

Source of Uncertainty	Wind Speed [%]	[m/s]	Energy Output[1] [%]	Wh/ Annum
Anemometer accuracy	2.0	0.14		
Correlation accuracy		0.19		
Period representative of long-term	1.3	0.10		
Total wind		**0.26**		**2.22**
Wake and topographic calculation	-	-	3.0	1.11
Wind variability (1 year)	6.0	0.43		3.75
Overall (1 year)				**4.49**

[1] Sensitivity of net production to wind speed is calculated to be 8.68 GWh/annum/(m/s)

The figures in these tables, when added as independent errors, give the following uncertainties in net energy production of 4.5 GWh/annum for a future one year period and 2.7 GWh/annum for a future 10 year period. The detailed derivation of the above uncertainties is presented below:

There are four main categories of uncertainty associated with the site wind speed prediction at Cuilliagh Mountain:

1 There is an uncertainty associated with the measurement accuracy of the site anemometers. The instruments used on this site have not been individually calibrated to MEASNET standards and a consensus calibration has been applied. Batch calibration of NRG Maximum 40 anemometers have shown them to conform to the consensus calibration to within 1.5%. Therefore, a figure of 2% is assumed here so as to account for other second order effects such as overspeeding, degradation, air density variations and sensor mounting. No allowance has been made for uncertainty in the Malin Head anemometer as consistency and not absolute accuracy is important.

2 An error analysis was carried out on the correlation for each direction sector and from this the standard error for the long-term mean wind speed was determined. This was carried out for the correlation between Malin Head and Cuilliagh Mountain.

3 There is an uncertainty associated with the assumption made here that the historical period at the meteorological site is representative of the climate over longer periods. A study of historical wind records from a number of reference stations indicates an average variability of 6% in the annual mean wind speed. This figure is used to define the uncertainty in assuming the long-term mean wind speed over a 20-year period.

4 For a finite number of future years, the mean wind speed may differ from the long-term mean due to the natural variability of a random process. Account is taken of the future variability of wind speed in the energy confidence analysis but not the wind speed confidence analysis.

It is assumed that the time series of wind speed is random with no systematic trends. Care was taken to ensure that consistency of the Malin Head measurement system and exposure has been maintained over the historical period and no allowance is made for uncertainties arising due to changes in either.

Uncertainties type 1, 2 and 3 from above are added as independent errors on a root-sum-square basis to give the total uncertainty in the site wind speed prediction for the historical period considered.

There are four categories of uncertainty in the energy output projection:

1 Long-term mean wind speed dependent uncertainty is derived from the total wind speed uncertainty (types 1, 2 and 3 above) using a factor for the sensitivity of the annual energy output to changes in annual mean wind speed. This sensitivity is derived by a perturbation analysis about the central estimate.

2 Wake and topographic modelling uncertainties. Validation tests of the methods used here, based on full-scale wind farm measurements made at small wind farms have shown that the methods are accurate to 2% in most cases. For this development, an uncertainty in the wake and topographic modelling of 3% is assumed.

3 Future wind speed-dependent uncertainties described in 4 above have been derived using the factor for the sensitivity of the annual energy output to changes in annual mean wind speed.

4 Turbine uncertainties are generally the subject of contract between the developer and turbine supplier and therefore no allowance has been made for them in this work.

Again, those uncertainties which are considered are added as independent errors on a root-sum-square basis to give the total uncertainty in the projected energy output.

C.13 Summary of the Results of the Analysis

Wind data were recorded at the Cuilliagh Mountain site for a period of 18 months. Analysis of this data, in combination with concurrent data and historical wind data recorded at Malin Head Meteorological Station, results in the following conclusions with regard to the wind regime at the Cuilliagh Mountain site:

1 The long-term mean wind speed is estimated to be 7.2 m/s at a height of 30 m above ground level.

2 The standard error associated with the predicted long-term mean wind speed at 30 m is 0.26 m/s. If a normal distribution is assumed, the confidence limits for the prediction are as given in Table C.9:

Table C.9: Confidence Limits – Wind Speed

Probability of Exceedence [%]	Long-term Mean Wind Speed at 30 m [m/s]
90	6.9
75	7.0
50	7.2

Site wind flow and array loss calculations have been carried out, from which the following conclusions are drawn:

3 The long-term mean wind speed averaged over all turbine locations at 45 m is estimated to be 8.1 m/s.

4 The projected net energy capture of the proposed Cuilliagh Mountain wind farm is predicted to be 36.9 GWh/annum.

These predictions of net energy include topographic effects, array losses, availability, electrical transmission losses, air density adjustments and factors to account for turbine icing, high wind hysteresis and the wake effect of existing turbines. Other potential sources of energy loss are listed section C.9.

The net energy predictions presented above represent the long-term mean, 50% exceedence levels, for the annual energy production of the wind farm. These values are the best estimate of the long-term mean value to be expected from the project. There is therefore a 50% chance that, even when taken over very long periods, mean energy production will be less than the value given in the table. Estimates of long-term mean values with different levels of exceedence are set out below.

5 The standard error associated with the prediction of energy capture has been calculated and the confidence limits for the prediction are given in Table C.10.

Table C.10 Confidence Limits - Energy

Probability of Exceedence [%]	Net Energy Output [GWh/Annum] 1 Year Average	Net Energy Output [GWh/Annum] 10 Year Average
90	31.1	33.4
75	33.9	35.1
50	36.9	36.9
75	39.9	38.7
90	42.7	40.4

C.14 Actual Production of the Wind Farm

Commissioning of the Cuilliagh Mountain wind farm took place in late 2000; by November 2000 the wind farm was in full commercial operation. A review of its performance was undertaken early in 2002.

Table C.11: Expected and Actual Production of Cuilliagh Mountain Wind Farm

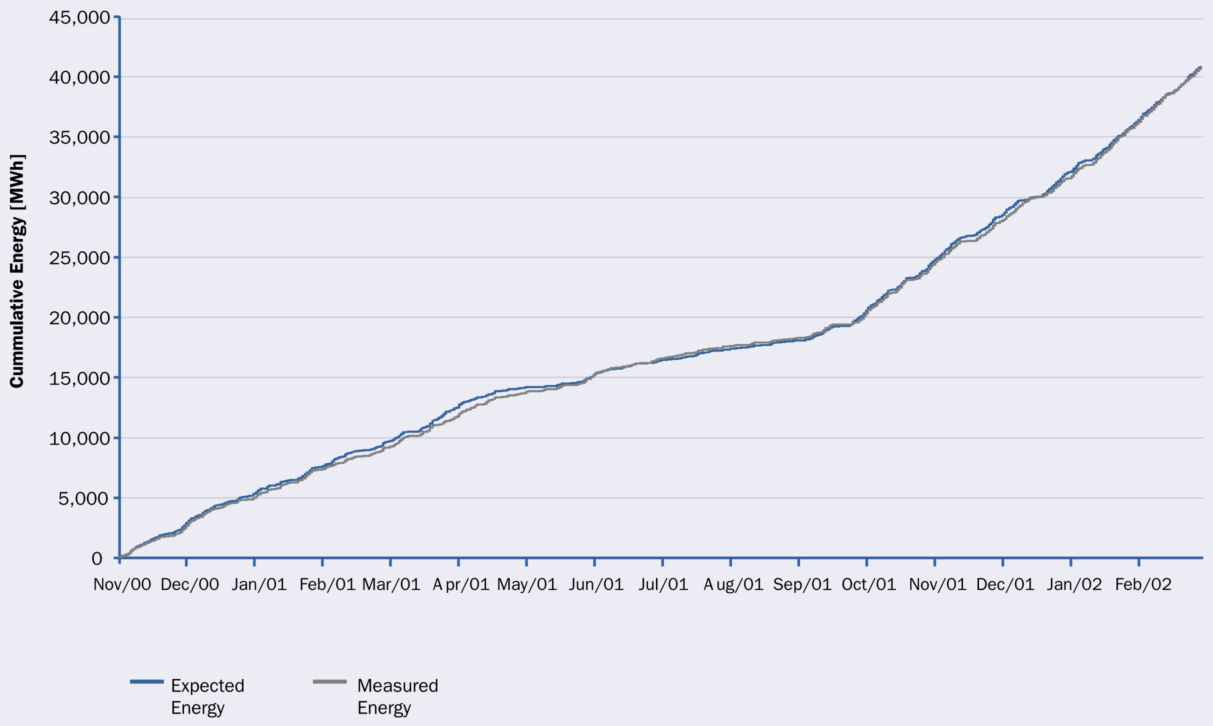
Month	Year	Expected Production (GWh)	Actual Production (GWh)
Nov	2000	3.670	3.703
Dec	2000	3.990	3.530
Jan	2001	4.270	3.546
Feb	2001	3.870	2.876
Mar	2001	3.840	3.410
Apr	2001	2.530	2.850
May	2001	2.160	1.699
Jun	2001	1.860	2.608
Jul	2001	2.050	1.813
Aug	2001	2.210	1.538
Sep	2001	2.850	2.941
Oct	2001	3.600	4.369
Nov	2001	3.670	3.645
Dec	2001	3.990	3.679
Jan	2002	4.270	4.801
Feb	2002	3.870	4.604
Mar	2002	3.840	4.037
	Total	**56.540**	**55.649**

Table C.11 presents the expected long-term monthly energy production of the wind farm, along with the actual energy production over the period November 2000 to March 2002. It can be seen that individual months can deviate substantially from long-term expectations; for example February 2001 experienced production which was only 74% of the long-term expectations for this month while in June 2001 140% of the long-term expectations for energy production in this month was produced. Over the 17-month period for which data are available the actual production of the wind farm was 1.6% below long-term expectations. This figure is well within the 75% and 90% exceedence levels for the prediction presented above. A detailed assessment of the availability of the wind farm over the above operational period has not been undertaken, but it is understood that high availability levels have been achieved.

The data recorded at Malin Head indicates that the windiness of the period from November 2000 to March 2002 was some 4.9% down on long-term expectations, making suitable assumptions about the seasonal variation of wind speed. This implies that over the longer term it is likely that the energy production of the wind farm will, in fact, exceed the central estimate value of 36.9 GWh/annum and may settle at a level which is close to the 25% exceedence level presented above. A more detailed assessment which includes issues such as wind direction, air density and availability would be required to provide a revised central estimate of wind farm production.

A separate validation of the accuracy of the modelling techniques employed to predict the long-term energy production of the Cuilliagh Mountain Wind Farm was undertaken. A comparison was made between the expected energy production of the wind farm, based on the actual mean wind speed recorded at Malin Head Meteorological Station and the actual wind farm energy production. This was undertaken on an hourly basis. Thus, the accuracy of the correlation relationships between Malin Head and the site, and of the site flow model and turbine wake models was assessed using a "wind in–energy out" test. Suitable adjustments were made to reflect the actual air density at the site. The comparison was undertaken for the operational period described above and data were only compared where all turbines were available and when wind farm SCADA data and data from Malin Head Meteorological Station were also available. Using these criteria, a comparison was made over a total of approximately 8,300 hours. The results of the comparison of the expected and actual energy production of the wind farm are presented in Figure C.5 as a cumulative plot. Over the full period considered, the actual production was 99.7% of that expected, which provides confidence in the accuracy of the methods employed. It is noted that for individual months and for individual turbines larger discrepancies between the expected and actual energy production is observed.

Figure C.5: Cumulative Plot Showing Measured Energy against Concurrent Expected Energy for the Operating Period



C.15 Concluding Remarks

This Appendix has shown that the techniques outlined in the main text can be used to predict the behaviour of a wind farm with a good level of agreement. It has also demonstrated that the methods can be used to determine both mean values and associated uncertainties. It is hoped that it has proved a useful illustration of the techniques which are presently used by the industry.

APPENDIX D: DETAILED DESCRIPTION OF CORRELATION TECHNIQUES

Over the past decade, there has been an ongoing industry debate over which correlation methodologies provide the best prediction of the long-term mean wind speed at a site. All correlation methods have common features in that they (i) establish a relationship between the concurrent data recorded at the site and reference station, and (ii) apply the relationship to the historic data recorded at the reference station to predict the long-term wind regime at the site. Such methodologies are commonly called measure correlate predict (MCP) analyses. Variables in such correlation analyses mooted over the past decade include those defined in Tables D.1 and D.2 below.

Table D.1: Prediction Methodologies Based on 10-minute or Hourly Data

Technique	Option 1	Option 2	Others ...
Directional bin size	30˚	Other	
Regression analysis technique	Principal component analysis	Least squares fit	
Fitting method	One parameter fit	Two parameter fit	Non-linear
Low wind speed cut off	Exclude lowest wind speed data	Include lowest wind speed data	

Table D.2: Prediction Methodologies Based on Longer Term Data

Technique	Option 1	Option 2	Others ...
Averaging period	Monthly	Daily	
Fitting method	One parameter fit	Two parameter fit	Non-linear
Threshold for data coverage	Varies		

The above tables present a bewildering array of options. While the technical merit of some methods over others can be argued, experience has shown that where the wind regimes at the site and reference meteorological station are well correlated, the results obtained tend to be relatively insensitive to the specific correlation methodology adopted. For cases where the correlation between the site and reference station is less good, then significant divergence is sometimes seen between the results obtained with different methods. In such circumstances, careful checks are required to ensure that the correlation is sufficiently good to justify the use of the reference meteorological station. Due consideration also needs to be given to the interpretation of the uncertainty associated with a specific correlation methodology.

The methods based on 10-minute data or hourly data typically use the long-term wind rose recorded at the reference meteorological station. Those based on daily or monthly correlations are dependent on the site wind rose. In practice, it is often observed that where hourly or 10-minute correlations between a site and reference station are poor, a reasonable correlation is observed over longer data collection periods, such as monthly.

Detailed Description of a MCP Analysis

A detailed description of the steps within a MCP analysis is described below, based on hourly data from the site and reference station. As indicated in the previous section, different approaches may be used. In the following discussion, the proposed wind farm site is referred to as the "target site" and the meteorological station is referred to as the "reference site".

The first stage is to measure, over a period of about a year, concurrent wind data from both the target site and the nearby reference site for which well-established long-term wind records are available. The short-term measured wind data are then used to establish the correlation between the winds at the two locations. Finally, the correlation is used to adjust the long-term historical data recorded at the reference site to calculate the long-term mean wind speed at the target site.

The concurrent data are correlated by comparing wind speeds at the two locations for each of 12 30˚ direction sectors, based on the wind direction recorded at the reference site. This correlation involves two steps:

- Wind directions recorded at the two locations are compared to determine whether there are any local features influencing the directional results. Only those records with speeds in excess of, say, 5 m/s at both locations are used.

- Wind speed ratios are determined for each of the direction sectors using a "principal component analysis".

In order to minimise the influence of localised winds on the wind speed ratio, the data are screened to reject records where the speed recorded at the reference site falls below 3 m/s (or a slightly different level) at the target site. The average wind speed ratio is used to adjust the 3 m/s wind speed level for the reference site to obtain the different level for the target site, so ensuring an unbiased exclusion of data. The wind speed at which this level is set is a balance between excluding low winds from the analysis and still having sufficient data to carry out the analysis. The level used only excludes wind speeds below the cut-in wind speed of a WT, which do not contribute to the energy production.

The result of the analysis described above is a table of wind speed ratios, each corresponding to one of 12 direction sectors. These ratios are used to factor the wind data measured at the reference site over the historical reference period, to obtain the long-term mean wind speed at the target site. This estimate therefore includes the following influences:

- "Speed-up" between the target site and the reference site on a directional basis. This can be a very important characteristic; sometimes speed-ups differ by a factor of as much as 2.
- The wind patterns at the reference site have been translated through the correlation process so that the long-term pattern at the target site has also been established.

APPENDIX E: CONNECTION CONSIDERATIONS

E.1 Timing Constraints

In many cases, the time to construct the network connection and any additional network reinforcement can be longer than the time it takes to design, finance and build the wind farm itself. This is a new situation which applies to all embedded generation and also to some new forms of large-scale generation. For traditional conventional generation projects, the network connection is not on the "critical path".

Timing issues are particularly significant on the transmission system, as it can take several years to obtain permission and construct new or reinforced transmission lines.

E.2 Network "Strength"

An important consideration is the strength of the network at the proposed point of connection, varying from "strong" to "weak". Embedded generation and large consumers, where either output or demand can change significantly over a short time-frame, can cause relatively large changes in the network voltage on a weak electrical system. A strong network, on the other hand, will be relatively unaffected by changes in generation and demand.

A weak electrical system will have a low "fault level" or "short circuit level", which is usually measured in MVA. The strength of a point on the network is determined by impedance between that point and the main generators on the system. Put another way, a weak point on the electrical system is one which is further away from large amounts of generation than a strong point on the system. The strength of a network also determines the current that will flow in the event of a fault.

Wind farms in windy rural areas often find that the network is weak, primarily because these are often sparsely populated areas of low demand, with long distances from the main users and generators. Although on its own the strength of a network does not indicate the maximum wind capacity that can be connected, it is a good indicator of the kind of issues that might emerge. If a study shows that the strength of a chosen network is not sufficiently high to enable the addition of new wind generation capacity, then the options are to connect to another stronger network (which may be further away), or to reinforce the network.

E.3 Voltage Range

For distribution networks, the rise in voltage adjacent to the wind farm is often the limiting factor for wind farm size. The power and reactive power produced or consumed by the wind farm causes the voltage levels within the network to change. The exact effect is complex and depends on other power and reactive power flows, as well as the voltage control equipment which already exists in the network. If the voltage level at a customer is estimated to go outside the statutory limits, then something must be done. For example:

- improve voltage control equipment;
- install power factor correction equipment;;
- control the reactive power output of the wind farm;
- limit the wind farm size; or
- reinforce the network.

Sometimes, the point on the network which is most affected by such changes is the wind farm itself. In this case, it is possible to agree a connection where the voltage range is expected to be greater than the statutory range. However, the voltage range at the WT terminals must still be within the acceptable range specified by the turbine supplier.

If this issue cannot be addressed through the above means then it may be necessary to curtail the output of the wind farm when voltage levels may go outside the acceptable range. It may be worth accepting this occasional loss of production for rare combinations of circumstances. Equally, it may be possible to adopt a different turbine choice that will be better equipped for dealing with the characteristics of the network.

E.4 Thermal Rating Limits

Thermal ratings of cables, overhead lines and transformers may also be limiting factors. In this case, network reinforcement is often the only solution. It may be possible to negotiate some automatic or manual means to reduce wind farm output when thermal limits are approached. This may only occur rarely, e.g. when one line of two is out of service, and the loss of production may therefore be acceptable.

E.5 Fault Current Ratings

The calculated ”fault current levels” (the current that flows in the event of defined faults) on a system may be close to the ratings of the switchgear which will have to interrupt that fault current. This is particularly true in urban and on higher voltage networks. New generation on the system may therefore force replacement of the switchgear with new equipment with a higher rating, which can be expensive.

The fault current issue may also be more significant at transmission level, as the high cost of uprated switchgear means that transmission networks are often already operated close to switchgear ratings.

E.6 Power Quality Issues

Power quality does not often limit wind farm size, but it is of concern to network operators and must always be considered. Network operators need to provide a certain quality of power to their customers. WTs can affect networks such that power quality seen by other customers is affected. Therefore, network operators demand that these effects are quantified and, if necessary, limited. There are four main issues:

- Voltage step changes.
- Flicker.
- Harmonic distortion.
- Voltage imbalance.

IEC 61400-21 is an international standard which provides means to calculate, from measurements, parameters that characterise the power quality of a WT design. WT manufacturers can get their machine tested by a third party and produce test certificates in a similar way to a power curve or noise emission characteristic.

The standard also provides formulae by which the characteristic parameters of a WT can be used in conjunction with project dependent parameters, in order to estimate what the power quality effects of a proposed wind farm will be. The results can be compared with the network operator’s requirements to decide if the wind farm will be acceptable.

E.6.1 VOLTAGE STEP CHANGE

Currents flowing in the electricity network affect the voltage seen by other customers. A sudden increase or decrease in current will cause a step change in voltage which may be perceptible to other customers. Such changes may also occur too rapidly for the voltage control systems operated by the network operator (principally adjustment of the ratio of main transformers), causing the voltage at some point in the network to go outside the statutory limits. Typically, the maximum voltage step is limited to between 2% and 5%.

Voltage step changes can be caused by WTs starting up, particularly fixed speed wind turbines with induction generators. It is especially an issue for fixed speed stall-regulated wind turbines because they have no control over the rate at which the rotor accelerates during start-up, and have to energise the generator just as its rotational speed matches synchronous speed. There is often some speed mismatch at this point and so there is an “inrush current” to accelerate or decelerate the rotor to match synchronous speed, as well as the normal inrush current to magnetise the generator.

The same effect occurs when fixed speed WTs with two speeds (two generators) change from one speed to the other. A similar effect is seen when the WT stops, especially when shutting down from full power due to the upper wind speed limit being exceeded.

Pitch-regulated WTs can control rotor speed during start-up, so this effect is reduced. The effect is even less for variable speed turbines. Fixed speed machines often use “soft start” power electronic devices to reduce the voltage step change to insignificant levels.

As it is accepted that WTs in a wind farm will not start simultaneously, this is only a problem for single turbines or small clusters, perhaps two or three, on weak networks.

E.6.2 VOLTAGE FLICKER

Flicker is a concern for many system operators. In reality, it is rarely a real problem, although it must always be checked. As a general rule, if the effect of a wind farm in terms of voltage rise and other basic technical issues is satisfactory, then flicker is probably satisfactory too.

Flicker is caused by small voltage changes occurring rapidly and sequentially, which causes lighting to flicker and hence customer annoyance. Flicker therefore tends to be more of an issue with one or a few WTs on lower voltage distribution networks with low fault levels. For large wind farms, the smoothing effect of the power fluctuations from large numbers of turbines means that the flicker effect is greatly reduced.

The most important flicker-producing events are turbine starts and stops, and switching between generators (for two-speed WTs). Fortunately, switching operations can be limited in frequency of occurrence through appropriate programming of the turbine controller. Again, flicker is not normally a problem for variable speed turbines.

E.6.3 HARMONIC DISTORTION

Variable speed WTs have power electronic converters which can emit currents at frequencies above the fundamental frequency (50 or 60 Hz). These harmonic currents can cause annoyance to customers and can even damage equipment. This is only an issue for variable speed wind turbines. There is a tendency for the more modern WTs to use power electronic converters and so harmonics do need to be addressed. Harmonic emissions are, however, well understood by WT manufacturers. Generally, they are also quite low and rarely considered an issue in practice.

To keep harmonic emissions within the required levels, WTs often use frequency converters with "pulse width modulation" (PWM). These produce very low levels of harmonics at frequencies (approximately 2 kHz) above the range usually of concern to network operators.

In summary, harmonic emissions should not be a problem unless there are specific features of the network in question.

E.6.4 VOLTAGE IMBALANCE

Network operators try to keep the currents in all three phases of the network similar so that the voltages are also similar. Unbalanced currents can cause the voltages to differ, which can damage customer equipment.

Voltage imbalance is often included within power quality by network operators. However, for WTs it is a different kind of issue and is not therefore dealt with by the IEC 61400-21 standard.

As three-phase rotating machines, WTs make no real contribution to system voltage imbalance. In fact, as induction machines they tend to reduce the imbalance. The downside of this is that large "negative phase sequence" currents can flow within the generator and cause excessive heating.

Network operators often do not know the existing levels of voltage imbalance at a specific point on their system. It can be measured but, as it is a function of load currents, it varies during the day, week and, possibly, over the year. Network operators may say they aim to keep it below agreed limits, but it could, in practice, be significantly higher at some locations. If this problem is identified, network operators will attempt to cure it by re-allocating single-phase customers across the three phases. This can take some time and may not be a complete solution. A complete solution may require network reinforcement which implies cost and delay.

In some rural networks these risks may justify making measurements of voltage imbalance before choosing a point of connection.

Voltage imbalance is usually only an issue on weak lower-voltage networks.

E.7 Typical Upper Limits

Table E.1 lists some "rule of thumb" limits for the amount of embedded generation that may be connected within a network. (Note that in many systems, 100 kV or above would be considered as part of the transmission system.)

These figures are upper limits. In any one case, there could be many factors which would limit the maximum capacity below these levels.

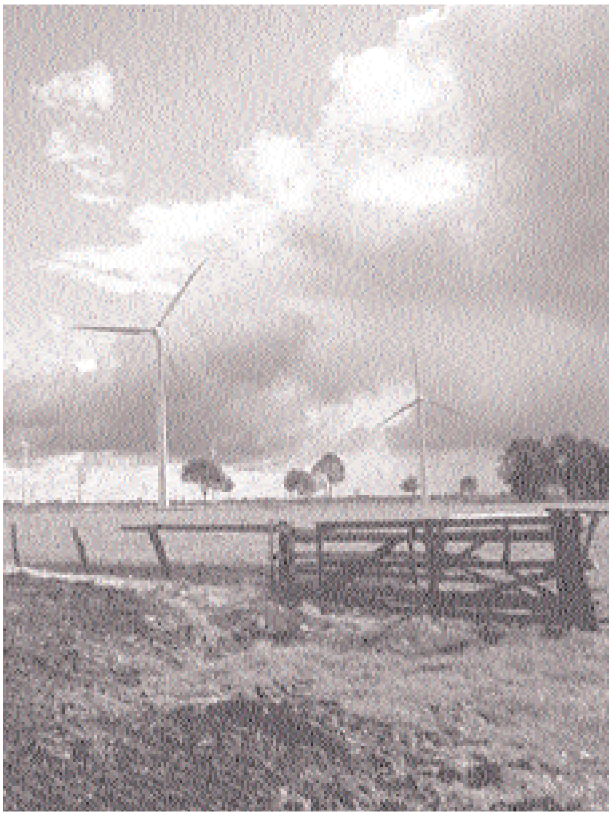
Table E.1: Rule of Thumb Limits for Embedded Capacity

Connection Point	Typical Maximum Generation Capacity Which May be Connected
Low voltage	A few kW of embedded generation capacity
Lower levels of the distribution system (typically 10 or 11 kV)	Up to 2 MW, or possibly more than 2 MW close to the transformer feeding the network
Upper levels of the distribution system (20 – 35 kV): existing overhead line or cable	Can take 10 to 15 MW
Upper levels of the distribution system (20 – 35 kV): existing busbar in a substation	Is likely to accept up to the rating of the transformers, which could be 60 MW or more.
'Subtransmission' system (70 – 150 kV): existing overhead line or cable	A typical limit is 100 MW
'Subtransmission' system (70 – 150 kV): existing busbar in a substation	A typical limit would be several hundred MW
Transmission systems	Generalisations not possible

E.8 Connections for Offshore Wind Farms

Offshore wind farms must connect to land-based networks in the same manner as for onshore wind farms. They are therefore subject to the same network considerations. However, as economic reasons favour most offshore wind developments to be large in comparison to onshore developments, it is more common for an offshore wind farm to connect directly into a transmission system rather than a distribution system. Issues such as power quality are therefore unlikely to be important.

It should be noted that, although offshore developments must connect to land-based networks, there may be cases where a utility will extend its own system out to an offshore development, rather than the wind farm constructing a line to an existing utility network. As with all wind farm developments, the location of the connection into the utility system is likely to bear heavily on the costs of the development and so will be subject to case-by-case discussions between the parties involved on how these costs are to be met.



APPENDIX F: POSSIBLE GRID CODE REQUIREMENTS

Grid code documents set the requirements for users of the transmission or distribution system. These have evolved to suit conventional generation, and substantial modifications are required to apply them to new forms of generation, particularly wind. Such modifications have been produced, or are in the process of being developed, in many European countries. The following sections summarise common grid code requirements for wind, drawn from published or draft documents.

F.1 Power Cap

A power cap is an adjustable maximum limit on the output of a wind farm. It is relatively easy to implement and is a function that is, or will shortly be, available from most of the major WT manufacturers. The power cap allows the system operator to limit the maximum output of wind farms in its area for short periods. This is particularly useful for critical periods such as:

- times of very low demand;
- times of great volatility in demand; and
- times when great volatility in the output of the wind generation is expected, for example, due to the passage of a storm.

Clearly, it is economically advantageous to use all other available options before applying a power cap, as this wastes “free” energy and increases emissions from conventional forms of generation.

F.2 Ramp Rate

A ramp rate is a limit on the maximum rate of change of the output from a wind farm. A positive ramp rate is easy to implement using WT and wind farm SCADA systems. Rates of around 10% of wind farm capacity per minute have been specified by network operators.

A negative ramp rate is much harder to achieve. A crude partial solution is to limit the rate at which turbines can shut down. To fully meet the intention of this requirement, forecasting of wind farm output is necessary so that if a sudden drop in output is foreseen, output can be reduced in advance in order to keep the ramp rate at less than the set limit.

As for the power cap function, ramp rate limits will waste free energy and should only be used when essential.

F.3 Voltage and Frequency Operating Range

Historically, when a disturbance was seen on the system (manifested as voltage or frequency going out of the acceptable range), wind farms were required to disconnect as soon as possible. However, when wind capacity penetration is high enough for the system not to be able to withstand this sudden loss of generation, this principle has to be changed. Instead, the wind generation must continue to operate over a wider range of voltage and frequency. This is perfectly feasible for most WTs, although not all existing designs will be able to meet the new criteria.

F.4 Frequency Regulation

Conventional generation provides frequency regulation by automatically changing the output of a few of the major generators in response to changes in system frequency which, in turn, are due to changes in customer demand. This is relatively easy to do.

Pitch-regulated WTs can also provide adjustment of output power in response to changes in system frequency but only by “spilling” available wind. This is, therefore, an expensive way to provide this function.

Stall-regulated turbines will have much greater difficulty in providing a similar effect.

An alternative solution is to set up a market for frequency regulation to which generators can bid. Those generators (such as major conventional plant) which can provide this service at relatively low cost will therefore be chosen to do so. Generation which finds this difficult (such as wind) will not need to do so.

F.5 Reserve

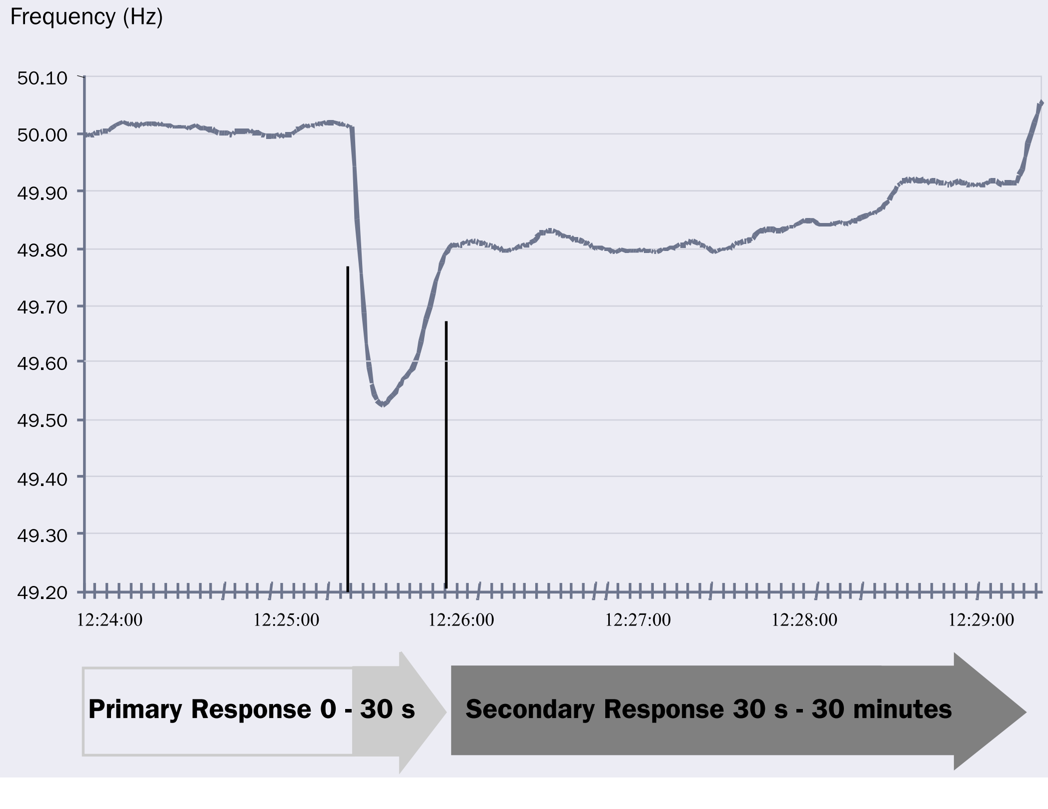
Reserve is required by system operators in order to cope with the sudden loss of a major generator either due to a failure of that generator or to a failure of the transmission system connected to that generator. Reserve is conventionally provided by the stored energy within conventional generation including that stored within the steam systems of thermal plant. For the first few seconds after the loss of a major generator, the system frequency will drop and energy is rapidly extracted from all the remaining generators by opening their steam governors (or equivalent) in response to the drop in frequency. This process takes only a few seconds; then, increased fuel flow into the conventional generators acts to restore system frequency. If necessary, other generators may be started up on timescales of minutes.

Figure F.1 demonstrates such a drop in frequency, and the rapid increase in production from the remaining generation within a 30-second timeframe.

Wind generation cannot provide a contribution to reserve requirements except at high cost, i.e. by always operating at a point below the power that could be produced in the given wind conditions. Wind is, therefore, a very expensive way of meeting reserve requirements and, as for frequency regulation, there is an argument that a market for reserve may be more appropriate than enforcement of reserve requirements on generators.

There is a possible argument that variable speed WTs may be able to contribute to reserve requirements for the first few seconds by extracting energy from the spinning inertia. Although in principle simple to achieve, in practice the implementation and the requirement to be able to demonstrate this capability to system operators mean that, in all likelihood, WT manufacturers will not develop this facility unless a market or some other reward for providing this benefit exists.

Figure F.1: System Reserve



F.6 Reactive Power and Voltage Control

Conventional generation can be controlled to produce or consume reactive power almost at will and at little cost. This feature is used to control voltages at points on the system. If conventional generation is displaced, wind must fulfil the same function. This is not currently possible with most WTs, but some manufacturers offer such a facility and more are expected to follow. The costs for this function are expected to be minor for variable speed WTs and more expensive for fixed speed turbines.

It is not clear whether electricity systems actually require the large reactive power production or consumption ability of synchronous generators (power factor 0.85 or less). Therefore, it is not clear if this wide range should be required of wind generation.

F.7 Transient Stability ("Fault Ride-through")

Wind farms can no longer expect to be disconnected in the event of system transient disturbances. As wind penetration increases, it is increasingly important that wind generation continues to operate during transient system disturbances. It is usually necessary to demonstrate that this is possible to the network operator before any such event occurs. For conventional power generation this is done using simulation models. Such models are being developed for WTs, but there is considerable difficulty in understanding, developing and validating these models. This is currently a research area.

APPENDIX G: CALCULATION OF SPECIFIC EMISSIONS OF STANDARD AIR POLLUTANTS FROM FOSSIL FUEL ELECTRICITY GENERATION (METHODOLOGY)

All calculations are based on the only available data, that for electricity generation per fuel (TWh/a) and for total emissions from electricity generation (kt/a). The latter are divided according to the shares of electricity generated from the different fossil fuels. It is assumed that different types of power plants have different specific emissions. Calculations are made assuming three different reference emission level scenarios (best case - very good scrubbers; intermediate case - good scrubbers; worst case - no scrubbers at all and worst fuel quality), shown in Table G.1.

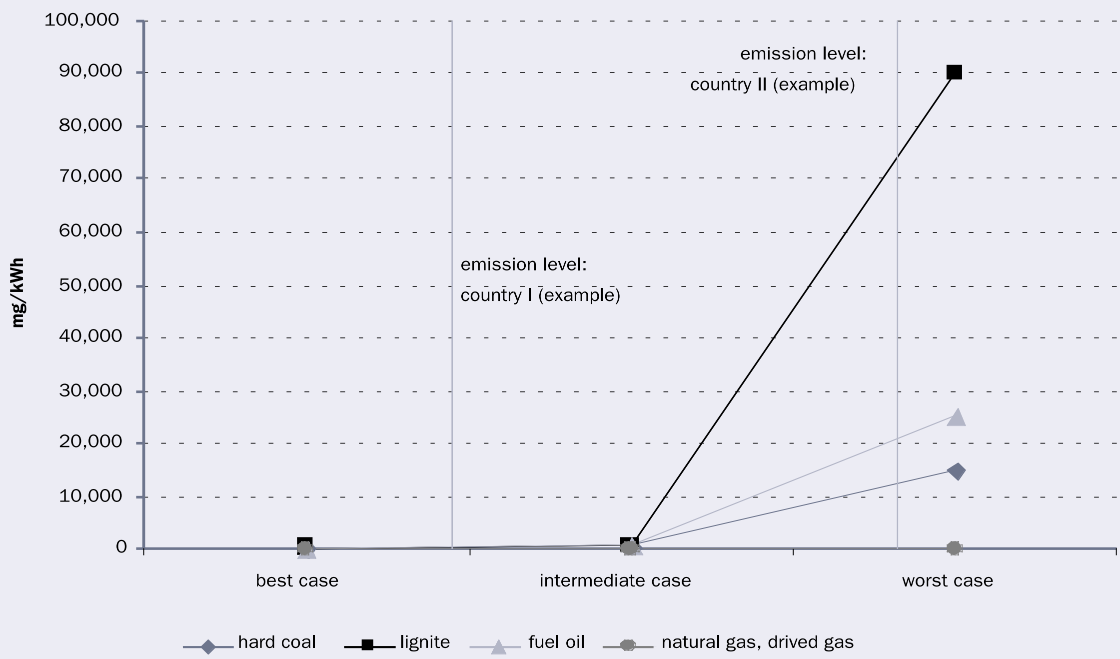
Table G.1: Assumed Emission Levels of Power Plants

Fuel Type	Best Case	Intermediate Case	Worst Case
		SO_2 (mg/kWh)	
hard coal	350	700	15000
lignite	350	700	90000
fuel oil	350	700	25000
natural gas, derived gas	0	0	100
mixed firing, not specified		Average emissions	
		NO_x (mg/kWh)	
hard coal	350	700	3000
lignite	350	700	3000
fuel oil	350	700	3000
natural gas, derived gas	150	300	1500
mixed firing, not specified		Average emissions	

It is assumed that the specific emissions for all types of power plants and fuels are at the same technical level for each country. The graphs in Figure G.2 show a fixed relationship between emissions and different fuels.

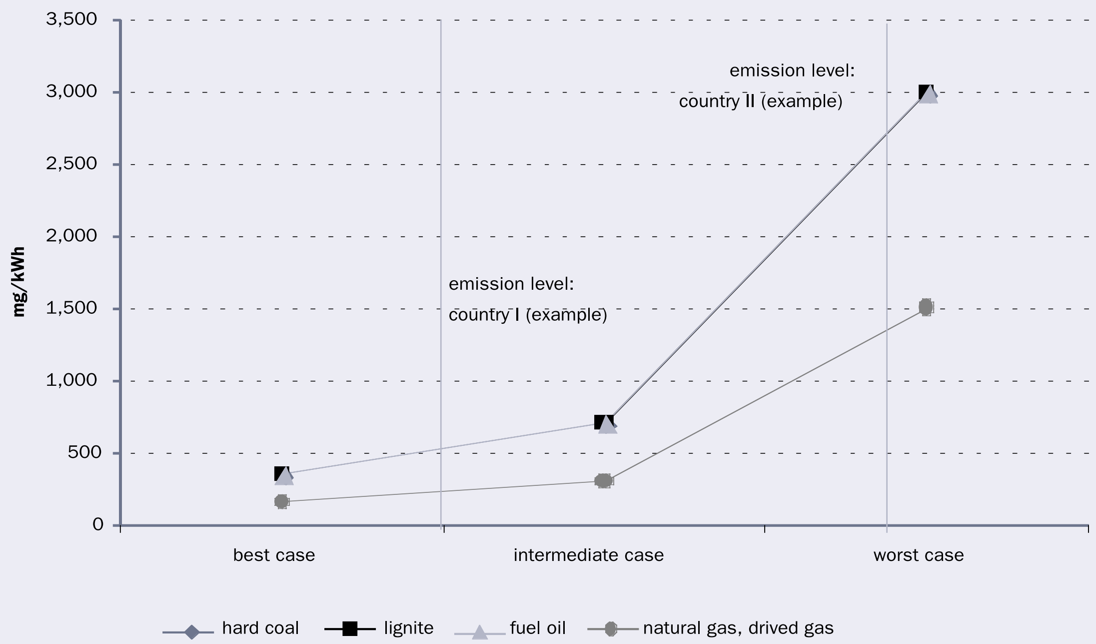
The mathematical model used for the calculation of specific SO_2 emissions, the inputs to the EcoSense model, plus the software and all other relevant calculations are documented on the CD attached to this report.

Figure G.1: Fixed Relations of Emission Levels of SO_2 for Different Fuels in a Country



Source: own calculations.

Figure G.2: Fixed Relations of Emission Levels of NO_X for Different Fuels in a Country



Source: own calculations.

APPENDIX H: ASSUMPTIONS FOR THE CALCULATIONS OF EXTERNAL COSTS WITH ECOSENSE

Calculations of Specific External Costs Assume the Following Geographical Locations of the Power Plants in each Country

	Country	Northern Latitude	Eastern Longitude
AT	Austria	48	16
BE	Belgium	51	4
DK	Denmark	56	12
FI	Finland	60	24
FR	France	49	2
DE	Germany	51	7
GR	Greece	40	22
IE	Ireland	53	-9
IT	Italy	45	9
LU	Luxembourg	50	6
NL	Netherlands	52	5
PT	Portugal	39	-9
ES	Spain	43	-6
SE	Sweden	56	14
GB	UK	53	-1
CY	Cyprus	35.25	29*
CZ	Czech Republic	50	13
EE	Estonia	59	27
HU	Hungary	48	20
LV	Latvia	57	24
LT	Lithuania	55	25
MT	Malta	36	14
PL	Poland	50	19
SK	Slovakia	49	22
SI	Slovenia	46	15
BG	Bulgaria	42	26
RO	Romania	45	25
TR	Turkey	40	29*
included area	from	35.25	-10
	to	73.86	29

* In the case of Turkey and Cyprus, the generation facilities are assumed to be at the eastern border of the area covered by the model because of the limited area covered by EcoSense.

APPENDIX I: MARGINAL COST OF CO_2 EMISSIONS

The values of the marginal cost of CO_2 in the following Table are in US$/tonne of carbon (1996 dollars). The lower value in each box corresponds to a time horizon of 300 years, the upper value to 1,000 years. In the first row, the distribution of income is not taken into account. In the second row, this aspect is included on the assumption that it remains constant over time (Azar and Sterner, 1996, p. 181).

	The Pure Rate of Time Preference			
	0 %/year	0.1%/year	1%/year	3%/year
The marginal cost of CO_2 emissions, MC1	85-200	75-140	32-33	13-13
The marginal cost of CO_2 emissions, MC2	260-590	230-410	95-98	39-39

APPENDIX J: CALCULATED EMPLOYMENT IN EU LEVEL SECTORS

Employment per Final Demand Unit (mio ECU) 1995 EU		Direct	Indirect	Total EU
1	Agriculture, forestry and fishery products	31.66	5.78	37.44
2	Fuel and power products	3.29	19.49	22.79
3	Ferrous and non-ferrous ores and metals	4.93	8.51	13.44
4	Non-metallic mineral products	10.13	4.73	14.86
5	Chemical products	6.12	13.83	19.95
6	**Metal products except machinery**	**13.11**	**6.73**	**19.84**
7	**Agricultural and industrial machinery**	**9.75**	**3.85**	**13.60**
8	**Office and data processing machines**	**9.87**	**0.85**	**10.72**
9	**Electrical goods**	**9.56**	**4.66**	**14.22**
10	Transport equipment	7.25	2.90	10.14
11	Food, beverages, tobacco	6.37	10.69	17.05
12	Textiles and clothing, leather and footwear	17.89	1.89	19.78
13	Paper and printing products	10.67	8.58	19.25
14	**Rubber and plastic products**	**9.11**	**5.16**	**14.27**
15	Other manufacturing products	15.12	1.91	17.03
16	**Building and construction**	**13.33**	**4.81**	**18.14**
17	Recovery, repair services, wholesale, retail	20.62	19.19	39.81
18	Lodging and catering services	19.04	2.37	21.41
19	Inland transport services	14.89	6.84	21.73
20	Maritime and air transport services	6.58	1.25	7.83
21	Auxiliary transport services	6.89	5.11	12.01
22	Communication services	13.60	4.52	18.12
23	Services of credit and insurance institutions	12.02	19.34	31.36
24	**Other market services**	**12.89**	**44.72**	**57.61**
25	Non-market services	21.30	3.33	24.62
	Simple Average	12.24	8.44	20.68

APPENDIX K: *EASTERN PROMISE*, WIND DIRECTIONS, EWEA, MARCH 2003

New EU member states and other Central and Eastern European countries

BULGARIA

Population: 8.3 million
Capital: Sofia
Generation capacity: Fossil fuels (54%), nuclear (31%), hydro (15%)
Although a countrywide wind atlas has identified areas with average wind speeds in excess of 9m/s, there are no turbines operating yet and no mechanism in place to encourage them. Nonetheless, a project with 19 Nordex 1.3 MW turbines has been proposed by a private developer at Peak Murgash, north of Sofia, where wind speeds are said to average 10 m/s. Construction is scheduled for 2005.

A study by the National Institute of Meteorology in Sofia has estimated the total wind power potential in Bulgaria at 2,200 to 3,400 MW. The most promising sites are on the Black Sea coast, in the central mountain range and in the Rhodop Mountains in the southwest. Meanwhile, four out of six reactors at the Kozloduy nuclear plant are scheduled to close as part of the conditions for Bulgaria's membership of the EU, expected to take place in 2007.

CZECH REPUBLIC

Population: 10.3 million
Capital: Prague
Generation capacity: Coal (54%), nuclear (32%), hydro (14%)
Wind power in the Czech Republic was given a boost at the end of 2001 with the introduction of a new feed-in tariff set at 9.5 c€/kWh. This is the minimum amount to be paid to wind producers by the distribution companies, who have an obligation to accept new supply. A number of areas around the country have wind speeds in the range of 8-9 m/s, so the prospects are good. The Czech Wind Power Association puts the total potential at 600-700 MW, half of which could be installed over the next five years if long-term contracts were available.

Operating wind capacity at the end of 2002 was 7 MW, mainly consisting of small turbines erected during the 1990s. But one development of 14 larger turbines is expected to start construction this spring, with more to follow. German developer UTEC-Thomsen, active across a number of East European states, has plans for up to 250 MW.

HUNGARY

Population: 10 million
Capital: Budapest
Generation capacity: Fossil fuels (77%), nuclear (22%), hydro (0.6%)
Although average wind speeds are relatively low, Hungary has the potential to join the wind power leaders among the new East European accession states, especially with successful implementation of government support programmes aimed at reducing CO_2 levels. One projection from the Horvath Engineering consultancy is that 800 MW could be installed over the next 10 years.

Hungary's electricity supply presently comes from a mixture of nuclear and fossil fuel plants, increasingly using natural gas. Under a new law, however, every licensed electricity company has to accept renewable power generation, as long as it complies with certain technical requirements. The price paid is guaranteed within a range varying from 6.5 c€/kWh up to 9.5 c€/kWh, depending on the time of day the power is delivered.

The Hungarian government has also pledged to meet 6% of the country's electricity needs from renewables by 2010, double the present 3%. However, the powerful Ministry of Economic Affairs, sees the main renewables contribution coming from biomass, geothermal and solar PV, and is rather less than enthusiastic about wind.

Supply competition: Steady privatisation has moved through Hungary's electricity sector, with a 2001 Electricity Act introduced specifically to bring the country into line with EU Directives on third party access, subsidy elimination and segmenting the electricity market into generation, distribution and power trading companies. Supply competition is also being introduced in a rolling programme. A handful of WTs have gone up so far, all individual Nordex and Enercon machines. Three Enercon E-40

600 kW turbines have been developed with backing from E.ON Hungaria, a major power supplier and developer. The most prominent developer active in Hungary is German company UTEC-Thomsen, which is progressing plans for a number of large wind farms using a mixture of Nordex and NEG Micon turbines. The first of these, 40 x 1.5 MW turbines near Tesz, should start building during 2003. Leading manufacturers Bonus, Vestas and GE Wind have also all shown interest in the market potential.

Consultant Dr Gabor Horvath says that the most important technical criteria for wind farms in Hungary are a minimum average wind speed of 5-6 m/s at a height of 40-50 m, a nearby grid connection, accessibility to a main road for heavy vehicle traffic and a satisfactory environmental impact assessment. Wind resource and environmental assessments are being carried out at sites with the potential for several hundred MW of capacity, he adds.

ESTONIA

Population: 1.4 million
Capital: Tallinn
Generation capacity: Oil shale (94%), gas (6%)
The coastal regions of Estonia have a good potential for wind energy, and a number of national policy decisions have already been taken to encourage its exploitation. Following a 1998 long-term development plan for the energy sector, which envisaged a strategic increase in the contribution from both wind and hydro power, an energy law passed the same year placed an obligation on the national distribution company to purchase renewable energy. Most recently, new legislation will link the tariff for renewable power to the price for output from the large oil shale power stations at Narva on the Russian border, which generates most of the country's electricity. Renewables, including wind, will receive 1.8 times the Narva price, at present 2.8 c€/kWh, bringing the wind price up to 5.1 c€/kWh.

Payments under the new law, expected to start operating from this summer, would last for two years, but with a cut-off date at the end of 2015. This is not a strong enough incentive, according to the Estonian Wind Power Association (EWPA), which has been calling for the tariff price to be raised to 6.2 c€/kWh, a level at which (combined with other incentives) developers would be prepared to invest. Working together with environmental organisations and the Ministry of the Environment, the EWPA would also like to see the price unbundled from the Narva plant and for contracts under the purchase obligation to last at least 10 years.

Weak grid: Estonia has the potential for at least 560 MW of wind capacity, generating roughly 1.28 TWh, according to the EWPA. But that would require major improvements to the relatively weak grid in many parts of the country. The best sites are to be found round the long Baltic coastline and on the large islands of Hiiumaa and Saaremaa. In the short term, the EWPA expects about 100 MW to be built. Only one wind farm is already operating – a 1.8 MW development with three Enercon E-40 turbines commissioned last October at Virtsu on the Baltic coast with German government assistance. This was inaugurated by the Estonian President, Arnold Rüütel. But many more are in the pipeline, the first of which should be a project with up to eight Nordex 2.5 MW turbines on the Paldiski peninsula, just along the coast from the capital Tallinn. German project developer Ostwind is involved in a joint venture with an Estonian partner at Tamba, on the Baltic coast near the town of Pärnu. Good wind conditions and a satisfactory grid connection have already been established, ready for the installation of four Südwind 1.5 MW turbines. Ostwind is looking for a total of 20-30 MW in Estonia, but "this requires partners willing to share the risk," says the company's Christoph Markl-Meider. "This is linked to the political and legal conditions, which do not yet comply with EU structures, but which are a prerequisite for successful development in the long run." German developer UTEC-Thomsen also has plans for 150 MW of capacity, using NEG Micon or Vestas turbines.

Tax concessions: Apart from the payment tariff still pending in the current legislation, wind developers can benefit from tax concessions under Estonian law. No VAT is payable on wind or hydro power until summer 2004, when a rate of between 5% and 10% will be introduced. Although import duty is payable on equipment such as turbines brought in from overseas, this is recoverable in full at the end of the financial year. Tax on business turnover of 18% is also recoverable if it is used for reinvestment in the business itself.

The EWPA adds that a soft loan may be available through the government agency KIK's environmental arm (www.kik.es) and equity involvement through the Baltcap fund (www.baltcap.com).

LATVIA

Population: 2.4 million
Capital: Riga
Generation capacity: Hydro (74%), fossil fuel (26%)
Latvia has 23.8 MW of installed wind capacity. Most of this is accounted for by the 19.8 MW Veja wind farm at Liepaja on the Baltic coast, with 33 Enercon E-40 turbines installed in April 2002. An indication of the problems encountered by such projects in a country with relatively poor infrastructure is that the crane used to install these turbines had to be imported from Finland. The Veja wind park was commissioned under a now abandoned system based on a payment of twice the household tariff. The government has since passed a new law providing a guaranteed tariff for the first eight years of a turbine's operation. This is set lower, at twice the average electricity selling price, about 5 c€/kWh. After eight years, however, the price falls to the average selling price, which is currently just 2.5 c€/kWh. A further drawback is that the system is based on competitive tenders for a fixed amount of capacity. A wind atlas of the country shows that there are several areas with wind speeds in excess of 6m/s at a height of 30 m. The best sites are located along the Baltic coast and around the Gulf of Riga. According to a study by the European Bank of Reconstruction and Development (EBRD), there is potential for 550 MW of wind capacity.

LITHUANIA

Population: 3.7 million
Capital: Vilnius
Electricity production: Nuclear (73%), fossil-fuelled CHP (21%), hydro (6%)
Lithuania could successfully accommodate 500 MW of wind capacity, according to a study carried out for the EBRD. This would be an important shift from the Baltic state's current dependence on the Ignalina nuclear plant for 73% of its power. However, phased closure of Ignalina, starting with one unit in 2005, is a condition of accession to the EU. According to the country's National Solar Programme, which runs until 2005, the aim is to introduce a range of renewable technologies, including solar PV, geothermal, wind and small hydro, but with the emphasis on biomass. The programme also calls for a lessening in the influence of state energy monopolies and the establishment of a guaranteed purchase price for renewable electricity.

The only WTs installed so far in Lithuania have been in the 60 kW range, mostly designed and built locally during the 1990s. Subsequent technical problems with these machines are explained by a mixture of lack of expertise and the need for more thorough resource assessment.

A 4 MW demonstration wind farm is planned at Butinge on the Baltic coast, but has yet to secure financing. Meanwhile, the Lithuanian government now says it wants to replace Ignalina with a new nuclear plant, a decision which, apart from the safety implications, would commit the country to a major capital outlay. It is still unclear how much of the promised EU compensation payment for the closure of Ignalina will go on decommissioning costs, and how much to support alternatives like wind.

POLAND

Population: 38.6 million
Capital: Warsaw
Generation capacity: Fossil fuels (94%), hydro (6%)
Poland encourages renewables through a quota system under which power utilities are expected to source an increasing proportion of their supply from renewables. This is supposed to rise from 2.4% in 2001 to 7.5% in 2010. The system does not contain any real penalty for failure to comply, however, and potential investors are now waiting for a new energy law, scheduled to come into force July 2003, to strengthen the purchase obligation. Wind power producers are currently obtaining a price of about 6-6.5 c€/kWh for their output from the distribution companies, although the power regulatory body URE has been reluctant to accept any "green premium" element in payments.

A demand by the national grid operator that generators provide details of their output 48 hours in advance has also disadvantaged wind producers. Although low interest loans and financial support are available from the EcoFund and National Fund for Environment Protection, the biggest problem for investors is the lack of long-term PPAs lasting at least 10 years. The country presently has 52 MW of modern WTs, all installed in the last three years. The largest developments, both with 2 MW Vestas machines, are 18 MW at Cisowo near Darlowo, developed by Energia-Eco, and 30 MW at Zagorze near Wolin on the Baltic coast, developed by EPA and commissioned at the beginning of this year. The best sites are in the southern mountainous region and close to the Baltic.

New developments: The Zagorze wind farm, Poland's largest to date, is located in an ideal site close to the Zalew Szczecinski seawater lake. Construction work was overseen by Wolin North Spolka, a subsidiary of the Danish utility Elsam, which owns the project. Polish companies were involved in supplying the towers, foundations and electrical connections. Annual output is expected to be between 63 and 70 million kWh. Many more projects are in the pipeline, a number involving developers from across the German border. UTEC-Thomsen, for example, says it wants to build up to 650 MW of capacity, using a mixture of Vestas and NEG Micon turbines, over the period up to 2007. German utility MVV, working with turbine supplier DeWind, is looking to install 10 wind parks, each with 50 MW capacity, along the Baltic coast. Dutch utility NUON has plans for 60 MW near Wolin, using the Kyoto Joint Implementation mechanism. The biggest Polish development company is EPA from Szczecin, which has been involved in all the recent projects.

Vis Venti, the Polish wind energy lobbying group, expects 50 MW to be installed during 2003 and 100 MW during 2004. Up to 1,600 MW could be built over the next five years, it anticipates. There are also major plans to develop Poland's offshore potential.

ROMANIA

Population: 22 million
Capital: Bucharest
Electricity production: Fossil fuels (62%), hydro (28%), nuclear (10%)
Although Romania has eagerly signed up to the principal international agreements on environmental protection and climate change mitigation, including the Kyoto Protocol, any follow-up measures, such as a clear environmentally based energy policy, have been hesitant and slow. Nuclear power is still viewed favourably by the government, whilst large hydro projects are seen as satisfying the need for renewable energy.

A broadly based national wind map was drawn up in the 1990s showing that the most favourable areas are along the Black Sea coast, with average wind speeds up to 7.1 m/s, and in the mountains at above 1,500 m. The same study assessed the overall potential at 2,000 MW, half of that offshore in the Black Sea itself. Work has also been carried out under the EU's OPET programme to map the wind potential along the Black Sea coast more closely. Only a few demonstration turbines currently operate in Romania, however, mainly because of the lack of any regulatory framework or incentives to encourage new renewables.

The most ambitious plan for a larger scale project has been a 24.5 MW wind farm proposed along two dikes totalling 14 km in length at the port of Constanta on the Black Sea. Despite these reservations, a recent assessment by the EBRD placed Romania as the "top candidate for wind energy development" among East European states. The assessment concluded: "Well documented resources, a broad range of applications, from small autonomous units for rural areas to large offshore potential, and the government's will to comply with EU regulations, all indicate fertile ground worth tilling."

RUSSIA

Population: 147 million
Capital: Moscow
Electricity production: Fossil fuels (66%), hydro (19%), nuclear (15%)
Less than 10 MW of wind capacity is currently operating in Russia, but an enormous potential is waiting to be tapped. One estimate is that the technically exploitable

wind resource in just the European part of the country, where most of the population lives, amounts to 2,308 TWh/year. This is as much as the whole of the EU's electricity consumption in 1995. The main problem is that some of the windiest sites, for instance in the north of the country, are both distant from population centres and often not easily accessible by the grid.

Most of the WTs erected over the past 10 years have been small, locally produced models. But the first substantial wind farm went up during 2002 at Kulikovo in the Kaliningrad region as a result of a cooperation agreement between the Russian Ministry of Energy and the Danish government. This 4.5 MW project consists of 20 Vestas V27 225 kW turbines originally installed in Denmark, and relocated to Kaliningrad by Danish company SEAS Energy Service following a repowering project. In the Arctic region, Russian company VetroEnergo has already installed an initial turbine near the port of Murmansk, and now has plans for a 3-5 MW wind park at Teriberka, 100 km east of Murmansk. A study of the Kola Peninsula, including Murmansk, shows that the region has the potential for up to 800 MW of wind capacity.

Two years ago, the Russian government approved a national energy plan which included installation of up to 232 MW in 28 regions. This was estimated to cost 10.6 billion roubles, 7% of which would come from the government, the rest from local budgets and private sources. The same plan envisaged domestic manufacture of turbines, with an investment of 1.3 billion roubles, 17% from the government. Specific future plans include the country's first offshore wind farm - a 50 MW development with 25 x 2 MW turbines set close to the Baltic coast near the town of Baltiysk. A €1 million feasibility study is due to be carried out by SEAS, and the project would be implemented by a joint Russian-Danish company. Like other East European countries, Russia is going through a process of electricity market liberalisation, with a timescale running through to 2009. This includes breaking up large state companies into competing units, establishing separate generation and distribution entities, and creating a wholesale market which, among other things, will need to see electricity prices rise in order to reflect the real cost of delivering power. This should help the economics of wind.

SLOVAKIA

Population: 5.4 million
Capital: Bratislava
Generation capacity: Nuclear (36%), fossil fuels (33%), hydro (31%),
There are no large-scale WTs operating yet in Slovakia, although a 2.4 MW project (4 x 600 kW) is being planned at Malé Kaparty, north of Bratislava, part funded under the EU's PHARE programme. A mixture of government inaction and low electricity prices hampers further progress. Under proposed legislation, however, there would be a duty on power companies to "purchase and transmit" electricity from renewable sources for "economically acceptable prices". A report to the EBRD has pointed out that increasing the renewables contribution would not only improve the environment, but would also create up to 5,000 jobs. German developer UTEC-Thomsen has plans for 35 MW of capacity, to be built during 2004-5 using a mixture of Vestas and NEG Micon turbines.

SLOVENIA

Population: 2 million
Capital: Ljubljana
Electricity production: Fossil fuels (43%), hydro (31%), nuclear (26%)
Assessing Slovenia's wind power potential is limited by a shortage of suitable meteorological data, although wind speeds are generally low (under 5m/s on average). The government provides only fiscal incentives for investment in renewables. Its favoured option is expansion of the current hydro capacity - by upgrading existing plant and building new ones.

UKRAINE

Population: 49 million
Capital: Kiev
Electricity production: Fossil fuels (48%), nuclear (45%), hydro (7%)
Although nearly all small turbines by European standards, Ukraine now has 44 MW of wind capacity. How fast this expands, however, may depend on establishing closer ties with the mainstream European industry.

The most important initiative has been the Complex Wind Farms Construction Programme, introduced by the government in 1996. This set a target for 1,990 MW of capacity to be installed by 2010. By 2030 it is projected that 20%-30% of the country's electricity production could be satisfied by wind power, saving the annual equivalent of 18 million tonnes of oil. Financial support for the programme comes through an additional payment for the output from officially accepted projects. This currently increases the tariff to between 3 and 3.5 $c/kWh. However, during 2003 it is planned to introduce a new variable tariff based on a turbine's productivity, with a lower rate for the most productive.

Guaranteed payback: For potential overseas investors, the uncertainty of return on their investment is the main stumbling block to involvement in the Ukrainian wind market. A number of companies have expressed interest over the past decade, including Enercon, Nordex and the US developer SeaWest, but the absence of a fixed tariff over a guaranteed period has eventually proved the major obstacle. The government is now working out a new appendix to the law on electricity supply which would stipulate a tariff guaranteeing a payback period of seven years. Quite apart from these fundamental economic questions, a number of technical issues must be addressed if wind power is to progress in Ukraine. Most important of these is the effective identification and selection of suitable sites, especially in a country with relatively low average wind speeds. The most promising areas are in the Crimean peninsula, along the coastline and shallow shores of the Azov and Black Seas, and in the Carpathian Mountains. Effective use of site selection programs still depends on reliable long-term data covering wind speed and direction. This is not generally available in Ukraine. Although the Inter-branch Scientific and Technical Centre has developed an original technique of numerically designing meteorological parameters where no wind data is available, which has proved its effectiveness in practice, this offers only a partial solution. Until historic wind monitoring data is available for at least a year at a given site there will be no guarantee against the sort of mistakes which have already been made at some operating wind farms.

New partnerships: Most turbines currently operating in Ukraine are USW 56-100s with a capacity of 107.5 kW. These are based on a design by the American company US Windpower, which successfully installed many thousands of similar machines in California during the 1980s and early 1990s. Altogether, over 490 of these turbines had been produced by autumn 2002 employing a cluster of Ukrainian factories, and they are still being installed.

If Ukraine is to seriously expand its wind capacity, however, it will almost certainly have to develop partnerships with established European manufacturers. This is already beginning to happen. German manufacturer Fuhrländer says it is working on a licensing agreement to produce its FL1000 1 MW turbine, but is still investigating suitable partners to produce the towers, nacelles and rotor blades, and to carry out a qualified service. Two Turbowinds 600 kW machines are also expected to be erected at existing wind farms during the first half of 2003. The Ukrainian government's main demand is that 100% of the components are manufactured inside the country, allowing former military production plants, for example, to be transformed into wind power factories. The plus side of this is that a Ukrainian produced 600 kW machine could cost as little as US$380,000, compared to more than US$650,000 if it was imported. The minus side is that some plants are just not capable of coping with more complicated production processes.

APPENDIX L: EWEA MEMBERS

Full details of the EWEA membership can be found at www.ewea.org

3E	Belgium
A2SEA A/S	Denmark
ABB Motors OY	Finland
ABB TRANSMIT OY	Finland
ACB Engineering	France
ADEME	France
AEDIE (Associacion para la investigation y Diagnosis de la Energia)	Spain
Airtricity	Ireland
ANZ Investment Bank	United Kingdom
APER	Italy
APPA	Spain
APREN Energias Renováveis	Portugal
ARMINES - Ecole des Mines de Paris	France
Australian Wind Energy Association	Australia
Austrian Wind Energy Association	Austria
Ballast Nedam Offshore Energy	The Netherlands
Baltimore Technologies	Spain
Barclays Bank	N. Ireland
Bayerische Hypo und Vereinsbank	Germany
Black Emerald	USA
Bonus Energy A/S	Denmark
British Wind Energy Association	UK
Brown Rudnick	United Kingdom
Bulgarian Wind Energy Association	Bulgaria
Bundesverband Windenergie (BWE)	Germany
Casco A/S	Denmark
Catamount Energy	USA
CDE	France
CENER, Centro Nacional de Energías Renovables	Spain
Ciemat	Spain
Circe Foundation	Spain
Clipper Windpower Inc	USA
CORUS BI-STEEL	UK
C-Power	Belgium
Czech Society for Wind Energy	Czech Republic
Danish Turbine Owners Association	Denmark
Danish Wind Industry Association	Denmark
De Brandt N.V.	Belgium
Densit A/S	Denmark
Det Norske Veritas	Denmark
Deutsche Structured Finance GmbH	Germany

DeWind GmbH	Germany
DHD France	France
DUWIND	The Netherlands
ECN Solar and Wind Energy	The Netherlands
Eco Wind Power Ltd	Ireland
Ecofys BV	The Netherlands
Ecotecnia SCCL	Spain
Electricité de France	France
EMD (Energi og Miljodata)	Denmark
Endesa Cogeneration and Renewables (ECYR)	Spain
Enercon GmbH	Germany
Energia Hidroelectrica de Navarra (EHN)	Spain
Enis Renewable Energy Systems LLC	USA
Envimac Technology and Consultants Corporation	Taiwan
Eole RES	France
EPA	Poland
ERGA	Italy
Ernst & Young	UK
Escuela Universitaria Politecnica (University L.P.G.C.)	Spain
Espace Eolien Developpement	France
Estonian Wind Power Association	Estonia
Eurowind AB	Sweden
Feria de Zaragoza	Spain
FINE - Faroe Island New Energy	Faroe Islands
Finnish Wind Power Association	Finland
FME-Groep Windenergie	The Netherlands
FOI - Aeronautics FFA	Sweden
Fördergesellschaft Windenergie e.V (FGW)	Germany
Forgital S.p.a.	Italy
France Energie Eolienne	France
Frisa Forjados SA de CV	Mexico
Gamesa Energia S.A.	Spain
Garrad Hassan and Partners Ltd	UK
GE Wind Energy GmbH	Germany
Germanischer Lloyd WindEnergie GmbH	Germany
Gothaer Allgemeine Versicherung AG	Germany
Hamburg Messe	Germany
Hammonds	UK
Hansen Transmissions Int. NV	Belgium
Hellenic Aeolian Parks	Greece
Hellenic Association of Wind Energy Investors	Greece
Hellenic Wind Energy Association	Greece
Hempel Paints	Denmark
Hrvoje Pozar Energy Institute	Croatia
Hungarian Wind Energy Association	Hungary

Hungarian Wind Energy Scientific Association	Hungary
Hydratight Sweeney Ltd	United Kingdom
IED Innovation Energie Développement	France
Indian Wind Energy Association	India
INEGI	Portugal
Institutt for energiteknikk	Norway
Irish Wind Energy Association	Ireland
IRO Offshore Wind Energy Group	The Netherlands
ISES Italia	Italy
ISET	Germany
Israeli Ministry of National Infrastructures	Israel
IVPC Srl	Italy
Japan Wind Energy Association	Japan
Japan Wind Power Association	Japan
KBC Finance Ireland	Ireland
KK Electronic A/S	Denmark
Korean Wind Energy Research Group	Korea
La Compagnie du Vent	France
La Française d'Eoliennes	France
Latvian Wind Energy Association	Latvia
LM Glasfiber A/S	Denmark
Madesta Trade Ltd	Ukraine
Mammoet Van Oord BV	The Netherlands
Messe Husum	Germany
Metso Drives OY	Finland
Moteurs Leory-Somer	France
National Technical University Athens	Greece
NEG Micon A/S	Denmark
Netherlands Wind Energy Association (NEWIN)	The Netherlands
New Zealand Wind Energy Association	New Zealand
Nigerian Wind Energy Association	Nigeria
Nippon Chemi-Con Corp.	Germany
NMH Search	UK
Nordex Energy GmbH	Germany
Norwegian University of Science and Technology (NTNU)	Norway
NRG Systems Inc	USA
Nuon Renewable Energy Projects	The Netherlands
Observ'ER	France
Orix Corporate Finance Ltd	United Kingdom
Orrick, Herrington & Sutcliffe	United Kingdom
Owens Corning Composites	Belgium
P&T Technology AG	Germany
Pauwels International NV	Belgium
PB Power	UK
Plataforma Empresarial Eolica	Spain

Polski Rejestr Statkow SA	Poland
Power@Sea NV	Belgium
Pricewaterhouse Coopers LLP	UK
Promau	Italy
QinetiQ	United Kingdom
Ramboll	Denmark
REM Chemicals, Inc.	USA
Renewable Energy Systems Ltd	UK
RISOE National Laboratory	Denmark
Romanian Wind Energy Association	Romania
Russian Association WindPower Industry (RAWI)	Russia
Saint-Gobain Advanced Ceramics	USA
Scanvib	Denmark
SER (Syndicat des Energies Renouvelables)	France
Shell WindEnergy BV	The Netherlands
SIIF ENERGIES	France
Slovak Association for Wind Energy	Slovakia
South African Wind Energy Association	South Africa
Ssesco, Inc	USA
Suisse-Eole	Switzerland
Swedish Wind Energy Technology Group - SWIND	Sweden
TBS Shipping Services Europe GmbH	Germany
Technical University of Denmark	Denmark
Tech-Wise A/S	Denmark
Tripod Consult APS	Denmark
TTZ - Bremerhaven	Germany
Turkish Wind Energy Association	Turkey
Ukranian Wind Energy Association (UANE)	Ukraine
United Utilities Green Energy Ltd	United Kingdom
Urenco Power Technologies	UK
VDMA	Germany
Vergnet	France
Verlinde SA	France
Vestas Wind Systems A/S	Denmark
Vindkraftforeningen i Finland	Finland
Vindkraftsleverantörerna i Sverige	Sweden
Vis Venti	Poland
Volker Stevin Marine Contracting	The Netherlands
WindLab Systems	Australia
Windpro	UK
WINDTEST Kaiser-Wilhelm-Kooj GmbH	Germany
WIP	Germany
Wirtshaftsverband Windkraftwerke e.V.	Germany
WKN WINDKRAFT NORD	Germany

APPENDIX M: DIRECTIVE 2001/77/EC

27.10.2001 EN Official Journal of the European Communities L 283/33

DIRECTIVE 2001/77/EC OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL

of 27 September 2001

on the promotion of electricity produced from renewable energy sources in the internal electricity market

THE EUROPEAN PARLIAMENT AND THE COUNCIL OF THE EUROPEAN UNION,

Having regard to the Treaty establishing the European Community, and in particular Article 175(1) thereof,

Having regard to the proposal from the Commission [1],

Having regard to the opinion of the Economic and Social Committee [2],

Having regard to the opinion of the Committee of the Regions [3],

Acting in accordance with the procedure laid down in Article 251 of the Treaty [4],

Whereas:

(1) The potential for the exploitation of renewable energy sources is underused in the Community at present. The Community recognises the need to promote renewable energy sources as a priority measure given that their exploitation contributes to environmental protection and sustainable development. In addition this can also create local employment, have a positive impact on social cohesion, contribute to security of supply and make it possible to meet Kyoto targets more quickly. It is therefore necessary to ensure that this potential is better exploited within the framework of the internal electricity market.

(2) The promotion of electricity produced from renewable energy sources is a high Community priority as outlined in the White Paper on Renewable Energy Sources (hereinafter referred to as 'the White Paper') for reasons of security and diversification of energy supply, of environmental protection and of social and economic cohesion. That was endorsed by the Council in its resolution of 8 June 1998 on renewable sources of energy [5], and by the European Parliament in its resolution on the White Paper. [6]

(3) The increased use of electricity produced from renewable energy sources constitutes an important part of the package of measures needed to comply with the Kyoto Protocol to the United Nations Framework Convention on Climate Change, and of any policy package to meet further commitments.

(4) The Council in its conclusions of 11 May 1999 and the European Parliament in its resolution of 17 June 1998 on electricity from renewable energy sources [7] have invited the Commission to submit a concrete proposal for a Community framework on access for electricity produced from renewable energy sources to the internal market. Furthermore, the European Parliament in its resolution of 30 March 2000 on electricity from renewable energy sources and the internal electricity market [8] underlined that binding and ambitious renewable energy targets at the national level are essential for obtaining results and achieving the Community targets.

(5) To ensure increased market penetration of electricity produced from renewable energy sources in the medium term, all Member States should be required to set national indicative targets for the consumption of electricity produced from renewable sources.

(6) These national indicative targets should be consistent with any national commitment made as part of the climate change commitments accepted by the Community under the Kyoto Protocol.

(7) The Commission should assess to what extent Member States have made progress towards achieving their national indicative targets, and to what extent the national indicative targets are consistent with the global indicative target of 12 % of gross domestic energy consumption by 2010, considering that the White Paper's indicative target of 12 % for the Community as a whole by 2010 provides useful guidance for increased efforts at Community level as well as in Member States, bearing in mind the need to reflect differing national circumstances. If necessary for the achievement of the targets, the Commission should submit proposals to the European Parliament and the Council which may include mandatory targets.

(8) Where they use waste as an energy source, Member States must comply with current Community legislation on waste management. The application of this Directive is without prejudice to the definitions set out in Annex 2a and 2b to Council Directive 75/442/EEC of 15 July 1975 on waste [9]. Support for renewable energy sources should be consistent with other Community objectives, in particular respect for the waste treatment hierarchy.

(1) OJ C 311 E, 31.10.2000, p. 320 and OJ C 154 E, 29.5.2001, p. 89.
(2) OJ C 367, 20.12.2000, p. 5.
(3) OJ C 22, 24.1.2001, p. 27.
(4) Opinion of the European Parliament of 16 November 2000 (OJ C 223, 8.8.2001, p. 294), Council Common Position of 23 March 2001 (OJ C 142, 15.5.2001, p. 5) and Decision of the European Parliament of 4 July 2001 (not yet published in the Official Journal). Council Decision of 7 September 2001.
(5) OJ C 198, 24.6.1998, p. 1.
(6) OJ C 210, 6.7.1998, p. 215.
(7) OJ C 210, 6.7.1998, p. 143.
(8) OJ C 378, 29.12.2000, p. 89.
(9) OJ L 194, 25.7.1975, p. 39. Directive as last amended by Commission Decision 96/350/EC (OJ L 135, 6.6.1996, p. 32).

Therefore, the incineration of non-separated municipal waste should not be promoted under a future support system for renewable energy sources, if such promotion were to undermine the hierarchy.

(9) The definition of biomass used in this Directive does not prejudge the use of a different definition in national legislation, for purposes other than those set out in this Directive.

(10) This Directive does not require Member States to recognise the purchase of a guarantee of origin from other Member States or the corresponding purchase of electricity as a contribution to the fulfilment of a national quota obligation. However, to facilitate trade in electricity produced from renewable energy sources and to increase transparency for the consumer's choice between electricity produced from non-renewable and electricity produced from renewable energy sources, the guarantee of origin of such electricity is necessary. Schemes for the guarantee of origin do not by themselves imply a right to benefit from national support mechanisms established in different Member States. It is important that all forms of electricity produced from renewable energy sources are covered by such guarantees of origin.

(11) It is important to distinguish guarantees of origin clearly from exchangeable green certificates.

(12) The need for public support in favour of renewable energy sources is recognised in the Community guidelines for State aid for environmental protection ([1]), which, amongst other options, take account of the need to internalise external costs of electricity generation. However, the rules of the Treaty, and in particular Articles 87 and 88 thereof, will continue to apply to such public support.

(13) A legislative framework for the market in renewable energy sources needs to be established.

(14) Member States operate different mechanisms of support for renewable energy sources at the national level, including green certificates, investment aid, tax exemptions or reductions, tax refunds and direct price support schemes. One important means to achieve the aim of this Directive is to guarantee the proper functioning of these mechanisms, until a Community framework is put into operation, in order to maintain investor confidence.

(15) It is too early to decide on a Community-wide framework regarding support schemes, in view of the limited experience with national schemes and the current relatively low share of price supported electricity produced from renewable energy sources in the Community.

(16) It is, however necessary to adapt, after a sufficient transitional period, support schemes to the developing internal electricity market. It is therefore appropriate that the Commission monitor the situation and present a report on experience gained with the application of national schemes. If necessary, the Commission should, in the light of the conclusions of this report, make a proposal for a Community framework with regard to support schemes for electricity produced from renewable energy sources. That proposal should contribute to the achievement of the national indicative targets, be compatible with the principles of the internal electricity market and take into account the characteristics of the different sources of renewable energy, together with the different technologies and geographical differences. It should also promote the use of renewable energy sources in an effective way, and be simple and at the same time as efficient as possible, particularly in terms of cost, and include sufficient transitional periods of at least seven years, maintain investors' confidence and avoid stranded costs. This framework would enable electricity from renewable energy sources to compete with electricity produced from non-renewable energy sources and limit the cost to the consumer, while, in the medium term, reduce the need for public support.

(17) Increased market penetration of electricity produced from renewable energy sources will allow for economies of scale, thereby reducing costs.

(18) It is important to utilise the strength of the market forces and the internal market and make electricity produced from renewable energy sources competitive and attractive to European citizens.

(19) When favouring the development of a market for renewable energy sources, it is necessary to take into account the positive impact on regional and local development opportunities, export prospects, social cohesion and employment opportunities, especially as concerns small and medium-sized undertakings as well as independent power producers.

(20) The specific structure of the renewable energy sources sector should be taken into account, especially when reviewing the administrative procedures for obtaining permission to construct plants producing electricity from renewable energy sources.

(21) In certain circumstances it is not possible to ensure fully transmission and distribution of electricity produced from renewable energy sources without affecting the reliability and safety of the grid system and guarantees in this context may therefore include financial compensation.

(22) The costs of connecting new producers of electricity from renewable energy sources should be objective, transparent and non-discriminatory and due account should be taken of the benefit embedded generators bring to the grid.

([1]) OJ C 37, 3.2.2001, p. 3.

(23) Since the general objectives of the proposed action cannot be sufficiently achieved by the Member States and can therefore, by reason of the scale or effects of the action, be better achieved at Community level, the Community may adopt measures, in accordance with the principle of subsidiarity as set out in Article 5 of the Treaty. Their detailed implementation should, however, be left to the Member States, thus allowing each Member State to choose the regime which corresponds best to its particular situation. In accordance with the principle of proportionality, as set out in that Article, this Directive does not go beyond what is necessary in order to achieve those objectives,

HAVE ADOPTED THIS DIRECTIVE:

Article 1

Purpose

The purpose of this Directive is to promote an increase in the contribution of renewable energy sources to electricity production in the internal market for electricity and to create a basis for a future Community framework thereof.

Article 2

Definitions

For the purposes of this Directive, the following definitions shall apply:

(a) '*renewable energy sources*' shall mean renewable non-fossil energy sources (wind, solar, geothermal, wave, tidal, hydropower, biomass, landfill gas, sewage treatment plant gas and biogases);

(b) '*biomass*' shall mean the biodegradable fraction of products, waste and residues from agriculture (including vegetal and animal substances), forestry and related industries, as well as the biodegradable fraction of industrial and municipal waste;

(c) '*electricity produced from renewable energy sources*' shall mean electricity produced by plants using only renewable energy sources, as well as the proportion of electricity produced from renewable energy sources in hybrid plants also using conventional energy sources and including renewable electricity used for filling storage systems, and excluding electricity produced as a result of storage systems;

(d) '*consumption of electricity*' shall mean national electricity production, including autoproduction, plus imports, minus exports (gross national electricity consumption).

In addition, the definitions in Directive 96/92/EC of the European Parliament and of the Council of 19 December 1996 concerning common rules for the internal market of electricity [1] shall apply.

[1] OJ L 27, 30.1.1997, p. 20.

Article 3

National indicative targets

1. Member States shall take appropriate steps to encourage greater consumption of electricity produced from renewable energy sources in conformity with the national indicative targets referred to in paragraph 2. These steps must be in proportion to the objective to be attained.

2. Not later than 27 October 2002 and every five years thereafter, Member States shall adopt and publish a report setting national indicative targets for future consumption of electricity produced from renewable energy sources in terms of a percentage of electricity consumption for the next 10 years. The report shall also outline the measures taken or planned, at national level, to achieve these national indicative targets. To set these targets until the year 2010, the Member States shall:

— take account of the reference values in the Annex,

— ensure that the targets are compatible with any national commitments accepted in the context of the climate change commitments accepted by the Community pursuant to the Kyoto Protocol to the United Nations Framework Convention on Climate Change.

3. Member States shall publish, for the first time not later than 27 October 2003 and thereafter every two years, a report which includes an analysis of success in meeting the national indicative targets taking account, in particular, of climatic factors likely to affect the achievement of those targets and which indicates to what extent the measures taken are consistent with the national climate change commitment.

4. On the basis of the Member States' reports referred to in paragraphs 2 and 3, the Commission shall assess to what extent:

— Member States have made progress towards achieving their national indicative targets,

— the national indicative targets are consistent with the global indicative target of 12 % of gross national energy consumption by 2010 and in particular with the 22,1 % indicative share of electricity produced from renewable energy sources in total Community electricity consumption by 2010.

The Commission shall publish its conclusions in a report, for the first time not later than 27 October 2004 and thereafter every two years. This report shall be accompanied, as appropriate, by proposals to the European Parliament and to the Council.

If the report referred to in the second subparagraph concludes that the national indicative targets are likely to be inconsistent, for reasons that are unjustified and/or do not relate to new scientific evidence, with the global indicative target, these proposals shall address national targets, including possible mandatory targets, in the appropriate form.

Article 4

Support schemes

1. Without prejudice to Articles 87 and 88 of the Treaty, the Commission shall evaluate the application of mechanisms used in Member States according to which a producer of electricity, on the basis of regulations issued by the public authorities, receives direct or indirect support, and which could have the effect of restricting trade, on the basis that these contribute to the objectives set out in Articles 6 and 174 of the Treaty.

2. The Commission shall, not later than 27 October 2005, present a well-documented report on experience gained with the application and coexistence of the different mechanisms referred to in paragraph 1. The report shall assess the success, including cost-effectiveness, of the support systems referred to in paragraph 1 in promoting the consumption of electricity produced from renewable energy sources in conformity with the national indicative targets referred to in Article 3(2). This report shall, if necessary, be accompanied by a proposal for a Community framework with regard to support schemes for electricity produced from renewable energy sources.

Any proposal for a framework should:

(a) contribute to the achievement of the national indicative targets;

(b) be compatible with the principles of the internal electricity market;

(c) take into account the characteristics of different sources of renewable energy, together with the different technologies, and geographical differences;

(d) promote the use of renewable energy sources in an effective way, and be simple and, at the same time, as efficient as possible, particularly in terms of cost;

(e) include sufficient transitional periods for national support systems of at least seven years and maintain investor confidence.

Article 5

Guarantee of origin of electricity produced from renewable energy sources

1. Member States shall, not later than 27 October 2003, ensure that the origin of electricity produced from renewable energy sources can be guaranteed as such within the meaning of this Directive according to objective, transparent and non-discriminatory criteria laid down by each Member State. They shall ensure that a guarantee of origin is issued to this effect in response to a request.

2. Member States may designate one or more competent bodies, independent of generation and distribution activities, to supervise the issue of such guarantees of origin.

3. A guarantee of origin shall:

— specify the energy source from which the electricity was produced, specifying the dates and places of production, and in the case of hydroelectric installations, indicate the capacity;

— serve to enable producers of electricity from renewable energy sources to demonstrate that the electricity they sell is produced from renewable energy sources within the meaning of this Directive.

4. Such guarantees of origin, issued according to paragraph 2, should be mutually recognised by the Member States, exclusively as proof of the elements referred to in paragraph 3. Any refusal to recognise a guarantee of origin as such proof, in particular for reasons relating to the prevention of fraud, must be based on objective, transparent and non-discriminatory criteria. In the event of refusal to recognise a guarantee of origin, the Commission may compel the refusing party to recognise it, particularly with regard to objective, transparent and non-discriminatory criteria on which such recognition is based.

5. Member States or the competent bodies shall put in place appropriate mechanisms to ensure that guarantees of origin are both accurate and reliable and they shall outline in the report referred to in Article 3(3) the measures taken to ensure the reliability of the guarantee system.

6. After having consulted the Member States, the Commission shall, in the report referred to in Article 8, consider the form and methods that Member States could follow in order to guarantee the origin of electricity produced from renewable energy sources. If necessary, the Commission shall propose to the European Parliament and the Council the adoption of common rules in this respect.

Article 6

Administrative procedures

1. Member States or the competent bodies appointed by the Member States shall evaluate the existing legislative and regulatory framework with regard to authorisation procedures or the other procedures laid down in Article 4 of Directive 96/92/EC, which are applicable to production plants for electricity produced from renewable energy sources, with a view to:

— reducing the regulatory and non-regulatory barriers to the increase in electricity production from renewable energy sources,

— streamlining and expediting procedures at the appropriate administrative level, and

— ensuring that the rules are objective, transparent and non-discriminatory, and take fully into account the particularities of the various renewable energy source technologies.

2. Member States shall publish, not later than 27 October 2003, a report on the evaluation referred to in paragraph 1, indicating, where appropriate, the actions taken. The purpose of this report is to provide, where this is appropriate in the context of national legislation, an indication of the stage reached specifically in:

— coordination between the different administrative bodies as regards deadlines, reception and treatment of applications for authorisations,

— drawing up possible guidelines for the activities referred to in paragraph 1, and the feasibility of a fast-track planning procedure for producers of electricity from renewable energy sources, and

— the designation of authorities to act as mediators in disputes between authorities responsible for issuing authorisations and applicants for authorisations.

3. The Commission shall, in the report referred to in Article 8 and on the basis of the Member States' reports referred to in paragraph 2 of this Article, assess best practices with a view to achieving the objectives referred to in paragraph 1.

Article 7

Grid system issues

1. Without prejudice to the maintenance of the reliability and safety of the grid, Member States shall take the necessary measures to ensure that transmission system operators and distribution system operators in their territory guarantee the transmission and distribution of electricity produced from renewable energy sources. They may also provide for priority access to the grid system of electricity produced from renewable energy sources. When dispatching generating installations, transmission system operators shall give priority to generating installations using renewable energy sources insofar as the operation of the national electricity system permits.

2. Member States shall put into place a legal framework or require transmission system operators and distribution system operators to set up and publish their standard rules relating to the bearing of costs of technical adaptations, such as grid connections and grid reinforcements, which are necessary in order to integrate new producers feeding electricity produced from renewable energy sources into the interconnected grid.

These rules shall be based on objective, transparent and non-discriminatory criteria taking particular account of all the costs and benefits associated with the connection of these producers to the grid. The rules may provide for different types of connection.

3. Where appropriate, Member States may require transmission system operators and distribution system operators to bear, in full or in part, the costs referred to in paragraph 2.

4. Transmission system operators and distribution system operators shall be required to provide any new producer wishing to be connected with a comprehensive and detailed estimate of the costs associated with the connection. Member States may allow producers of electricity from renewable energy sources wishing to be connected to the grid to issue a call for tender for the connection work.

5. Member States shall put into place a legal framework or require transmission system operators and distribution system operators to set up and publish their standard rules relating to the sharing of costs of system installations, such as grid connections and reinforcements, between all producers benefiting from them.

The sharing shall be enforced by a mechanism based on objective, transparent and non-discriminatory criteria taking into account the benefits which initially and subsequently connected producers as well as transmission system operators and distribution system operators derive from the connections.

6. Member States shall ensure that the charging of transmission and distribution fees does not discriminate against electricity from renewable energy sources, including in particular electricity from renewable energy sources produced in peripheral regions, such as island regions and regions of low population density.

Where appropriate, Member States shall put in place a legal framework or require transmission system operators and distribution system operators to ensure that fees charged for the transmission and distribution of electricity from plants using renewable energy sources reflect realisable cost benefits resulting from the plant's connection to the network. Such cost benefits could arise from the direct use of the low-voltage grid.

7. Member States shall, in the report referred to in Article 6(2), also consider the measures to be taken to facilitate access to the grid system of electricity produced from renewable energy sources. That report shall examine, *inter alia*, the feasibility of introducing two-way metering.

Article 8

Summary report

On the basis of the reports by Member States pursuant to Article 3(3) and Article 6(2), the Commission shall present to the European Parliament and the Council, no later than 31 December 2005 and thereafter every five years, a summary report on the implementation of this Directive.

This report shall:

— consider the progress made in reflecting the external costs of electricity produced from non-renewable energy sources and the impact of public support granted to electricity production,

— take into account the possibility for Member States to meet the national indicative targets established in Article 3(2), the global indicative target referred to in Article 3(4) and the existence of discrimination between different energy sources.

If appropriate, the Commission shall submit with the report further proposals to the European Parliament and the Council.

Article 9

Transposition

Member States shall bring into force the laws, regulations and administrative provisions necessary to comply with this Directive not later than 27 October 2003. They shall forthwith inform the Commission thereof.

When Member States adopt these measures, they shall contain a reference to this Directive or shall be accompanied by such a reference on the occasion of their official publication. The methods of making such reference shall be laid down by the Member States.

Article 10

Entry into force

This Directive shall enter into force on the day of its publication in the *Official Journal of the European Communities.*

Article 11

Addressees

This Directive is addressed to the Member States.

Done at Brussels, 27 September 2001.

For the European Parliament	*For the Council*
The President	*The President*
N. FONTAINE	C. PICQUÉ

ANNEX

Reference values for Member States' national indicative targets for the contribution of electricity produced from renewable energy sources to gross electricity consumption by 2010 (*)

This Annex gives reference values for the fixing of national indicative targets for electricity produced from renewable energy sources ('RES-E'), as referred to in Article 3(2):

	RES-E TWh 1997 (**)	RES-E % 1997 (***)	RES-E % 2010 (***)
Belgium	0,86	1,1	6,0
Denmark	3,21	8,7	29,0
Germany	24,91	4,5	12,5
Greece	3,94	8,6	20,1
Spain	37,15	19,9	29,4
France	66,00	15,0	21,0
Ireland	0,84	3,6	13,2
Italy	46,46	16,0	25,0 (1)
Luxembourg	0,14	2,1	5,7 (2)
Netherlands	3,45	3,5	9,0
Austria	39,05	70,0	78,1 (3)
Portugal	14,30	38,5	39,0 (4)
Finland	19,03	24,7	31,5 (5)
Sweden	72,03	49,1	60,0 (6)
United Kingdom	7,04	1,7	10,0
Community	338,41	13,9 %	22 % (****)

(*) In taking into account the reference values set out in this Annex, Member States make the necessary assumption that the State aid guidelines for environmental protection allow for the existence of national support schemes for the promotion of electricity produced from renewable energy sources.

(**) Data refer to the national production of RES-E in 1997.

(***) The percentage contributions of RES-E in 1997 and 2010 are based on the national production of RES-E divided by the gross national electricity consumption. In the case of internal trade of RES-E (with recognised certification or origin registered) the calculation of these percentages will influence 2010 figures by Member State but not the Community total.

(****) Rounded figure resulting from the reference values above.

(1) *Italy* states that 22 % would be a realistic figure, on the assumption that in 2010 gross national electricity consumption will be 340 TWh. When taking into account the reference values set out in this Annex, Italy has assumed that gross national electricity production from renewable energy sources will attain up to 76 TWh in 2010. This figure includes the contribution of the non-biodegradable fraction of municipal and industrial waste used in compliance with Community legislation on waste management.
In this respect, the capability to reach the indicative target as referred to in this Annex, is contingent, *inter alia*, upon the effective level of the national demand for electric energy in 2010.

(2) Taking into account the indicative reference values set out in this Annex, *Luxembourg* takes the view that the objective set for 2010 can be achieved only if:
— total electricity consumption in 2010 does not exceed that of 1997,
— wind-generated electricity can be multiplied by a factor of 15,

— biogas-generated electricity can be multiplied by a factor of 208,
— electricity produced from the only municipal waste incinerator in Luxembourg, which in 1997 accounted for half the electricity produced from renewable energy sources, can be taken into account in its entirety,
— photovoltaically generated electricity can be raised to 80 GWh, and

in so far as the above points can be achieved from the technical standpoint in the time allowed.

In the absence of natural resources, an additional increase in electricity generated by hydroelectric power stations is ruled out.

(3) *Austria* states that 78,1 % would be a realistic figure, on the assumption that in 2010 gross national electricity consumption will be 56,1 TWh. Due to the fact that the production of electricity from renewable sources is highly dependent on hydropower and therefore on the annual rainfall, the figures for 1997 and 2010 should be calculated on a long-range model based on hydrologic and climatic conditions.

(4) *Portugal*, when taking into account the reference values, set out in this Annex, states that to maintain the 1997 share of electricity produced from renewable sources as an indicative target for 2010 it was assumed that:
— it will be possible to continue the national electricity plan building new hydro capacity higher than 10 MW,
— other renewable capacity, only possible with financial state aid, will increase at an annual rate eight times higher than has occurred recently.

These assumptions imply that new capacity for producing electricity from renewable sources, excluding large hydro, will increase at a rate twice as high as the rate of increase of gross national electricity consumption.

(5) In the *Finnish* action plan for renewable energy sources, objectives are set for the volume of renewable energy sources used in 2010. These objectives have been set on the basis of extensive background studies. The action plan was approved within the Government in October 1999.

According to the Finnish action plan, the share of electricity produced from renewable energy sources by 2010 would be 31 %. This indicative target is very ambitious and its realisation would require extensive promotion measures in Finland.

(6) When taking into account the reference values set out in this Annex, *Sweden* notes that the possibility of reaching the target is highly dependent upon climatic factors heavily affecting the level of hydropower production, in particular variations in pluviometry, timing of rainfall during the year and inflow. The electricity produced from hydropower can vary substantially. During extremely dry years production may amount to 51 TWh, whereas in wet years it could amount to 78 TWh. The figure for 1997 should thus be calculated with a long-range model based on scientific facts on hydrology and climatic change.

It is a generally applied method in countries with important shares of hydropower production to use water inflow statistics covering a time span of 30 to 60 years. Thus, according to the Swedish methodology and based on conditions during the period 1950-1999, correcting for differences in total hydropower production capacity and inflow over the years, average hydropower production amounts to 64 TWh which corresponds to a figure for 1997 of 46 %, and in this context Sweden considers 52 % to be a more realistic figure for 2010.

Furthermore, the ability of Sweden to achieve the target is limited by the fact that the remaining unexploited rivers are protected by law. Moreover, the ability of Sweden to reach the target is heavily contingent upon:
— the expansion of combined heat and power (CHP) depending on population density, demand for heat and technology development, in particular for black liquor gasification, and
— authorisation for wind power plants in accordance with national laws, public acceptance, technology development and expansion of grids.