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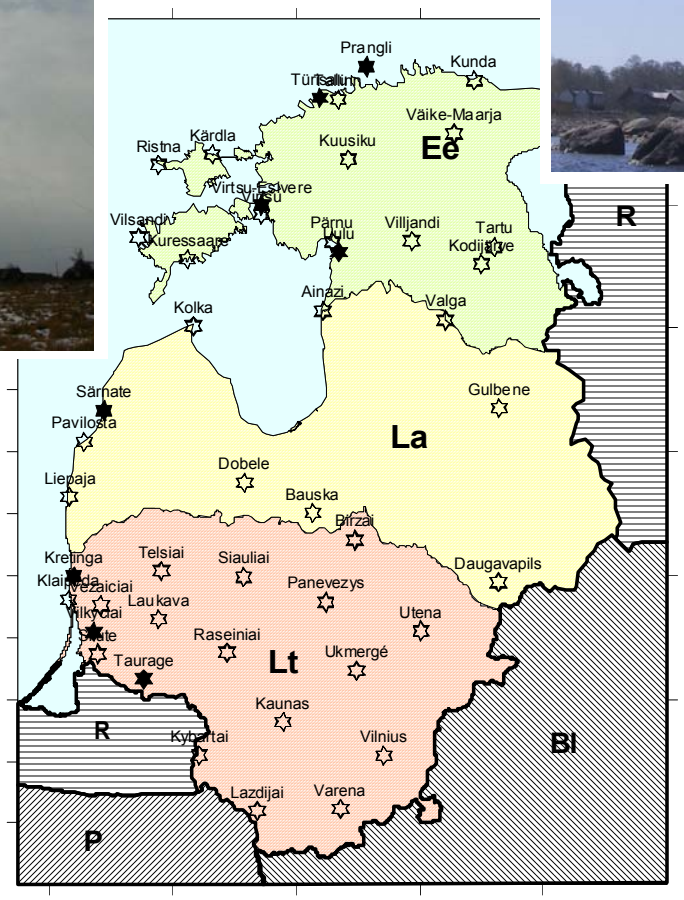
United Nations Development Programme

The UNDP/GEF Baltic Wind Atlas

Ole Rathmann



The UNDP/GEF Regional Baltic Wind Energy Programme

Risø National Laboratory, Roskilde, Denmark

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Abstract In the frame of the Regional Baltic Wind Energy Programme, sponsored by the Global Environment Facility through the UNDP, a publicly available wind resource database for the wind-energy relevant areas of the Baltic Countries has been established. A 2-year measurement campaign has been performed based on 7 stations in the coastal area: the 3 Lithuanian sites Kretinga, Vilkyciai and Taurage; the Latvian site Särnate; and the 3 Estonian sites Prangli, Virtsu and Uulu. In addition, private data measured at the Estonian site Türisalu was made available to the project.
Although the campaign was running for about two years it was only possible to get one full one-year data series for each site with start time ranging from primo May 2001 to primo October 2001. The measured data have been analysed according to the "Wind Atlas Method", implying cleansing the wind data for nearby terrain effects, and resulting in regional wind climates or Wind Atlases referring to a number of standard conditions. To the extent possible measures have been taken to make the regional wind climates represent long-term wind statistics (> 10 year). This was done by using correlation techniques based on reference data from met-institute stations with long-term records as well as data for the short-term measurement period of the present campaign. Similarly, inter-comparison techniques were used to adjust for data fall-out for longer unbroken periods. The data from this project have been supplemented by in-land data from measuring stations of the three national meteorological institutes. All relevant data files regarding the 8 stations of the project will be available from the wind atlas web of Risø National Laboratory: www.windatlas.dk - with the exception of the private data measured at Türisalu.

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Preface

The United Nations Development Programme (UNDP), with the funding of the Global Environmental Facility (GEF), initiated in year 2000 a project entitled "The Regional Baltic Wind Energy Programme" with one of its objectives to establish a wind energy database for the Baltic countries - a database, which should be publicly available to guide the wind energy investors, project developers and policy makers on the overall potential and possible locations for wind energy development in the Baltic countries. This has now resulted in 8 predicted regional wind climates ("Wind Atlases") based on measurements from the 7 stations established during the project at near-coast sites in the three Baltic countries and one set of additional measurements in Estonia obtained from a private company "AS Tuulepargid" . Focus was on near-coast sites as here wind resources are expected to be the highest. These wind atlas data have been supplemented with data from met-stations of the three national meteorological institutes to illustrate the in-land wind resources.

It is the hope that this Baltic Wind Atlas will form a decision basis for, and to assist future wind energy development in Lithuania, Latvia and Estonia.

1 Introduction

The project entitled "The Regional Baltic Wind Energy Programme", sponsored by the Global Environmental Facility through UNDP, was initiated in year 2000 with one its objectives to establish a publicly available wind resource database for the wind-energy relevant areas of the Baltic countries. A number of near-coast sites were considered and finally 7 sites were selected for performing measurements. An additional coastal site was included courtesy of a private company who made their proprietary measured data available to the project. The reason for considering only near-coast sites was the pre-knowledge that in-land sites have considerably lower wind speeds than near-coast sites and are thus less relevant for wind energy.

Although not the technically optimal solution, the measurement stations were established in existing antenna masts (mostly GSM-masts) where possible. The draw-back of this choice is some shadowing effect from the mast on the anemometers, but this can be reduced by suitable mounting techniques. In the end 5 of the measurements were established in existing antenna masts, whereas it proved possible to establish the remaining three ones in ad-hoc masts with a freely exposed top-anemometer. This procedure was followed as it was judged to be more important to have a broad coverage of the coastal area along the Baltic coast (with a relatively large number of measuring stations) instead of a fewer number of stations with very high precision. The high-precision-data could be difficult to benefit from as the stations would be distributed very sparsely and the data would have to be heavily supplemented by data from met-institute stations which could be expected to be of standard (i.e. medium) quality and precision. Whereas the precision of the wind speed measurements from each of the stations may be somewhat poorer than use of ad-hoc masts and high precision equipment (5-10% precision in stead of 3-5%) the quality of the entire wind atlas is believed to have benefited from this choice.

The measurement campaign, extending over 2 years, involved the 8 stations in the coastal area: the 3 Lithuanian sites Kretinga, Vilkycia and Taurage; the Latvian site Särnate; and the 4 Estonian sites Prangli, Türisalu, Virtsu and Uulu. Within the two year campaign it was possible to get a full one-year data series for each site with the data period ranging from May 1st 2001-April 30th 2002 to October 1st 2001-September 30th 2002.

The establishment and operation of the measurement stations, including data collection, were sub-contracted to local competent institutions and/or companies. The equipments in existing masts were mounted on long booms in order to reduce the shadowing effect from the mast to an acceptable level. The stations Prangli, Virtsu, Uulu and Vilkyciai were established in GSM-masts, while the Kretinga station was established in an antenna mast in connection with a natural gas control station. A more detailed description of the masts is given in chapter 3.

The measured data have been analysed according to the "Wind Atlas Method", to produce long-term regional wind climates ("Wind Atlases") referring to a number of standard conditions: a number of standard surface roughnesses in combination with a number of standard heights above terrain. Data from met-station masts of the national met-institutes with long-term records as well as data for the short-term measurement period of the present campaign were used to provide data for the conversion from the short term measurement periods to a long-term period.

Finally, the 8 regional wind climate data sets of the project were supplemented with long-term data from in-land stations of the national meteorological institutes to illustrate the wind resources at longer distance from the Baltic coast line.

The wind atlas preparation and supervision of the mast establishment and data collection in the project was sponsored by GEF/UNDP under contract no RER/99/G41 which is hereby acknowledged. Acknowledgement is also directed to UNDP-representative Vesa Rutanen for his supervision and project management, as well as to wind energy consultant Lars Mach (Krefeld, Germany) for his assistance during the first survey mission. Finally the contribution by the local subcontractors and co-operation partners is greatly acknowledged:

- in Lithuania, Kestutis Navickas of the *Regional Environmental Centre for Central and Eastern Europe*, Vilnius,
- in Latvia, Prof. Barons of the *Latvian Wind Energy Association* and Uldis Johansons of the *Alter Energo* company; and
- in Estonia, prof. Vello Selg and his group at the *Technical University of Tallinn,* prof. Ain Kull of the *University of Tartu* and Hannu Lamp from the company *AS Tuulepargid* who very kindly made the measured wind data from the Türisalu site available to the project.

2 Methodology

2.1 The Wind Atlas Method

The basis of the processing of the measured wind data has been the Wind Atlas Method [1]. The wind resource program WAsP version 8 [2], developed by Risø, implements this methodology, and was consequently used for the analysis. Using the wind atlas method means that the measured wind data, by means of flow modelling, is transformed to a regional wind climate[*)], where the local terrain effects have been cleansed away. The regional wind atlas thus contains wind statistics for a number of standard conditions: a number of standard surface roughnesses (of an assumed uniform flat surface) in combination with a number of heights above terrain. The flow modelling includes the effect of surface elevation variations ("orography"), surface roughness changes and the near-field effects of wind obstacles (e.g. buildings, wind breaks).

2.2 Adjustment for short-term effects

A second issue, not directly addressed by the wind atlas method, is that of the short-term (ST) measurement period, in this case a year. Wind measurement data series less than a year are normally avoided in order to have a balanced representation of the different seasons of the year. However, there may be rather large year-to-year variations, and one must take that into account to avoid the error caused by just assuming the year(s) at hand to be representative for a long-term (LT) period (>10 years). This problem is usually taken into account by using some nearby reference met-station with a long-term data record as well as short-term measurement data series, where the short term period is the measurement period of the site in question. If the reference station and the site are within the same wind climate region, which is fulfilled approximately in the cases in this work, one uses simply the ratio between the long-term-average and the short-term-average of the reference station wind speed to scale the site wind statistics when performing the wind atlas analysis to obtain a long-term regional wind climate. This LT/ST scaling method was used in this work.

For the Estonian UNDP-stations the relevant reference met-stations would be the Estonian Met-institute stations Tallin/Harku, Virtsu and Pärnu, for which 10-year-average data are existing

[*)] Traditionally the term "Wind Atlas" has been used instead of the more correct Regional Wind Climate.

(1981-1990), but unfortunately not available at reporting time. Consequently the closest set of long-term met-data were used instead: data from the Latvian met-stations Liepája and Pavilosta.

Inevitably, wind data measurements will have some data fall-out. If not randomly scattered over the measurement period, but concentrated over a longer unbroken period, this could lead to seasonal bias if not corrected for properly. For 3 of the Estonian sites data fall-outs for a continuous period of about one month were seen. This was treated in a way similar to that of the ST/LT problem, using as reference station one of the Estonian stations of the project (Türisalu) which had no data fall-out, and assuming that all Estonian sites were approximately within the same wind climate region. Based on this, the reference site average wind speed ratio of the "clipped period" to that of the full year was used to adjust the Estonian data suffering from data fall-out by combining the LT/ST factor with this fall-out ratio.

3 UNDP Mast Sites and Wind Measurements

This chapter, for each of the 8 sites, gives a) the name of the site with the country abbreviation letters, b) a site description regarding the measuring mast as well as the terrain at and around the mast, c) a table listing the data files available from the site, the 1-year data set (data file) selected, and also the numbers relevant for adjustment for the LT/ST and data fall-out issues. All except one mast were equipped with 2 anemometers to be able to obtain – from measurements – a measure of the wind profile. Locations are given in Lat-Lon coordinates as well as in UTM-coordinates and Baltic-93 grid coordinates (corresponding to UTM "Zone 34.5", using WGS84 geodetic datum) and in addition, where relevant, also in System 42 grid coordinates (used in Soviet-type maps).

The tables list the measured wind data available, and the period where wind data are missing due to errors. For each mast a 1-year data series has been selected so as to minimize the number of missing data. The number of data records available and the number selected for use are listed in the table together with the raw average measured wind speed for the periods in question for the lower and upper anemometer (U#low and U#up, respectively). Also the judged error caused by data fall-out is given in the table.

As described in the preceding chapter, corrections were made for three of the Estonian stations to compensate for data fall-out. Only for one of the masts, Uulu, this effect was significant: -2.3% (on wind speed), while for the others it was 1% or less. The wind statistics for these three Estonian masts were subsequently corrected for the data fall-out to get the most reliable one-year statistics.

An additional table gives the background for the short-term adjustment.

3.1 Kretinga (Lt)

Location:

	E	N
Lat-Lon (degrees)	21°07'02.6"	55°54'27.2"
UTM Z.34 (WGS84)	507339 m	6195797 m
Baltic 93	319817 m	6199546 m
System 42 (metric)	4507466 m	6198410 m

About 4 km East of the coastal city of Palanga along the road to the Kretinga town.

Mast: An existing communication (antenna) mast in connection with a natural gas pressure control station.

Terrain: very flat and open grass land, but with some farm-houses and natural fences (bushes and low trees).

Measuring devices:

		Zero-direction
Anemometer, upper:	27.5 m	
Anemometer, lower:	15.0 m	
Wind vane:	27.5 m	189°

Measured data:

Table 3.1. Kretinga-measured data.

Kretinga – Lt					
	Start	End	Number	U#low	U#up
Available Kre-01-02.dat	2001-04-13/09:42	2002-04-28/15:40	54751	5.5	6.1
Missing	2001-05-11/10:59 2001-10-23/15:30 Total	2001-05-11/11:20 2001-10-23/15:43	3 2 5		
Selected for use Kre-01-02-Clipped.dat	2001-04-28/15:50	2002-04-28/15:40	52555	5.5	6.2
1-year fraction			99.99%		

The short-term adjustment was based on the Klaipéda met-station as follows:

Table 3.2. Kretinga - short-term adjustments based on Klaipéda.

Klaipéda	Period	Mean ref. speed
Long-term Short-term	1981-90; 1993-98; May 2001-Apr.02 May 2001-Apr.02	4.63 m/s 5.52 m/s
ST/LT ratios Speed Power density		 1.19 1.68

3.2 Vilkyciai (Lt)

Location:

	E	N
Lat-Lon (degrees)	21°24’19.6”	55°30’25.1”
UTM Z.34 (WGS84)	525608 m	6151284 m
Baltic 93	336149 m	6154268 m
System 42 (metric)	4525742 m	6153879 m

About 25 km SSE of Klaipeda city.

Mast: An existing GSM (mobile phone) 50-m antenna mast.

Terrain: Flat grass land but with scattered farm houses and rows of trees (wind breaks); a near-by farm house is situated some 50 m to the East of the mast; the location is about 1 km SE of Vilkyciai village.

Measuring devices:

		Zero-direction
Anemometer, upper:	43.0 m	
Anemometer, lower:	21.5 m	
Wind vane:	43.0 m	156°

Table 3.3. Vilkycia – measured data.

Vilkyciai					
	Start	End	Number	U#low	U#up
Available Vil-01-02.dat	2001-05-11/16:42	2002-04-28/15:50	44412	5.2	6.3
Missing	2001-07-29/12:30 2002-01-03/08:40 Total	2001-08-14/15:20 2002-01-30/19:01	2322 3951 6273		
Selected for use Vil-01-02.dat	2001-05-11/16:42	2002-04-28/15:50	44412	5.2	6.3
1-year fraction			84.44%		

The short-term adjustment for Vilkyciai was based on the Šilute met-station, also including adjustments for data fall-out, as follows:

Table 3.4. Vilkyciai – short-term adjustments based on Šilute.

Šilute	Period	Mean ref. speed
Long-term Short-term	1981-90; 1993-98; May 2001-Apr.02 May 2001-Apr.02	3.86 m/s 4.08 m/s
ST/LT ratios Speed Power density		 1.05 1.18

3.3 Taurage (Lt)

Location:

	E	N
Lat-Lon (degrees)	22° 03' 36.9"	55° 10' 46.3"
UTM Z.34 (WGS84)	567518 m	6115283 m
Baltic 93	376480 m	6116487 m
System 42 (metric)	4567669 m	6117863 m

About 15 km SW of Taurage city.

Mast: An ad-hoc 26-m mast constructed from a second-hand lattice-beam crane arm, secured by guy-wires.

Terrain: The mast was situated near the top of a round hill with open landscape in all directions. No wind-breaking obstacles except for the brick-foundation of an old wind mill some 250 m to the East of the mast.

Measuring devices:

		Zero-direction
Anemometer, upper:	28.0 m	
Anemometer, lower:	15.0 m	
Wind vane:	26.0 m*	275°

*Distance from upper anemometer estimated from photo.

Table 3.5. Taurage - measured data.

Taurage					
	Start	End	Number	U#low	U#up
Available Tau01-02.dat	2001-09-15/17:30	2002-10-17/12:10	56284	6.0	6.6
Missing	2001-09-26/10:10 2002-05-01/11:00 Total	2001-09-26/10:20 2002-05-07/09:00	2 852 854		
Selected for use Tau01-02-Clipped.dat	2001-10-01/00:00	2002-09-30/23:50	51708	6.0	6.7
1-year fraction			98.31%		

The short-term adjustment of Taurage was based on the Laukuva met-station as follows:

Table 3.6. Taurage - short-term adjustments based on Laukuva.

Laukuva	Period	Mean ref. speed
Long-term Short-term	1981-90; 1993-98; Oct.2001-Sep.02 Oct.2001-Sep.02	3.63 m/s 3.53 m/s
ST/LT ratios Speed Power density		 0.97 0.92

3.4 Särnate (La)

Location:

	E	N
Lat-Lon (degrees)	21°25'39.0"	57°07'01.0"
UTM Z.34 (WGS84)	525888 m	6330485 m
Baltic 93	344238 m	6333341 m

About 30 km SSW of Ventspils, about 750 m from the coast line.

Mast: A mobile 30-m telescope mast of military antenna-mast type, secured by guy-wires.

Terrain: The mast was situated in very flat grass-land terrain, with open landscape in all directions except for scattered bushes. A 3 m high garage building was situated about 15 m to the SE, and an old wind mill foundation, about 2.5 m high, was found about 30 m S of the mast. A few other abandoned farm buildings were located SW of the mast, but more than 100 m away.

Measuring devices:

		Zero-direction
Anemometer, upper:	31.3 m	
Anemometer, lower:	21.7 m	
Wind vane:	31.3 m	0°

Table 3.7. Särnate - measured data.

Särnate – La					
	Start	End	Number	U#low	U#up
Available Sär01-02.dat	2000-11-05/15:56	2002-06-07/13:20	69094	5.7	6.2
Missing	2001-01-11/00:10 2001-03-25/02:00 2001-04-05/23:30 2001-07-15/19:40 2001-11-04/20:20 2002-03-04/18:30 Total	2001-01-29/13:10 2001-03-25/03:00 2001-05-10/09:16 2001-07-21/11:50 2001-11-09/11:34 2002-04-09/14:20	2670 6 4955 817 668 5159 14275		
Selected for use Sär01-02-X.dat Sär02-X.dat (*) Total	 2001-03-04/18:30 2002-04-09/14:20	 2002-03-04/18:20 2002-05-10/09:10	 46121 4434 50555	 5.9 4.7 6.3	 6.4 5.2 5.8
1-year fraction			96.2%		

(*) added to compensate for a gap of missing data April-May 2001.

The short-term adjustment of Särnate was based on the average of the close-by Latvian met-stations Liepája and Pavilosta. Minor deviations in the averaging period from that of the Särnate data periods were found to have negligible impact on the ST/LTt ratios.

Table 3.8. Särnate - short-term adjustments based on Liepája and Pavilosta.

Liepája + Pavilosta	Period	Mean ref. speed	
		Liepája	Pavilosta
Long-term Short-term	1992-2001 May 2001-Apr.02	3.54 3.67	3.13 3.05
ST/LT ratios Speed Power density		 1.005 1.02	

3.5 Prangli (Ee)

Location:

	E	N
Lat-Lon (degrees)	25°00'22.8"	59°38'16.3"
UTM Z.35 (WGS84)	387595 m	6612771 m
Baltic 93	556741 m	6611513 m

On the Northern sea-shore of the island of Prangli, close to the harbour; about 10 km N of Tallinn city.
Mast: A 50-m GSM antenna mast, secured by guy-wires.

Terrain: In the Northern half of the horizon there is free wind access from the sea. In the Southern half the wind is affected by the terrain of the island, which is rather flat with only minor terrain relief. The terrain of the island is dominated by low wood and the Prangli village surrounding the harbour, but with scattered grassland clearings.

Measuring devices:

		Zero-direction
Anemometer, upper:	44.5 m	
Anemometer, lower*:	26.5 m	
Wind vane:	26.5 m	0°

*Not functioning.

Table 3.9. Prangli - measured data.

Prangli					
	Start	End	Number	U#low	U#up
Available Pra2001Apr—2002July.dat	2001-04-10/11:03	2002-08-01/ 00:00	60972	--	7.00
Missing	2001-08-02/ 20:40 2002-02-01/00:10 2002-03-01/ 00:10 Total	2001-08-22/ 00:28 2002-02-04/11:10 2002-04-01/23:10	2759 499 4603 7861		
Selected for use Pra2001May-2002Apr.dat	2001-05-01/00:00	2002-04-30/23:50	44773	--	7.29
1-year fraction Data fallout deviation			85.2%		-0.15%

The short-term adjustment of Prangli was based on the average of Liepája and Pavilosta Latvian met-stations – in lack of adequate data for 2001-2002 from near-by Estonian met-stations. In addition to the adjustment for the short term measurement period, the wind atlas analysis also included the adjustment for data block fall-out (see sect. 2.2).

Table 3.10. Prangli - short-term adjustment based on Liepája and Pavilosta.

Liepája + Pavilosta	Period	Mean ref. speed	
		Liepája	Pavilosta
Long-term Short-term	1992-2001 May 2001-Apr.02	3.54 3.10	3.13 3.05
ST/LT ratios Speed		1.03	
ST/LT + missing data ratio Speed Power density		1.03 1.09	

3.6 Türisalu (Ee)

Location:

	E	N
Lat-Lon (degrees)	24°20'06.6"	59°24'47.9"
UTM Z.35 (WGS84)	348765 m	6589105 m
Baltic 93	519025 m	6586124 m

A few hundred meters from the NW-facing Baltic sea-shore, about 24 km W of Tallinn. There is a little uncertainty regarding the exact location (about 100m), but this is regarded to have negligible impact on the result.

Mast: A standard 40-m meteorological tubular mast.

Terrain: The location is a former Soviet rocket station. The terrain is flat and open and covered by low-grass, but scattered remains of minor military bunkers and ramparts (up to 3 m high) break the uniformity. A wood belt some hundred meters to the NW separates the open area from the about 10 m high coastal escarpment.

Measuring devices:

		Zero-direction
Anemometer, upper:	40.5	
Anemometer, lower:	20.5	
Wind vane:	40.5	0°

Table 3.11. Türisalu - measured data.

Türisalu – Ee					
	Start	End	Number	U#low	U#up
Available Tür2000Oct-2002Aug.dat	2000-10-04/23:20	2002-09-01/00:00	96047	5.40	6.05
Missing	2001-01-12/13:50 Total	2001-02-10/13:40	4176 4176		
Selected for use Tür-2001May-2002Apr.dat	2001-05-01/00:10	2002-05-01/00:00	52557	5.58	6.27
1-year fraction Data fallout deviation			100.0 %	0%	0%

The short-term adjustment of Türisalu was based on the average of on the average of Liepája and Pavilosta Latvian met-stations – in lack of adequate data for 2001-2002 from near-by Estonian met-stations.

Table 3.12. Türisalu - short-term adjustments based on Liepája and Pavilosta.

Liepája + Pavilosta	Period	Mean ref. speed	
		Liepája	Pavilosta
Long-term Short-term	1992-2001 May 2001-Apr.02	3.54 3.10	3.13 3.05
ST/LT ratios Speed Power density		 1.03 1.09	

3.7 Virtsu (Ee)

Location:

	E	N
Lat-Lon (degrees)	23°31'00.0"	58°37'59.3"
UTM Z.35 (WGS84)	297807 m	6504453 m
Baltic 93	471937 m	6499304 m

About 6 km N of Virtsu town and about 500 m E of the coast line, about 120 km SW of Tallinn city.

Mast: A 52-m GSM mast.

Terrain: The mast is situated in flat terrain, in the middle of a large clearing for a power substation in a wooden area consisting of low, scattered trees. The nearby low substation buildings and installations are the closest wind obstacles; however, they are too low to affect the measurements in any practical magnitude.

Measuring devices:

		Zero-direction
Anemometer, upper:	52.3	
Anemometer, lower:	31.3	
Wind vane:	52.3	0°

Table 3.13. Virtsu - measured data.

Virtsu					
	Start	End	Number	U#low	U#up
Available Virtsu2001July-2002Aug.dat	2001-07-26/10:37	2002-09-01/00:00	54802	5.90	6.73
Missing	2001-10-19/16:20 Total	2001-11-09/14:17	3012 3012		
Selected for use Virtsu2001Aug-2002July.dat	2001-08-01/00:00	2002-07-31/23:50	49537	6.03	6.88
1-year fraction Data fallout deviation			94.2%	 -1.0%	 -1.0%

The short-term adjustment for Virtsu was based on the average of Liepája and Pavilosta Latvian met-stations – in lack of adequate data for 2001-2002 from near-by Estonian met-stations. In addition to the adjustment for the short term measurement period, the wind atlas analysis also included the adjustment for data fall-out (see sect. 2.2).

Table 3.14. Virtsu - short-term adjustments based on Liepája and Pavilosta.

Liepája + Pavilosta	Period	Mean ref. speed	
		Liepája	Pavilosta
Long-term Short-term	1992-2001 Aug 2001-July.02	3.54 3.85	3.13 3.18
ST/LT ratios Speed		1.051	
ST/LT (incl. Data fall-out) Speed Power density		1.04 1.12	

3.8 Uulu (Ee)

Location:

	E	N
Lat-Lon (degrees)	24°35'14.4"	58°17'34.2"
UTM Z.35 (WGS84)	358574 m	6463847 m
Baltic 93	534433 m	6461463 m

About 11 km SSW of Pärnu city, about 500 m E of the coast line.

Mast: A 50-m GSM mast.

Terrain: The mast is situated in flat terrain in a large clearing in a forest of about 15 m high coniferous trees. The clearing contains also some farm buildings some hundred meters to the South. The farm buildings are too low to present any sheltering for the wind measurements whereas the forest surrounding the clearing must be assumed to have an effect on the lower anemometer - but only to a smaller extent on the upper anemometer.

Measuring devices:

		Zero-direction
Anemometer, upper:	44.5 m	
Anemometer, lower:	26.5 m	
Wind vane:	44.5 m	0°

Table 3.15. Uulu - measured data.

Uulu					
	Start	End	Number	U#low	U#up
Available Uulu2001Mar-2002May.dat	2001-03-20/00:00	2002-05-31/23:50	60642	4.91	3.81
Missing	2001-11-02/17:40 Total	2001-11-19/13:18	2422 2422		
Selected for use Uulu2001May-2002Apr.dat	2001-05-01/00:00	2002-04-30/23:50	50130	5.02	3.86
1-year fraction Data fallout deviation			95.4%	-2.3%	-2.3%

The data records contains rather many "Calms" (=zero or very low wind speed) for the upper anemometer; it is likely that a number of these calm-measurements are due to anemometer mal-functioning.

The short-term adjustment for Uulu was based on the average of Liepája and Pavilosta Latvian met-stations – in lack of adequate data for 2001-2002 from near-by Estonian met-stations. In addition to the adjustment for the short term measurement period, the wind atlas analysis also included the adjustment for a missing data block (see sect. 2.2).

Inadequate terrain description of the clearing where the mast is located, as well as faulty calm-measurements, may have resulted in too low regional wind climate by up to 5% (in wind speed).

Table 3.16. Uulu - short-term adjustments based on Liepája and Pavilosta.

Liepája + Pavilosta	Period	Mean ref. speed	
		Liepája	Pavilosta
Long-term Short-term	1992-2001 May 2001-Apr.02	3.54 3.10	3.13 3.05
ST/LT ratios Speed		1.03	
ST/LT (incl. Data fall-out) Speed Power density		1.01 1.03	

4 Terrain Model

The terrain description used for the analysis of the measured wind data was obtained from available 1:50 000 topographical maps, modern official map series as well as available Soviet-type maps.

5 Wind Atlas Analysis

The analysis was made using WAsP version 8.

The results are given in terms of the *Observed Wind Climate* and *Regional Wind Climate*. The Observed wind climate consists of wind rose, all-direction wind speed distribution histogram and annual wind speed variation. The annual variation is presented in terms of the monthly mean speed from the upper anemometer. The Regional Wind Climate contains wind statistical values adjusted for local terrain effects at and around the measuring site for five standard heights above terrain in combination with four surface roughness values (classes). Roughness values are explained in table 5.1. In the plot of the observed wind speed distribution the so-called Weibull parameters [1] characterizing the distribution are given: the scale parameter A and the shape parameter k, and also the corresponding mean speed U and power density P. The same four properties are also used in the regional wind climate tables for each of the height-roughness combinations. As described in Chapters 2 and 3, proper adjustments were made to produce long-term regional wind climates. The appropriate compensations were introduced in the wind atlas analysis process. Please note, that the observed wind climate, incl. the annual wind speed variation, is not compensated for short-term and data fall-out effects.

Table 5.1. Roughness class explanations.

Roughness Class	Roughness length	Description
0	0 cm	Water surfaces - sea or lakes
1	3 cm	Very smooth grass-land with few building and trees
2	10 cm	Farm land with scattered houses and some higher vegetation (trees)
3	40 cm	Closed landscape with vegetation; villages; woods.

As measurements for two heights above terrain were performed at all sites but one it is possible – to some extent – to check the quality of the flow modelling inherent in the terrain compensation scheme. The uncertainty limits given with the regional wind climate tables reflect this flow modelling quality – whereas they should not be used as a measure of the full uncertainty.

5.1 Kretinga

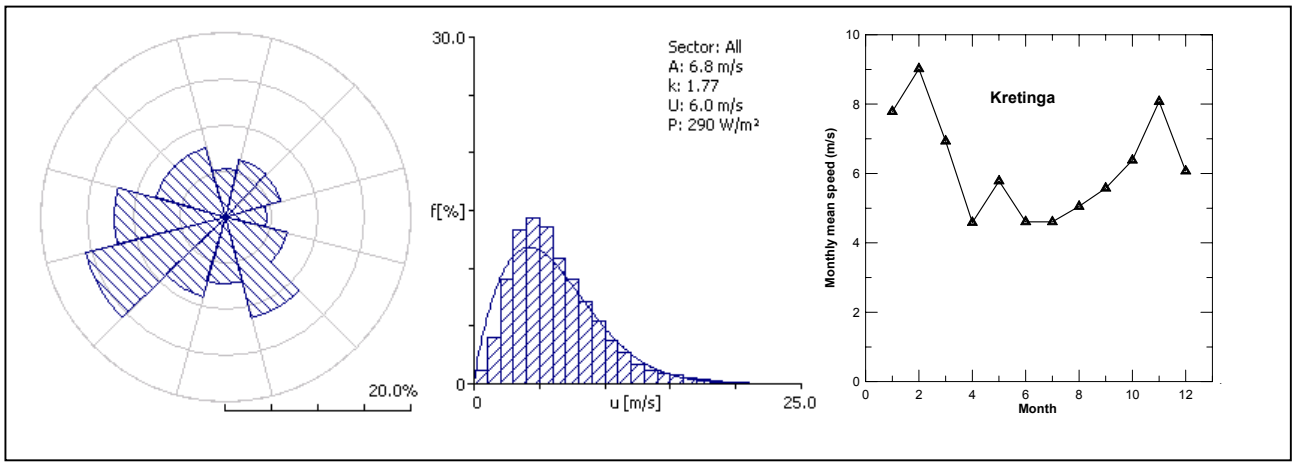

Figure 5.1.Kretinga observed wind climate.

Mean speed uncertainty*): 2%
Power density uncertainty*): 2%

Table 5.2 Kretinga regional wind climate.

	Roughness class	0	1	2	3
	Roughness length (m)	0.00	0.03	0.10	0.40
10 m	Weibull A [m/s] Weibull k Mean speed U [m/s] Power density P [W/m²]	6.8 1.97 6.0 262	4.8 1.70 4.2 107	4.1 1.70 3.7 71	3.3 1.71 2.9 35
25 m	Weibull A [m/s] Weibull k Mean speed U [m/s] Power density P [W/m²]	7.5 2.03 6.6 334	5.7 1.82 5.1 169	5.1 1.81 4.6 124	4.3 1.80 3.8 74
50 m	Weibull A [m/s] Weibull k Mean speed U [m/s] Power density P [W/m²]	8.0 2.08 7.1 405	6.6 2.03 5.9 234	6.0 1.98 5.4 182	5.2 1.94 4.6 121
75 m	Weibull A [m/s] Weibull k Mean speed U [m/s] Power density P [W/m²]	8.4 2.05 7.4 471	7.3 2.17 6.5 294	6.7 2.15 5.9 226	5.8 2.08 5.2 157
200 m	Weibull A [m/s] Weibull k Mean speed U [m/s] Power density P [W/m²]	9.6 1.92 8.5 753	9.8 2.05 8.7 744	8.9 2.07 7.9 553	7.7 2.11 6.8 356

*) Wind profile modelling uncertainty derived from comparisons of upper and lower anemometer results. Other uncertainties – e.g. measuring uncertainties – should be added to this value.

5.2 Vilkyciai

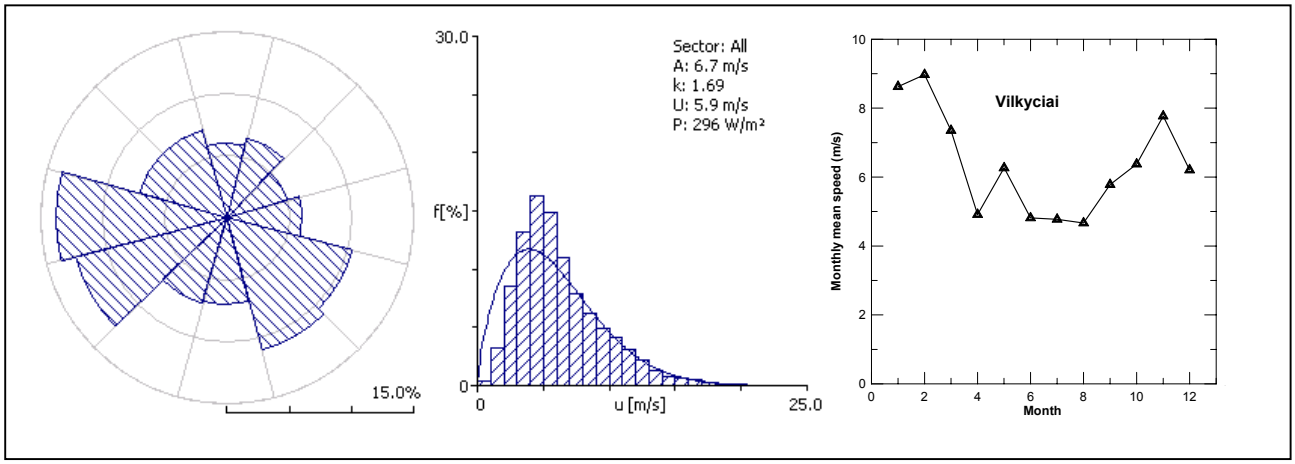

Figure 5.2.Vilkyciai observed wind climate.

Mean speed uncertainty*): 5%
Power density uncertainty*): 12%

.

Table 5.3. Vilkyciai regional wind climate.

	Roughness class	0	1	2	3
	Roughness length (m)	0.00	0.03	0.10	0.40
10 m	Weibull A [m/s] Weibull k Mean speed U [m/s] Power density P [W/m²]	7.5 1.90 6.6 358	5.2 1.68 4.7 146	4.6 1.69 4.1 96	3.6 1.70 3.2 47
25 m	Weibull A [m/s] Weibull k Mean speed U [m/s] Power density P [W/m²]	8.2 1.94 7.2 456	6.2 1.78 5.6 228	5.6 1.78 5.0 168	4.7 1.78 4.2 100
50 m	Weibull A [m/s] Weibull k Mean speed U [m/s] Power density P [W/m²]	8.8 1.99 7.8 548	7.2 1.94 6.4 314	6.6 1.92 5.8 244	5.7 1.89 5.1 161
100 m	Weibull A [m/s] Weibull k Mean speed U [m/s] Power density P [W/m²]	9.4 1.96 8.4 702	8.5 2.08 7.5 473	7.8 2.10 6.9 366	6.9 2.10 6.1 249
200 m	Weibull A [m/s] Weibull k Mean speed U [m/s] Power density P [W/m²]	10.4 1.90 9.2 961	10.3 2.05 9.2 874	9.5 2.07 8.4 665	8.3 2.09 7.3 441

5.3 Taurage

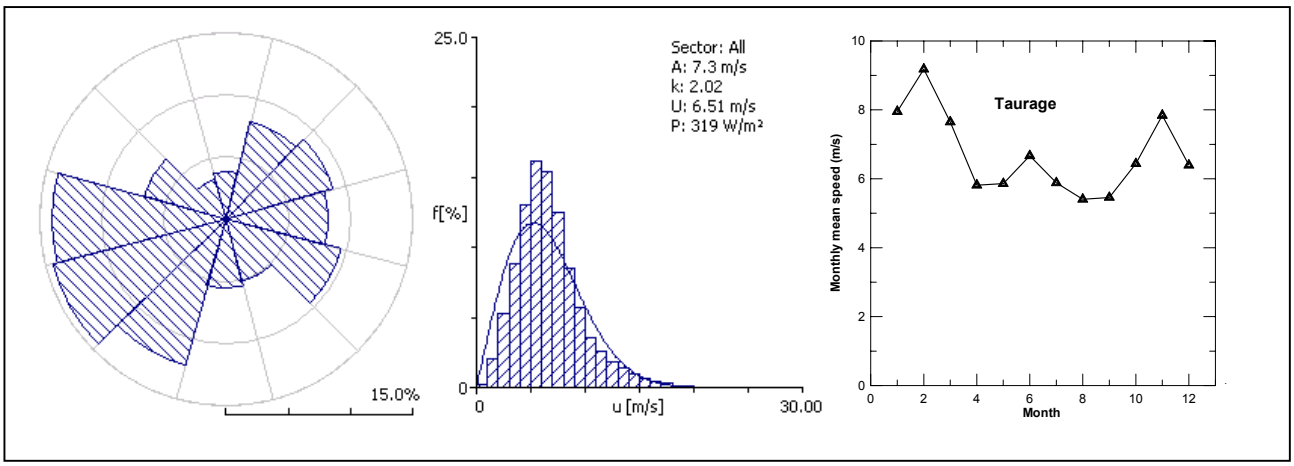

Figure 5.3. Taurage observed wind climate

Mean speed uncertainty*): 1.4%
Power density uncertainty*): 4 %

Table 5.4.Taurage regional wind climate.

	Roughness class	0	1	2	3
	Roughness length (m)	0.00	0.03	0.10	0.40
10 m	Weibull A [m/s] Weibull k Mean speed U [m/s] Power density P [W/m²]	8.5 2.24 7.6 456	6.0 1.97 5.3 181	5.2 1.97 4.7 119	4.1 1.99 3.7 58
25 m	Weibull A [m/s] Weibull k Mean speed U [m/s] Power density P [W/m²]	9.3 2.28 8.3 585	7.2 2.08 6.3 287	6.4 2.07 5.7 210	5.4 2.08 4.8 125
50 m	Weibull A [m/s] Weibull k Mean speed U [m/s] Power density P [W/m²]	10.0 2.35 8.9 702	8.2 2.27 7.3 400	7.5 2.23 6.6 309	6.5 2.21 5.8 204
100 m	Weibull A [m/s] Weibull k Mean speed U [m/s] Power density P [W/m²]	10.8 2.32 9.5 890	9.6 2.48 8.5 595	8.8 2.47 7.8 462	7.8 2.45 6.9 319
200 m	Weibull A [m/s] Weibull k Mean speed U [m/s] Power density P [W/m²]	11.8 2.26 10.5 1193	11.6 2.47 10.3 1066	10.6 2.47 9.4 816	9.3 2.47 8.3 551

5.4 Särnate

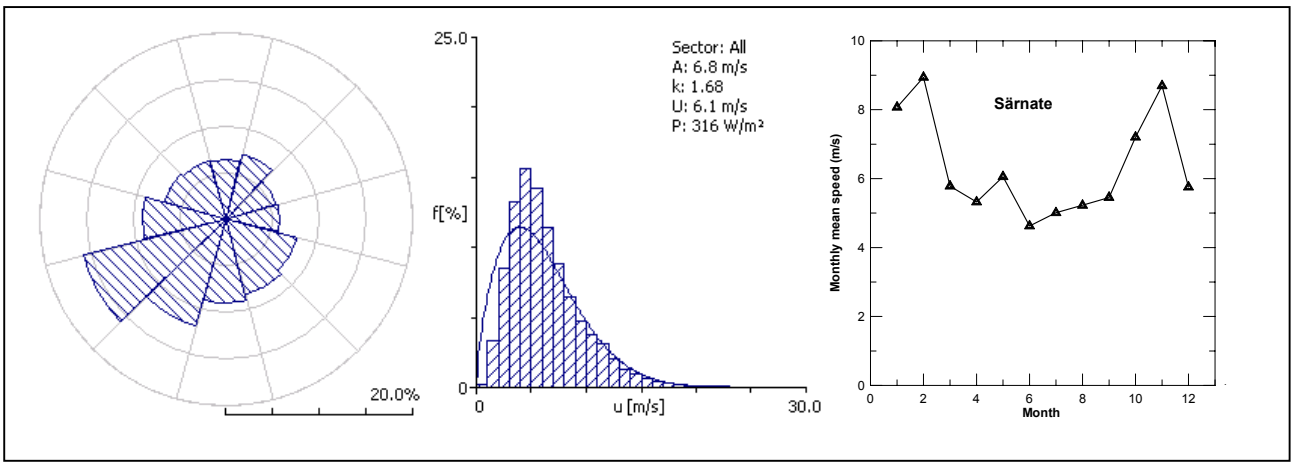

Figure 5.4. Särnate observed wind climate.

Mean speed uncertainty*): 1%
Power density uncertainty*): 3%

Table 5.5. Särnate regional wind climate.

	Roughness class	0	1	2	3
	Roughness length (m)	0.00	0.03	0.10	0.40
10.0 m	Weibull A [m/s] Weibull k Mean speed U [m/s] Power density P [W/m²]	7.4 2.05 6.56 322	5.2 1.75 4.60 132	4.5 1.76 4.02 88	3.6 1.78 3.17 42
25.0 m	Weibull A [m/s] Weibull k Mean speed U [m/s] Power density P [W/m²]	8.1 2.11 7.18 411	6.2 1.88 5.50 208	5.6 1.87 4.96 153	4.7 1.88 4.17 91
50.0 m	Weibull A [m/s] Weibull k Mean speed U [m/s] Power density P [W/m²]	8.7 2.17 7.71 497	7.2 2.09 6.35 287	6.5 2.06 5.80 222	5.7 2.03 5.03 147
100.0 m	Weibull A [m/s] Weibull k Mean speed U [m/s] Power density P [W/m²]	9.4 2.11 8.35 647	8.5 2.23 7.51 448	7.8 2.26 6.90 343	6.8 2.29 6.06 230
200.0 m	Weibull A [m/s] Weibull k Mean speed U [m/s] Power density P [W/m²]	10.4 2.01 9.21 912	10.5 2.15 9.29 876	9.6 2.18 8.47 655	8.3 2.22 7.37 424

5.5 Prangli

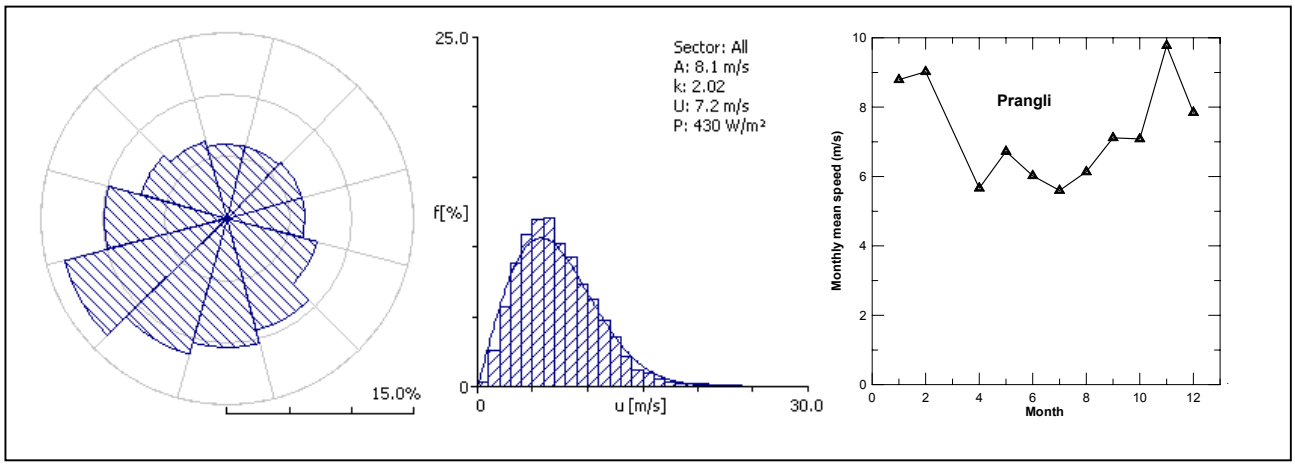

Figure 5.5. Prangli observed wind climate.

No uncertainties available.

Table 5.6. Prangli regional wind climate.

	Roughness class	0	1	2	3
	Roughness length (m)	0.00	0.03	0.10	0.40
10.0 m	Weibull A [m/s] Weibull k Mean speed U [m/s] Power density P [W/m²]	7.1 1.99 6.32 297	5.0 1.69 4.44 124	4.3 1.69 3.87 82	3.4 1.71 3.06 40
25.0 m	Weibull A [m/s] Weibull k Mean speed U [m/s] Power density P [W/m²]	7.8 2.05 6.92 378	6.0 1.82 5.31 193	5.4 1.81 4.77 142	4.5 1.80 4.02 85
50.0 m	Weibull A [m/s] Weibull k Mean speed U [m/s] Power density P [W/m²]	8.4 2.11 7.43 456	6.9 2.03 6.13 265	6.3 1.99 5.59 206	5.5 1.95 4.85 137
100.0 m	Weibull A [m/s] Weibull k Mean speed U [m/s] Power density P [W/m²]	9.1 2.05 8.05 596	8.2 2.17 7.26 413	7.5 2.19 6.65 316	6.6 2.21 5.85 213
200.0 m	Weibull A [m/s] Weibull k Mean speed U [m/s] Power density P [W/m²]	10.0 1.95 8.88 841	10.1 2.09 8.99 813	9.2 2.11 8.18 608	8.0 2.15 7.12 394

5.6 Türisalu

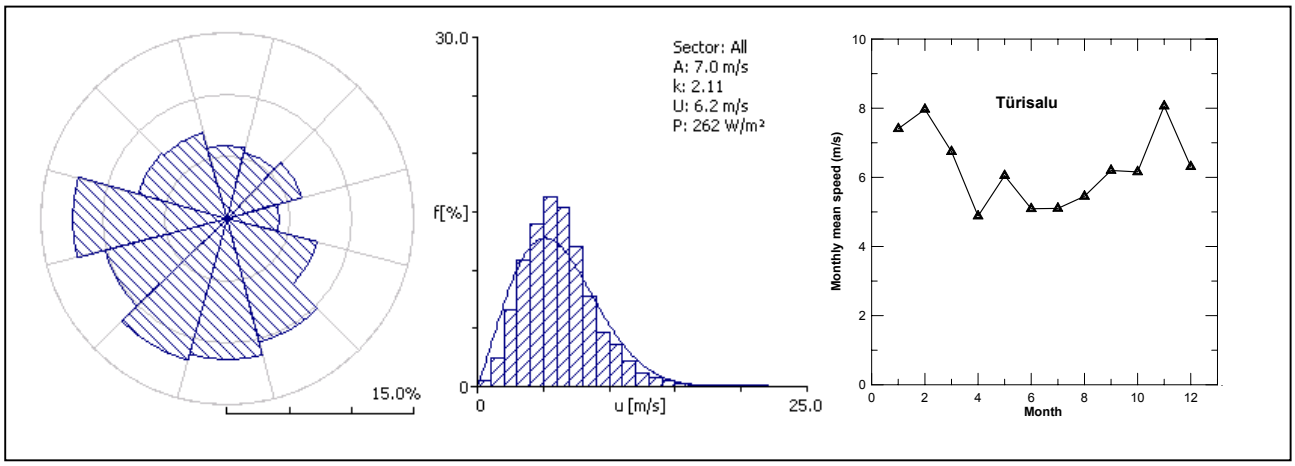

Figure 5.6. Türisalu observed wind climate.

Mean speed uncertainty*): 3%
Power density uncertainty*): 9%

Table 5.7.Türisalu regional wind climate.

	Roughness class	0	1	2	3
	Roughness length (m)	0.00	0.03	0.10	0.40
10.0 m	Weibull A [m/s] Weibull k Mean speed U [m/s] Power density P [W/m²]	7.3 2.22 6.49 289	5.1 1.87 4.54 118	4.5 1.87 3.96 78	3.5 1.88 3.13 38
25.0 m	Weibull A [m/s] Weibull k Mean speed U [m/s] Power density P [W/m²]	8.0 2.29 7.10 369	6.1 2.02 5.43 186	5.5 2.01 4.89 136	4.6 1.99 4.11 82
50.0 m	Weibull A [m/s] Weibull k Mean speed U [m/s] Power density P [W/m²]	8.6 2.35 7.63 449	7.1 2.26 6.28 260	6.5 2.21 5.74 201	5.6 2.17 4.97 133
100.0 m	Weibull A [m/s] Weibull k Mean speed U [m/s] Power density P [W/m²]	9.3 2.28 8.27 587	8.4 2.40 7.46 413	7.7 2.43 6.84 316	6.8 2.46 6.00 211
200.0 m	Weibull A [m/s] Weibull k Mean speed U [m/s] Power density P [W/m²]	10.3 2.16 9.14 830	10.5 2.30 9.26 818	9.5 2.33 8.43 611	8.3 2.37 7.32 395

5.7 Virtsu

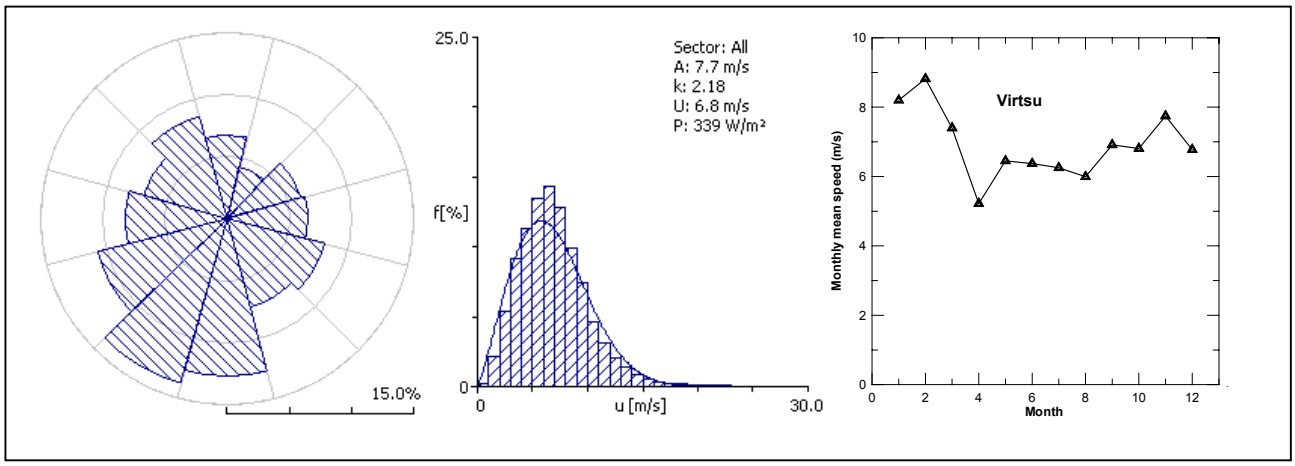

Figure 5.7. Virtsu observed wind climate.

Uncertainty, speed*): 2 %.
Uncertainty, power density*): 7 %.

Table 5.8. Virtsu regional wind climate.

	Roughness class	0	1	2	3
	Roughness length (m)	0.00	0.03	0.10	0.40
10.0 m	Weibull A [m/s] Weibull k Mean speed U [m/s] Power density P [W/m²]	7.3 2.22 6.51 293	5.1 1.87 4.56 119	4.5 1.87 3.97 79	3.5 1.87 3.14 39
25.0 m	Weibull A [m/s] Weibull k Mean speed U [m/s] Power density P [W/m²]	8.0 2.28 7.12 374	6.1 2.01 5.45 188	5.5 1.99 4.90 138	4.7 1.99 4.13 83
50.0 m	Weibull A [m/s] Weibull k Mean speed U [m/s] Power density P [W/m²]	8.6 2.35 7.65 454	7.1 2.25 6.30 262	6.5 2.20 5.75 203	5.6 2.15 4.98 135
100.0 m	Weibull A [m/s] Weibull k Mean speed U [m/s] Power density P [W/m²]	9.4 2.28 8.29 592	8.4 2.40 7.47 415	7.7 2.42 6.84 318	6.8 2.45 6.01 213
200.0 m	Weibull A [m/s] Weibull k Mean speed U [m/s] Power density P [W/m²]	10.3 2.16 9.16 835	10.5 2.30 9.27 820	9.5 2.32 8.43 613	8.3 2.37 7.33 397

5.8 Uulu

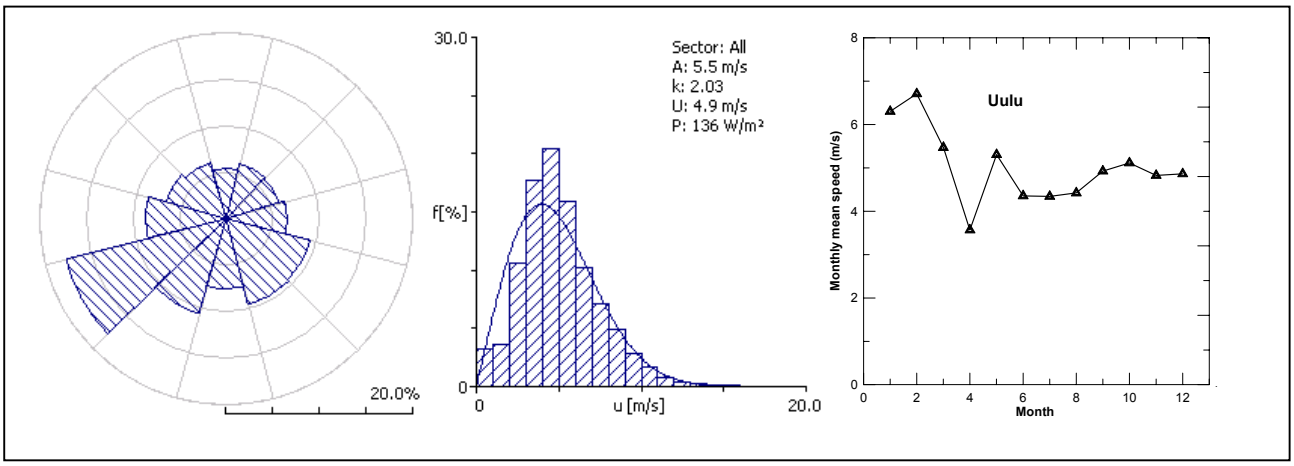

Figure 5.8. Uulu observed wind climate.

No uncertainties available.

Table 5.9. Uulu regional wind climate.

	Roughness class	0	1	2	3
	Roughness length (m)	0.00	0.03	0.10	0.40
10.0 m	Weibull A [m/s] Weibull k Mean speed U [m/s] Power density P [W/m²]	6.1 2.18 5.40 170	4.3 1.88 3.81 69	3.7 1.85 3.31 46	3.0 1.87 2.62 23
25.0 m	Weibull A [m/s] Weibull k Mean speed U [m/s] Power density P [W/m²]	6.7 2.25 5.91 217	5.1 2.01 4.56 110	4.6 1.97 4.09 81	3.9 1.98 3.46 49
50.0 m	Weibull A [m/s] Weibull k Mean speed U [m/s] Power density P [W/m²]	7.2 2.30 6.35 264	6.0 2.24 5.28 155	5.4 2.17 4.79 120	4.7 2.14 4.17 80
100.0 m	Weibull A [m/s] Weibull k Mean speed U [m/s] Power density P [W/m²]	7.8 2.24 6.89 345	7.1 2.38 6.27 247	6.5 2.36 5.72 189	5.7 2.42 5.04 127
200.0 m	Weibull A [m/s] Weibull k Mean speed U [m/s] Power density P [W/m²]	8.6 2.12 7.61 487	8.8 2.28 7.80 492	8.0 2.27 7.05 365	6.9 2.33 6.15 237

6 Supplementary data from met-office stations

In order to have some inland representation of the wind resources, the wind measurements from the present project were supplemented with data kindly made available from the national met-offices. These data have been converted to 50 m above terrain, where necessary by assuming a flat surface with roughness class 2 (10 cm).

6.1 Lithuania

Average wind speeds for the period 1981-1990 + 1993-1998 were obtained from 16 met-office stations. Measurements at 10 m above terrain were converted to 50 m above terrain. The data were made available by the Lithuanian Hydrometeorological Institute [3], [4].

Table 6.1. Wind data from Lithuanian met-office stations.

	Location				Mean speed m/s	
	Lon-Lat		Baltic 93			
Height (m)					10	50
Station	Lon	Lat	E	N		
Birzai	24°46'	56°12'	547568	6228604	3.57	4.81
Telsiai	22°15'	55°58'	390769	6203752	3.12	4.21
Siauliai	23°19'	55°56'	457309	6198871	2.87	3.87
Panevezys	24°23'	55°45'	524062	6178322	3.34	4.50
Klaipeda	21°04'	55°44'	315826	6180299	4.55	6.14
Vezaiciai	21°29'	55°42'	341846	6175561	3.42	4.61
Laukava	22°14'	55°37'	388735	6164833	3.62	4.89
Utena	25°36'	55°32'	600983	6155305	2.64	3.57
Raseiniai	23°07'	55°23'	444035	6137805	3.96	5.34
Silute	21°28'	55°21'	339379	6136662	3.84	5.18
Ukmergé	24°46'	55°15'	548737	6122880	3.78	5.10
Kaunas	23°50'	54°53	489308	6081822	3.93	5.31
Kybartai	22°47'	54°38'	421465	6054670	3.30	4.45
Vilnius	25°06'	54°38'	571004	6054546	3.45	4.66
Varena	24°33'	54°15'	535836	6011477	2.52	3.40
Lazdijai	23°31'	54°14'	468495	6009591	3.38	4.57

6.2 Latvia.

Average wind speeds for the period 1992-2001 were obtained from 8 met-office stations. Measurements at 10 m above terrain were converted to 50 m above terrain. The data were made available by the Latvian Met-office [5].

Table 6.2. Wind data from Latvian met-office stations.

	Location				Mean speed m/s	
	Lon-Lat		Baltic 93			
Height (m)					10	50
Station	Lon	Lat	E	N		
Ainazi	24°22'	57°52'	521754	6413925	4.22	5.69
Bauska	24º13'	56º24'	513373	6250621	2.75	3.71
Daugavapils	26º37'	55º52'	663736	6194336	2.68	3.61
Dobele	23º19'	56º37'	458064	6274925	3.63	4.90
Gulbene	26º43'	57º08'	664416	6335503	2.98	4.03
Kolka	22º36'	57º45'	416675	6401739	3.79	5.12
Liepaja	21º01'	56º29'	316297	6263864	3.54	4.78
Pavilosta	21º11'	56º53'	328386	6307934	3.13	4.23

6.3 Estonia

Regional wind climate speeds (prepared by the wind atlas method) based on measured wind speed for various long-range periods between 1980 and 2001 were obtained from 14 stations met-stations via the Estonian Wind Atlas [6]. Most of the data cover the 10-year period 1981-1990, the shortest period (1 data set) being $4^1/_3$ years. The regional wind speeds are referred to 50 m above terrain of roughness class 2 (10 cm roughness height).

Table 6.3. Wind data from Estonian met-office stations.

	Location				Mean speed m/s
	Lon-Lat		Baltic 93		
Height (m)					50
Station	Lon	Lat	E	N	
Kodijärve	26°33'	58°11'	649935	6451957	5.89
Kunda	26°33'	59°31'	644280	6600353	5.88
Kuressaare	22°30'	58°14'	411918	6455669	5.66
Kuusiku	24°44'	58°58'	542172	6536572	5.03
Kärdla	22°49'	59°00'	432017	6540654	5.92
Pärnu	24°30'	58°22'	529252	6469642	5.29
Ristna	22°04'	58°55'	388667	6532382	5.68
Tallinn	24°36'	59°24'	534070	6584747	6.15
Tartu	26°44'	58°18'	660185	6465363	5.44
Valga	26°02'	57°47'	620903	6406404	4.10
Villjandi	25°36'	58°22'	593601	6470646	3.95
Vilsandi	21°49'	58°23'	372341	6473461	6.86
Virtsu	23°31'	58°34'	471883	6491903	4.72
Väike-Maarja	26°14'	59°08'	627798	6557037	5.56

7 Wind resource colour maps

In the following the results of the wind atlas study are summarized in four colour-maps, one for the entire region and one for each of the three countries. The colour-coding represents the long-term wind resource in terms of the 50-m mean wind speed of the regional wind climates referring to a standard condition of flat, homogenous terrain of roughness class 2 (10 cm roughness length). The term "long term" indicates that care has been taken to assure that the colour maps do not only represent the wind resource for the few years the UNDP-project have been running, but the long-term wind climate (10 years or more).

Conversion to other standard conditions than roughness class 2 and 50 m above terrain are given in the table below.

The colour maps have the location of the met-stations indicated by star-markers; filled stars for the met-stations established and operated during the present UNDP-project and for the private met-station at Türisalu, and open stars for the national met-institute stations used for supplementing the data from the UNDP-stations.

The all-over precision of the wind resource maps cannot be derived in a strict, statistical manner. Instead, experience is used for the agreement between wind atlases values derived using the procedures of this study and actual wind data. The precision of the mean wind speed in such cases is somewhere between 5 and 10% - and in the present study, where a mixture of data from own as well as from foreign sources, and where the distances between the measuring stations are sometimes rather large, a precision better than the one stated above is very hard to achieve.

As no detailed knowledge of the processing of the met-institute-stations is available it is not advisable to use the shown estimated in-land wind resources for more than a guide as to how fast the wind resource decreases with the distance form the Baltic sea. More specifically, no significance should be put in the minima and maxima seen around some of the met-institute-stations in the colour-maps (e.g. the minimum at Siauliai and the maximum at Birzai in Lithuania); these features are merely a consequence of the general uncertainty of the entire processing procedure, especially for the in-land stations.

Table 7.1. Conversion of mean wind speed from regional wind resource colour maps.

Roughness class	2			1			0 (Water)		
Roughness length (m)	0.1			0.03			0		
Height above terrain (m)	50	10	100	50	10	100	50	10	100
Mean speed (m/s)	**4.0**	2.8	4.8	4.4	3.2	5.2	5.4	4.6	5.8
	5.0	3.5	5.9	5.5	4.1	6.5	6.7	5.7	7.2
	6.0	4.2	7.1	6.6	4.9	7.8	8.1	6.8	8.7
	7.0	4.9	8.3	7.7	5.7	9.1	9.4	8.0	10.1

The conversion is from the standard condition used in the colour maps to alternative height-above-terrain/roughness combinations. An explanation of the characteristics of the different roughness classes is given in the table 5.1. The speed-up effect of hill-location is typically an increase in wind speed of 10% to 15%, but in very favourable locations up to 30% increase may be reached.

7.1 All Baltic countries.

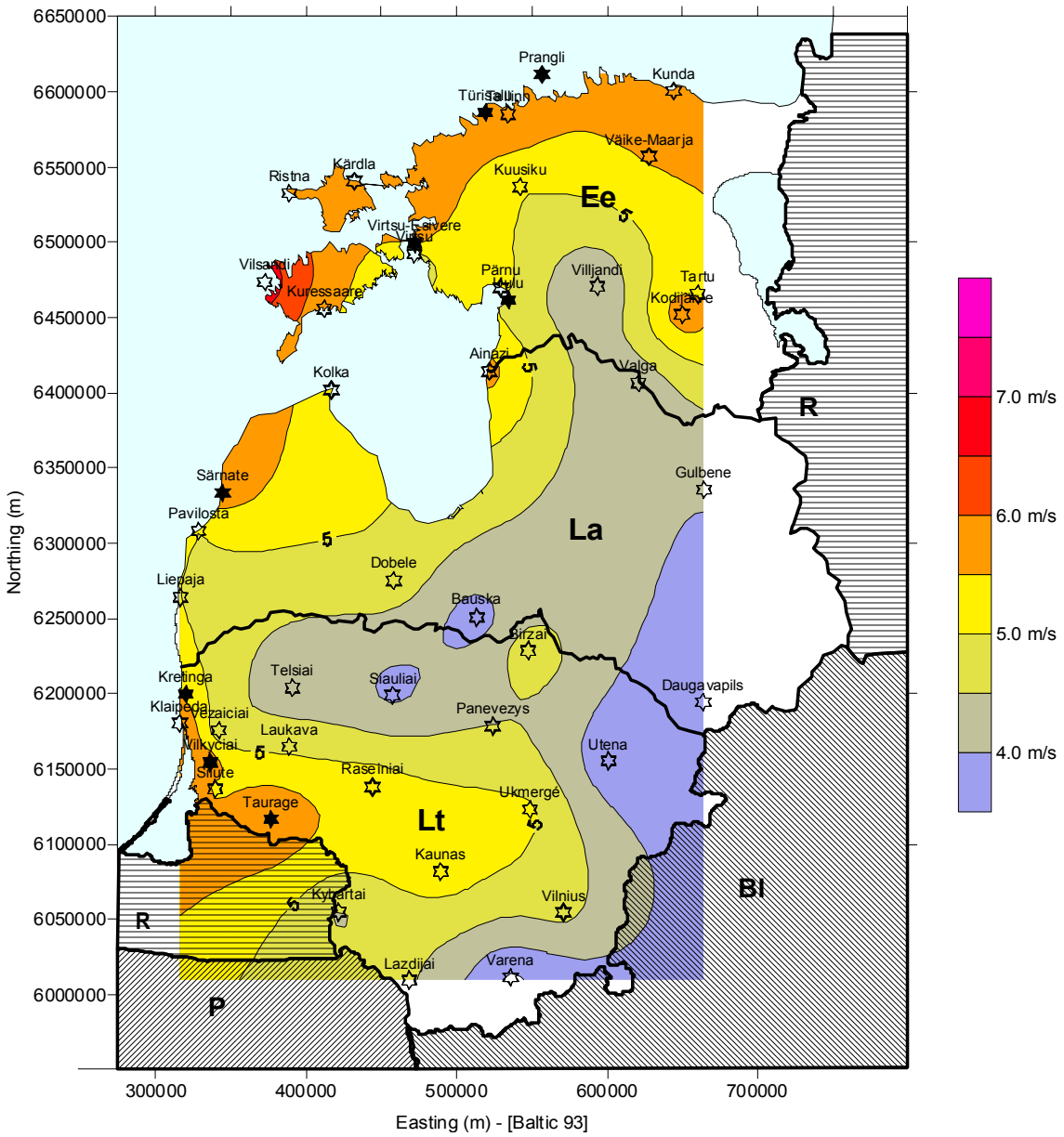

Figure 7.1. Wind resources in all three Baltic countries.
Given by the regional wind climate mean wind speed at 50 m above flat terrain of homogenous roughness of class 2 (10 cm roughness length).

Country designations:
Ee: Estonia; La: Latvia; Lt: Lithuania;
R: Russia; Bl: Belarus; P: Poland.

7.2 Individual countries

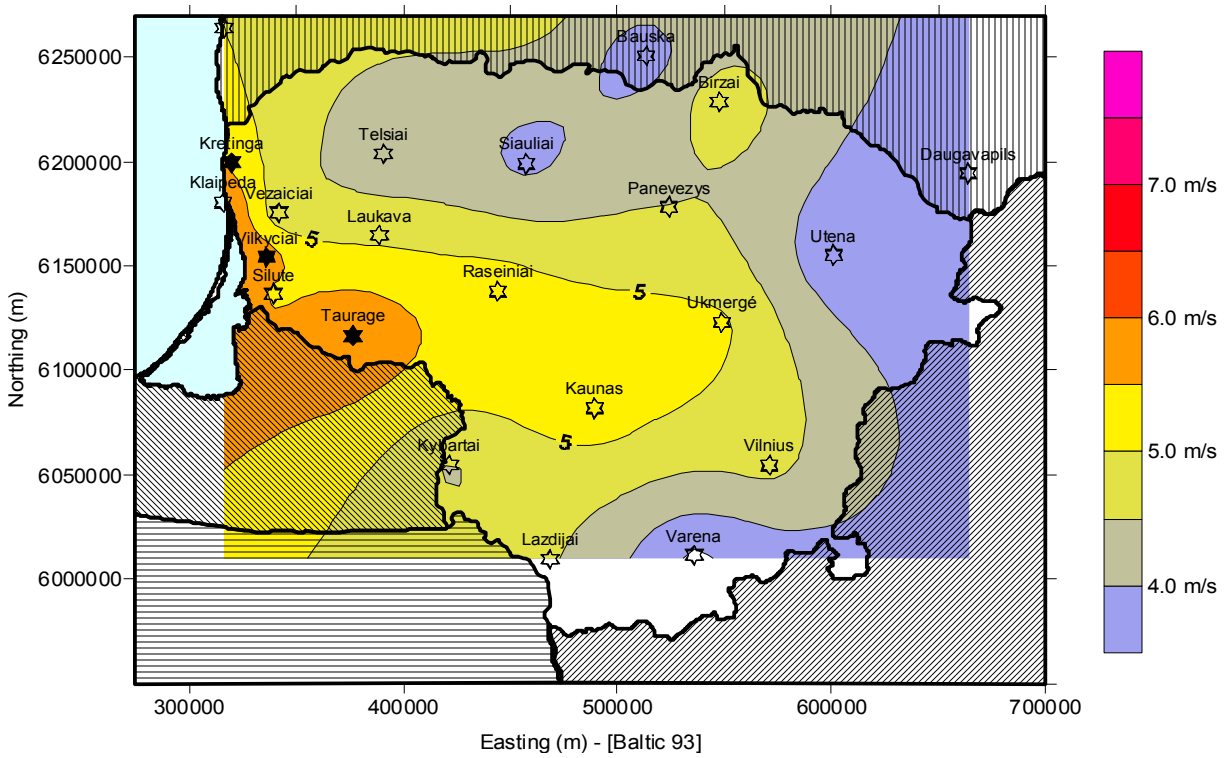

Figure 7.2. Wind resources in ***Lithuania****.*
Given by the regional wind climate mean wind speed at 50 m above flat terrain of homogenous roughness of class 2 (10 cm roughness length). The "cold" and "hot" spots (around the met-stations Siauliai and Birziai) is not believed to be a true feature but due to the general uncertainty.

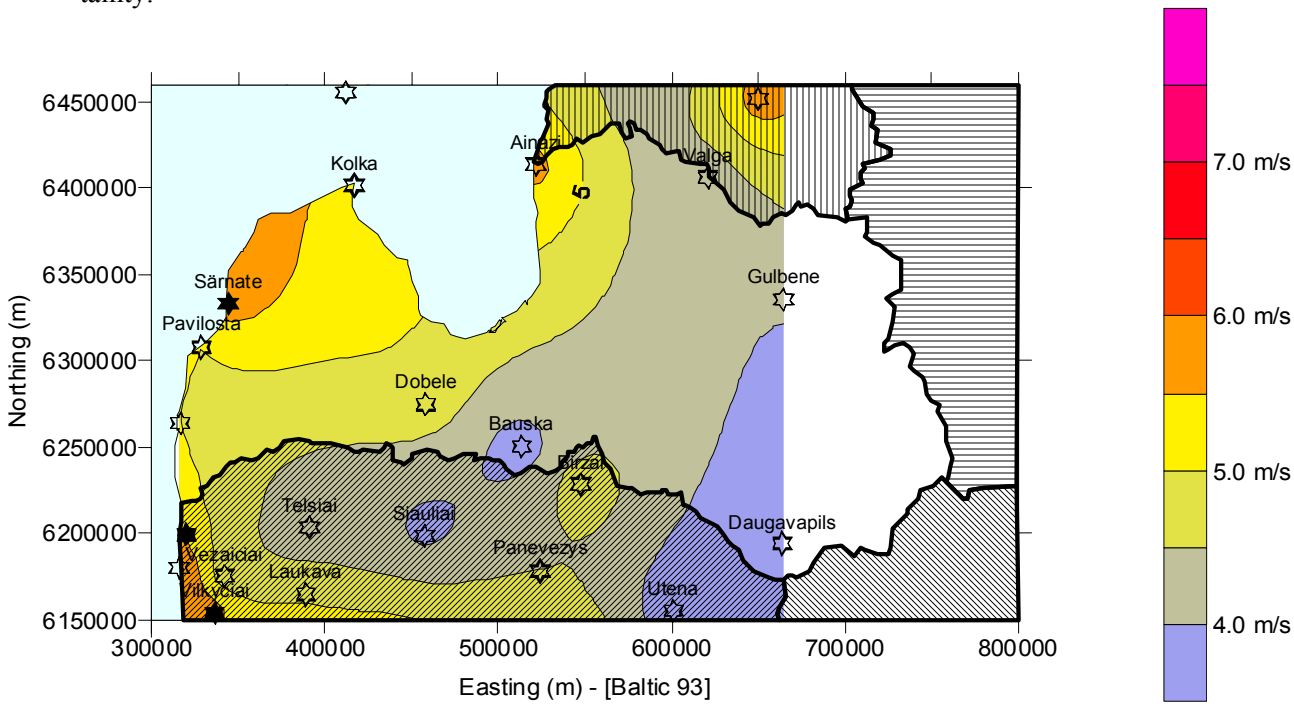

Figure 7.3. Wind resources in ***Latvia****.*
Given by the regional wind climate mean wind speed at 50 m above flat terrain of homogenous roughness of class 2 (10 cm roughness length). The "cold" spot (around the met-station Bauska) is not believed to be a true feature but due to the general uncertainty.

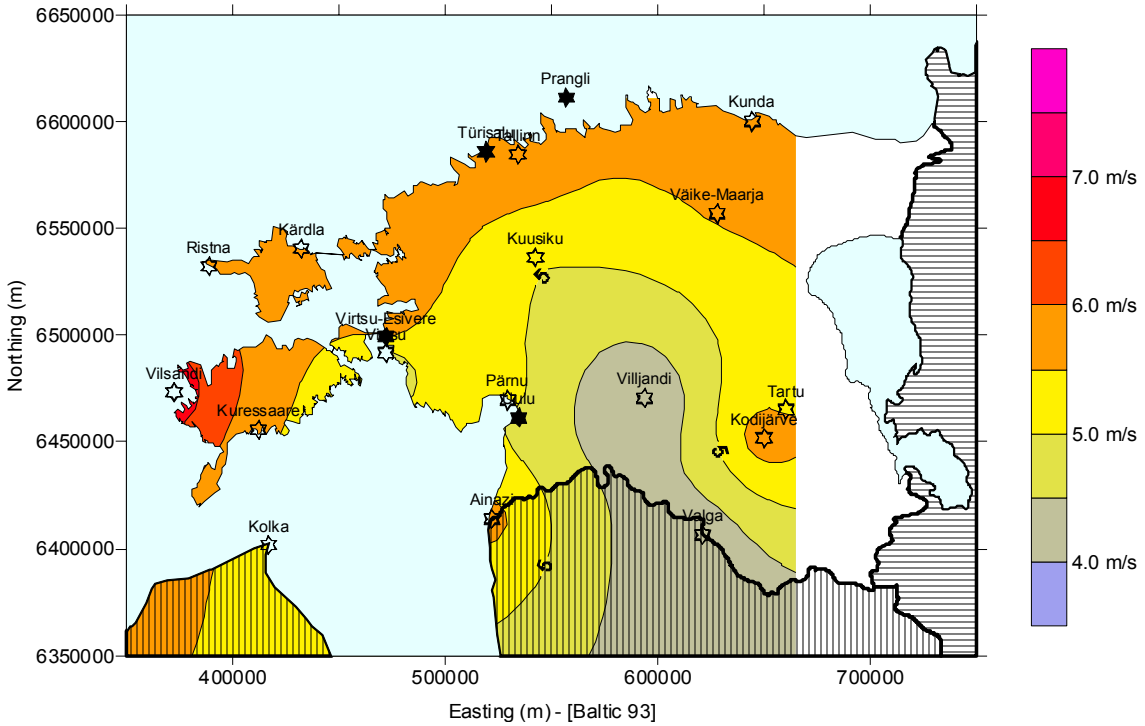

Figure 7.4. Wind resources in ***Estonia****.*

Given by the regional wind climate mean wind speed at 50 m above flat terrain of homogenous roughness of class 2 (10 cm roughness length). The "hot" spot (around the met-station Kodijärve) is not believed to be a true feature but due to the general uncertainty.

8 Conclusion

A wind atlas of the wind resources in the three Baltic countries, Estonia, Latvia and Lithuania, has been prepared on basis of a measurement campaign from 2000 to 2002. The work was initiated and sponsored by the Global Environment Facility through UNDP, which has been responsible for the management and supervision of the various activities. 8 measurement stations were established, 3 in Lithuania, 1 in Latvia and 4 in Estonia, in the coastal area, where the highest wind resource is to be expected.

In order to achieve a broad coverage of the countries it was found reasonable, for 5 of the stations, to use existing masts (mostly GSM-masts) in order to be able to deploy as many measuring stations as possible. This means that the obtained precision is not that technically obtainable from using dedicated masts. However it was judged, that the overall precision would be acceptable when considering that the obtained precision would in any case be limited by the combination with existing external data from met-institute stations, external data where the precision would be out of control of the present project. In all, this procedure is believed to have improved the usefulness - and in fact also the quality - of the wind atlas.

The overall precision of the resource maps is judged to be 5-10 % regarding the mean wind speeds obtained from the project. The in-land wind speed values in the resource maps, obtained from the national met-institutes, should be taken with precaution and only used to judge how fast the wind resource decreases with distance from the coast of the Baltic Sea.

It is the hope that the present wind atlas will be a valuable help in future wind energy projects in the three Baltic countries by establishing a public database on the wind resources for wind energy project developers, investors and public authorities. The data files for the 8 measuring stations, wind measurements, histograms of wind measurements, the resulting regional wind climates ("Wind Atlases") and digital maps, will be available from Risø National Laboratory through the UNDP with the exception of the raw data files of the Türisalu measurements. These data are the property of "AS Tuulepargid" and any requests for obtaining them data should be directed to "AS Tuulepargid".

9 References

[1] I.Troen, E.L. Petersen: European Wind Atlas. Risø National Laboratory 1989.

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[3] Lithuanian Hydrometeorological Institute: Wind Climatology 1961-1990 (in Lithuanian: Lietuvos Hidrometeorologijos Tarnyba: Klimato Zinynas Vejas. 1961-1990 m.) Vilnius 1996.

[4] Lithuanian Hydrometeorological Institute: Wind Climatology 1993-1998 (private communication)

[5] Latvian Meteorological Institute: Wind statistics from 6 met-stations 1992-2001. Private communication.

[6] Kull, A.: Estonian Wind Atlas. University of Tartu, Institute of Geography / UNDP. Tartu 2003 (In print).

Appendix. Associated data files.

The data files listed in the table below, used and produced in the present project, are available in the form of a single compressed archive (ZIP-archive) on diskette or CD-ROM together with the present report in hard-copy. The ZIP-archive will also be available on the internet to be downloaded together with the report from the wind atlas web of Risø: www.windatlas.dk (the site-map page will contain a link to the UNDP/GEF Baltic Wind Atlas).

The copyright of the report applies to the data set as well. This means that (1) when used in published works, the data integrity must be respected and the data must be properly referenced stating UNDP and Risø National Laboratory as the source. Also, (2) the data set may only be forwarded to third parties in the form of the original ZIP-archive.

The ZIP-archive is organized in three "national" folders Lt, La (Latvia), and Ee (Estonia), each of which is subdivided according to stations.

Station	Raw wind measurements	Observed wind climate	Digital map	Regional wind climate
Lt				
Kretinga	Kre-01-02.dat Kre-01-02-Clipped.dat	Kre-Up-Apr01-Apr02.tab	Kretinga.map	Kre-Up WA.lib
Vilkyciai	Vil-01-02.dat	Vil-Up-May2001-April2002x.tab	Vilkyciai.map	Vil-Up-WA.lib
Taurage	Tau01-02.dat Tau01-02-Clipped.dat	Tau-Up-01Oct-02Sep.tab	Taurage.map	Tau-Up-01Oct-02Sep.lib
La				
Särnate	Sär01-02.dat Sär01-02-X.dat Sär02-X.dat	Sär-Up-01Mar-02May.tab	Särnate.map	Sär-Up-LT-WA.lib
Ee				
Prangli	Pra2001Apr-2002July.dat Pra2001May-2002Apr.dat	PraUp2001May-2002Apr.tab	Prangli.map	PraUp-LT-WA.lib
Türisalu	Tür-2000Oct-2002Aug.dat (*) Tür-2001May-2002Apr.dat (*)	Tür-Up-2001May-2002Apr.tab	Türisalu_B93.map	Türisalu-Up-LT.lib
Virtsu	Virtsu2001July-2002Aug.dat Virtsu2001Aug-2002July.dat	VirtUp-2001Aug-2002July.tab	Virtsu.map	Virtsu-Up-LT-2001Aug-2002July.lib
Uulu	Uulu2001Mar-2002May.dat Uulu2001May-2002Apr.dat	Uulu-Up-2001May-2002Apr.tab	Uulu_B93.map	Uulu-up-LT-WA.lib

(*)Proprietary data; only available through agreement with the company "AS Tuulepargid"#)

#) Address:
AS Tuulepargid
Pärnu mnt. 15
10141 Tallinn, Estonia
Tel: +372 66 51 751, Fax: +372 66 51 752

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Abstract (max. 2000 characters)

In the frame of the Regional Baltic Wind Energy Programme, sponsored by the Global Environment Facility through the UNDP, a publicly available wind resource database for the wind-energy relevant areas of the Baltic Countries has been established. A 2-year measurement campaign has been performed based on 7 stations in the coastal area: the 3 Lithuanian sites Kretinga, Vilkyciai and Taurage; the Latvian site Särnate; and the 3 Estonian sites Prangli, Virtsu and Uulu. In addition, private data measured at the Estonian site Türisalu was made available to the project.
Although the campaign was running for about two years it was only possible to get one full one-year data series for each site with start time ranging from primo May 2001 to primo October 2001. The measured data have been analysed according to the "Wind Atlas Method", implying cleansing the wind data for nearby terrain effects, and resulting in regional wind climates or Wind Atlases referring to a number of standard conditions. To the extent possible measures have been taken to make the regional wind climates represent long-term wind statistics (> 10 year). This was done by using correlation techniques based on reference data from met-institute stations with long-term records as well as data for the short-term measurement period of the present campaign. Similarly, inter-comparison techniques were used to adjust for data fall-out for longer unbroken periods. The data from this project have been supplemented by in-land data from measuring stations of the three national meteorological institutes. All relevant data files regarding the 8 stations of the project will be available from the wind atlas web of Risø National Laboratory: www.windatlas.dk - with the exception of the private data measured at Türisalu.

Descriptors INIS/EDB
COASTAL REGIONS; ESTONIA; LATVIA; LITHUANIA; MAPPING;
RESOURCE ASSESSMENT; WIND.