Danish-Czech wind resource know-how transfer project. Interim report 2002

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Danish-Czech Wind Resource Know-how Transfer Project

Interim Report 2002

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Abstract The progress of the Danish-Czech Wind Resource Know-how Transfer Project is reported. The know-how transfer component of the project has consisted in performing a wind resource training workshop for about 13 individuals from the Czech Republic, ranging from scientists to wind farm project developers, and in donating modern software for evaluating wind resources. The project has also included a review of a Czech overview-study of wind speeds inside the country as well as performing of an investigation of the electricity tariffs and their impact on wind energy utilization in the Czech Republic. A problematic existing Czech wind farm project, locked up in a no-production situation, was also addressed. However, this situation turned out to be related to problems with economy and ownership to a higher degree than to low wind resources and technical problems, and it was not possible for the project to point out a way out of this situation.

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1 Introduction

The present project has the title *"Transfer of Wind Resource know-how to and Reorganisation of Demonstration Project in The Czech Republic"*. It was initiated as a result of discussions between the Wind Energy Department of Risø National Laboratory and the Danish Environmental Protection Agency (DEPA) during the follow-up phase of a Danish evaluation [1] of wind energy projects in the Czech Republic (CR). Especially, a problematic 6-wind-turbine pilot project highlighted the importance of national wind resource know-how and expertise in CR.

The project, funded by the Danish Environmental Protection Agency under contract J.nr. M 124/043-0056, went formally into operation November 1999.

The scope of the project can be summarised as follows:

The project aims at an introduction of wind energy in the Czech Republic, thereby mitigating future air pollution caused by use of fossil fuels.

A central item is a training course where staff members from public institutions and private companies will get hands-on experience with modern techniques for wind resource assessment and establishment of wind farms, thereby enabling independent assessments of the wind resources in the Czech Republic. The training course will include a case study for the establishment of a Czech wind farm at a suitable site - where the participants will go through the entire process, from analysis of meteorological data to ensuring a proper connection of the wind turbines to the electrical grid.

The other main items of the project is a general assessment of the nation-wide wind resources and the economical effort that can be justified to exploit the potential wind energy, and the preparation of a plan for reorganisation of the pilot wind farm to improve its power production.

The achievements of the project will be presented at a seminar for interested parties.

Thus, the project was formulated to contain the following components:

a) **Training** of 8 scientists or technicians from the Czech project participants in wind resource estimation;

b) **Case study:** In continuation of the training the participants will perform an entire wind power study for already identified wind farm candidate sites.

c) A **general assessment** (notably not specific) of the wind energy potential in the Czech Republic, and the preparation of a study of the impact of electricity tariffs on exploitable wind energy in CR. A **seminar**, to present the results of the project to interested Czech parties.

d) An investigation Ostružna/Jesenik demonstration wind farm and the preparation of a **proposal** for the future operation.

The wind resource assessment methodology, on which to base the training workshops and the analyses of this project, was, already in the project description,

chosen to be the "Wind Atlas Method" developed by Risø [2] and implemented in the wind resource software program WAsP [3], also developed by Risø.

The target persons and organizations of the project were expected to be the administrative bodies and the scientific community involved in wind energy as well as private wind project developers.

The outcome of the project was expected to be an upgrading of the wind energy expertise in the CR to perform national wind resource assessments, to obtain an independent overview of the national wind resources, and, if possible, a proposed plan for setting the Ostružna/Jeseník demonstration wind farm back in operation.

As could be expected, the above project components were partly changed during the project to the extent that changes in the assumed preconditions were experienced.

In addition to the know-how transfer activities the project was also expected to evaluate or come out with an overview of Czech wind resources; and also to investigate electricity tariffs and their impact on the possibilities for future use of wind energy in CR.

2 Fact-finding mission, October 1999.

Prior to the start of the project there was an urgent wish from DEPA to get an overview of the status of the Jeseník / Ostružna – wind farm project. The 6-turbine wind farm (6 pieces of Vestas V39-500kW) was established in October 1994 but had stopped operation in mid 1999. A fact-finding mission was performed immediately prior to the formal project start with participation of Sten Frandsen (Risø), Ebbe Stuhr (free-lance consultant), Lars Hedegaard (DEPA). The findings of the mission were reported in a travel report, Annex 1 (in Danish).

Through inspection and during a meeting with representatives for the owner company the following was clarified:

The turbines operated technically satisfactorily until October 1996, where a lightening strike and later on a flooding incident caused a stop of normal operation. The turbines came into operation again after a repair, but the production was unsteady and degrading until a full stop in August 1999.

The wind farm suffers from a very poor economical situation due to the fact that a high tariff for wind electricity, expected at planning time, was never established in a new electricity act in January 1995. Thus, nearly from the beginning, the economical basis of the wind farm was missing. From the above it seems clear that the technical problems with low or missing production are in fact of secondary importance compared to the problems of economy and ownership.

The conclusion of the fact-finding mission was, that until it has become possible to perform an economical / ownership-wise reconstruction, no matter who a possible donor might be, it will make no sense to give economical support to put the wind farm back in operation.

From the part of the present project it was found that Danish assistance and proposal for the revival of the wind farm project were impossible for the moment; but would have to await a clarification of the future ownership and the position of the creditors of the project. It was therefore decided to make no further actions in

this project component, except for staying in contact with the relevant persons to be kept informed about future developments in the wind farm project.

3 Kick-off Meeting in Prague, Apr.2000

3.1 Invitation

Early in 2000 an invitation letter was sent out to all relevant institutions and individuals within the Czech wind energy community in order to identify the possible Czech counterparts and participants in the project. The letter contained an invitation to participate in the project as well as participating in a "kick-off" meeting for more precise definition of the project according to Czech wishes and priorities. About 16 positive reactions were received. Among those, the most informative reply was obtained from the Ministry of Environment (Director General, Jiři Hlaváček), see App.1. A short summary of this reply is given below.

The Ministry had established a steering committee for the Czech side of the project with representatives from the Ministry of Environment, The Ministry of Industry and Trade, the Energy Agency and from the Czech Wind Energy Association. Candidates for the training course had been pointed out (8 individuals from the Charles University, the Academy of Science and the Wind Energy Association). A visit to the test site Dlouhá Louka, operated by the Academy, was recommended to be included in the training course. Furthermore it was said, that an overview of the wind resources in CR had already been prepared by staffs from the Academy of Science; hence the planned general assessment of wind resources was considered less important – with the understanding that a transfer of the resources for this component to more relevant parts of the project was preferred. Finally the Ministry gave its opinion on the sad fate of the Ostružna/Jesenik wind farm: The establishment of the wind farm had been performed without consulting relevant Czech experts and authorities, and a solution of the problem – including possibly moving the turbines to a new locality - had to wait for a clarification of a new owner/operator and the position of the main creditor.

3.2 The meeting itself

The kick-off meeting was held on the 18th of April 2000 in the Ministry of Environment in Prague with 15 participants from the Czech "wind energy community" – see the list of participants in App.2. The considerable span in the affiliation of the participants is noteworthy: staff members from the Ministry of Environment, students from the Charles University, staffs from the Academy of Science; staffs from the Czech Wind Energy Association; as well as wind energy developers and investors. A local assistant (Mr. J. Švarc) had been attached to the project as coordinator and translator.

The agenda of the meeting was as follows:

1. 10:00 Welcome (Rathmannn, Miessler)
2. 10:05 Presentation of participants
3. 10:20 Presentation of project framework (Rathmann)
4. 10:50 Existing Czech wind atlas (Miessler)
5. 11:10 Wind resource assessments (Rathmann)
6. 11:30 Status for Czech wind farm projects (Frandsen, Buchta, Karlik, Podzemný)
7. 11:45 The energy market in the CR: Impact on wind energy utilization (Frandsen, Kloz)
8. 12:00 *Lunch*
9. 13:00 Discussion of planned workshop (Nørgård)
10. 14:30 Work plan (Nørgård)
11. 15:00 Adjourn

In the following the outcome of the most important of the meeting items are given.

Ad.3. The components and the economical framework of the project were presented, and it was made clear that these economical frames were fixed. It was also made clear, that the *Czech Steering Committee* by the project was seen as the body to express the Czech opinion and wishes regarding the project, but without final control over the budget; this opinion on the Steering Committee was confirmed by the representatives of the Ministry of the Environment.

Ad.4. The existing Czech wind resource assessments were presented by Dr. Milan Miessler. In 1996 the Institute for Atmospheric Physics of the Academy of Science had finished a study on basis of 70 synoptical meteorological stations (operated by the Hydro-Meteorological Institute). A computer program, mainly based on interpolation, was used to estimate the wind resources in a 2x2km grid. Mean winds higher that 6 m/s were only seen in the mountains along the border of the country. The result was published in a Czech wind energy journal [4], the data are still existing and has been used later in a public evaluation of national renewable energy resources [6]. In 1999 a thorough national energy efficiency study, sponsored by the World Bank, was performed (by ECN, Holland) [7]. From this study, software for estimating the wind energy resource at given sites by an interpolation model is still available. Due to this fact it was the Czech opinion that, within the present project, a study of wind resource variation over CR should be limited to a review of the above mentioned Czech wind resource studies.

Ad.5. The Wind Atlas methodology (as used in the WAsP software) was presented by Ole Rathmann.

Ad.6. Sten Frandsen reviewed the status of the 3 “old” wind farm projects in CR: Ostružna/Jesník, Jarcová and Liberec, however, without going into details with the problematic Jeseník wind farm. Two of the Czech participants presented some later projects. Mr. Buchta (company Wintex) presented the Oldris project in the Bohemian mountains close to the German border with an estimated average wind speed of 8 m/s; the wind farm consists of 10 660kW wind turbines; building permission has been issued, but the financing is missing; cooperation is going on with Dutch investors. Mr. Karlik (company Větrna Liberec) presented the Liberec project in the Bohemian mountains with an estimated average wind speed of 6.4 m/s at 42m (based on 18 months of measurements); the wind farm consists of 6 660kW turbines; the wind study and the project preparation had been funded by the EU-program PHARE in cooperation with the German company Heliotech; financing of the project may be possible from a German idealistic “green” bank.

Ad. 7. Sten Frandsen expressed the view, that from existing tariffs – about 1 CzK/kWh *) or about 0.22 DKK/kWh – it was very difficult to see a possibility for profitable wind energy in CR, as a larger part, if not all, of the payment for the produced electricity would have to cover maintenance and repair. Consequently, the effort by the wind energy community should go in the direction of making this point clear to the decision makers, to convince them to increase tariffs if wind energy is wanted as a part of the Czech electricity supply. Mr Kloz informed about a state subsidy for energy saving and renewable energy of originally 700 mill CzK, but now reduced to 500 mill. CzK. A "green cent" fund to finance a bonus for produced wind energy was being discussed.

Ad.8. At an informal meeting during the lunch Mr. Krajčik (company Wenergo, present owner of the Jesenik wind farm) informed the Danish participants of the status of the status of the Jesenik project. Due to a break-down in the control system the turbines are not operating. For the moment the future ownership situation was unclear, and the earlier obtained impression, that the future of the project was completely dependent on a clarification of the ownership, was confirmed. It seemed that the owners were waiting for an initiative from the creditor banks. Mr. Krajčik was however willing to have technicians inspect the turbines to judge a repair to allow the turbines to operate again.

Ad. 9. Per Nørgård went through the plans for the training workshop. A large interest to participate was expressed, not just from the academics but also from developers and project owners. The steering committee would have the final decision on participants, but it was agreed that – tentatively – 8 participants should take part, distributed on 4 teams with at least one academic (student, scientist) on each team. A workshop in two parts, each consisting of three days with an interval of about one month, was found ideal. It was accepted that existing projects could be used as cases in the workshop. Since all participants seemed to have their own computer, a larger part of the budget would be available for useful software.

Ad. 10. Per Nørgård went through the working plan of the project. It was arranged that registration for the training workshop should be done through the local representative of the project (Mr. Švarc).

The general impression after the kick-off meeting was that – due to the rather limited wind resources - there were poor perspectives for wind energy in CR unless the present low electricity tariffs for wind energy are increased markedly. (made very clear by Sten Frandsen at point 7) It was also felt that in CR there was a lack of knowledge of how to systematically estimate wind resources, which justifies the training workshop of the project.

4 Training Workshop, September and October 2000

This workshop had the aim of training the participants in performing wind resource assessments in a systematic way and to perform entire wind energy project

*) 1 CzK is about 0.24 DKK.

analyses. As agreed on during the kick-off meeting, the workshop was organized in two parts:

1. 5th –7th September, Hotel Murom, Most. Content: Training in wind resource technologies; wind turbine technology; wind power project preparations.
2. 10th-12th October, Local Democracy Training Centre, Libeň, Prague. Content: Legal and authority issues; wind resource case studies.

Part 1 took place in the town of Most due to its proximity to the Czech wind test site Dlouhá Louka in the Bohemian mountains, as a visit to the test site was a part of the training workshop.

The number of participants was allowed to be increased somewhat from what had been originally planned. Thus part 1 had 13 participants and part two had 15 participants, as seen in the list of participants in App.3. Two Risø instructors with a local interpreter / organizer were in charge of the workshop. The programmes of the two parts of the workshop are given below.

Training workshop programme.

Tuesday, September 5

9:00	Welcome
9:10	Registration, test of PCs
10:00	Introduction & theory
11:30	Measurement and Input of meteorological data
12:00	*Lunch*
13:00	Measurement and Input of meteorological data (Continued)
14:00	Terrain description and the Map Editor
15:15	*Break*
15:45	Terrain roughness and roughness change
17:00	*Close*

Wednesday, September 6

8:30 – 11:30	*Visit to Dlouhá Louka test polygon*
12:00	*Lunch*
13:00	Welcome to day 2
13:10	Hills and complex terrain
14:30	Shelter from buildings and natural obstacles
15:00	*Break*
15:30	Shelter from buildings and natural obstacles (continued)
16:00	WAsP analysis: Wind atlas generation
17:00	*Close*
18:00	*Workshop Dinner*

Thursday, September 7

8:30	Welcome to day 3
8:40	WAsP application: Wind resource prediction
9:30	Wind power calculations
10:30	Help system
11:00	Wind turbine technology and project preparation
12:00	*Lunch*
13:00	Wind turbine technology and project preparation (continued)
14:00	Preparation of “large exercises”/case studies in part 2
15:00	*Close of Workshop part 1*

Training workshop programme (continued).

Tuesday, October 10

9:00 Welcome
9:10 Team building, test of PCs
10:00 Teams and instructors present data available.
Discussion on which data to use for wind farm case studies.
12:00 Lunch
13:00 Legal and authority issues:
* Certification of wind turbines
* Compliance with certification and international standards.
* Environmental impacts of wind farms;
* Normal authority processing of wind farm cases.
* Assessment of the economy of a wind farm.
15:15 Break
15:45 Preparation of plans for the case studies of the individual teams.
Presentation and discussion.
17:00 *Close*

Wednesday, October 11

9:00 Large Case study in working teams.
12:00 Lunch
13:00 Large Case study in working teams (continued)
15:00 Break
15:30 Large Case study in working teams (continued)
17:00 Close
18:00 Workshop Dinner

Thursday, October 12

9:00 Reporting of results of the large case study
12:00 Lunch
13:00 Presentation of the results of the large case study by the working teams
15:30 Close of Workshop.

In part 1, the participants were organized in 5 teams with two or three members. Following the concept of the Risø "WAsP-courses" on wind resource evaluation, nearly all lectures were followed by an exercise focussing on the item in question to give the participants practical experience and training in performing the different parts of wind resource estimations. The exercises were performed on computers locally rented for this purpose. In part two some reorganizing of the teams had to made due change in the list of participants and because only 4 computers were available. In the resulting 4 teams - with 3 or 4 members – the participants worked together on performing their case study.

As seen from the list of participants there was a considerable span in knowledge and experience regarding wind resources and how to assess them using modern computers and software. Nevertheless, the general impression was that the participants took part in the workshop and the exercises with enthusiasm, and as compared to participants in normal WAsP-courses on wind resource evaluation, they did surprisingly well, and it is believed that they had a great benefit from the workshop. Some of the participants could use the training directly in their professional work on wind energy, while for the rest the workshop gave them an insight in and an understanding of the process of performing wind resource assessments.

The following 3 sections have been devoted to more thorough descriptions of the visit to the Dlouhá Louka test site, the result of the case studies, and some impressions from the informal contacts and discussions that came up during the workshop.

4.1 Visit to the Dlouhá Louka Test Site

The Dlouhá Louka wind energy test site is owned and operated by the Institute for Atmospheric Physics of the Academy of Science since 1994. It is located 870 m above sea level in an open terrain on the southern slopes of the North-Bohemian mountains close to the German border, Krušné Hory (in German: "Ertzegebirge"). Relative to the centre of the town of Most the location is about 15 km to the North. The operation of the test site was until ultimo 2000 funded by the Czech Electricity Utility, but this obligation (including salaries) will in the future be transferred to the Academy of Science.

An old summer-cottage serves as a control room with place for computers, electronics and personnel. The conditions are somewhat primitive (wood-stove heated), but tolerable.

The activities of the test station comprises wind measurements (anemometers + wind vanes; and sonics) from 10 to 45 m above terrain with the sensors mounted in a military-type observation tower; wind profile measurements with sodar; measurements of icing on blade-probes; and test operation of a Czech-type 315 kW wind turbine.

Wind measurements with anemometers and wind vanes had been performed for six years; however, due to problems with icing (in humid weather during winter time) and lightening, one had so far not succeeded to obtain any unbroken whole-year time series. Activities regarding wind flow modelling had also been undertaken, however, with poor result.

Based on Danish experiences it seemed preferable that the test site concentrated its efforts to obtain unbroken, reliable whole-year series of wind measurements as reference data, and for the time being leave out the more sophisticated activities.

Prior to the visit by the workshop a demonstration set of standard wind measuring equipment (anemometer, wind vane and data logger) had been installed in the observation tower to be operating there for about one month until part 2 of the workshop. During part 2 of the workshop it was possible to demonstrate the fair agreement between the demonstration equipment and the equipment permanently installed in the tower.

During the visit the workshop participants got an impression of the Czech state-of-the-art in wind measuring and the on-going scientific activities in this field. Most important, however, was the demonstration of simple commercially available wind measuring equipment to get an overview of wind resources as early as possible in the course of a wind energy project. Such equipment is a quickly installable and relatively cheap. Furthermore, the participants got an example of performing a site-description of the terrain around a measuring tower. Finally, the visit demonstrated that one may have quite high wind speeds in this kind of mountain areas (during the installation of the demonstration equipment, wind speeds of about 15 m/s were measured at 10 m above terrain).

4.2 Case study results

Each of the 4 teams had brought their own set of data to be used for the case study - thus four different cases were treated.

The teams worked as independently as possible, only using assistance from the instructors in case of software problems or when severe problems of understanding prevented them to proceed further.

The 4 cases were:

1. Pavlov: a proposed 2-turbine wind farm in a mountain area in the Southern part of CR, altitude 673 m (about 75 km West of Brno, 38 km North of the Austrian border) with data measured at an on-site mast.
2. Renna/Jarcová: a proposed wind farm on a mountain ridge in the South-eastern part of CR, altitude 495-518 m (100 km East-north-east of Brno), with data from a local low-land met-station (Mošnov).
3. Klatovy pod Hůrkou: a wind turbine in the neighbourhood of the flat-area town Klatovy in the South-western part of CR, altitude 435 m (40 km South of Plzeň), with data from a met-station in the outskirts of the town.
4. Lysa Hora: a proposed wind turbine in the North-western part of the Krušné Hory mountain ridge, altitude 875 m (5 km South of the German border, about 30 North-east of Karlovy Vary - Karlsbad), with data from the German Fichtelberg met-station.

The case studies comprised the following items

- Wind data treatment and analysis
- Terrain
- Wind atlas
- Wind farm set-up, production estimate
- Economical analysis

The case study reports are given in Annex 2 (in Czech).
The results of case studies may be summarized as follows:

	Project	Turbines	Rated turbine power (kW)	Hub height (m)	Yearly output (GWh)	Capacity factor(*)
1	Pavlov	2xV47	660	60	3.8	33%
2	Renna	4xW4200	600	45	6.8	32%
3	Klatovy	1xBonus Mk III	150	30	0.041	3%
4	Lysa Hora	2xV66	1650	67	12.18	42%
(*) Actual yearly production relative to rated power production the entire year. Normally this number should be more than 25% for a wind farm to be economically feasible.						

For the three of the case studies the estimated wind farm productions were rather high as given in terms of the capacity factor; however reservation should be for the fact that the underlying wind measurements may not be representative for the wind farm sites, thus resulting in too optimistic wind resource estimates. For one of the case studies the proposed project was placed in a location with very low wind resources, much too low to be economically feasible. This is an example of the need for systematic wind resource estimation methodology to separate out too poor wind farm projects – normal "sound feeling" may not be enough for such a judgement.

4.3 Informal contacts and discussions

During the workshop some informal contacts were established, and some closer insight into the state of wind energy know-how in CR was gained.

During part 1 of the workshop a newly graduated PhD-student showed his PhD work on wind resources in the Prague area. It had been performed with a Czech model in comparison with the Risø model WAsP. The time did not permit a judgement of the quality of this work, but it was encouraging to see that the transfer of modern wind resource know-how did not have to start from scratch.

A private project developer showed out to be really competent - he had brought with him a fully prepared wind farm project document and wanted the instructor's comments. The project had been prepared using WAsP for the wind resource estimate. The developer was rather eager to get Danish points of view and experiences to convince the Czech authorities that a certain "green bonus" on top of the commercial electricity tariffs is necessary for wind energy to be feasible. Such a green bonus should account for, and be justified by, the CO_2 reduction gained when wind replaces fossil fuel as the energy source.

Furthermore the participants showed out to include two consultants: one running a company specialized in wind measurements and the other specialized in energy consultancy with a very good overview of all wind energy projects in CR.

During the second part of the workshop a contact was established to the chairman of the "Czech Association for Utilization of Renewable Energy". During a short meeting with the instructors he asked for Danish support regarding tariff bonus for renewable ("green") energy / wind energy, as this matter was going to be treated soon after in the Czech parliament and a decision was going to be taken by the Czech government. A rise in green electricity tariff from about 1.00 CzK to 2.80CzK had been suggested. More specifically he was interested in Danish experiences regarding the magnitude of the necessary bonus (for green energy to be feasible) and regarding the administration of the "Green øre" arrangement in Denmark. The Czech Association for Utilization of Renewable Energy wanted the present project or the Danish Ministry of Environment to address its Czech counterpart, stating the Danish views and experiences and, if possible, to directly offer its assistance in formulating Czech rules in this area. However, this rather political matter was felt to lie outside the scope of the present project, and the Czech request was instead later on handed over to DEPA for further treatment.

4.4 Supply of Wind Resource Software WAsP and Assisting Software

As planned, one package of the Risø wind resource software WAsP [2], [3], supplemented with helping tools, was delivered to the Institute of Atmospheric Physics of the Czech Academy of Science. Installation of the software and the initial bringing it into use was taken care of by one of the workshop participants (Jiři Hosek). Apart from research work the software was planned to be used for judging wind farm projects applying for public approval and/or financial support. Contacts from the Institute of Atmospheric Physics has later confirmed that WAsP is now being used as expected for standard wind resource estimation (e.g.

for a paper presented at the Prague 2001 Conference on Wind Energy, see below).

5 Prague 2001 Conference on Wind Energy

The Danish participants in the project were invited to participate in this 2-day conference. It was decided to omit the planned presentation seminar of the project, and instead use this conference as the forum where the results of the project could be presented to the Czech wind energy community.

The scope of the conference was "Wind energy utilization in Central Europe" with the *Czech Society for Wind Energy* as the organizer (especially by its secretary Jiři Čermak). It took place 4-5 October in central Prague in the building of the Czech Association of Scientific and Technical Societies (CSVTS).

Between 30 and 40 individuals participated in the conference, mostly from the Czech Republic, but also from Austria and Germany. The Danish participants from the project were Ole Rathmann and Per Nørgaard. Unfortunately, although announced in the programme, participants and speakers from other Central European countries (Slovakia, Hungary and Poland) had sent their excuses.

The papers were on:

- Legislative issues, EU plans, tariffs
- Wind turbine technology and experience with wind turbine establishment
- Wind resource measurement and estimation/overview

The Czech contributions were influenced by the small amount of actually installed wind turbines in CR, and they contained mostly theoretical studies of different approaches. Papers reporting on real experiences were nearly only given by German and Austrian speakers.

The paper presented by the Danish project members [8], "Estimating the wind energy yield at a given location exemplified by Czech Sites", gave an overview the present project in addition to presenting the Wind Atlas Method and an assessment of "The Czech Wind Atlas", a Czech wind resource study from 1996.

Further, a few speakers / papers should be highlighted :

- Prof. Josef Štekl: The "Big Name" in Czech wind energy: on the introduction of wind energy in CR in the past and in the future, especially in the light of tariff politics laid down in recent and probable future legislation.
- Jiři Hosek, (young scientist at Inst. Atm. Physics of the Czech Academy of Science): a paper on wind resource estimation by different methods and software .
- Winkelmeier, Energiewerkstatt Gmbh, Austria: Austrian experience on wind energy and on establishment of wind turbines in the mountainous area just South of the Austrian/Czech border

- Lietzmann (senior and junior), ENWERTEC Ing. Büro, Freiberg, Germany: Experience on wind energy and establishment of wind turbines in the German part of the Erzegebirge / Krušne hory mountains (North Bohemia).
- A. Bühler, ENRON Wind GmbH (Hamburg): EU plans for renewable / wind energy and their impact on the EU entering process for countries applying for EU membership; very competently presented. (ENRON Wind ENRON is the owner of *Zond* and *Tacke* wind turbine manufacturing companies.)

Proceedings from the conference will be prepared but have in writing time not yet been issued.

The following interesting points were encountered:

Future Wind Energy in CR: At present 7.6MW is installed; a drop during 1996-2000 from 8.35 MW occurred due to too low tariffs (0.90 – 1.13 Kč/kWh), which did not suffice to cover repair and maintenance. The future perspective (2010) is: 600 – 700 MW installed with a yearly production of 1200 GWh at likely tariffs of about 3 Kč/kWh.

Icing of instruments and wind turbines is a serious problem in the Central European mountains, the only terrain types here with interesting wind resources! In winter, temperature changes between +4 and –4 °C are quite frequent, giving rise to heavy icing when clouds/humidity deposits as ice. Heated anemometers are necessary. Most important, shock-heating of blades on wind turbines at start-up is necessary as well, which implies safety-distances between wind turbines on the one hand and roads and skiing paths on the other. An icing probe has been developed and tested by Inst. Atm. Physics of the Cz. Academy of Science at its Dlouhá Louka test site in cooperation with ENWERTEC (Paper by Ř. Hrdlička).

Wind measurements in mountain woods. On the Austrian (South) side of the Austrian/Czech boundary, wind measurements are performed in cleared areas in the moderately high forests (~ 10 m) in the mountains. Wind turbines are planned to be erected in such clearings as well. This requires tall measurement masts and turbines. So far, little experience with measured wind speed profile exists in such areas. A contact person is Dr. Winkelmeier (Energiewerkstatt Gmbh, Austria).

Wind resource estimation with modern methods in CR: The presentation by Jiři Hosek showed that modern, systematic methods of wind resource estimation has established in CR. For the present project it was very encouraging to observe that a major part of the study presented had been performed with WAsP, supplied by the present project (see section 4.4).

6 Review of Czech Wind Resource Study

6.1 Czech wind atlas

An overview of the wind resources in the Czech Republic, called the "Czech Wind Atlas", was prepared by Sokol and Štekl and published 1995-1996 [4],[5]. It was based on a 4-year (1989-1992) data series from around 200 meteorological stations. The data consisted of recordings 3 times a day, measured at 10 m above terrain. A quality check was applied to remove unreliable data sets, leaving about 150 sets of data to be used. By investigating the data from a number of selected stations where more than 40 years of data were available it was made plausible that all the 4-year data sets were indeed sufficiently representative for a long term period (20 year).

No terrain compensation through flow modelling was performed as the authors considered the terrain features to be too complex for reliable flow modelling with available flow modelling tools. Instead a 3-D interpolation scheme based on a 2x2 km horizontal grid was applied, the 3rd dimension being the elevation.

The Czech Wind Atlas indicates that in most of the CR the wind resources are low. However, high yearly average wind speeds (> 5m/s) were found in the mountain areas, mostly along the Northern border, but also in a few areas in the internal part of the country, and these areas seem to be the prospective sites for wind farms.

6.2 Comparison with Wind Atlas examples.

In order to get an impression of how results from the wind atlas method (used in WAsP) relate to the "Czech Wind Atlas", the wind speed ranges of the Czech Wind Atlas were compared to results from the training workshop of the present project, Annex 2, and to Dlouhá Louka-data. (The Dlouhá Louka-data were calculated as part of the preparation of the Risø-paper for the Prague 2001 Conference, [8], and are reported in section 3 in this paper).

These Comparisons gave the impression that the "Czech Wind Atlas" gives a fair representation of where to find the "good" and the "poor" wind resources, whereas one should not expect it to contain high precision data – deviations in mean speed of 1 m/s from reality may easily be found.

6.3 General impression

If one considers the purpose of the "Czech Wind Atlas" to be limited to getting the large-scale variation in the wind resources, the approach applied seems adequate, although the Z-interpolation instead of flow modelling may be questionable. However, flow modelling with simple linear flow models in steep terrain, and/or in connection with special stability effects, is questionable as well.

The Czech Wind Atlas is judged to be able to point out prospective wind power areas. The comparison with examples confirms this impression. The details, however, are not sufficiently reliable for judging the feasibility of a specific wind farm project, if not supplemented by additional data. On candidate sites for wind farms it is recommended that local wind measurements for at least one year, in combination with long-term wind data from nearby reference met-stations, should be used to estimate more precisely the wind resources by use of the wind atlas method (or a similar method).

7 Evaluation of Czech Wind Energy Tariffs

The scope of "electricity tariff study" component of the project was to investigate the Czech electricity tariffs as preconditions for successful introduction of wind energy in the Czech republic. Previous (at the project formulation time) and present tariffs were considered. Thus, the evaluation of the profitability of wind energy was made for a number of different economical and physical conditions to find the sensitivity to: electricity tariffs, discount rate, lifetime and 10-m wind speed. The corresponding economical wind energy potential in the CR was then found with sensitivity to tariffs. The details of this study are reported in Annex 3.

Basic data from NEES. Figures in italic were calculated in the present study.

Potential capacity in Cz. Repub.

Wind speed regions		5-6 m/s	>6 m/s	>5 m/s	All Cz.Republ
All, km2		4298	1269		78866
		5.45%	1.61%		100%
Excl. Nat. Parks and forests, km2		765.7	111.5	877.2	
		0.97%	0.14%		
Available potential, 12% of the above (*)		91.88	13.38		
		0.117%	0.017%		
	Density Units/Km2				
Unit capacity [MW]		0.6	0.6	0.6	
Unit AEP [MWh/y]		*1547*	*1960*		
Units	5.67	521	76	597	
Installed capacity [MW]		313	46	358	
AEP [GWh/y]		*806*	*149*	*955*	
Unit capacity [MW]		1.0	1.0	1.0	
Unit AEP [MWh/y]		*2530*	*3307*		
Units	*4.04*	*371*	*54*	*425*	
Installed capacity [MW]		*371*	*54*	*425*	
AEP [GWh/y]		*939*	*179*	*1118*	

(*) Taking into account environmental constraints (residential and built-up areas, noise etc.)

The basic data for the variation of 10-m wind speed (average wind speed at a height of 10 m above ground surface) over the CR, and the areas available to wind turbines were obtained from "National Energy Efficiency Study – Czech republic" (NEES) [7] and from the "Czech Wind Atlas" [4], as shown in the table above. When evaluating "available areas" only rural areas, that did not conflict with considerations on visual impact, noise and other environmental issues, were taken into account. The relation between 10 m average wind and turbine annual energy production (AEP) for a 600 kW and a 1 GW turbine was based on the terrain around Dlouhá Louka as representing a typical Czech landscape suitable for wind energy (given in the above table in italic).

Values for the Czech electricity tariffs for wind energy were obtained from NEES as well as from the October 2001 wind energy conference in Prague, and later confirmed by personal communication with Dr. J.Čermak from the Czech Society for Wind Energy.

7.1 Base-case result.

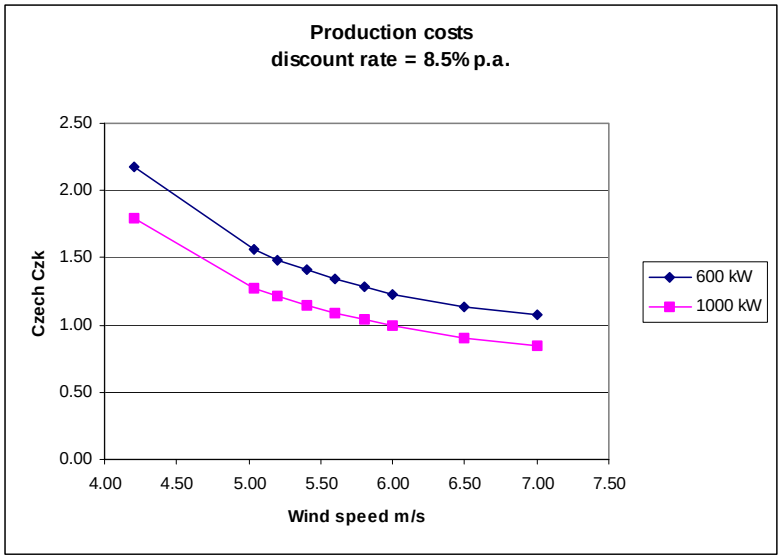
The following assumptions were used:

- A discount rate of 8.5% p.a.
- A lifetime of the turbines of 20 years
- An exchange rate of 1 CzK = 0.034 € (= 0.25 DKK)

The production costs in dependence of 10-m wind speed (in the range 4.2 m/s to 7.0 m/s) were then found to change from 2.37 to 1.17 CzK/kWh for a 600 kW turbine and from 1.95 to 0.92 CzK/kWh for a 1 GW turbine as shown in the table and figure below.

Average production costs calculated at different average wind speeds

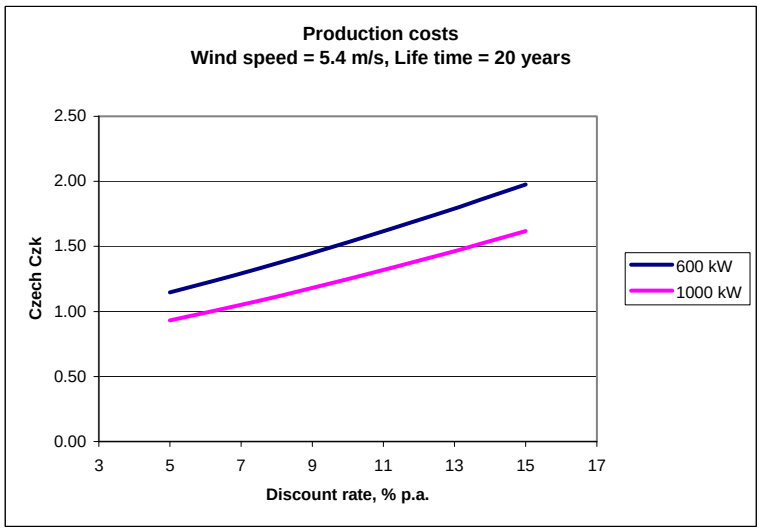
Wind speed at 10 m above the ground m/s	Average production costs 600 kW turbine CzK/kWh	Average production costs 1 GW turbine CzK/kWh
4.20	2.37	1.95
5.04	1.70	1.39
5.2	1.62	1.32
5.4	1.53	1.25
5.6	1.46	1.18
5.8	1.39	1.13
6	1.34	1.08
6.5	1.24	0.99
7	1.17	0.92



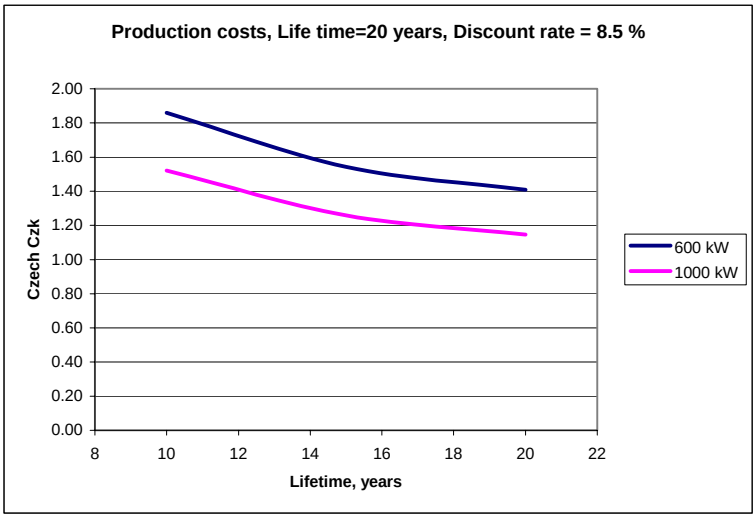
7.2 Sensitivity analyses

With basis in the base case, the sensitivity to expected discount rate and expected lifetime were investigated for a constant 10-m wind speed of 5.4 m/s.

A discount rate of 15% relative to 5% would mean an increase in production costs of nearly 80% - from 0.9 to 1.6 CzK for a 600 kW turbine. Similarly, an increase in expected life time from 10 to 20 years would mean a drop in production costs from 1.85 to 1.40 CzK for a 600 kW turbine. The calculated sensitivities to discount rate and lifetime are shown in the figures below.



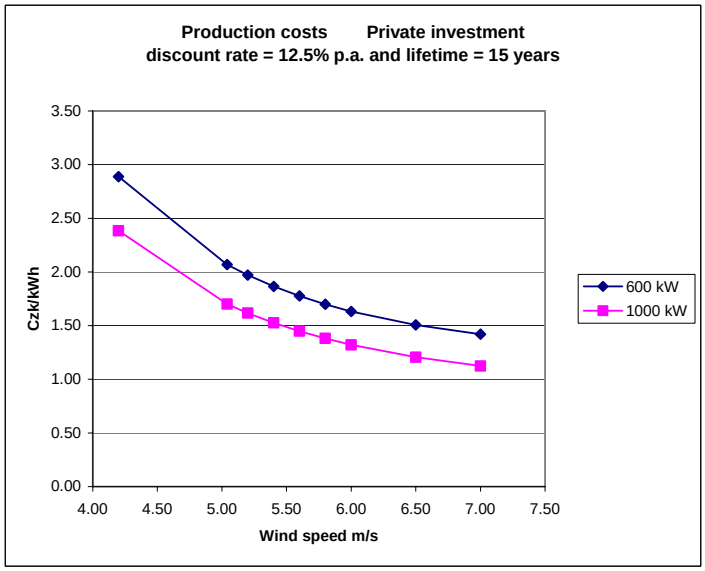
The calculated production costs for power generated by a 600 kW or a 1 GW wind turbine as a function of the applied discount rate.



The calculated production costs for power generated by a 600 kW or a 1 GW wind turbine as a function of the expected economic lifetime of the turbines.

7.3 Private investments in wind turbines

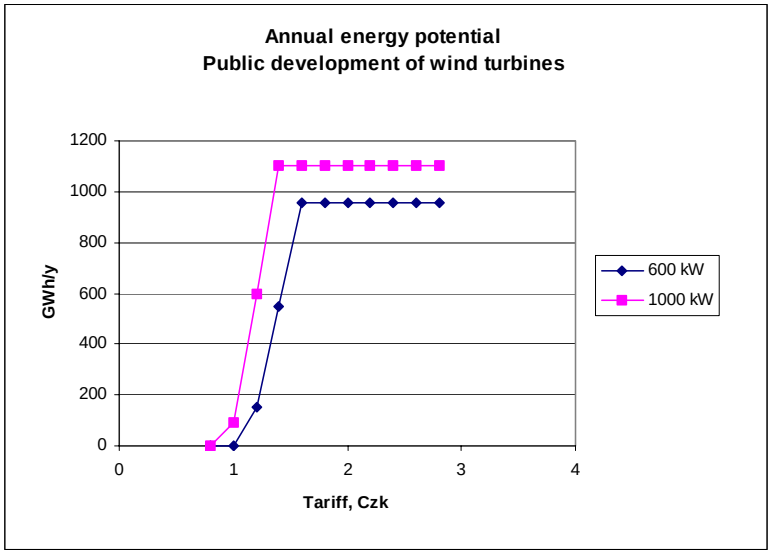
Private companies or individuals investing in wind turbines will presumably require a higher risk premium than utility or public companies would do. The corresponding production costs in dependence of wind speed were calculated under these conditions, a discount rate of 12.5% and a lifetime of 15 years, as shown in the figure below. At a 10-m wind speed of 6 m/s the production costs were calculated to be 19% higher than for wind turbines financed by public investment, namely 1.6 CzK/kWh against 1.34 CzK/kWh for a 600 kW turbine.



Expected production costs for wind-generated power for a private investor.

7.4 Potential energy production from wind turbines in the Czech Republic

Using the base-line calculations and the "private investment" calculations in combination with the spatial wind speed distribution the annual wind energy production potential in CR was calculated in dependence of the electricity tariff as shown in the figures below.



The profitable public initiated deployment of the potential for establishing wind turbines in the Czech Republic, depending on the size of the feed-in tariff.

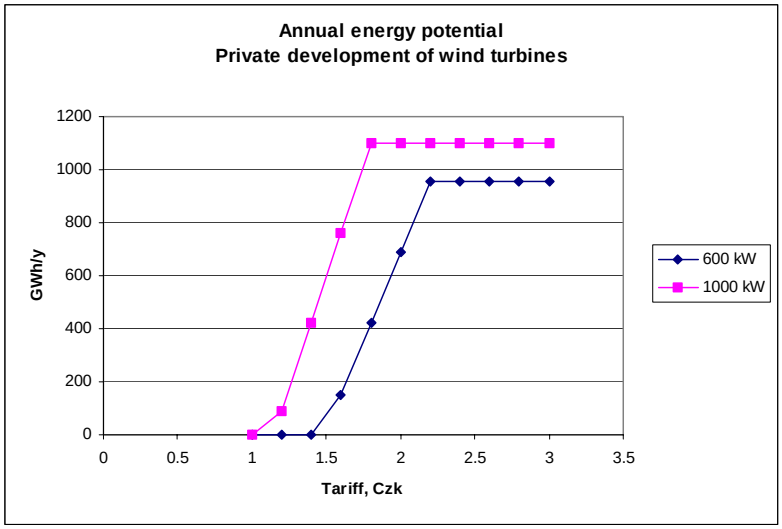
For publicly financed turbines a tariff increase from about 1.00 CzK to about 1.3 CzK seems sufficient to make the profitable deployment of wind turbines rise from 0 to a maximum of 360 MW and 420 MW installed capacity for 600kW and 1.0 GW turbines, respectively. This maximum was evaluated taking the available areas for wind speeds down to 5 m/s into account. The annual energy production corresponding to maximum deployment of wind turbines is seen to be about 1000 GWh/y (about 950 for 600 kW turbines, 1100 for 1 GW turbines).

If all deployed wind turbines are assumed to be financed by private investors the rise from zero to maximum profitable deployment was found to take place in the tariff range from 1.2 CzK to 1.9 CzK, somewhat depending on the assumed turbine size.

The calculations were also performed for a deployment with 1.65MW turbines. The result regarding sensitivity to tariffs is about the same as for 1.0MW turbines. However, the installed capacity and the annual production for maximum deployment are somewhat larger: 520 MW and 1200 GWh, respectively.

Thus, according to this analysis the situation is as follows: At the previous feed-in tariff of about 1.0 CzK/kWh no or very few wind turbines would be profitable. However, a tariff of about 2.2 CzK/kWh would make maximum deployment just profitable (privately financed 600 kW turbines). The present tariff of 3.0 CzK/kWh (applying from January 2002) is seen to be sufficient to give a good

economical motivation for a deployment of wind turbines up to the maximum installed capacity.



The profitable private initiated deployment of the potential for establishing wind turbines in the Czech Republic, depending on the size of the feed-in tariff.

8 Status of Jeseník project.

It has not been possible for the project to make any contributions to reviving the Jeseník wind farm project, except for staying in contact with Czech key-persons. These contacts did not show any real change in the situation revealed already in the beginning of the present project (during the fact-finding mission and during the kick-off meeting): that the problems of the wind farm project are due to poor economy and an unclear ownership situation, rather than being of technical nature and due to low wind resources.

One might speculate of reviving the Jeseník project by moving the wind farm to a site with a higher wind resource. However, due to the unclear economy and ownership situation of the wind farm project, it has been outside the possibilities of the present project to suggest any such or other solution models, or to take other initiatives, to bring the wind farm project out of its locked situation.

The latest information from key-people in the Czech Society of Wind Energy are that the awaited reconstruction regarding economy and ownership will take place in April 2002 through a public sale. As already stated, it will make no sense from Danish – or any other – side to assist economically in reviving the wind farm project until such a reconstruction has provided the necessary clarification.

9 Conclusion

The main objective of the project – transferring know-how on wind resource estimation to the Czech wind energy community – has been fulfilled through a 2x3-day training workshop for about 13 individuals ranging from scientists to wind farm project developers. It is believed that the participants have received a good introduction to modern techniques for estimating wind resources and practical training in using modern software in performing such estimating analyses. One set of wind resource software - WAsP and assisting software – was delivered to the Institute for Atmospheric Physics of the Czech Academy of Science, where it is being used in scientific work, but also in connection with approval of wind farm projects in the Czech Republic.

The Czech wind resource overview study "Czech Wind Atlas" (1995-1996) has been judged and found to be suitable for pointing out prospective wind farm areas. However, for analysing wind power production and judging the feasibility of specific wind farm projects, more detailed wind resource software tools as WAsP should be used.

A study of electricity feed-in tariffs and their impact on the deployment of wind energy in the Czech Republic has been prepared. It confirmed the impression, that with old tariffs of about 1 CzK/kWh (from before 2002), wind energy would hardly be feasible even at the high-wind sites in CR. However, with the new tariffs for renewable energy - 3 CzK/kWh – wind energy seems to be feasible at all "sensible wind resource" sites (with 10-m average wind speeds not lower than 5 m/s) in the CR.

Regarding the problematic Jeseník/Ostružna wind farm it showed out not to be possible for the project to assist in reviving the wind farm project due to problems with economy and future ownership. A clarification of these problems will probably take place in April 2002 through a public sale of the wind farm project.

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Annex 1 Stuhr, E. Frandsen,S. and Hedegård,L.I. Fact-finding Travel Report, Wind Farm Project Jesenik, Czech Republic ("Rejserapport" – in Danish.). October 1999. *Confidential.*

Annex 2 Rathmann,O. and Nørgård,P. (editors) Training Workshop Case Studies. October 2001.

Annex 3 Morthorst,P.E., "Production costs of Wind Power in the Czech Republic". Risø National Laboratory February 2002.

11 Appendices

App.1 Answer from Ministry of Environment

MINISTRY OF THE ENVIRONMENT OF THE CZECH REPUBLIC
Section of International Relations

Vršovická 65, 100 10 Praha 10
Tel: (00420 2) 67 12 29 16
Fax: (00420 2) 67 31 03 07

In Prague February 23, 2000
Ref: 517 /900/00

Dear Mr. Rathmann,

Ministry of the Environment of the CR and Czech Wind Energy Association (CSVE) welcome implementation of the project entitled "Transfer of Wind Resource know-how, and Reorganisation of Demonstration Project in the Czech Republic" presented as a seminar, which is planned preliminary in March 2000.

The Ministry of the Environment has established the Steering Committee (SC) for purpose efficient leadership of this project. This SC comprise the representatives of the Ministry of the Environment, representatives of Czech Wind Energy Association (CSVE), representative of Czech Energy Agency and of the Ministry of the Industry and Trade.

With regard to the project proposal the Steering Committee has the following comments:

a) Because there already exist a good capability to assess wind energy in the Czech Republic we would recommend that the training course of meteorological measurement techniques take place near the testing polygon Dlohá Louka where the Danish techniques and instrumentation can be compared to the local equipment and assessment methods. At Dlouhá Louka there is also an ongoing research (since 1994) on icing and turbulence in mountain condition and their effect on the output from the experimental WTG, EWT 315 kW. All research is carried out people from Academy lead by Dr. Štekl.
b) The computerised wind resource assessment using WAsP could be demonstrated at the Faculty of Natural Science of the Charles University in Prague. They have already installed WAsP and the facilities at the faculty, including well equipped lecture room which would be available from the beginning of June to the end of September.
c) The Czech Wind Energy Association (CSVE) has 8 candidates for the seminar: 4 from the Academy, 2 from the University and 2 from the CSVE.
d) The offer with regard to certification we find particularly interesting. Because the plans for Dlouhá Louka have include a discussion of equipment needed for such a laboratory.

The general assessment of the wind energy potential in the CR we would consider as less important part of the offer because both the total wind energy assessment and the wind atlas (2km x 2km) already exist and were worked out people from the Academy in 1995-1996. Data from the wind atlas for specific localities will be available to instructors and participants of the training course

With regard to the unsuccessful wind farm Ostružná (6 Vestas turbines V39-500kW) it is possible to state the following:
Wcnergo developed this farm without consulting the Academy, CSVE or any other specialist of repute. The measured average wind speed was then recalculated for the height of the rotor, again without asking advice from a competent meteorologist. They also did not consider the effect icing on the WTG output.
The fate of Ostružná has a negative influence on further development of wind energy in the CR, so it is very important that this problem be solved. We see the main problem in resolving the question of law/ownership, both in the current and the future locality, including finding the new owner/operator. The CEA (Czech Energy Agency) is going to contact the Consolidation Bank, who is the main creditor for the farm Ostružná, with the aim to start a discussion of possible solution to this problem.

Representatives of the Ministry of the Environment and representatives of CSVE are ready to take part in the suggested kick-off meeting to be held in March.

Best Regards,

Jiří Hlaváček
Director General

Mr. Ole Rathmann
Senior Scientist
Wind Power Meteorology
Risø National Laboratory
Roskilde
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fax: +45 4677 5970

App.2 List of participants at the kick-off meeting

Name	Affiliation	Country
Ole Rathmann	Risø	Denmark
Per Nørgård	Risø	
Sten Frandsen	Risø	
Michal Pastvinsky	MZP-OES (Ministry of Environment)	Czech Republic
Martin Kloz	MZP (Ministry of Environment)	
Ivan Sladek	ČSVE (Cz. Society for Wind Energy)	
Milan Miessler	ČSVE	
Cermak	ČSVE, Academy of Science	
Selouf	ČSVE	
Tosovsky	(Own company)	
Jan Jurica	Company E&EC	
Stanislav Buchta	Company Windtex	
Zdenek Podzemny	Project Renna	
Jaroslava Stojanova	Project Renna	
Jiri Krajcik	Company Wenergo	
Petr Kurina	Company Sapo	
Stanislav Karlik	Company Vetrna Liberec	
Hosek	PhD-student, Charles' University, Academy of Science	
Jiri A. Svarc	(Own company, translator,organizer)	Slovakia

App.3 List of participants at the training workshop.

Workshop part 1 5-7 Sept. 2000, Hotel Murom, MOST

Team	Name	Affiliation
	Ole Rathmann	Risø, Danmark
	Per Nørgård	Risø, Danmark
	Jiri A. Svarc	(Interpreter), Slovakia
1	Martin Kloz	MZP (Czech Ministry of Environment), Prague
1	Peter Križan	Slovakian Hydromet Institute (SHMU)
2	Jiři Hostýnek	ČHMU (Czech HydroMet Inst.), Plzeň
2	Tereza Šindelářová	PFFUK, Student
3	Jan Juřica	Company E&EC, Pardubice
3	Stanislav Buchta	Company Windtex, Hlinsko
3	Petr Kuřina	Company Sapo, Batelov
4	Jiři Hosek	Inst. of Atm. Physics*), PhD Student
4	Kateřina Neumannová	Inst. of Atm. Physics*), PhD Student
4	Ctirad Prokeš	Company Revolt
5	Jacek Kerum	Inst. of Atm. Physics*), Scientist
5	Jaroslava Stojanova	Project Renna, Valašské Meziřičí
5	Erika Chromá	Project Renna

*) Institute of Atmospheric Physics, Czech Academy of Science (UFA AV ČR), Prague

Workshop part 2 10-12 Oct. 2000, Local Democracy Training Centre, Lebeň, Prague.

Team	Name	Affiliation
	Ole Rathmann	Risø, Danmark
	Per Nørgård	Risø, Danmark
	Jiri A. Svarc	(Interpreter), Slovakia
1	Jan Juřica	Company E&EC, Pardubice
1	Stanislav Buchta	Company Windtex, Hlinsko
1	Petr Kuřina	Company Sapo, Batelov
2	Jacek Kerum	Inst. of Atm. Physics*), Scientist
2	Jaroslava Stojanova	Project Renna, Valašské Meziřičí
2	Erika Chromá	Project Renna
2	David Hanslian	Student
3	Jiři Hostýnek	ČHMU (Czech HydroMet Inst.), Plzeň
3	Zdeněk Lepka	
3	Tereza Šindelářová	PFFUK, Student
4	Jiři Hosek	Inst. of Atm. Physics*), PhD Student
4	Jan Mertl	
4	Ctirad Prokeš	Company Revolt
4	Pavla Ernekerová	Ministr. of the Environment
	Jiři Čermák	Cz. Wind Energy Association, Inst. Atm. Phys*)

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Danish-Czech Wind Resource Know-how Transfer Project

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Ole Rathmann,Per Nørgård and Sten Frandsen

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Abstract (max. 2000 characters)

The progress of the Danish-Czech Wind Resource Know-how Transfer Project is reported. The know-how transfer component of the project has consisted in performing a wind resource training workshop for about 13 individuals from the Czech Republic, ranging from scientists to wind farm project developers, and in donating modern software for evaluating wind resources. The project has also included a review of a Czech overview-study of wind speeds inside the country as well as a study of the electricity tariffs and their impact on wind energy utilization in the Czech Republic. A problematic existing Czech wind farm project, locked up in a no-production situation, was also addressed. However, this situation turned out to be related to problems with economy and ownership to a higher degree than to low wind resources and technical problems, and it was not possible for the project to point out a way out of this situation.

Descriptors INIS/EDB

CZECH REPUBLIC; DENMARK; RESOURCE ASSESSMENT; TECHNOLOGY TRANSFER; WIND POWER