COLD CLIMATE WIND ENERGY CO-OPERATION UNDER THE IEA

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ABSTRACT: An annex on "wind energy under cold climates" will start in March 2001 within the framework of the IEA Implementing agreement on wind energy R&D. The annex will collect information on the operation performance of as many of the turbines operating under harsh icing conditions as possible and present guidelines for implementing wind energy under these. The project will also cover more specific monitoring projects and share information on these. VTT Energy from Finland will act as Operating Agent and Denmark, Norway, Sweden and the United States will join.

1 BACKGROUND

The international Energy Agency (IEA) was formed in 1974 as an autonomous body within the Organization for Economic Co-operation and Development (OECD). The IEA has established a legal framework for international collaboration and carries out an energy technology programme among its 23 member countries including R&D, demonstration and information exchange. The IEA collaboration takes place under the Implementing Agreements, which currently cover a wide assortment of energy technologies in fossil fuels, renewable energy, nuclear fusion research and efficient energy end-use. The Implementing Agreements "mechanism" is flexible and accommodates collaboration among different entities, such as governmental institutions, universities, utilities and private companies.

Implementing Agreements are supervised by the IEA Committee on Energy Research and Technology (CERT). As far as renewable energy sources are concerned, The Working Party for Renewable Energy Technologies (REWP) has a mandate from CERT to identify technologies likely to contribute to the IEA goals, to promote collaborative R&D and to initiate, evaluate and review Implementing Agreements in this field.

The IEA "Implement Agreement for Co-operation in the Research of Wind Turbine Systems" (In short "R&D Wind") started in 1977. Presently 19 contracting parties, designated by the governments of 16 countries, are participating.

The general objective of the IEA "R&D Wind" programme is to undertake collaborative R&D projects, called Tasks, and to exchange information on the planning and execution of national large-scale systems. The overall programme is headed by an Executive Committee, where each participating country is represented, while each Task is managed by an Operating Agent, usually one of the Contracting Parties.

The Implementing Agreement on Wind Turbines aims to promote and foster collaborative research. Current activities under the Agreement include:

- development of recommended practices for wind turbine testing and evaluation;
- joint actions in the form of workshops and symposia on subjects such as aerodynamics of wind turbines, fatigue of wind turbine blades, offshore wind systems, and wind conditions/turbine loads;
- reviewing progress in the implementation of wind energy by the IEA Member Countries to provide an overview of progress in the commercial development of wind turbine systems to present to decision makers in government, planning authorities, the electricity supply industry, financial institutions and the wind energy industry;
- validation of wind turbine testing procedures through a round robin test programme; and
- maintenance and further development of a database (Annex XVII) containing a huge number of measured wind time series, representing many different terrain types and climate systems from all over the world, to provide wind turbine designers easy access to quality controlled field data in a standardised format. The database is available at http://www.winddata.com.

2 OBJECTIVES

Wind energy is increasingly used under arctic and cold climates and adapted technology has been developed. Various national activities are going on in a number of countries and the first steps from demonstrations into fully commercial implementations are taken. Applied technology has been developed along some different paths and different solutions are being tried out. With regard to blade heating different systems are being marketed, i.e. electrical, hot air and microwave heating. Other technologies adapted for cold/icing conditions relate to anemometers, material selections and other monitoring equipment. Technical development is going on and several solutions are being demonstrated. As the applications are entering a commercial phase, there is a request to gather the experiences in a form that can be utilised by developers, manufacturers, consultants and other financiers.

The objectives of this Annex are to:

- gather and share information of all wind turbines operating in cold climates.
- establish a site-classification formula, combining meteorological conditions and local needs. This is of relevance for wind turbine designers, manufacturers, project developers and wind energy producers.
- establish classification formula on standard and adapted technologies and operational strategies to match the site assessment classification. It has relevance for the same group as above, in particular project developers, decision makers and their advisors/consultants.
- monitor the reliability and availability of standard and adapted wind turbine technology that has been applied.

– establish and present guidelines for applying wind energy in cold climates.

3 MEANS

The activities will focus on fundamental questions related to cold climate applications of wind energy, i.e. meteorological and operational information. Adapted technical development is going on in different countries and is about to reach a competitive stage. The actual technical and operational developments will be included to the extent necessary for meeting the objectives.

3.1 Site assessment and classification

When planning for wind turbines to be sited in cold climate conditions the specific properties of the site has to consider. To some extent these properties can easily be taken into account but in some cases special means are necessary.

A site assessment under cold climate conditions is difficult to carry out, as the functionality of instruments is difficult to verify. Both wind and the icing conditions need to be analysed in order to enable the making of proper production estimates and a selection of the most suited technology. The work will therefore include:

– methods for monitoring icing events in site assessment
– methods for assessing wind conditions in cold climate regions.

The basis for this work is the development of a classification procedure taking the following properties into account:

– energy demand
– grid infrastructure
– wind conditions and measurements
– general climate conditions
– temperature levels; extremes and variations
– type and rate of icing
– site accessibility
– safety aspects
– other demands related to infrastructure
– offshore locations.

The classification procedure should include all aspects of cold climate, recommend data sources or ways to obtain new data and should, as far as possible, be based upon existing information, recommend data sources or ways to obtain new data. The activity will support entering new wind energy markets and can be extended to cover also non-OECD countries.

3.2 Technology and operations classification

When evaluating bids or proposed specifications by bidders relating to sites classified as per 3.1, the proposed technical and operational solutions should be classified and processed accordingly.

This approach should include the classification of technical features such as:

- material specifications
- temperature control
- lubricants
- ice detection
- etc.

and operational strategies such as:

- operation only within specified temperature ranges
- stop of turbine if icing occur
- etc.

Methods for predicting ice accretion and the methods to prevent it from affecting wind turbine operation will also be assessed. However, the cost for attaining a gain in energy production is hard to predict due to a lack of knowledge concerning both the benefit of ice prevention as well as which technologies to choose.

The activity will make it possible to correlate manufacturer's proposed solutions with the classification of the site specifications and thus facilitate a systematic and efficient assessment of bids and other proposals. Thus the activity will support entering new markets.

3.3 Operation and performance experiences

Wind turbines are being operated under various icing conditions both with and without adapted technology. Various national production and failure statistics sometimes also contain information on e.g. icing but on a global level there is no general knowledge of how much production is lost due to extraordinary climatic effects. The project would thus contain:

- monitoring of production and failure events, related to O&M under cold conditions

- development of power performance measurement techniques under cold climate conditions

- development of methods to monitor icing events during operation

- monitoring availability and reliability of as well standard as adapted technology during extreme events

- gathering information and experiences from construction under cold climate conditions

- assessment of the reliability of anemometers, ice detectors and other instruments.

The monitoring should be carried out following a standard procedure in order to enable comparison of results on a scientific level results. At the same time, experiences from applying standard cold climate technology and materials in wind turbines should be gathered and assessed. The procedures will be established in the beginning of the project.

3.4 Extraordinary operational events

In addition to the overall monitoring, specific sites representing different conditions will be chosen for detailed monitoring of extraordinary events, e.g. icing, storms, voltage losses, etc. The number of sites should be large enough to give a representative spread of conditions but small enough to be manageable.

Proven technical methods should be used for monitoring, in order to have comparable results. Different methodologies might, however, be used under different conditions. The procedures for monitoring and dissemination of information will be agreed upon in the beginning of the project.

3.5 Dissemination of results

1. The findings will be published for the Executive Committee in a report.

2. Guidelines for assessing and deploying wind energy under cold climate conditions will be given.

3. Results will be presented at various international conferences.

4 TIME SCHEDULE

The annex will cover 36 months during starting March 1, 2001. The time schedule will adhere the following outline:

– 6 months for agreements on monitoring and reporting procedures. During this period the selection and organisation of specifically monitored sites will be completed. Methods to monitor icing will be developed.

– 2 years for monitoring, including presenting procedures for site-classification.

– 6 months for communications, results and reporting, including guidelines.

5 SPECIFIC RESPONSIBILITIES OF THE PARTICIPANTS

Each participant will to the extent that is possible under commercial contracts collect and submit national statistics and other relevant information, submit information from monitored installations, account for adapted design being used and bear its own cost for the scientific work, including travel expenses.

All participants have costs related to monitoring and collecting data from wind turbines in operation. The costs can be divided into background and foreground costs. Background costs are related to established measurement campaigns and basic research whereas foreground results are related to present monitoring, modification and presentation of data for this project. The difference between these varies, depending on the level of previous activities in the various countries.

In addition the individual Participants will carry out the following tasks:

5.1 Denmark

A review of the technical options as seen by the turbine industry will be carried out with respect to the different market aspects. The survey will comprise standard cold climate packages and blade de-icing additional add-on packages.

Especially the possible higher emphasis on blade icing in the future, due to large scale offshore expansion will be assessed.

In addition experiences from harsh arctic conditions, i.e. Greenland will be reviewed, with respect to continued R&D.

5.2 Finland

Wind turbines are monitored at a number of sites, which are facing various climate conditions. Most of the monitored turbines are equipped with an ice-preventing system and the functionality of that is a topic of interest. Power performance measurements are carried out at a number of sites and load measurements under extreme icing conditions. Information on the operation and performance of wind power plants will be reviewed and shared as allowed under existing contracts.

A site classification formula, which relates to different icing conditions, will be proposed. A state-of-art review of current technical options will be carried out with respect to different market segments.

In addition VTT Energy will act as operating agent for the annex.

5.3 Norway

Statistics from wind turbines under operation will be gathered. So far Norway does not have to many operating wind turbines. There are one 1650 kW located 230 m a.s.l. at about latitude 65. Here one will possibly find a few icing events. Summer 2001 a large wind farm are planned to be installed at latitude 71 degrees 250 m a.s.l. If the installation will be realised, the case will be included in the annex.

The full physics mesoscale model MM5 for wind resource mapping has been used and developed. So far the energy balance in the model has been without the wet processes. One of the national activities will be to extend the energy balance to include evaporation and condensation of water. The model will then be used to map icing.

Statistical methods for icing prediction will be further developed. Effort will be spent on extending the simple method of using cloud and temperature data from a weather station to predict icing. A national project for producing a detailed icing map is applied for. The challenge in the project is to calculate time series for cloudiness and temperature for locations around the weather stations. For both cloudiness and temperature other weather parameters like wind speed, wind direction, time of year, atmospheric stability will be tested. For the case of the cloudiness a possible approach is to define a set of weather situations for the different weather stations.

5.4 Sweden

The Bockstigen offshore wind farm is equipped with a measurement system which continuously monitors operation of all five 550 kW wind turbines in general and loads in turbine #4 in particular. Atmospheric conditions and loads are simultaneously measured in a 40 m offshore mast. Power performance data will be evaluated with respect to low production possibly caused by accretion on the turbine blades. Drifting ice, as well as steady ice, on the sea surface will, if existent, be detected using a video camera. The loads in the monopile and in the 40 m tower will be compared to any ice monitored by the camera. Meteorological data are acquired in three different masts at an offshore, a coastal and an inland site. Any detected icing in these three masts will be reported.

Suorva: A 600 kW wind turbine from Bonus, which is owned by the utility Vattenfall, has been in operation in northern Sweden since late 1998. The turbine is equipped with strain gauges measuring bending moments in all three blade roots. A high resolution video camera mounted in the hub facing one of the blades is to be used to detect ice accretion. An IR-camera is foreseen to be needed to detect rime ice but funding is presently unavailable for this extension. Comparisons will be made between data acquired under non-icing conditions and data from known icing conditions. If possible to detect using either strain gauge data or blade images, any changes in blade aeordynamics/dynamics will be reported.

Rodovålen: This is probably the most interesting and existing cold climate wind farm in Sweden so far. The farm, which has been in operation since early 1998, consists of three 600 kW wind turbines from three different manufacturers. The location is well known for its severe icing conditions. At present no measurement system is installed at the site. It is our intention to have a Bonus 600 kW wind turbine of the same kind as the one found in Suorva (see previous paragraph) equipped with a similar measurement system. However, a measurement system at Rodovålen is presently lacking financial support. Consequently and at this stage, no obligations can be made regarding the safe supply of data from Rodovålen.

5.5 The US

Basic assessment studies of current and planned sites of wind turbines in cold climates will be performed. Anemometer and icing data for current sites will be investigated for icing calibration. Experience from existing arctic sites can be reviewed for relevant information.

Tests are ongoing and through contractors on the performance of key turbine components in cold climates. This work includes pull testing blade studs. Operational procedures of existing wind turbine installations will be reviewed to report on operational parameters. The results of any research and experience will be shared with Annex members as allowed under current cooperate agreements.

Available information on the operation and performance of wind power plants will be reviewed and shared as allowed under existing contracts. Future surveys of plant operational experience may include questions relating to turbine operation in winter conditions.

Detailed monitoring of wind turbine operation in cold climates at select sites will be conducted. Data from these sites available as allowed under existing monitoring contracts will be made. Severe events dealing with cold can also be investigated and described.

6 EXPECTED RESULTS

The experiences of as well building, installing and operating wind turbines in a new market segment with specific requirements as availability, accessibility and reliability.will be collected.

A site-classification procedure for feasibility studies and market assessments will be established.

A methodology for monitoring icing conditions during site assessment and operation will be presented.

Estimated losses of production due to icing will be quantified. Tools for estimating the feasibility of different adapted technical solutions will be developed.

Guidelines for developing wind energy in cold climate conditions, including all aspects of cold climate engineering, not only limited to icing will be presented. These are necessary when entering new markets, e.g. in non-OECD countries.