Modern wind energy technology for Russian applications. Main report

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Abstract The general objective of the project is to establish a technical foundation for an intensified application of wind energy in Russia with medium to large wind turbines and transfer/adaptation of Danish and European wind turbine technology as a basis for future joint ventures and technology exports. More specifically, the objective is to develop and establish the basic knowledge and design criteria for adaptation and development of Danish wind turbine technology for application under Russian conditions. The research programme is envisaged to be carried out in three phases, the first phase being the project reported herein.

The main purpose of phase 1 is to assess the needs for modifications and adaptations of established standard (in casu Danish) wind turbine designs for decentralised energy systems with a limited number of medium sized wind turbines and for grid connected wind turbines in cold climate and in-land sites of Russia. As part of this work it is necessary to clarify the types of operational conditions and requirements that are to be met by wind turbines operating in such conditions, and to outline suitable test procedures and test set-up's for verifications of such adapted and modified wind turbines.

The reporting of this project is made in one main report and four topical reports, all of them issued as Risø reports. This is the Main Report, (Risø-R-1069), summing up the activities and findings of phase 1 and outlining a strategy for Russian-Danish cooperation in wind energy as agreed upon between the Russian and the Danish parties.

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Contents

Preface

The Danish contribution to the project has been financed by Danish Ministry of Energy under the energy research programme (EFP96), jour. No. 1363/97/0003.
The project partners are:

- Risø National laboratory, Roskilde, Denmark
- Ministry of Fuel and Energy (Mintopenergo), Moscow, Russia
- All Russian Institute for Electrification of Agriculture (VIESH), Moscow, Russia
- Russian-Danish Institute for Energy Efficiency (RDIEE), Istra, Russia
- Darup Associates Ltd., Roskilde, Denmark
- Busch & Partners, Copenhagen, Denmark

The reporting of this project is made in one main report and four topical sub-reports, all of them issued as Risø reports (the sub-reports with restricted distribution):

Modern Wind Energy Technology for Russian Applications:
- Main Report, (Risø R-1069)
- Wind Energy Test Site in Istra, (Risø-I-1333)
- Inspection of Representative Sites in the Arkhangelsk Region, Risø-I-1373)
- Survey of Relevant Russian, Danish and International Standards, (Risø-I-1334)
- General Survey of Site Conditions in the Northern Russia, (Risø-I-*1335)*

This is the main Report Risø-R-1069, summing up the activities and findings of phase 1 and outlining a strategy for Russian-Danish cooperation in wind energy as agreed upon between the Russian and the Danish parties.

1 Introduction

The Ministry of Fuel and Energy in Russia (Mintopenergo) has estimated the potential demand for wind energy for 4 classes of wind energy applications, cf. ref. 1 which is included in Appendix 2 of this report. The classes, mode 1-4, are defined as

1. Systems of individual use, including a 0.1-5 kW wind turbine. Potential 1000-1500 systems per year.
2. Small systems of collective use, including one or more 5-50 kW turbines. Potential 1000-1500 per year.
3. Medium and big systems of collective use, including one or more 50-500 kW wind turbines. Potential 85 MW per year during the next 5 years.
4. Grid connected wind power stations with 100-1000 kW wind turbines. Potential 470 MW per year during the next 5 years.

As indicated in the Russian programme "Power supply for the Northern Territories" the potential in Russia is primarily found in the northern territories, mostly including areas with moderate wind conditions and other external conditions different from most Danish applications. The programme involves almost 70 % of Russian territory, including European North, Siberia and Russian far East. Here, large land areas are available for wind installations and the need of locally produced electricity is widespread in sparsely populated areas with local or regional grids.

In order to obtain large scale commercial application of wind turbines in Russia it is necessary to utilise existing, proven and reliable wind turbine designs, since very high technical reliability is a precondition for successful application in the very often difficult and demanding Russian conditions. Denmark and Europe has pioneered development of such designs, and they account for two thirds of all installations world wide (including 60 per cent of the working installations in USA). However, the designs may need to be adapted and modified for use under Russian conditions, in particular cold climate and moderate wind in-land sites with regional grids in Russia.

The necessary adaptations and modifications need to be tested and verified in Russia under Russian conditions in order to establish the technical credibility that is a precondition for getting the necessary financial and institutional support and acceptance. An important part of the technical credibility is a set of design criteria for wind turbines and wind turbine applications for Russian conditions, and guidelines and recommendations for implementation of wind energy under commercial conditions. As any large scale wind energy application in Russia is unthinkable without a large component of Russian manufacture and supply, the technology transfer and co-operation aspect must be included.

Therefore the project has been carried out as first step in a strategy in which research shall be followed up by a demonstration and implementation programme.

The general objective of the envisaged research programme is to establish a technical foundation for an intensified application of wind energy in Russia with medium to large wind turbines and transfer/adaptation of Danish and European wind turbine technology as a basis for future joint ventures and technology exports. More specifically, the objective is to develop and establish the basic knowledge and design criteria for adaptation and development of Danish wind turbine technology for Russian conditions for application

- in grid connected wind power stations with 100-1000 kW wind turbines (mode 4 systems), and
- in medium or big systems of collective use with one or more 50-500 kW combined with diesel generators or hydro (mode 3 systems),

including:

- to determine external conditions (wind, temperature, soil, energy system interface, earthquake, lightning and other critical conditions) to act as design criteria for wind turbines in Russia
- a consistent set of relevant Russian design and construction standards applicable for wind turbines
- to establish common procedures and experience for measurement and analysis of wind turbine performance, loads and function, and finally
- to develop verified design and load criteria for wind turbines for cold climate and in-land Russia, and
- to develop technical guidelines for project design with medium to large wind turbines including recommendations for application of design criteria and Russian/Danish/international standards.

The research programme is envisaged to be carried out in three phases, the first phase being the project reported herein.

The main purpose of phase 1 is to assess the needs for modifications and adaptations of established standard (in casu Danish) wind turbine designs for mode 3 and 4 applications in cold climate and in-land sites of Russia. As part of this work it is necessary to clarify the types of operational conditions and requirements that are to be met by wind turbines operating in such conditions, and to outline suitable test procedures and test set-up's for verifications of such adapted and modified wind turbines. Status at the completion of phase 1 is, that

- Phase 1 indicates the feasibility of continuing the project as stipulated
- Phase 2 application has been submitted for to the Danish Energy Agency
- Strategy considerations are warranted

A strategy for Russian-Danish co-operation in wind energy has been drafted and is included in the present report.

2 Survey of Main Activities

During the project, the main activities listed in the programme overview have been carried out according to the EFP 97 project plan. Both programme overview and project plan are included in Appendix 1 of this report.

2.1 Wind measurements at the test site in Istra

The Nikulino wind test site is located in the town of Istra some 70 km NW of Moscow. The Nikulino test site is close to RDIEE in Istra, and it is owned and operated by VIESH.

A wind measurement system has been supplied from Denmark and erected at the Nikulino test site. The instrumentation and the data logger was supplied by Risø, and the mast was supplied by VIESH according to specifications from Risø.

Data from a approx. 1 year of operation of the measurement system have been collected and analysed. A WAsP analysis of the Nikulino site has been carried out and the results have been compared with data from a nearby meteorological station (New Jerusalem), where long term data are available.

More details on the wind measurements and the test site are given in section 4 of this report and in the report Risø-I-1333.

2.2 Planning of test facility and test programmes

A number of visits to Russia were made and meetings were held in Moscow, (at VIESH, RDIEE in Istra, and at Nikulino) and Risø. The Nikulino site in Istra has been visited and inspected on several occasions.

The test set-up has been decided upon based on discussions in the joint Russian-Danish project group. A main issue in the integration of standard wind turbines into a mode 3 diesel powered grid is the interaction between the wind turbine(s) and the diesel generators, in particular the dispatch strategies for power plants with more than one diesel generator. The proposed test set-up reflects this.

A joint memorandum on the WD test set-up has been elaborated, including notes on mode 3 wind turbine (WD) test set-up and mode 4 wind turbine test set-up. The memorandum is developing into the proposed specifications for the test set-up, Risø-I-1333.

2.3 Survey of representative site conditions

The survey covered site conditions for the programme "Power supply for the Northern Territories", and it included limited reviews of climate conditions and energy system characteristics

A visit was made by members of the joint Russian-Danish project group to the Arkhangelsk region. The visit included the town of Mezen and a few villages. Mezen seems to be a suitable site for a mode 3 wind diesel demonstration project.

Travel reports from the site visits have been written that include data provided by the Russian party for the respective sites/areas. The travel reports and a memorandum from the wrap-up meeting in Arkhangelsk is included in the report Risø-I-1373.

WAsP analyses of the wind resources in the Russian North West regions have been made jointly between Risø and RDIEE, Istra.

Is was decided to select a Russian consultant to obtain the relevant information in terms of specifications of the grid conditions that can be expected in the Northern Territories of the Russian Federation, to be used in connection with establishing technical criteria for wind turbine design for the Northern Territories. TOR outlining the tasks and formats involved in the specification of the grid conditions were developed and a report on grid conditions in the Northern Territories has been made by the Russian consultant, ref. 2.

Is was furthermore decided to select a Russian consultant to review Russian standards and certification requirements relevant to mode 3 and 4 wind turbines with respect to climatic and other external conditions for the Russian North, and TOR outlining the tasks and formats involved in this review were developed. A report on climatic conditions and other external conditions for the Russian North has been made by the Russian consultant, ref. 3.

The TOR's and the reports by the Russian consultants are included in the report Risø-I-1335.

2.4 Compilation of readily available Russian standards

The purpose of this activity was to compile Russian wind turbine related standards and practices and compare them to Danish and International technical requirements.

Meetings were held in Risø and in Moscow, and there has been a substantial exchange of information and material on wind turbine related standards. In a joint effort a number of relevant Russian standards, comparable to Danish and international standards, were identified and translated into English. The most important of the translated standards are dealing with wind energy plant certification, common engineering requirements and standards for testing.

The overall build up of the different systems of requirements is more or less the same and the areas covered in the Russian standards are also covered in the Danish and International standards (but not vice versa). Generally the Russian standards are less specific meaning that the Russian standards contain less specific numbers and references.

A comparison of the Russian wind turbine related standards with Danish and International (IEC) standards has been made. The comparison is reported in Risø-I-1334.

2.5 Exchange of scientists

In 1997 a visit was made by Russian scientists to Risø for an introduction to wind measurements and wind measurement equipment. Subsequently, in March 1998, a group of scientists visited Risø to discuss mode 3 and 4 measurement set-up, including instrumentation and monitoring techniques.

2.6 Seminar in Denmark for Danish and Russian industry/authorities

The seminar was originally planned and announced for early 1998. However, at the time the registration was modest and especially industry interest was limited, and the seminar was therefore postponed.

The seminar was held during the week 18 – 23 January, 1999, as part of a visit to Denmark by a Russian delegation with representatives from the State Duma of the Russian Federation, Mintopenergo, VIESH and RDIEE Istra. Programmes for the Seminar and for the visit are included in Appendix 3. A few strategy-related notes from the seminar are given below.

The Russian delegation described the difficulties connected with introduction of wind power in Russia in a way that can briefly be summarised in the following way:

- Psychological barriers: High degree of availability of fossil fuel and strong traditions to use it, strong coal, oil, gas lobbies, big-scale fixation and centralist habits

- Economic barriers: Consumers' lack of ability to pay (the "non-payment problem", social problems), insufficient support from the state, lack of federal planning
- Legal barriers: Lack of legislation concerning use of renewable, lack of regulations, no tax incentives
- Technical barriers: Unavailability of autonomous systems (e.g. wind-diesel), lack of wind turbines with a capacity larger than 30 kW, lack of infrastructure, lack of knowledge, information and demonstration.

The Russian delegation pointed to the lack of reliable electricity supply in many regions and the often very high kWh-price. The State Duma is considering a federal law providing a framework for application of renewable energy sources in Russia (first reading of the law is scheduled for March 1999).

The Russian delegation made it clear that the Russian first wind power priority is wind-diesel systems, next comes the use of big grid-connected wind turbines (i.e., wind power parks). NEG Micon made it equally clear that the company finds that wind power parks with big grid-connected wind turbines "are the future", because they are most cost-effective. Erection of a few wind turbines is relatively too expensive irrespective of the size of the turbines.

Danish and Russian standards have the same fundamental structure. All elements in the Russian standards are covered in the Danish ones that are more comprehensive, have more quantitative information and more references. There is a need for development of the Russian standards especially as concerns climatic parameters.

It was mutually agreed that the draft strategy presented and discussed at the seminar would form a useful platform for future cooperation. The State Duma and Mintopenergo will have the draft strategy translated and expanded in order to use it in the State Duma and in the central administration.

It was also agreed that a suggestion made by a representative of Danish industry that support to and utilisation of idle, Russian research capacity in technical and scientific cooperation. In this connection it was suggested that the possibilities for support from the European Communities of such cooperation should be explored and exploited.

The Russian delegation emphasised that many former state companies are looking desperately for new products to manufacture. The delegation wanted this mentioned in the draft Strategy.

2.7 Drafting of a strategy for Russian-Danish co-operation in wind energy

During a visit in Moscow in the first week of November, 1998, Per Lundsager and Niels E. Busch had conversations with a number of Russian colleagues representing the federal authorities, trade unions, the State Duma, RAO EES Rossia, and scientific institutions.

The conversations concerned the continuation of the Russian-Danish co-operation in the field of wind energy. They centred around the expediency of development of a strategic frame within which plans could be formulated for joint activities with typical time horizons of 3 - 5 years.

At the wrap-up meeting the results of the above mentioned conversations were summarised and discussed with Pavel P. Bezroukikh, MinTopEnergo, Dmitri S. Strebkov, VIESH, and Alexander N. Starkov, RDIEE. It was agreed that:

A. There is a strong interest both in Russia and in Denmark in continued and strengthened co-operation which at present has resulted in the near-publication of a Russian wind atlas, the conclusion of the 1st phase of the project on adaptation of modern wind energy technology for Russian applications, several concrete demonstration projects and a number of feasibility studies.
B. It seems advantageous to bring the future projects into a common strategic frame in order to obtain maximum impact, visibility and funding.
C. The common goal for the strategy is to establish a Russian wind energy market
D. The strategic frame should accommodate the already existing and successful elements of the Russian-Danish wind energy co-operation and could contain the following main items:

1. Publication, continuation, perfection and usage of the Russian wind atlas.
2. Continued work with establishing a wind-diesel test and knowledge centre in Nikulino.
3. Development and implementation of a hierarchy of Russian-Danish courses ranging from introductory courses for decision makers to diploma courses for wind power engineers.
4. Implementation of continuous monitoring of the wind power scene in Russia both in terms of the politico-economic development and in terms of identification of local and regional interest in wind power.
5. Identification of and participation in concrete and sustainable demonstration projects.
6. Formation of a small Russian - Danish group of specialists that shall assist in the implementation of the strategy, provide new ideas, guidelines and moral support, but without responsibility for neither the economy nor the outcome of the individual project.

Subsequently a draft strategy was elaborated, based on these ideas, and it was discussed with the Russian parties during the seminar. The revised draft strategy was submitted to the Danish Energy Agency ultimo January, 1999, for further consideration.

The background for the strategy and an outline of the strategy are given in Chapters 3 and 6, respectively.

3 Status for Wind Energy in Russia

It is obvious that the development of wind power is highly dependent on political decisions. Russia was one of the first countries to exploit wind power in modern times, and yet today Russian wind power still amounts to very little. This is neither because of the wind climate, which in many regions of Russia is favourable for wind energy, nor is it because wind energy is not competitive. The reasons are rooted in economic and political crises and fostered by lack of political will to implement the legislation that is necessary, if wind power shall develop into national significance.

3.1 Background, Russian conditions and needs

Russians maintain - and for good reason - that Russia was the first and foremost country in the world to use modern wind energy. Wind energy has long traditions in Russia. So have other energy sources, and generally speaking one cannot claim that Russia is marked by lack of capacity for electricity production.

On the other hand, approximately 70% of the landmass - and approximately 30% of the population - do not have access to grid or pipe delivered energy in spite of the fact that a considerable part of Russia's raw materials and foreign currency income stem from these parts.

This need for new electrical power plants is primarily due to:

- Outdated, inefficient and run-down equipment with inferior operational reliability
- High consumption of primary energy because of low efficiency of the energy conversion in general
- High production costs because of high cost of fuel
- A national electricity grid that is neither fully developed nor of sufficient standard

From the point of view of operational economy, new electricity capacity will be most competitive where the present production price per kWh is the highest, everything included. That will naturally be the case where the existing equipment is outdated, inefficient and worn-out, where fuel prices are high, and where the need exceeds the existing production capacity.

Such circumstances are found many places in Russia. Wind energy is a significant part of the Russian government's energy plan for the Northern Region that stretches along the Arctic Sea from Murmansk in the west to Tjukotskij Khrebet (Tjukotka) in the east. A population of ten to twenty million (approx. 10% of the Russian population) live in this region. The needs for electricity are considerable - especially in the western parts. The production facilities are outdated and the fuel is primarily expensive diesel oil.

The immediate need for wind energy in Russia for a period of three to five years has been estimated by Mintopenergo to be in the vicinity of 500 MW new-installed per year or about one quarter of the capacity that globally was installed in 1998 or close to 40% of the capacity built by Danish manufacturers in 1998.

3.2 Analysis of the present situation in Russia, possibilities and difficulties

It is probable that the politico-economic impediments to marketing of wind power in Russia will disappear in the course of relatively few years, e.g. five years. It is worth noticing that even under the present circumstances wind power would indeed be competitive many places in Russia, if legislation were in place to protect investments and secure payment for consumption.

Although many regions in Russia have over-capacity for electricity production - not everywhere can electricity be sold abroad - and in spite of Russia's great amounts of traditional energy (coal, oil, natural gas, nuclear) in a world market with falling prices, it is a fact that in some Russian regions there is a strong and economically conditioned interest in wind power as a component of the energy supply system.

The present strategy considerations are base on the following observations:

- The federal authorities (the government) show little interest in wind energy. The federal government has stopped supporting energy development. Construction of new power plants has practically ceased, and it is impossible to find (federal) money in support of wind power installation. The general (federal) attitude is that wind power must wait to better times. The Danish interest is welcome, but it should take its starting point in the needs of the local regions.
- In the State Duma attempts have been made several times to pass laws that allow the local regional governments to use federal fuel-transportation money to buy fuel-saving windmills. So far the attempts have failed. The federal government seems committee practically all the governors of the regions are supportive. Even though the local governments cannot use saved federal fuel-transport money for windmills, they may choose to use their own fuel-savings.
- Yeltsin's government has a limited lifetime left. When government changes, a great number of decision-makers will change with it. The situation will remain unclear until then. This will not make co-operation easier. Attention should be focused on the fact that the real decision-makers in connection with wind power are the local authorities, especially the governors and their administrations. RAO EES Rossia still has considerable influence, partly because of the money it controls, partly because of tradition and its grip on norms and standards for electricity production and distribution.
- The local authorities are charged with the responsibility of securing the energy supply in the regions. Many are hard pressed because of failing supplies of primary energy. The shortages are due to failing control of the economy as a consequence of the so-called non-payment problem and the impenetrable subsidising of the energy sector.
- A considerable number of trained, experienced, and well educated scientists are going idle these years for lack of funding. Research potential is wasted also in fields related to wind energy. This potential could be utilised at a very reasonable cost.
- A significant number of former state companies are desperately looking for new products to manufacture.

It is our expectation and understanding:

- that active interest in wind energy will be considerable in some regions in Russia
- that the will to economic engagement is present in these regions
- that this engagement will grow as the economic and political situation is stabilised in the course of the coming five years
- that not much active and economic support to development of renewable energy resources can be expected from the federal authorities
- that it will be necessary to secure understanding, co-operation, and support from Mintopenergo and RAO EES Rossia in order to make the contact to the local government easier and to raise the credibility
- that during the next five years the Russian-Danish co-operation on wind energy expediently will be less focused on investments and more on the understanding and knowledge necessary to develop wind energy in Russia, to transfer the technology and to plan and prepare investment projects

3.3 Russian-Danish co-operation up to now

Until now the co-operation on wind energy has largely been on projects of four different types. The projects have been well carried out, They have been solid and successful, but been neither of any great economic magnitude nor to any extent co-ordinated with consideration of joint strategic goals.

One type of projects has been evaluation of possible sites for wind power parks in St. Petersburg, Kolskij Poluostrov (Kola Peninsula) and Arkhangelsk.

Another type has been demonstration projects through which wind turbines - partly or fully donor paid - were established on Komandorskije Ostrova (Commandor Islands), in Kaliningrad and in Karelia. Time will show whether these project will achieve the desired effect, namely to be examples of what we in this connection will call (technically, economically and institutionally) "sustainable" projects, i.e., projects, implemented in a suitable institutional framework, that demonstrate convincingly that wind power is a technically and economically passable road to the solution of certain energy supply problems.

The Russian Danish Institute for Energy Efficiency (RDIEE) in Istra has collected a great amount of climatological data. The data have been analysed in cooperation with Risø National Laboratory and turned into a wind atlas for Russia. The atlas makes it possible by means of local terrain data and suitable computer programmes to estimate the expected annual electricity production from a windmill or a wind power park anywhere on Russian territory.

Finally, the Danish Energy Research Programs (EFP) have co-financed with Mintopenergo and Risø National Laboratory the first phase of the present project "Modern wind energy technology: Applications in Russia". The project is now on its way into the second phase. Its aim is adaptation of Danish wind power technology to Russian - often extreme - conditions and encompasses various aspects of testing and certification. As described in this report, Phase 1 contained the beginning establishment of a test station in Nikulino near Istra, site evaluations, and review of relevant Russian, Danish and international standards and norms.

These activities should be widened through addition of more general information and education activities, they should be brought to complement and supplement each other better, and such efforts could be assisted by bringing them into a strategic frame. This could increase the useful impact of the activities, give them clearer visibility and a better chance of proper financing.

4 Wind Energy Test Facility in Istra

The test set-up for mode 3 (basic wind diesel) and mode 4 (standard grid connection) wind energy system testing at Nikulino has been decided upon based on the realisation that a main issue in the integration of standard wind turbines into a mode 3 diesel powered grid is the interaction between the wind turbine(s) and the diesel generators, in particular the dispatch strategies for power plants with more than one diesel generator.

There are two major parts of the Wind Diesel test set-up, the experimental wind turbine & diesel system, and the monitoring and data recording system. Later on a supervisory control system should be added.

More details on the test facility are given in the topical report Risø-I-1333(EN).

4.1 Purpose and Function of Wind Energy Testing at Nikulino

The main purpose of the Wind Energy and Wind Diesel testing at Nikulino test station is to establish the test station as a knowledge centre in relation to the Russian strategic programme "Supply of electric power to northern territories of Russia". Functions will include

- Determination of functions & requirements including multiple diesel dispatch
- Advice to users regarding system layout & economy
- Training of local staff from power plants in the Russian North
- Demonstration and advice to potential manufacturers & suppliers

The Nikulino test centre is a department in VIESH, who owns the centre. VIESH will operate the centre under contract to MinTopEnergo, delegating (some) studies to VIEN, a project executing subsidiary of VIESH.

4.2 Map and Location

The Nikulino wind test site is located in the town of Istra 70 km NW of Moscow, Fig 4.1. The Nikulino wind test site is close to RDIEE in Istra, and it is owned and operated by VIESH. Under VIESH administration the Nikulino test site has for many years performed wind measurements from a 16 m mast and tested small wind turbines for use in agriculture. Academic and technical staff as well as equipment is designated to the test site.

4.3 The experimental wind turbine and diesel generator system

The proposed test set-up reflects the proposed purposes and functions, and the mode 3 wind energy system layout decided upon consists of the following components:

• Wind Turbine (Danish)	kW 225/50
• Diesel generator # 1 (Russian)	kW 100
• Diesel generator # 2 (Russian)	kW 60
• Dump load (Russian)	kW 75
• Consumer load (Russian)	kW 180

This system layout may work with a smaller (e.g. 150 kW) wind turbine, even if it is single speed, due to the low wind speeds at Nikulino.

The layout of the test facility is based on the Simple, Robust &Reliable Wind Diesel system at Risø, refs. 4 and 5. The experimental system is connected in the simple, robust and reliable architecture to a switchboard with a column for each component and with a local busbar connected to the load simulator. The switchboard will have contactors for connection of the wind turbine/dump load to the grid at Nikulino. Figure 3 shows a diagram of the test facility.

Figure 4.1. Map showing the location of Istra relative to Moscow

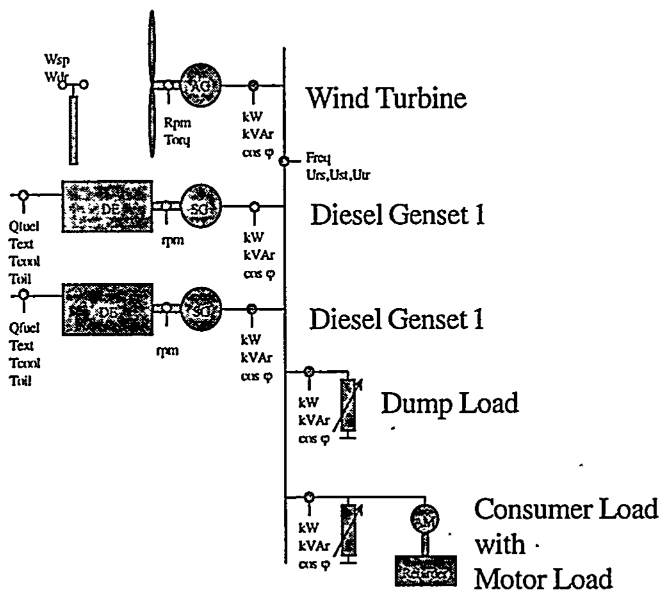


Figure 4.2. Test Facility diagram

The Russian diesel generators may be supplied in four steps of automation, but the diesel generators for Nikulino will have the highest level of automation, step 4 automatic, with possibility to operate at lower levels to simulate present state of diesels in local communities. The diesel generators will be installed in containers rather than in the existing building.

Noise suppression e.g. by insulation and special silencers may be necessary due to noise regulations at Nikulino.

4.4 The monitoring and data recording system

For study and R&D purposes an instrumentation similar to that of the experimental system at Risø will be suitable. An overview of the signals to be monitored is given in table 4.1 below.

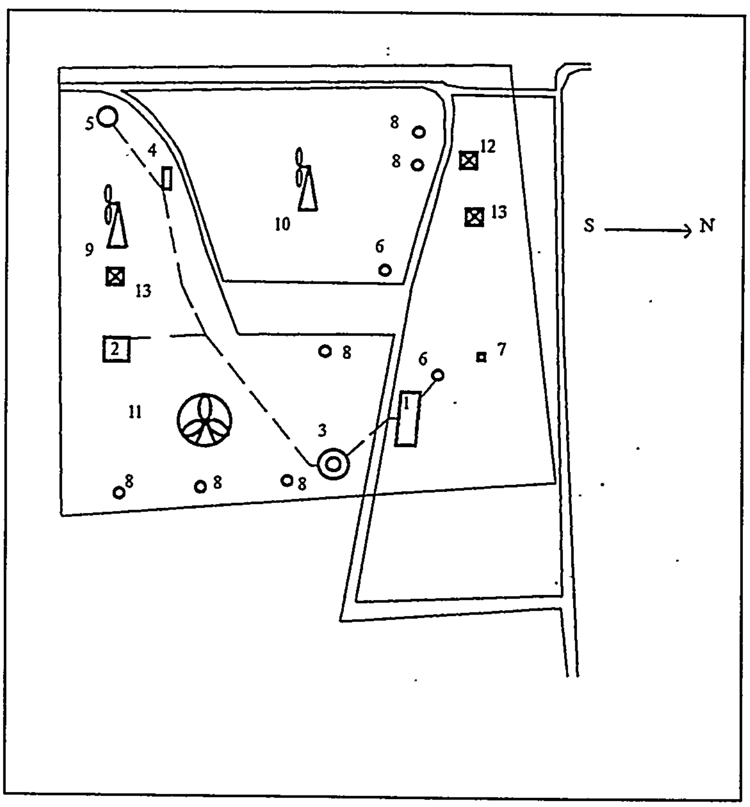
Table 4.1. Estimated number of signals to be monitored.

Signal	WTG	Dump	DGS 1	DGS 2	Bus Bar	Load/ grid	Total
Power	3	3	3	3	7	2	22
Other	2	0	5	5	0	0	12
Control	1	1	1	1	0	1	5
Total	6	4	9	9	7	4	39

The data recording system should be a standard PC based system laid out for recording 64 channels, since standard PC cards for AD conversion come with 16 channels apiece.

4.5 The Nikulino Site Plan

Figure 4.3 shows the proposed site plan of the Nikulino test site



1. Laboratory building
2. Solar house
3. Transformer TIT100/ 6 kV
4. Pump building
5. Water tower
6. Water supply wells
7. Telephone poles
8. Filling wells & chinks
9. BOY-6 (USA)
10. BOY-10 (USA)
11. Vestas 29 (225 kW)
12. Met mast 34 m
13. Met mast 18 m

Figure 4.3. Nikulino site layout

4.6 Budget estimate and plans

A tentative budget estimate given in table 2 below, based on western prices for all equipment. This budget estimate is intended as a basis for discussions with western financiers. Later on a budget estimate should be made with Russian costs for Russian contributions.

Table 4.2. Budget estimate (1988).

Part	1000 DKK
Experimental Wind Energy System	2,900
Data acquisition system	400
Supervisory controller	100
Contingencies	300
Total	**3,700**

The knowledge centre is envisaged to be established in the following phases:

- Hardware purchase and installation
- Study of systems
- Development of systems/concepts specifically for Russia
- Preparation of training programmes
- Training of local staff

These phases are envisaged to be operating in parallel.

5 Wind Energy Conditions in the North of Russia

This chapter gives an overview the conditions for the implementation of wind energy in the North of Russia. The overview is based on site visits Arkhangelsk region, Russian surveys of grid conditions and climatic conditions, and a survey of the wind resource in the north-west Russia based on the Russian Wind Atlas.

More details are available in the topical reports of the project and in other references as specified in the sections below.

5.1 General conditions

This section gives a brief outline of the conditions in the town of Mezen in Arkhangelsk Region, based on a note from the visit included in Appendix 1 of Risø-I-1373. Mezen is an example of a mode 3 system, i.e. utility grade wind turbines connected to a large diesel powered grid, and it is believed to be representative for the application of wind energy in such systems in the North of Russia.

Mezen is located approx. 200 km ENE of Arkhangelsk on the bank of the river Mezen. The location for the planned wind farm is to the N of the city nearby the city power plant, and the location of the wind turbine(s) is motivated by the easy access to the electrical grid (and qualified staff) and is not optimised to wind conditions.

In the city of Mezen several minor heat plants are distributed, apparently feeding small local heating systems.

Wind Turbine System

There are plans for connecting a 2 - 2.5 MW wind farm with 300 to 600 kW wind turbines to the diesel grid in Mezen. This level of wind energy penetration requires quite detailed analyses of the impact on the operation of diesel system, including the use of optional and deferrable loads from the wind turbines. In that case a need for automatic start up and shut down of diesel generators should be envisaged. With a minimum consumer load of 1,850 kW as mentioned below, up to 1,000 kW of wind turbines (suitably modified according to local conditions as mentioned below) may be incorporated in the existing system in standard mode.

Diesel Power Plant

The cost of energy (COE) is typically around 1,200 rbl/kWh (approx. 0.21 US$/kWh). Consumers pay standard rates, approx. 260 rbl/kWh, i.e. 20% of the COE, and the regional administration pays the difference. Fuel cost is approx. 3,300,000 rbl/ton, but a COE breakdown for the fuel is generally not available.

In Mezen there are 9 diesel units of size 600 to 1,000 kW, with total installed capacity 6,600 kW. Maximum consumer load is around 5,000 kW, minimum load 1,850 kW. Cooling water from the diesel generators is not used for the district heating system. Fuel consumption is Approx. 4500 Tons/year corresponding to an average of 250 g/kWh for a total energy production of 19,000 MWh/year.

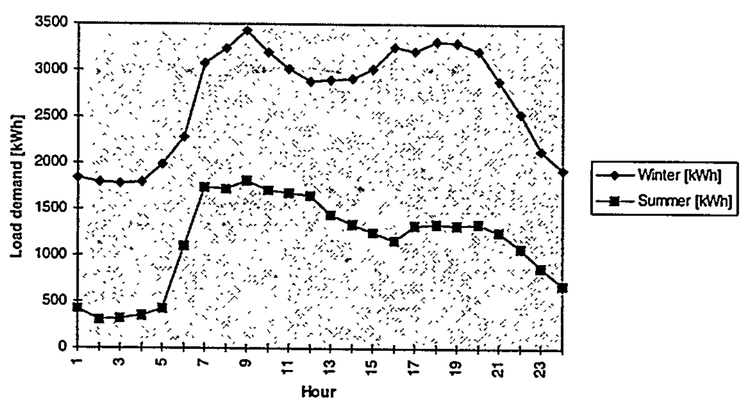


Figure 5.1. Daily & seasonal load pattern

Examples on daily and seasonal load patterns are given in fig. 5.1. Diesel dispatch is decided "manually" based on knowledge about the load demand, but once chosen the diesels are connected to the busbar by automatic synchronisation. Load sharing during parallel operation is controlled by the P-regulators of the diesels.

Wind and other Climatic Conditions

Potential wind sites are not necessarily the optimal wind sites, and the wind may have to pass the town or other obstacles before reaching the turbine(s), which implies some reduction in wind speed and some increase in turbulence.

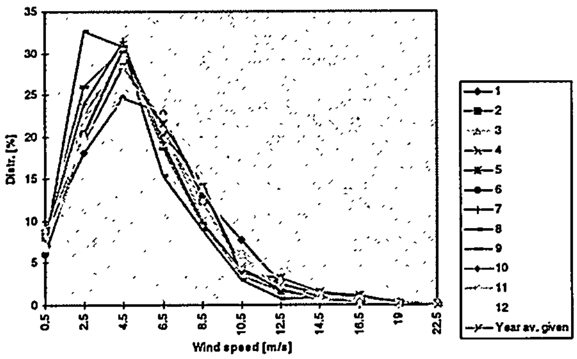


Figure 5.2. Monthly & annual wind speed distributions

The temperatures are typically rather low. The normal temperature in the winter time is approx. -25 deg. C and the lowest peaks can be -40 deg. C. In winter time, typically in November - December during calm wind, icing on the electrical lines is a serious problem.

Lightning does not appear to be a serious problem.

Other Site Conditions

In most locations there are no needs for special local foundation techniques, and consequently standard concrete mass foundation techniques are expected to be applicable in most places, although permafrost may be a problem in a few locations.

Access to the power plant is typically straightforward, but access to the site may be more difficult. Availability of cranes with the necessary capabilities in terms of lifting height (m) and moment (tm) has to be assessed in view of the requirements for the wind turbine sizes considered.

Depending on the distance to the sea there may be salt water corrosion.

Main findings of the Site Visits

The main findings on the sites in the Arkhangelsk Region are, that Mezen is a representative site for Mode 3 wind energy applications and that the two small settlements Nijnya Zolotitsa and Koida are representative sites for Mode 2 wind energy applications. Projects with Russian & International funding are being planned for the visited sites.

The implications for the Wind Energy Test Site in Nikulino are, that there is a need for training of staff at the power plants to be used for mode 3 and (in particular) mode 2 wind energy applications. There is a need for further investigation of multiple diesel dispatch issues for mode 3 and (in particular) mode 2 wind energy applications.

These findings have been incorporated in the application to the Danish Energy Agency for Phase 2 of the project.

5.2 Climatic and Other External Conditions

This section is based on the Russian study "Climatic and Other External Conditions of the European North of Russia and Specifications for Arctic Wind Turbines", ref. 2, included as appendix 2 of the project report *General Survey of Site Conditions in the Northern Russia, Risø-I-1335 (EN).*

The work was carried out under contract to Risø as a part of this project and based on the note "List of Parameters and Terms of Reference for the Consultant Work on Construction Codes", included as appendix 1 of the project report *General Survey of Site Conditions in the Northern Russia, Risø-I-1335 (EN).*

The Russian study contains description of climatic conditions as wind, temperature, icing, lightning etc. as well as requirements to wind turbine components caused by the arctic climate. The climatic information is mainly given for six representative sites.

In the table 5.2.1 values for wind speeds and temperatures are given for the site Kharlov, which has the highest wind speed of the chosen sites. Further the numbers defined in the Danish load and safety standard for wind turbine DS472 and in the IEC standard for wind turbine safety requirements IEC61400-1 (second edition) are given.

Table 5.2.1. Comparison of wind speeds and temperatures in the study, DS472 and IEC61400-1

	Average wind speed in h = 10 m [1]	Extreme (gust) wind speed in h = 10 m [2]	Turbulence intensity	Operational temperatures [T in °C]	Extreme temperatures [T in °C]
Kharlov	9.1 m/s	> 40 m/s [3] 50 m/s [4]	Not defined	-34 < T < 30 [3]	- 50 < T < 40 [4]
DS472 (Roughness Class 0)	6.9 m/s	47 m/s	0.11	-10 < T < 30	-25 < T < 35
IEC61400-1 (WTGS Class I)	10 m/s	70 m/s	0.16 to 0.18	-10 < T < 40	-20 < T < 50

1) The comparison – especially concerning the mean wind speeds – is a little uncertain because the methods described in the different standards are not totally comparable. E.g. the average wind speed is in IEC61400-1 defined as the annual average in the actual hub height where it in DS472 and the Russian study is defined related to 10-m height.
2) The average period for the extreme gust wind speed can differ a little from standard to standard (the value in DS472 is a 2 sec value and in IEC61400-1 a 3 sec value)
3) Measured at the Kharlov site.
4) General value for the European part of North of Russia area.

From the study it is clear, that the conditions differ a lot from site to site in the enormous European part of the North of Russia area (covering 730000 square km). Especially the average wind speeds are different. For the six sites the mean wind speeds are as described in the table 5.2.2.

Table 5.2.2. Wind speeds and Weibull factors for six sites in the area

Site	Average wind speed	Weibull C factor	Weibull k factor
Zip-Navolok	7.1	7.9	0.89
Gavrivolo	7.0	7.8	0.89
Kharlov	9.1	10.2	0.89
Kanin Nos	7.5	8.4	0.89
Morgiovets	6.8	7.6	0.89
Mezen [1)]	4.7	6.0	0.6

1) See further "Wind atlas for Mezen 1974 – 1988 in section 5.4

The European of the North of Russia is mainly characterised by the very low temperatures in the winter period. Because of that problems related to the low temperatures (as selection of materials, icing and permafrost) have to be taken into account in the design of the turbines.

The build up of ice and snow on structures is discussed in the study. Some values are given, but because of big differences from site to site it is difficult to obtain a general picture. On the other hand it is obvious that ice build up on blades, brake systems, wind vanes and anemometers has to be taken into account for wind turbines erected in the area.

Most of the area is defined as permafrost grounds. For different types of foundations minimum depths are given related to the depth of the seasonal thawing of the ground. For most types of foundations the minimum depth is given as the depth of the seasonal thawing plus one meter. A Russian standard "Basis for Foundations on Permafrost Grounds", Construction Norms and Rules 2.02.04-88 describes the subject. Problems with cable laying caused by permafrost are described in the Russian standard "Electrical devises", Construction Norms and Rules 3.05.06-85. Unfortunately none of these standards are translated to English yet.

Other conditions as lightning (low, 10 – 20 hour's pr. year), seismic activity and emission of harmful substances are described in the study, but none of these are remarkable.

5.3 Grid conditions

This section is based on the Russian study ref. 3, carried out under contract to Risø as part of this project. Ref. 3 is included as Appendix 3 of the project report *General Survey of Site Conditions in the Northern Russia, Risø-I-1335(EN).*

The installation of a significant capacity of wind energy in isolated and/or weak grids in, typically, rural areas has influence on the operation of the wind turbines and on the power quality in such grids. In isolated grids with, typically, diesel power plants the operation of the power plants may also be influenced. Power quality issues include:

- Grid availability and capacity
- Reactive power
- Voltage unbalance
- Voltage ranges
- Frequency ranges
- Harmonics
- Voltage fluctuations
- Islanding and overcompensation

Reactive power, which influences losses and capacity of grid and generators, is presently the most important parameter for utilities and power plant operators. Grid availability, frequency range, voltage unbalance and voltage range are the primary parameters influencing the wind turbine operation.

A survey ref. 4 (not included in this report) of present European standards and practices in this area has been published as part of a joint Danish – Indian project on Power Quality and Integration of Wind Farms on Weak Grids. The survey forms a good basis for comparison of Russian and International standards, and the study includes an outline of possible strategies for grid connection and reactive power compensation in rural grids.

The survey ref. 3 of the Russian standards for power quality etc. operates with a classification of existing autonomous power supply systems in the north regions of Russia. The systems are classified into 4 types as shown in the table below:

Table 5.1. Classification of Autonomous rural power supply systems

Type	1	2	3	4
# of units	1 or 2	Some	Several	Several
Total rated power	< 100 kW	100 – 1,000 kW	0.8 – 5 MW	3 – 10 MW
Busbar voltage	0.4 kV	0.4	6 kV	6 kV
Line voltage	0.4 kV	6 or 10 kV	6 kV	6 or 35 kV

Representative diagrams for a number of power supply systems in the north regions are presented in the study. Fig 5.3 shows the power supply system of Mezen, a mode 3 system that is considered for a possible demonstration project as described in the project report *Inspection of Representative Sites in the Arkhangelsk Region (Risø-I-1373).*

The conditions of connection wind turbines to the existing power supply systems are defined and the values of short circuit currents are calculated for one specific power system configuration. The Russian and international standards for power quality are compared, and the ability of the rural power supply power systems to comply with the standards is assessed. Type 1 and most often also type 2 are unable to comply with the standards while type 3 and 4 systems are found to have satisfactory power quality.

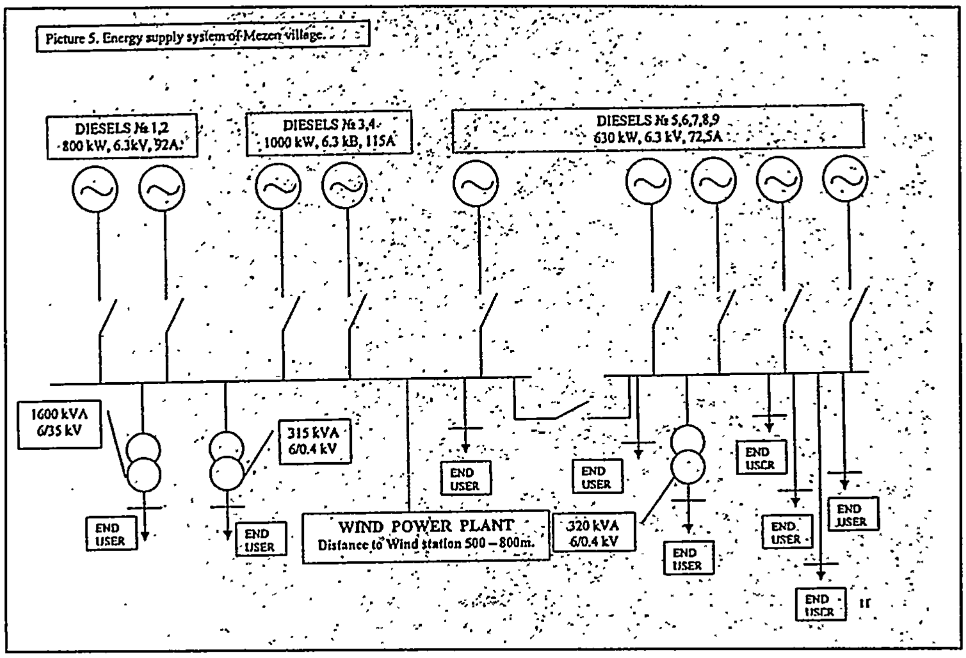


Figure 5.3. The power system of Mezen

The Russian and international standards for power quality are compared and are found to be comparable, with the following main findings:

- The Russian study gives a description of normative requirements in IEC and Russian standards, rather than a quantification of the actual conditions in the North Russian Rural Regions. A description of the actual conditions would require measurements.
- The list of electrical energy quality characteristics (Sections 4.2.1-12) include the most important parameters required to specify the power quality according to international standards.
- The point of common coupling (PCC) where wind turbines and consumer loads are connected together is typically on the medium voltage (MV) level, and the rated current from the wind turbine terminals (690V or 400V) is much higher than 16A. It is therefore more relevant to refer to IEC 1000-3-7 than IEC 1000-3-3 concerning flicker, and likewise concerning harmonics emission. The limits in IEC 61800-3 are more relevant than IEC 1000-3-2.

Ultimo 1998 IEC issued a draft of IEC 61400-21 for "Power Quality Requirements for Grid Connected Wind Turbines". This standard specifies the characteristics for wind turbine power quality, describes measurement procedures, and gives methods for assessment of compliance with the power quality requirements specified in other relevant IEC standards.

5.4 Wind Resources and Extreme Winds in North-West Russia

This section gives an overview of the wind resources based on a Survey of Wind Resources in the North-West Russia, ref 7, carried out as part of this project. The survey is based on data from 12 meteostations in the Murmansk Region (Kola Peninsula) and 5 meteostations in the Arkhangelsk Region, and it is included in Appendix 4 of the project report *General Survey of Site Conditions in the Northern Russia, Risø-I-1335(EN).*

The wind resources have been evaluated using the wind atlas methodology, refs. 8 and 9, based on regional wind climatology statistics contained in wind atlas files (tables).

The wind atlas files for the Kola Peninsula were prepared in a previous project, refs. 10 and 11, focusing specifically on the potential for wind energy use there. The wind atlas files for the Arkhangelsk-Mezen region have been prepared from available digital maps and wind statistics.

Wind Atlas for Mezen 1974 - 1988

The wind atlas for Mezen is included here as part of the characterisation of a representative wind energy site. The meteostation is placed to the north-west of the Mezen town, on the right coast of the river Mezen. The height of the anemometer is 12.8 m a.g.l.

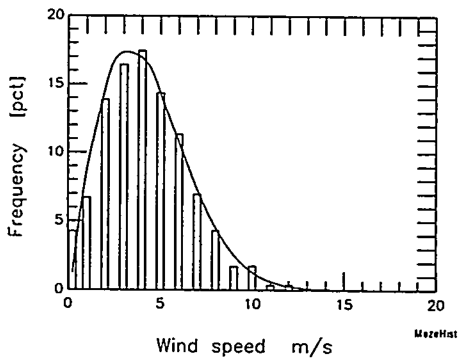


Figure 5.4. Wind speed distribution for Mezen

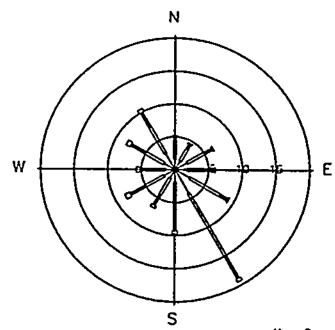


Figure 5.5. Wind Rose for Mezen

The annual average wind speed for Mezen in 12,8 m a.g.l. is 4,25 m/s corresponding to the Weibull A parameter 4,80, somewhat different from the 4,8 m/s @ 10 m a.g.l. quoted in the Russian survey ref. 1. At a hub height of 40 m a.g.l. the corresponding wind speed will be approx. 5 m/s.

Wind Resource Map

On basis of the above wind atlas files a wind resource map has been prepared, figure 5.6. As a representative measure for the wind resource the mean wind speed in a height of 25 m is shown for a roughness class 2 landscape, i.e. a hypothetical flat landscape with an equivalent surface roughness height of 0.1 m.

The meteorological stations used as basis are distributed rather sparsely over the area. For the areas far away from meteorological stations the wind atlas values have been supplemented with sound engineering judgements based on general knowledge of the wind climate in the area, especially its dependence on the distance to the coast line.

The general picture is that high wind resources are found along the borders to open sea, especially the North coats facing the Barent's Sea (6-7 m/s), and to a smaller extent the coast lines facing the Northern parts of the Beloye Sea, the White Sea (5-6 m/s).

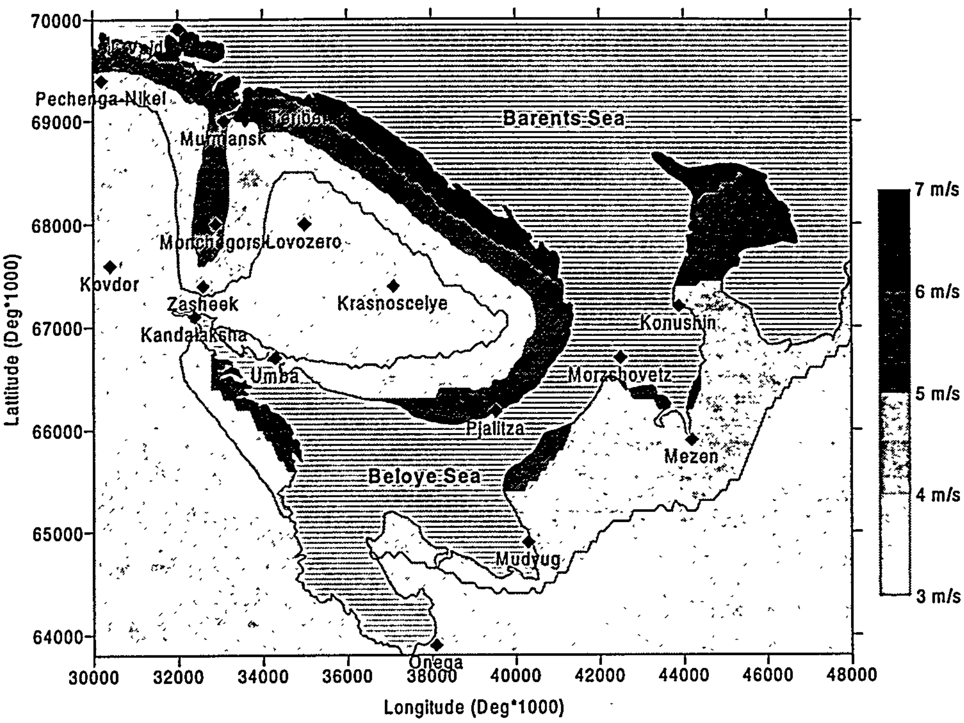


Figure 5.6. Estimated wind resource variation over North-western Russia. Mean velocities refer to roughness class 2 (0.1 m surface roughness height) of a hypothetical flat terrain, at a height of 25 m above ground level. The wind speeds referring to 50 m a.g.l. are approximately 15 % higher than the values referring to 25 m.

In contrast to this, for in-land areas more than, say, 100 km away from the border to open sea, the wind resources may be characterised as 'low'.

Extreme Winds

This subsection is based on the second part of the Survey ref. 7, Appendix 4 of the project report Risø-I-1335(EN).

In order to shed some light on the extreme impacts that wind turbines may be exposed to in this region a rough extreme wind estimation has been performed. It is based on a nearly 19 years time series from the Vaida-Guba meteorological station on Northern-most coast of the Kola peninsula. Scaling arguments regarding extreme and mean wind speeds have then been used to give judgements for the entire area.

The details of the analysis methodology are described by Kristensen *et al, 1998,* ref. 12. The data are transformed WAsP-generated directional speed-up parameters to correct the data for local terrain influence. The WAsP parameters and other details of the methodology are given in Appendix 4 of the project report Risø-I-1335.

The extreme wind speed is related to the basic wind velocity U_{50} , which is defined as the 50-year storm at the height 10 m. The analysis results in an estimated extreme wind speed U_{50} of 37 m/s, based on the Vaida-Guba date, which is a high estimate.

Ref. 3 argues that an extreme wind at Vaida-Guba of up to 32 m/s, 18% over the Danish value of 27 m/s, should be considered plausible. It furthermore speculates that on the other hand it cannot be ruled out that the proximity to the

Northern Ice Sea could cause a wind climate with a considerably higher variability than that seen under Danish conditions, so that the very high 50-year wind of 37 m/s may in fact be true.

Extrapolation to the Entire Region

Judgements of the extreme winds (50 year) for the entire region by simply assuming proportionality with the mean wind speed is of course rather uncertain, but is on the other hand the only way. However, the very high estimates based on proximity to the Northern Ice Sea is hardly relevant in the inner part of the Beloye Sea (White Sea). The judgement for the 50-year extreme wind thus becomes:

Area	*50-years wind Plausible estimate (m/s)*	*50-years wind High estimate (m/s)*
Northerly coastal areas facing the Barents Sea	27 m/s	may be up to 37
Coastal areas facing the northern part of the Beloye Sea, including the easternmost part of the Kola Peninsula and the part of the mainland coast facing it	23 m/s	
Coastal areas facing the southern and innermost parts of the Beloye Sea	19 m/s	

The plausible estimate for the 50-year wind speed is 27 m/s for the coastal regions northerly facing the Barents Sea, with a high estimate up to 37 m/s. In the Beloye Sea regions, the high estimate seems very unlikely as the Northern Ice Sea is not "visible" here, and the 50-year wind is judged to be 23 m/s, and in the least exposed region even down to 19 m/s.

6 A Strategy for Russian-Danish Co-operation in Wind Energy

Status at the end of phase 1 of the study is, that

- Phase 1 indicates the feasibility of continuing the project as stipulated
- Phase 2 application has been submitted to the Danish Energy Agency
- Strategy considerations are warranted

The outline of a future strategy for Russian-Danish co-operation in wind energy has been agreed upon between the Danish and the Russian parties in the project, and this chapter presents the proposed strategy. The strategy builds on 7 sub-

strategies and includes an outline of an action plan for implementation of the strategy.
The proposed strategy has been submitted to the Danish Energy Agency .

6.1 Executive summary

Russian wind power still amounts to very little. The reasons are rooted in economic and political crises and fostered by lack of political will to implement the legislation that is necessary, if wind power shall develop into national significance.

It is probable that the politico-economic impediments to marketing of wind power in Russia will disappear in e.g. five years. Wind power would be competitive many places in Russia, if legislation were in place.

The immediate need for wind energy in Russia has been estimated by Mintopenergo to be in the vicinity of 500 MW new-installed per year.

It appears likely that Russia over a period of a few years could become a market of the same size as the present German market.

However, the Danish interests in Russia are not limited to the commercial sphere. Support to the development of Russia's democratic institutions and legislation, to the stabilisation of the economy, and to the protection of the environment are significant motives for use of Danish public funds in programs that aim at development of a Russian market for cleaner technology including wind power technology.

The Danish interest is welcome, but it should take its starting point in the needs of the local regions.

The local authorities are hard pressed because of failing supplies of primary energy. The shortages are due to failing control of the economy as a consequence of the so-called non-payment problem and the impenetrable subsidising of the energy sector.

The aim of the strategy is co-operation on development of a well functioning Russian wind power market. Such a market presupposes a consistent Russian energy policy - with a wide time horizon - followed up by specific legislation.

The strategy should aim at direct co-operation with local authorities in those Russian regions that have the greatest needs, will benefit the most and demonstrate will to follow up with action.

The strategy should be implemented in full understanding and co-operation with the central authorities (e.g. Mintopenergo and RAO EES Rossia).

The strategy can be implemented through:

- Pre-competitive, generic activities on which competing Danish wind turbine manufacturers can co-operate on (e.g. training, education, information, standards, certification)
- activities closer to the market and therefore more individual (e.g. demonstration projects, direct contacts with interested parties)

The implementation of the strategy could be assisted by a strategy implementation group with a small number (e.g. 3-4) experts. The strategy should be concise and allow activities already running satisfactorily.

Sub-strategy for evaluation of wind energy potential: Ensure that wind power resources are estimated in a uniform manner and on a widely accepted basis.

Sub-strategy for evaluation of the Russian need for wind energy: Direct contact to the governments of interested regions. Documentation of needs, technical circumstances, economic possibilities, legislation, tariffs, ownership, subsidies, cash flows, guaranties, etc..

Sub-strategy for information, education and training: Dissemination of information, direct promotion to the regions, influencing top decision-makers. Next level, inform technical chiefs, responsible for implementation of wind power to greater depth. Education and training of wind project engineers.

Sub-strategy for other forms of technology transfer: Test and knowledge centres, norms and standards: Local Russian testing and verification of Danish technology necessary. Russian tradition for norms and standards needs expansion but must be respected. So must the extreme climatic conditions in Russia. Possibilities of utilisation of Russian research capacity.

Sub-strategy for demonstration projects: Demonstration projects are necessary. A set of criteria should be developed and confirmed with which demonstration projects must comply to be acceptable.

Finally are presented elements of a plan that tie the strategy to work on the Russian wind atlas, to decentralised collection of data on the regions, to development of a hierarchy of Russian-Danish courses, to continued establishment of the Wind Energy Knowledge Centre Nikulino, and to demonstration projects and criteria for their selection.

6.2 A future strategy

The aim of the strategy may briefly be formulated as co-operation on the development of a well functioning Russian wind power market. Such a market presupposes changes in the Russian energy sector. It also implies a consistent Russian energy policy - with a wide time horizon - followed up by specific legislation.

The understanding of the possibilities that wind power offer do not come on its own. However, it may be helped along by clear and well adapted information, by convincing demonstration and by co-operation on technology transfer and financing.

The strategy should aim at direct co-operation with local authorities in those Russian regions that have the greatest needs and will benefit the most from an engagement in wind power at the same time as they clearly demonstrate will to follow up the co-operation with action.

The strategy should be implemented in full understanding and co-operation with the central authorities (e.g. Mintopenergo and RAO EES Rossia).

The strategy can be implemented through:

- pre-competitive, generic activities on which competing Danish wind turbine manufacturers can co-operate (e.g. training, education, information, standards, certification)
- activities closer to the market and therefore more individual (e.g. demonstration projects, direct contacts with interested parties)

The first type of activities may support the latter. Both may obtain support from the Danish Energy Agency.

The implementation of the strategy could be assisted by a strategy implementation group with a small number (e.g. 3-5) experts. The strategy should be concise and formulated such that it allows activities already running and running satisfactorily.

Sub-strategy for evaluation of wind energy potential

Procedures should be arranged that ensure that the wind resource assessments in connection with evaluations of possible locations as well as specific projects are carried out in a uniform manner and on a generally - also by western investors - accepted basis.

Sub-strategy for evaluation of the Russian need for wind energy

Direct contact should be established to the governments of interested regions. An overview and deeper understanding of their needs and possibilities should be established through dialog. Knowledge about technical circumstances, economic possibilities, legislation, tariffs, ownership, subsidies, cash flows, guaranties, etc. should be documented with a view to discussions of needs in the light of economic expediency.

Sub-strategy for information, education and training

Dissemination of information may in Russia's present situation be considered both the most important and the safest investment in Russian-Danish wind power co-operation. In many ways it is also the most difficult to bring off effectively.

Direct promotion to interested parties in the regions should be implemented at several levels. Influencing the attitudes of top decision makers is an important goal. Promotion must be based on clear evidence and concrete results. The next level, technical chiefs and directors, who in reality are responsible for the implementation of possible projects, should be informed to greater depth. Project leaders, who can participate in the preparation of bankable projects plan, implement, lead and carry out major wind energy projects, are in short supply in Russia. Education and training of such wind project engineers should be an element in the implementation of a Russian-Danish strategy.

Sub-strategy for other forms of technology transfer: Test and Knowledge centres, norms and standards

A precondition for accept of Danish wind technology in Russia is local Russian testing and verification of this technology. Russia has a long and strong tradition for norms and standards, a tradition it will be necessary for Danish partners to accept. The climatic conditions in Russia vary strongly geographically and may occasionally be extreme. A Russian-Danish strategy should beware of this and support co-operation on this point.

Sub-strategy for demonstration projects

It is said in Russia that a wise man never buys a dog without patting it first, and nobody buys anything without recommendations from a trusted friend. Concrete and carefully selected demonstration projects are therefore necessary components of the Russian-Danish wind energy co-operation.

A set of criteria should be developed and confirmed with which demonstration projects must comply to be acceptable. The most important criterion seems to be that projects must document economic and technical sustainability or clearly explain why such sustainability could not be achieved. Long term technical and economical follow up must be the rule.

6.3 Elements of a plan

The plan is only sketched as it is not a natural / direct part of strategy considerations. The purpose of the plan is to put into practice the accepted strategy and turn it into action.

Russian wind atlas

Publication, continued development and use of the Russian wind atlas: A wind atlas in under publication. It makes it possible on basis of local topographical data and descriptions of the landscape to estimate the mean annual production from windmills erected anywhere in Russia. This atlas should be further developed and used to identify areas in which wind resources and needs make wind power an interesting possibility, in the planning of local wind power projects, and for educational and training purposes. Projects to these ends should be implemented as joint Russia-Danish projects.

Monitoring of the Russian wind energy market, identification of interests and needs

Collection and analysis of data concerning the development of the wind energy market in Russia: It would be useful if honestly interested regions in Russia could be identified, their needs assessed and the wind resources mapped. Furthermore it would be useful if their more or less local legislation, economy, structure, financing, tariffs, etc. were described in a way that allowed both Russian and Danish participants to understand them and to recognise them from the description. Projects to this end could be implemented in two or three regions in the first phase.

Information, education and training (incl. visitors program)

Development and implementation of a hierarchy of Russian-Danish courses ranging from introductory courses for decision-makers to diploma courses for wind energy engineers: It is suggested that a visitor's and information program for decision-makers (governors and their top-aids) from 8-10 selected regions is implemented. The program could take the form of 8-10 ten-days courses in Denmark with the wind turbine manufacturers and Risø National Laboratory as responsible for the preparations. Moreover we suggest development of a diploma course for qualified engineers or people with similar training. It could last half a year or more and take place in Denmark as well as in Russia. Development of such a course will be a considerable task, but the course could get far-reaching significance for the technology transfer between Denmark and Russia and for Danish companies' possibilities for finding qualified Russian co-workers.

Wind Energy Knowledge Centre Nikulino

Continued establishment of a wind energy knowledge centre in Nikulino near Moscow: The project is through its fist phase (design criteria, test needs and test methods for windmills for use in the northern region) and on its way into the second phase (establishment of test facilities and procedures). The second phase should lead to extended co-operation on standards, norms, technical guidelines and certification. Establishment of wind power will in Russia's present situation only be possible where wind power is immediately and directly competitive compared to other energy sources. It can hardly be expected that wind power will be credited for low external costs (e.g. environmental costs), and substantial foreign financing must be foreseen necessary. Therefore the interest will in the first instance concentrate on projects in which wind replaces expensive diesel oil. This is the background for the Russian interest in wind-diesel systems. The systems may be relatively big - several megawatt installed capacity - but irrespective of size, wind-diesel systems is undoubtedly one of the important keys to the Russian wind energy market. The Russian ministry of fuel and energy (Mintopenergo) gives the development of the Nikulino centre a high priority. Through the Nikulino Centre the possibilities of utilising Russian researchers through specific research contracts - e.g. with EU support - could be explored.

Other possibilities: Demonstration projects

Identification of regions in which strong Russian partners are interested in "sustainable" demonstration projects, i.e. economically healthy projects that are followed up by technical and economic analyses: Concrete wind energy projects that convincingly demonstrate and document the viability of wind power should be implemented. Emphasise should be on strict ground rules for the completion of the projects with examination of all phases of the projects including project development, financing, implementation, project organisation, testing, certification, operation, maintenance and economy. Two projects of importance to Russian partners are presently (primo 1999) being considered: A project in Mezen near Arkhangelsk and one in St. Petersburg.

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Appendix 1. Project strategy & framework

In a seminar arranged by the Russian-Danish Institute for Energy Efficiency (RDIEE) and the All-Russian Institute of Electrification of Agriculture (VIESH), the Ministry of Fuel and Energy in Russia (Mintopenergo) presented a paper, ref. 1, in which the potential demand for wind energy was estimated for 4 classes of wind energy applications (mode 1-4). The paper is included in Appendix 1 of this report.

1. Systems of individual use, including a 0.1-5 kW wind turbine. Potential 1000-1500 systems per year.
2. Small systems of collective use, including one or more 5-50 kW turbines. Potential 1000-1500 per year.
3. Medium and big systems of collective use, including one or more 50-500 kW wind turbines. Potential 85 MW per year during the next 5 years.
4. Grid connected wind power stations with 100-1000 kW wind turbines. Potential 470 MW per year during the next 5 years.

As indicated in the Russian programme "Power supply for the Northern Territories" the potential in Russia is primarily found in the northern territories, mostly including areas with moderate wind conditions and other external conditions different from most Danish applications. The programme involves almost 70 % of Russian territory, including European North, Siberia and Russian far East. Here, large land areas are available for wind installations and the need of locally produced electricity is widespread in sparsely populated areas with local or regional grids.

In order to obtain large scale commercial application of wind turbines in Russia it is necessary to utilise existing, proven and reliable wind turbine designs, since very high technical reliability is a precondition for successful application in the very often difficult and demanding Russian conditions. Denmark and Europe has pioneered development of such designs, and they account for two thirds of all installations world wide (including 60 per cent of the working installations in USA). However, the designs may need to be adapted and modified for use under Russian conditions, in particular cold climate and moderate wind in-land sites with regional grids in Russia.

The necessary adaptations and modifications need to be tested and verified in Russia under Russian conditions in order to establish the technical credibility that is a precondition for getting the necessary financial and institutional support and acceptance. An important part of the technical credibility is a set of design criteria for wind turbines and wind turbine applications for Russian conditions, and guidelines and recommendations for implementation of wind energy under commercial conditions. As any large scale wind energy application in Russia is unthinkable without a large component of Russian manufacture and supply, the technology transfer and co-operation aspect must be included.

Therefore the research programme is proposed to be carried out as part of a strategy in which the research programme (proposed to be carried out in three phases) is followed up by a two phase implementation programme. The implementation programme is envisaged to have different participation and to be funded primarily by commercial (international) sources, on account of the technical basis and credibility established by the research programme.

Research Programme

The general objective is to establish a technical foundation for an intensified application of wind energy in Russia with medium to large wind turbines and transfer/adaptation of Danish and European wind turbine technology as a basis for future joint ventures and technology exports. More specifically, the objective is to develop and establish the basic knowledge and design criteria for adaptation and development of Danish wind turbine technology for Russian conditions for application

- in grid connected wind power stations with 100-1000 kW wind turbines (mode 4 systems), and
- in medium or big systems of collective use with one or more 50-500 kW combined with diesel generators or hydro (mode 3 systems),

including:

- to determine external conditions (wind, temperature, soil, energy system interface, earthquake, lightning and other critical conditions) to act as design criteria for wind turbines in Russia
- a consistent set of relevant Russian design and construction standards applicable for wind turbines
- to establish common procedures and experience for measurement and analysis of wind turbine performance, loads and function, and finally
- to develop verified design and load criteria for wind turbines for cold climate and in-land Russia, and
- to develop technical guidelines for project design with medium to large wind turbines including recommendations for application of design criteria and Russian/Danish/international standards.

The research programme is envisaged to be carried out in three phases, reflecting the reasoning outlined above and initiated by subsequent annual grants from the Danish Energy Research programme and by Russian sources, but to some extent they can be carried out in parallel to each other.

Phase 1: Design conditions and test needs for wind power in the Northern territories

The main purpose of phase 1 is to assess the needs for modifications and adaptations of established standard (in casu Danish) wind turbine designs for mode 3 and 4 applications in cold climate and in-land sites of Russia. As part of this work it is necessary to clarify the types of operational conditions and requirements that are to be met by wind turbines operating in such conditions, and to outline suitable test procedures and test set-up's for verifications of such adapted and modified wind turbines.

It is proposed to carry out the survey of representative sites and conditions with reference to the Russian strategic project "Power supply for the Northern territories", and to include a survey of readily available Russian standards and recommendations. It is furthermore proposed to make the outline of test procedure and set-up with reference to Istra, where both RDIEE and VIESH are located, and therefore to include supplementary wind measurements at Istra. The technology transfer and co-ordination aspect is included in the form of staff exchange and seminars for industry and authorities.

The output will include detailed project plans for the subsequent phases of the programme.

Phase 2: Wind energy technology testing

The main purpose of phase 2 is testing of a suitably adapted Danish wind turbine at a test facility, established for the purpose at Istra, where both RDIEE and VIESH are located. As part of this work relevant procedures for testing will be developed and established in addition to the concrete test results. The output of the phase is measured results for wind turbine loads, performance and function under Russian The main purpose of phase 2 is to provide experimental input to the process based on testing conditions and mode 3 and 4 operation.

It is proposed to install test facilities at Istra for wind turbines in both mode 3 and mode 4 applications in a framework, where the Danish wind turbine in mode 3 applications is tested in operation with a Russian diesel power plant installation. The technology transfer and co-ordination aspect is included in this phase in the form of technical and system co-operation in addition to staff exchange.

The output will include general procedures for type testing of mode 3 and 4 wind energy systems.

Phase 3: Modelling, standards and certification criteria for Russian conditions

The main purpose of phase 3 is to establish general design criteria for mode 3 and 4 wind energy systems as a basis for developing actual standards and recommendations, certification and procurement. As part of this work project design guidelines will be developed for both mode 3 and mode 4 wind energy installations.

It is proposed to perform a detailed data compilation on operating conditions for such wind energy installations in Russia, and to carry out a corresponding analysis and review of both climatic conditions and power system characteristics. This work includes a comparison of the proposed design criteria against Russian and Danish standards and practices. The technology transfer and co-ordination aspect is included in this phase in the form of technical and standards co-operation in addition to staff exchange.

The output will include general technical guidelines for project design, including a reference design concept for a reference case in the framework of the "Power supply for the Northern territories" strategic programme of Russia.

Application Programme

The application programme is envisaged to be carried out in two phases (that may also be considered two types of activities). The first is basically a (partly) commercially funded contribution to verification and establishing of credibility, the second is real large scale (almost entirely) commercially funded implementation of wind energy in Russia.

The implementation programme will have different participation and be funded primarily by commercial (international) sources, possibly with support from international demonstration programmes, on account of the technical basis and credibility established by the research programme.

Phase 4: Limited wind energy implementation

The main purpose of phase 4 is to demonstrate technical and economical viability of commercial wind energy technology under real life conditions. There should be a strong participation by commercial companies and financial institutions.

It is proposed to develop and implement a limited amount of carefully selected and monitored Russian/Danish installations at the end user, i.e. under representative real life conditions. As part of this process useful results on the performance of recommended adaptations and modifications will be obtained, if necessary to be used for last-minute alterations. The technology transfer and co-ordination aspect is included in this phase in the form of technical and manufacturing co-operation in addition to staff exchange.

During this phase the wind energy centre at Istra may develop to act as a general Russian centre for testing and certification of commercial wind turbines.

The output will be a number of reference cases to support the technical and economical credibility of wind energy technology.

Phase 5: Large scale implementation

The main purpose of phase 5 is to implement wind energy technology in a large scale under commercial conditions, i.e. driven mainly by the end users in interaction with commercial companies, financial institutions and relevant authorities on account of the credibility established as a result of the previous phases of the research and implementation programme.

It is proposed to develop and implement a number of Russian/Danish/-European mode 3 and 4 installations with tested and certified equipment. As a result of the technology transfer and co-ordination activities in the previous phases there will be a very considerable amount of Russian/Danish (license based and other) produced wind energy capacity.

The output will be a significant contribution from wind energy technology to the power supply in central and northern Russia.

Modern wind turbine technology and Russian applications - Programme outline

Phase	Title:	Objectives	Activities	Outputs/milestones
1	Design conditions and test needs for wind power in the Northern Territories. (Preliminary specifications for design adaptation and test set-up)	• To develop preliminary design requirements for typical mode 3 and 4 cold-climate and in-land installations • To assess wind technology testing needs • To prepare a detailed project implementation plan for phase 2 and 3	• Survey of representative site conditions for the "Power supply for the Northern Territories" programme, including limited review of climate conditions and energy system characteristics • Compilation of readily available Russian standards and practices and analysis in relation to Danish technical requirements • Wind measurements at test site in Istra • Seminar for industry and authorities • Planning of test facility and test programmes • Exchange of scientists	• Project start (Apr 97) • Preliminary design criteria for typical mode 3 and 4 installation (Dec 97) • Technical specifications for test wind turbine and test facilities in Istra (Mar 98) • Interim report (Sept 97) • Measured and predicted wind conditions in Istra (June 98) • Detailed project implementation plan for phase 2 and 3 (Mar 98) • Final report (June 98)
2	Wind energy technology testing	• To establish test facilities in Istra, including a suitably adapted Danish wind turbine • To develop procedures for load, performance and function testing of wind turbines in mode 3 and 4 applications • To obtain measured results for wind turbine loads, performance and function under Russian conditions	• Build test infrastructure, civil and electrical works • Installation of test wind turbine • Installation of Russian diesel generator and accessories • Measurements on wind turbine in mode 4 operation • Measurements on wind turbine, diesel generator etc. In mode 3 operation • Analysis and reporting of test results • Develop general procedures for type testing of mode 3 and 4 wind energy systems • Exchange of scientists	• Start of phase (Apr 98) • Test facility (June 98) • Wind turbine ready for testing (Aug 98) • Diesel generator and accessories ready for test (Dec 98) • Interim test report - mode 4 operation (Jan 99) • Interim test report - mode 3 operation (June 99) • Test procedure guidelines (July 99) • Final test reports (Dec 99)
3	Modelling, standards and certification criteria for Russian conditions. (Design criteria and guidelines for project design)	• To establish general design criteria covering external conditions and energy system interface as basis for standards development, certification and procurement • To prepare project design guidelines for mode 3 and 4 wind energy installations	• Compilation of data on wind condition, temperatures, grid conditions and load patterns • Analysis, review and modelling of climate conditions and energy system characteristics • Comparison of proposed design criteria with Russian standards and practices and Danish and international standards and technical requirements for certification • Analyse a reference case in the power for the north programme and design a reference system concept • Develop technical guidelines for project design • Exchange of scientists	• Start of phase (Apr 99) • Design criteria for wind turbines in mode 4 grid connected applications (Nov 99) • Design criteria for wind energy systems in mode 3 applications (Apr 00) • Reference system design (Sept 00) • Technical guidelines for project design (Dec 00) • Final report (Dec 00)
(4)*	Limited wind energy implementation on state level	• To demonstrate the technical and economical viability of commercial wind energy technology	• Project development and implementation • development of testing and certification at the wind centre in Istra	• Demonstration projects with Danish/Russian wind turbines • Russian testing and certification scheme
(5)*	Large scale implementation	• To provide a significant energy contribution from wind energy technology to the power supply in central and northern Russia	• Project development and implementation • Testing and certification of Danish/Russian wind turbines	• Large scale commercial wind energy installations

*Mode 3: medium or big systems of collective use with one or more 50-500 kW wind turbines in wind-diesel or wind-hydro systems. mode 4: grid connected wind power stations with 100-1000 kW wind turbines, * expected subsequent phases but with different participants and funding*

Appendix 2. The Russian Wind Energy Market

Ref. 1

P. P. Bezroukikh (1996) *The Russian Wind Energy market.* Presented at a seminar arranged by the Russian-Danish Institute for Energy Efficiency (RDIEE) and the All-Russian Institute of Electrification of Agriculture (VIESH).

The Russian wind energy market.

P.P. Bezroukikh (1996)

1. Concept of renewable energy sources use.
2. The role of wind energy.
3. What kinds of wind turbines are needed ?
4. Obstacles to use of renewable energy sources.
5. Ways of market creation.

1. The concept of renewable energy sources use

One of the most urgent tasks in energy supply in Russia is to provide heat and electricity to regions of decentralised energy supply. These regions and non-electrified areas cover nearly 70 % of the territory of Russia with population more than 10 million people. There are some non-electrified colonies even in the areas of centralised energy supply.

There are frequent breaks in centralised energy supply in rural areas, causing serious harm to animal husbandry and poultry farming. High costs of transportation make it difficult to deliver fuel to distant and northern regions.

Pollution of the environment is a serious problem in a number of Russian regions. A concept of solving the above mentioned problems by means of using renewables has been developed and adopted by Mintopenergo of Russia. The tasks are the following:

1. To provide decentralised regions with reliable electricity and heat supply.
2. To guaranty electricity and heat supply in regions of centralised energy supply during accidental breaks. More than a half of Russian energy systems are deficient and energy supply is limited there.
3. To reduce consumption of diesel oil in distant and northern regions by 50 % by 2005. About 5 thousand small petrol and diesel power stations with the total fuel consumption of 6-8 million tons per year work in these regions.
4. To halve harmful emissions of power stations in polluted areas and in popular resorts by 2010. More than 180 thousand small boiler stations work in Russia with the total annual emission of 2.5 million tons of solid and 4 million tons of gaseous harmful wastes.

Wind energy will play an important role in fulfilling these tasks.

2. The role of wind energy

The problems of energy supply are most serious in the Far North and Far East of Russia. Fortunately, wind energy potential is high in these regions. Moreover, in winter, when energy is needed most of all, mean wind speed is the highest.

The main focus in wind energy development in Russia should be made on stand alone wind turbines and wind-diesel systems. Wind turbines for heat production are very perspective too. This does not mean that grid connected wind stations should not be created in Russia. They should be used in deficient energy systems (this matter will be considered below).

The whole situation is the following. Annual fuel consumption in Russia is about 1200 million tons in coal equivalent. Wind resources potential that can be utilised is 2000 million tons in coal equivalent. If we take into consideration prices of fuel and wind turbines equipment, we estimate that today it is economically profitable to utilise wind energy amounting to 10 million tons in coal equivalent.

3. What kinds of wind turbines and how many of them are needed ?

There are no statistical data concerning consumption of energy by individual consumers. That is why in this report we will rely upon energy consumption forecast.

The criteria are data about the number of people living in decentralised areas and population distribution in these areas. We will also estimate the number of potential consumers of wind energy in regions with centralised energy supply.

This chapter will only deal with the potential demand of wind energy without concerning solvency.

The situation is the following:

1. *Regions of decentralised energy supply.*
   10 million people permanently live in these regions (2.5 million in rural areas). More than 400 thousand people live in expedition settlements.
2. *Regions of centralised energy supply.*
   Let us assume that 20 % of rural population (6 million people) live in areas with frequent breaks in energy supply (a very optimistic assumption).
   Wind energy can cover up to 20 % of energy consumption of country garden (dacha) owners. It is 5 million people.
   As far as towns are concerned, utilising wind energy instead of small boiler stations is equivalent to energy supply for 5 million people.

So, the whole amount of potential consumers of wind energy can be estimated as 25-30 million people.

Territorial distribution of the people is shown in the following table:

The number of people in a settlement	Regions of decentralised energy supply	Regions of centralised energy supply
up to 50 people (average: 5)	172 600 people	3 120 000 people
51 - 500 people (average: 250)	2 400 000	5 200 000
501 - 3000 people (average: 1000)	5 900 000	5 600 000
3001 – 10000 people (average: 5000)	2 600 000	2 080 000
Total	≈11 000 000	16 000 000

Let us consider what kind of wind energy systems could satisfy the people's needs. We are suggesting the following classification of energy supply systems based on wind energy.

1). *Systems of individual use*, including a 0.1-5.0 kW wind turbine, accumulator, charger, control unit.

Potential customers:
Service organisations for lighthouses, relay stations, oil and gas pipe systems, geological groups, separately living families, hunters, fishermen, dacha owners.

Potential demand:
1000-1500 systems a year (according to the first line of the table).

2). *Small systems of collective use*, including one or several 5-50 kW turbines, accumulator, rectifier, inverter, control unit.

Potential customers:
Small villages, frontier posts, etc.

Potential demand:
1000-1500 systems a year (according to the second line of the table).

3). *Medium and big systems of collective use*, including one or several 50-500 kW wind turbines. As a rule, these must be wind-diesel or wind-hydro systems.

Potential customers:
Big rural settlements, small towns (the third and forth lines of the table).

Potential demand (S_P) can be estimated in the following way:

$S_P = Q \times N \times P$,

Q - the number of people
N - specific power consumed by one person (assumed 1 kW)
P - a percentage of wind energy in total energy consumption (assumed 1 %)

$S_P = 8\,500\,000 \times 1 \times 0.01 = 85$ MW

This figure can be taken for annual demand of this class of wind systems during the next 5 years.

4). *Grid connected wind power stations* (100-1000 kW wind turbines).

Potential customers:
Regional deficient energy systems. The number of such energy systems is 44 (the total number of energy systems in Russia is 70).

Potential demand can be estimated in the following way:
Let us consider only those deficient energy systems which are situated in areas with high wind energy resources. There are 18 such systems. The total power deficiency sums up to 9432 MW. At present time this deficiency is being covered by means of other energy systems or remain uncovered. We assume that 5 % of this deficiency can be covered by means of wind energy. This amounts to 470 MW. This figure can be taken for annual demand of this class of wind systems during the next 5 years.

4. Obstacles to use of renewable energy sources

The obstacles are determined mainly by three factors: psychological, economical and technical. The order of these factors given here is defined by their importance.

The psychological factor

Russia is one of few countries able to provide themselves with organic fuel and even export it.

There has been a conviction that renewable energy sources should be considered as something exotic - nothing more. Now the situation is changing. Shortage of fuel in some Russian regions and fast growing energy prices make people change their minds and pay serious attention to renewables, primarily, to wind energy.

The second aspect of the psychological factor is a habit to giant things. Russian power specialists are used to work with 5 MW and more generators. It is a matter of time to make Russian power specialists believe that a 200 kW power unit is worthy of their attention.

More and more heads of local administrations begin realising that they should not rely upon central authorities to solve energy problems in their regions. They start looking for non-conventional methods of overcoming energy shortage situation.

There now appears an understanding of an important role of renewables in protecting environment.

The economical factor

First of all, it is a crisis of companies mutual insolvency. This abnormal situation should be eliminated during this year, otherwise any progress is impossible.

The technical factor.

There are 3 problems here.

1. There are no available stand alone combine systems (wind turbine-diesel).
2. There are no reliable stand alone 10-50 kW wind turbines of high quality.
3. There is no infrastructure (maintenance, consultancy, insurance, marketing, etc.).

5. Ways of market creation

The most important task is to carry out a wide information campaign to assure people, primarily, local authorities that wind energy is just what they need. This is one of the objectives of the Russian-Danish Institute for Energy Efficiency. This task would be much easier if there were examples of successful operation of wind turbines in Russia. Unfortunately, today Russian wind energy equipment is not up to promote wind energy. We hope for co-operation with foreign countries:

1). Joint venture "HSW (Germany)-"Sowena" (Russia)"
Moscow

Power (kW)	Purpose	Stage of development
30.0	grid connected	pilot station

- The pilot station is organized in Rostov and consists of 10 HSW-30 wind turbines. All 10 wind turbines were delivered by Germans free of charge, except for gear boxes. The price of German gear boxes (25.000 German marks for one unit) was too high for "Sowena". Therefore gear boxes for the wind turbines were produced in Russia.
- The Ministry of Science is financing this project.
- The station was put into operation in December 1995.

2). Joint venture "LMV wind energy" (Russia-Holland)
Khabarovsk

Power (kW)	Purpose	Stage of development
1.1	stand alone	few units a year
2.5	stand alone	few units a year
3.6	stand alone	few units a year
10.0	stand alone	few units a year

- The joint venture was organized 5 years ago.
- The Dutch company LMV is a small one. There is information that production is partly performed in Russia.
- The wind turbines are very expensive (a 10.0 kW wind turbine costs $41.500).
- Probably the Russians run this business simply because they are allowed to bring some electrical devices (ex., storage batteries) to Russia duty-free.

3). Project "Kola wind"
Murmansk region

Coordinator - VTT Energy (FI); contractors - RISO National Laboratory (DK), Darup Associates (DK), DEWI (DE), CRES (GR); associated contractors - PA-Energy (DK), Finnish Meteorological Institute (FI), University of Lapland (FI), Kola Science Centre (RU).

The overall objective of the project is to form a basis and necessary tools for a substantial integration of wind energy into the energy system of the Kola Peninsula.

4). The agreement about the US grant for purchasing American wind turbines was reached:
1.5, 10 and 30 kW wind turbines, 10 units of each type. The wind turbines are supposed to be installed in Murmansk and Arkhangelsk regions.

5). The agreement with Denmark was reached about installing a 525 kW Danish wind turbine in Kaliningrad region.

Some information from the Ukraine.

6). "Windenergo"
Ukraine, Kiev

Power (kW)	Purpose	Stage of development
110.0	grid connected	series-produced

- The wind turbine was developed by the US company "Kenetech". The Americans presented design documentation to the Ukrainians free of charge.
- Financed by the Ukrainian Ministry of Energy. Ukrainian government has adopted a law. According to this law a certain percentage of money paid for electricity in the Ukraine is allocated to perform construction of wind turbines and wind stations (but it does not concern any research, only production).
- The most respectable company (dealing with wind turbines) in the Ukraine.
- Produces around 15 wind turbines a month.
- 93% of the production work is performed at several plants in the Ukraine and Russia (the rest is purchased in the USA).
- The price of a wind turbine of this kind in the USA is $100.000, in the Ukraine - $50.000.
- Now 34 such wind turbines work in Donuslav (Crimea). It is supposed to create a wind station (5000 wind turbines, ≈500 MW, 25% of a total electricity production in the Ukraine).
- There are projects of creating two wind stations (15 MW each) using these wind turbines in Krasnodar region.
- The company has an order to deliver 8.000 such wind turbines to Kazakhstan (but so far Kazakhstan has not had any money to pay for that).

Translated by Safonov V.

Appendix 3. Project Seminar 18 – 23 January, 1999

Tentative program for the visit

Mon 18 Jan 98	Arrival & accommodation	
1610	Arrival, pick up and transport to hotel	
1900	Dinner in Copenhagen	Rus, PL
Tue 19 Jan 98	Visits & meetings in Copenhagen	
1000-1200	Meeting in Danish Energy Agency	Off. Manager Fl. Secher & staff
1200-1300	Lunch at Danish Energy Agency	
1330-1430	Meeting Energy Committee of the Danish Parliament	Chairman Martin Glerup
1900	Dinner in Copenhagen, St Peterburg project	Rus, Peter Ahm, PL
Wed 20 Jan 98	Visit & project meeting at Risø National laboratory	
0915-1000	Welcome & Risø presentation	Director Jørgen Honoré
1000-1100	System Analysis Department	Dept head Hans Larsen & staff
1100-1200	Research reactor DR3	Reactor Chief Heinz Floto & staff
1200-1300	Lunch	Rus, ELP, NEB, PL, MWJ, HWB
1300-1400	Wind Energy Department (WAsP etc)	Dept head Erik L. Petersen & staff
1400-1600	Project meeting at the test station	Rus, PL, NEB, MWJ, HWB
Thu 21 Jan 98	Russian – Danish Seminar at Risø National Laboratory	
0900-1230	Seminar, morning session	
1230-1430	Lunch	
1430-1700	Seminar, afternoon session	
1900	Welcome at NEB	Rus, NEB, PL
2000	Dinner in Copenhagen	Rus, NEB, PL
Fri 22 Jan 98	Visit to NEG Micon	
Morning	Transport by car & ferry	RUS,PL
1030-1200	Presentation of NEGM & Lunch	NEGM staff
1200-1330	Inspection of nearby Wind Cluster	NEGM staff
Afternoon	Transport by car via Great Belt Bridge	RUS, PL
Sat 23 Jan 98		
1200	Check-out from hotel (unless otherwise agreed with the hotel)	
1730	Departure	

The Russian delegation

Mr. Anatoly P. Jartsev	Head of Administration, State Duma Committee on Problems of Industry, Construction, Transport & Energy
Dr. Pavel P. Bezrukikh,	Deputy Head of Science & Technology Dept, Ministry of Fuel & Energy
Dr. Dmitri S. Strebkov	Professor, Director of VIESH (All-Russian Institute for Electrification of Agriculture)
Dr. Alexander N. Starkov	Senior Scientist, RDIEE (Russian-Danish Institute for Energy Efficiency)
Ms. Anna A. Solovieva	Interpreter, RDIEE

Program for the Seminar 21 January 1999

9:00	**Registration**		
9:15	**Introduction and project status**	*Peter Hauge Madsen*	Risø
9:30	**Wind energy policy in Russia**	*A.P. Jartsev*	State Duma / Head of administration of Sub-committee Industry, Buildings, Transport & Energy
10:00	**Wind power in the Northern Region**	*P.P. Bezroukikh*	Ministry of Fuel & Energy (Mintopenergo)
10:30	**Coffee break**		
11:00	**Wind resources in Russia**	*A.N. Starkov*	Russian/Danish Institute for Energy & Efficiency (RDIEE)
11:30	**Conditions of power supply system in the Northern Region**	*D.S. Strebkov*	All-Russian Research Institute for Electrification and Agriculture (VIESH)
12:00	**Prerequisites for commercial developments**	*Representatives*	Danish wind turbine industry and investors
12:30	**Lunch break**		
13:30	**Design criteria and standards**	*Martin Winther-Jensen*	Risø
14:00	**The Nikulino Test Station**	*Per Lundsager*	Darup Associates
	Wind Energy Feasibility study for the Kola Peninsula		
14:30	**Wind Farm Feasibility Study at Sct. Petersburg**	*Peter Ahm*	PA Energy A/S
15:00	**Coffee break**		
15:30	**The Project Phase II**	*Peter Hauge Madsen*	Risø
16:00	**Strategies for further co-operation**	*Niels E. Busch*	Busch & Partners
16:30	**Discussion**		
17:00	**Closing**		

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Title and authors

Modern Wind Energy Technology for Russian Applications

Main Report

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Abstract (max. 2000 characters)

The general objective of the project is to establish a technical foundation for an intensified application of wind energy in Russia with medium to large wind turbines and transfer/adaptation of Danish and European wind turbine technology as a basis for future joint ventures and technology exports. More specifically, the objective is to develop and establish the basic knowledge and design criteria for adaptation and development of Danish wind turbine technology for application under Russian conditions. The research programme is envisaged to be carried out in three phases, the first phase being the project reported herein.

The main purpose of phase 1 is to assess the needs for modifications and adaptations of established standard (in casu Danish) wind turbine designs for decentralised energy systems with a limited number of medium sized wind turbines and for grid connected wind turbines in cold climate and in-land sites of Russia. As part of this work it is necessary to clarify the types of operational conditions and requirements that are to be met by wind turbines operating in such conditions, and to outline suitable test procedures and test set-up's for verifications of such adapted and modified wind turbines.

The reporting of this project is made in one main report and four topical reports, all of them issued as Risø reports. This is the Main Report, summing up the activities and findings of phase 1 and outlining a strategy for Russian-Danish cooperation in wind energy as agreed upon between the Russian and the Danish parties.

Descriptors INIS/EDB

DENMARK; DISPERSED STORAGE AND GENERATION; RUSSIAN FEDERATION; TECHNOLOGY TRANSFER; TEST FACILITIES; WIND POWER PLANTS; WIND TURBINES

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