Executive Summary

of the project

“ Pakri Peninsula wind farm feasibility study in Estonia as a climate change mitigation pilot project in the frame of Joint Implementation”

Introduction

Estonia as a Party to UN Framework Convention on Climate Change has been successful in following the responsibilities and challenges for international co-operation set by the convention and its’ Kyoto Protocol. The climate change mitigation is most efficiently performed in energy sector which has the biggest potential in greenhouse gases mitigation. One of the major opportunities is included in active promotion of renewable energy sources wider introduction. For Estonian Republic biomass and wind energy are the major sources to be promoted in the first order. The present feasibility study is devoted to wind energy potential study with the aim of further implementation in the frame of international climate co-operation.

The Pakri Peninsula wind farm feasibility study which was performed by a team of environmentalists, climate experts, geographers, power engineering experts, economists, and wind farm developers brought together an enthusiastic team who worked under the coordination of the Estonian Institute for Sustainable Development on the most various issues connected to the wind energy use.

North-West region of Estonia is considered as one of the most feasible areas for wind energy production in Estonia. The test site for the present study is chosen Paldiski municipality. The area is of great interest to the power engineers, experts on renewable energy, environmentalists, nature conservationists, non-governmental organizations, entrepreneurs, etc.

The study was organised in a way that the wind energy potential was carefully studied for whole area. Various restrictions to the construction of wind turbines and wind farms were analysed with the tools of Environmental Impact Assessment. Further on the pilot area was selected out to exercise on small scale the different type of generators with the final aim to use this experience for much larger area. The cost-efficiency calculations followed all stages of the study. Optional financial models were worked out for that purpose. In so doing the final aim was reached in a so-called bottom up approach where step-wise movement from single to generic was performed.

In the following the concentrated content of the whole feasibility study is given. A number of geographical maps, also spreadsheets were created to quantify the results of the analysis. The limited volume of present summary made possible to include a few of them only. A number of original numeric results have been worked out, which will have significant value for further promotion of wind energy implementation in Estonia.

Pakri Peninsula – the test site for the first large-scale wind farm

Estonia is situated on the eastern coast of the Baltic Sea which is a region with intensive cyclonic activity and therefore with a relatively high mean annual wind speed (4-8 m/s). Pakri Peninsula (40 km^2) is located about 50 km from the capital of Estonia Tallinn. The peninsula is situated on the limestone plateau between the Pakri and Lahepera Bays along the Estonian northern coast.

The former Soviet Naval Base located in town and harbour of Paldiski and its surrounding Pakri Peninsula has a high potential for socio-economic development. The most important favouring factors for the economical development of the area are a favourable geographical position, ports, railway network, accessibility by roads and a functional infrastructure of the town. A military airfield is located at about 20 km distance at Ämari, with a runway of approximately 2000 m. Pakri Peninsula is easily accessible through various good transport links.

Paldiski Harbour is ice-free during winters. The two ports – North (deep-sea potential) and South (less deep, owned by Tallinn Port) are handling volumes of traffic increasing by about 20% a year. In longer run, an oil terminal is being discussed. A ferry link has been operating successfully to Kappelskär (Sweden) near Stockholm since 1999. Paldiski North Port could, if further developed, handle all vessels capable of entering the Baltic Sea.

After the former Soviet Naval Base had left the town a number of important sectors of economy have turned to fast development path. At present there exists the general development plan for next 10 years which foresees the following main lines: harbour development, metal works, recreation and tourism, nature park, logistics center, wind farms construction.

High wind energy potential, favourable geographical position, existing transportation network, availability of labour and the support of the local municipality (local government) are the most important advantages for the wind farms development in Pakri peninsula and at neighbouring two islands.

Local government - Paldiski Municipality has started in cooperation with SEI-Tallinn a Sustainable Development programme titled “Green Paldiski”, which is aimed to comprehensive sustainability and includes the renewable energy sub-programme on wider development of wind energy and biomass.

Available wind potential for power production

The general character of the Estonian wind regime is determined by atmospheric circulation and its seasonal variation over the Atlantic Ocean and Eurasia. However, very important factor affecting wind climate is the Baltic Sea itself, having strong influence on wind regime in coastal areas. In winter the monthly mean wind speed on islands and on the western coast reaches 7- 8.5 m/s, in the inland areas it remains between 4 -5 m/s. In summer, the season with lowest wind speed, wind is blowing in average 4-6 m/s in coastal areas and in the inland parts of Estonia it is up to 3 -3.5 m/s. The test site Pakri Peninsula is a typical coastal location with moderate to good wind condition and thereby it is very well suitable for feasibility study for wind farms that should represent Estonian coastal conditions.

Mean annual wind speed at 10 m above the ground level in Pakri Peninsula remains between 3.5-4.5 m/s at wooded sites, while open areas have wind speed of 4.5-5.5 m/s and open coastal locations 5-7 m/s. At wind turbine hub height (80 m above the ground level) mean annual wind speed reaches 7-8 m/s and the coastal locations 7.5-9 m/s.

Seasonal distribution of power production by wind turbines at Paldiski region is highly correlated with seasonal pattern of energy consumption. The highest energy yield is characteristic for period from October to January (more than 10% of annual energy production in every month) when the consumption is highest. The lowest energy yield is represented in summer from May to August (see for details in Fig 1).

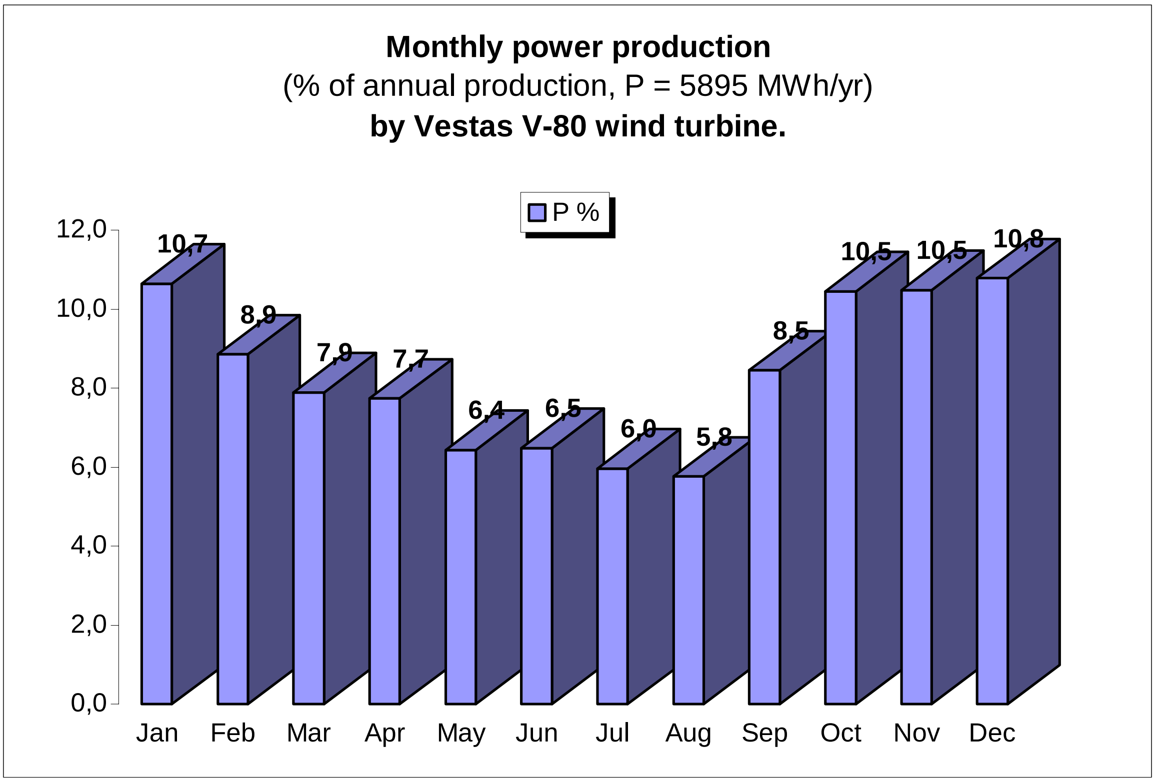

Figure 1. Monthly power production (% of annual production, P = 5895 MWh/yr) by Vestas V-80 2 MW wind turbine.

To ensure high energetic efficiency of wind farms and suitable location of wind turbines according to good practices, most of the elements of Environmental Impact Assessment (EIA) were applied when identifying possible sites for wind turbines. The highest number of building restrictions were set in the Pakri Landscape Protection area (cliff, wooded meadows and coastal meadows), coastal protection zone and off-shore areas (so called Important Bird Areas). Several other restrictions should be taken into consideration. Requirement on noise prevention zone is caused by local settlement. Generic safety zones are requested along roads and power lines. Wooded areas and wetlands also pose certain restrictions to design of wind farms due to negative effect on wind resources or high construction costs respectively. In the frame of present evaluation those sites are considered as unsuitable.

Acording to wind energy sources targeted use all over the suitable land as intensively as technically possible, different areas were selected based on EIA. These selected areas possess no conflicts in sense of natural values or social and economical regulations. Despite of all above-mentioned restrictions there are still 1134 hectares suitable land for building wind turbines in Paldiski region, i.e. in Pakri Peninsula and two neighbouring islands. In conditions, where all free-of-restrictions available land will be used for construction of wind turbines to produce “green electricity” the maximum number of 1.5 to 2.0 MW class wind turbines reaches 73 (see Fig 2). Potential wind turbines’ and wind farms’ specification by size to 7 suitable plots allows the following ranking:

- areas for 12 stand alone wind turbines, total <= 12 wind turbines,
- areas for 2 wind turbines in 3 wind farms, total <= 6 wind turbines,
- areas for 3 wind turbines in 1 wind farm, total <= 3 wind turbines,
- areas for 4 wind turbines in 2 wind farms, total <= 8 wind turbines,
- areas for 5 wind turbines in 2 wind farms, total <= 10 wind turbines,
- areas for 6 wind turbines in 2 wind farms, total <= 12 wind turbines,
- areas for 7 or more wind turbines in 3 wind farms, total <= 22 wind turbines.

Total maximum number of wind turbines for Paldiski region equals to 73 units with capacity 1.5 to 2,5 MW each. The optimal rated power considering various restrictions is 2.0 MW.

The estimated annual power production in case of using small wind turbines (850 kW) varies per unit between 1750-2500 MWh/yr in the inner part of the peninsula and reaches 3000 MWh/yr in open coastal areas. In case the 2 MW wind turbines are used, the available wind energy enables to produce more than 5000 MWh/yr per unit in open inland areas and 6000-8000 MWh/yr in open coastal regions. The total yearly power production in Paldiski area may reach to 390 GWh**!**

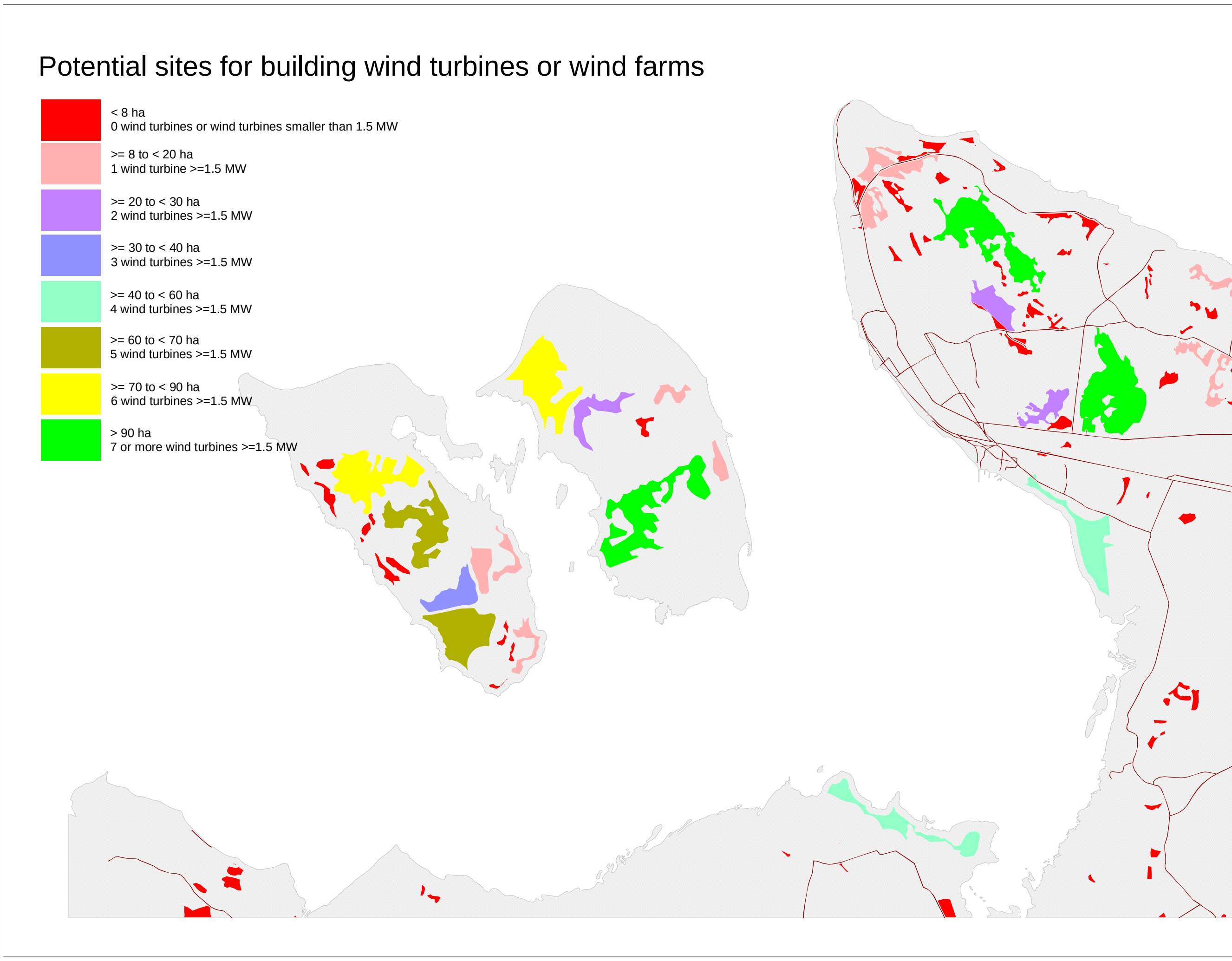

Figure 2. Potential sites for wind farms according to maximum possible number of wind turbines with rated power more than 1.5 MW.

Wind turbines related technical issues

As the markets for wind turbines have grown very fast the technology has developed significantly. In 1993, for example, the average size of turbines installed in the leading markets was around 300 kW, today it is 1000 …1500 kW. Modern wind turbines features state-of-the-art technology with major properties, such as high energy yields, silent operation, superior grid compatibility and long service life. All functions of the wind turbine are monitored and controlled by microprocessor based control units. A number of manufactures offer direct-drive generators with solid-state energy converters. The low content of harmonic distortion, absence of inrush currents, and adjustable reactive power supply mean these modern inverters make wind turbines particularly suitable for weaker grids. Also high technical availability and economic efficiency are important factors.

For the present feasibility study well proven *Vestas V80* with 2.0 MW rated power wind turbine from leading Danish manufacture Vestas was chosen. It has the pitch regulated upwind turbine with active yaw and a rotor with three blades, the special pitch regulating system allows the blades direction constant regulation.

Vestas Converter System (VCS), ensures steady and stable electric power from the turbine. VCS enables variable speed operation in range of approx. 60% of nominal rotations per minute. VCS together with the pitch control ensures energy optimization, low noise and reduction of loads on the gearbox and other vital components. VCS controls the current in the rotor circuit in the generator. This gives precise control of the reactive power. The blades are made of glass fibre reinforced epoxy. All functions of the wind turbine are monitored and controlled by microprocessor-based control units. This control system – including the transformer – is placed in the nacelle. Changes in the pitch of the blades are activated by a hydraulic system, which enables the blades to rotate 95 degrees. This system also supplies the pressure for the brake system. As an option, Vestas offers a service lift in the tubular tower.

Optional two different hub heights are available – 3-parted, modular tower (67m) or 4-parted, modular tower (78m). The wind turbines can be placed in wind farms with a distance of at least 5 rotor diameters (400 m) between the wind turbines. If the wind turbines are placed in one row perpendicular of the predominant wind direction, the distance between the wind turbines must, at least be 4 rotor diameters (~320m).

The soil conditions for building the foundations for wind turbines are good in Pakri peninsula. Mostly limestone basis with not high ground water level is dominating. For ensuring the foundations steel section with stiffenings, regulation screws and wiring tubes are foreseen by the Vestas. The reinforcement bars are delivered by the producer or importer holding relevant certifying license.

Shipping of the wind turbines, towers and foundation sections from place of manufacture to site will be performed via Paldiski South port according to international Incoterms 2000: DDU-on site (Delivery Duty Unpaid on site). Transportation from port to the site will be performed using special trailer. The road must be minimum 5m width and load capacity per axle should never be less that 15 tons per axle. Road minimum bend radius must correspond requirements of 47 m long blade trailer. From port until the site (~3 km) exists good road. Inside of the area were wind turbines are being built the roads must be constructed.

Grid connection is eased as Paldiski town is connected to main high voltage grid through two 110 kV lines, both able to transfer about 70 MW of capacity. The 32 MW transformer station is situated just nearby of feasibility study area, less than 1000 m of 20 kV lines/cables must be installed. The pilot project wind turbines could be connected to this transformer. For the whole test site, i.e. Pakri wind farm a new 110/20 kV transformer is needed. The time of interruptions per year caused from grid connection will be fixed in the contract with main grid owner.

The wind turbine can be mounted and started-up in relatively short time. Beside the construction team one highly qualified supervisor and several experienced service engineers are needed in assembling and erection phase as well as in the period of tuning, testing and final commissioning. Finnish crane company *Pekkaniska Ltd* has the biggest crane suitable for assembling of turbines *Liebherr 1600 LR/1*, capable to lift a 100-tonne item to 130 m height.

Operation and maintenance include service on site, consumables, repair, turbine insurance, lease of the land for site, administration, etc. Maintenance could be agreed with turbine manufacture. Consumables, such as oil for gearboxes, brakes and clutches are replaced at fixed intervals of three years. Particular details of the yaw system are replaced at intervals of five years.

Legal and institutional issues in relation to wind energy

Estonia is a country in accession to European Union (EU) and has potentially good possibilities for acceptation of membership during next coming years. In energy sector the legislative basis has been mostly approximated to that of EU, which means, country has adopted basic legal acts and principles which are valid in EU Member Countries.

Energy policy in European Union towards renewables

The main priorities of the EU energy policy are security of energy supplies, competitiveness and environmental protection. Promotion of renewable energy sources (RES), aimed at increasing their share in the primary energy supply is compatible with all abovementioned policy priorities (objectives), being at the same time one of major elements of sustainable development. The enforced in October 2001 EU Directive on promotion of RES based electricity production (2001/77/EC) is aimed to create a common strategy and framework. The new Directive foresees increasing the share of electricity generated from RES in the EU as an average of Member States from 13.9 % in 1997 to 22.1 % by 2010.

Situation in Estonia

In strategical documents of Estonian environmental and energy policy the wider use of RES is emphasised as a key principle having growing importance. However, the actual policy has been more modest up today as the only measures provided in legislation are the feed-in tariff rate (90% of households' basic tariff) together with the purchase obligation. Moreover, these measures can be applied to electricity generated based on any RES and the total volume of it is restricted with the upper limit of 2% of electricity consumption of previous year in Estonia.

It is hereby important to point out in connection of present feasibility study that it has been decided by the Government to rearrange the energy-related legislation in Estonia. According to the plan the current *Energy Act* shall be replaced by three new acts: *Electricity Market Act*, *Gas and Heat Supply Act* and *Liquid Fuels Act*. The preparation of these new acts is in progress. Hence, the process of drafting of the *Electricity Market Act* is still in the phase in which no information on principles and provisions of the new electricity market, especially on RES based electricity, are not yet available. The adoption of the act by Parliament is foreseen in the second half of 2002.

Main barriers

One of the major barriers to more extensive and wider development of RES (incl. wind) based electricity production is the vague state of national energy strategy, which needs upgrading as it is still oriented towards the utilisation of the main local fossil fuel resource – oil shale and therefore does not match yet with the new strategic directions of the European Union.

Also, institutional capability is one of the basic barriers at state level. Institutional enhancement and capacity building at all administrative levels could be still reached with the help of well-targeted policies at local level.

One of the direct barriers to extensive development of wind energy in Estonia is the lack of confidence in local electricity market conditions for the potential investors. Also, lack of confidence of local wind energy developers in world financing opportunities. Wind energy implementation is connected with relatively high investment need, therefore the knowledge on international financing institutions is urgently needed to be improved. Still, recently emphasized climate change mitigation policies, raised on international climate negotiations in Bonn and Marrakesh, do assist the RES promotion policies also in Estonia. In particular, those oriented to the Joint Implementation in UN FCCC Annex I countries in frame of Kyoto Protocol will give more possibilities for introducing wind energy extensive use in country.

The present structure of Estonia's electricity sector is not favourable for new independent power plants as the sector is dominated by a state owned public limited company (*Eesti Energia AS*), which is a vertically integrated company being at the same time in charge of generation, transmission, distribution and sales as well as of exports of electricity. Total restructuring of electricity sector and liberalisation of electricity market are still in an initial phase.

Present electricity production and its' price formation

The main producer of the oil shale based electricity (which formed 91% in 2000) dominating in Estonia is the power company *Eesti Energia AS*. During the period 1991-2000 the electricity consumption in Estonia has declined nearly 1.3 times and exports more than 5 times. The decline of inland consumption is connected with the general structural changes in economy and decline of industrial production in Estonia. The decline of electricity export is mainly caused by decline of export to Russia, demand by our second export partner – Latvia has been relatively stable. Since 1996 the annual electricity net production has stabilised around 7500 - 8000 GWh and inland consumption on the level 5500 GWh. Electricity export has been quite unstable changing from 400 to 1000 GWh per year in the period 1996-2000. Forecasts of the electricity demand foresee the electricity net production in 2005 in interval 7485 - 8025 GWh (actually the present level) and in 2010 in interval 7945 - 8785 GWh (little growth). For the inland consumption the respective forecasts are 5580 - 5900 GWh (2005) and 6000 - 6500 GWh (2010).

The present electricity price level (in force from 01.01.2001) is 0.76 EEK/kWh (4.87 EUR/100 kWh) for households and 0.73 EEK/kWh (4.65 EUR/100 kWh) for medium size industrial users (excl. VAT). These levels are relatively high, especially for industrial consumers if compared for example with developed neighbouring countries (Finland, Sweden).

According to the data of the annual report of *Eesti Energia AS* the producer price (production costs per 1 kWh of net production) in Narva Power Plants in 2000 was 0.35 EEK/kWh (2.24 EUR/100 kWh). In Estonia the rates of environmental pollution charges are relatively low compared to neighbouring Nordic countries, therefore the fossil fuels still have preferable status over renewable energy sources. The planned pace of increase of pollution charges, incl. CO_2, for near-term is quite modest. The environmental costs in the producer price were about 0.05 EEK/kWh (0.32 EUR/100 kWh) which is 14.3%. In the households basic tariff the environmental costs form 6.6 %.

Considering that oil shale based electricity production is highly polluting and development of national system of environmental taxation including pollution charges and resource payments is at very initial stage yet due to huge economic changes beginning from 1991 the charge rates were set at low level (the rates are planned to increase now). The share of environmental costs in oil shale based electricity producer price can be significantly increased (approximately doubled) by 2010.

The oil shale based electricity producer price would be actually at least 4.50 – 5.00 EUR/100kWh already today (in 2002) in case the pollution charge rates available in Nordic countries are applied. Moreover, in case some other environmental externalities like; surface and ground water huge consumption, losses of land, forest, peat and accompanying mineral resources, will be considered, the electricity producer price will be further raised. This will give obvious advantages to wind energy based electricity production and will allow phase out appropriate share of fossil fuel based power generation. This will be in good coherence with the requirements of the referred above EC Directive on RES wider promotion in Europe

Pakri Peninsula wind farm cost-efficiency analysis

Investments for Pakri Peninsula wind farm

Price estimates of wind turbines include the design, manufacture and supply of complete standard wind turbines with steel foundation sections and steel conical tubular towers. A two year warranty with 5 preventative maintenance visits and remote control equipment are included in the price of turbine. All prices exclude import duties and VAT.

Comparison of wind turbines V52- 850 kW- 65m, V80- 2000 kW- 67m, V80-2000 kW- 78m, S70- 1500 kW- 65m and S70- 1500 kW- 85m indicated that the most suitable wind turbine for Pakri wind farm is V80-2000kW -78m.
<u>The total price of 36 wind turbines V80 for Pakri wind farm is EUR 57 million.</u>

Transportation cost of the wind turbines, towers and foundation sections from place of manufacture to Paldiski is estimated according to International Incoterms 2000 DDU-on site (Delivery Duty Unpaid on site).
<u>Total transportation cost of 36 wind turbines V80 is EUR 3 million.</u>

Erections of wind turbines and towers on foundations prepared by the client are performed by the supplier. Erection cost include the provision of the needed cranes, project management, one qualified and experienced working supervisor and experienced service engineers for the duration of the assembly and erection of the wind turbines as well as the tests and commissioning of same.
<u>Total erection cost of 36 wind turbines V80 is EUR 1.6 million.</u>

Wind turbine steel conical tower foundation cost include the geological investigations, excavation, concrete and construction works made under the supervision of wind turbine supplier.
<u>Total cost of 36 foundations for V80 is EUR 1.4 million.</u>

Wind turbines are located near the existing local roads and about 100-400 m of new roads or the average road construction cost of EUR 8500 are estimated for each wind farm tower. Total cost of <u>Pakri wind farm roads construction is about EUR 0.3 million</u>.

Land purchase is not included into the investment costs, because it is not clear right now how much, mainly state-owned, land is needed for each wind turbine and for the roads. The average cost of grid connection and transformer is estimated about EUR 64,000 per 1 MW of rated power. For the pilot project this cost may be lower, in case the existing transformer can be used. But for the Pakri wind farm the new 100-200 MW transformer and new 100 kV cables are needed.

<u>Grid connection cost for Pakri wind farm is about EUR 4.6 million</u>.
<u>Total investment costs (TIN) for Pakri wind farm are about EUR 69 million.</u>
<u>Annual maintenance costs are estimated 9.59 EUR/MWh</u> (incl. insurance) for the Paldiski pilot project and Pakri wind farm.
<u>Project management costs are assessed 2% of investments.</u>
<u>Land lease is about EUR 64,000 for Pakri wind farm.</u>

Wind energy based electricity production cost

The cost of wind energy based electricity may depend on Estonian oil shale electricity prices, electricity market liberalisation and Estonian new RES policy. In case the government will decide to stimulate the profit-oriented wind energy production, the wind energy based electricity feed-in tariff must be at least 90 EEK or 5.75 EUR/100 kWh (in Germany the relevant rate is approximately 6 EUR/100 kWh). The higher purchase price to grid will accelerate the growth of wind energy production, but it also will increase the consumer prices. If the wind based energy share will stay less than 10% of total electricity consumption, then the additional increase of electricity prices for consumers will be about 1-2 % per year only. The another strategy is to minimise the electricity price and the cost of wind energy based production. Then the proportion of equity capital must be higher and the interest rate lower.

The Pakri Peninsula wind farm feasibility study compared 3 financial models of wind energy based electricity production for selected wind turbines for 20 year depreciation period (without taking into account the inflation). Brief results on three options are presented below.

A. Profit-oriented option

1/3 TIN - equity capital with 8% interest rate per year (20 years);
2/3 TIN – 6% loan paid back in 10 years;
depreciation 8% during the 11-20 years;
electricity feed-in tariff - 5.75 EUR/100 kWh (20 years).
Profit-oriented wind energy production (model A) has the annual costs for the first 10 years in Pakri wind farm - 5.12 EUR/100 kWh and the next 10 years - 4.80 EUR/100 kWh (incl. depreciation).

B. Profit-oriented option with investment subsidies

1/3 TIN - equity capital (state) with 0% interest rate;
2/3 TIN – 3% (subsidised) loan for 10 years;
depreciation 8% during the 11-20 years:
electricity feed-in tariff - 4.48 EUR/100 kWh (20 years);
annual profit at least 10% of annual income.
For model B the annual costs for the first 10 years in Pakri wind farm are - 3.75 EUR/100 kWh and the next 10 years - 3.85 EUR/100 kWh (incl. depreciation).

C. Non-profit co-operative option

TIN – 100% co-operative equity capital;
electricity feed-in tariff - 2.56 EUR/100 kWh (20 years).
Non-profit wind energy production (model C) has the annual depreciation 4%. Total sum of depreciation is 80% of the TIN. It is enough, as the wind turbines prices are declining, foundations and towers can sustain wind turbines at least for 40 years. Wind energy based electricity production annual cost for Pakri wind farm in model C is only 2.42 EUR/100 kWh.

The most cost-efficient option is C, however, it can be used for co-operative members with enough investment power only. Therefore, more realistic for Estonia is the option B, which presumes firstly the participation of the government in the implementation of the first climate oriented renewable energy wider promotion project. Secondly, the participation of the country in the climate change mitigation oriented international co-operation towards the implementation of Joint Implementation between Un FCCC Annex I parties, foreseen in the Kyoto Protocol. Favourable long term loans form actually the driving force and financial basis of this option.

Public participation and capacity building

The local community needs appropriate information about planned activities on wind energy potential further possible use in Paldiski region since the very early stage of the investment project. Major conflicts and misunderstandings by general public and in particular by local community could be avoided in case the relevant capacity building measures are planned in advance. Close contact between project developers and local authorities is also important.

The aims of public participation and capacity building in the frame of the Pakri Peninsula wind farm project could be listed in the following:

- to encourage the favorable social and economic changes like increase of the employment, integration of the non-Estonian people to the society, to increase the tax base, etc. in the community of Paldiski region;
- to inform local people about the designing of the wind farm project;
- to provide appropriate information to the technical, environmental and economical experts but also to the representatives of the government and local authorities;
- to raise the general knowledge in Estonia about renewable energy resources, to introduce wind energy related RES possibilities and promote its' wider use;
- to promote the implementation of the Estonian and EU energy policy in Estonia.

The target groups for public participation regarding the Pakri wind farm project are determined on the basis of their interest in relation to the wind power use. The target groups are defined on the ground of their relationship to the activities planned in the project. The following target groups could be differentiated:

- group what is directly influenced by the project implementation activities, i.e. inhabitants of Paldiski community and local authorities;
- group what is influenced indirectly by the activities entrepreneurs, farmers, landowners, fishermen, people oriented to recreation, or business in Paldiski region, etc.;
- people from public, also experts in their field, who have the professional interest towards the nature and nature conservation objects in the area of project implementation like experts on nature conservation and environmental protection, green movement, experts on energy, NGOs, teachers, students, academic staff, journalists, etc.;
- the general public of Estonia;
- public in neighbouring countries like Finland, Sweden, other Baltic States and Russia.

Local community habitants in Paldiski town and Pakri Peninsula often are considered as a socially vulnerable group having social problems like high rate unemployment, integrating to Estonian society, problems based on lacking of local language skills, etc. This target group needs a special attention from the point of view of capacity building and adult education. The economic development in this area; extension of the Paldiski harbor, establishment new enterprises, starting the tourism and recreation, starting the wind farms or beginning the production of wind turbines parts, also being involved in construction of turbines foundations and roads, etc. creates very probably a number of new jobs, also opens new opportunities for the local people.

Several other target groups need particular attention as they may pose a source of conflicts between developers. For example, nature conservationists and environmentalists. There are the Important Bird Areas and a landscape protection area what are in focus of mentioned groups. Considering different levels of those groups in early planning stages, also the general public involvement with informing, participation and consensus, the highest level of the public participation – consensus – could be achieved here in a reasonable way. On this level the people outside the project management team could give their advice and support to the project developers and assist in relevant manner the decision-making process.

There is number of different methods suitable for capacity building and public participation process for wind park project. The use of them depends on the specific character of target groups, however, also the human, time and financial resources are needed to be foreseen in the wind farm development project.

Concluding remarks

The Pakri Peninsula wind farm feasibility study has revealed a number of significant conclusions of generic policy character, also detailed technical and economic character.

The study was organised in a bottom-up way (i.e. from single to generic approach). This means from single wind turbine analysis to small-scale pilot project including several options as for the number and rated power of turbines and finally to wind farm spread over whole Pakri Peninsula. The wind energy potential however, was studied for even more wide scale area – Paldiski region, which covers additionally two neighbouring to peninsula islands. It was studied bearing in mind the more strategic approach towards extensive use of good wind resources potential available in this region. However, for the present feasibility study 36 potential sites proved on the basis of EIA have been selected out and mapped. The VESTAS 80 wind turbines of 2.0 MW rated power have been chosen to perform detailed calculations with the help of three different financial models A, B and C.

Model A was the profit-oriented wind energy investment with 6-8% annual interest. Model B was the moderate profit-oriented investment with state and international support and with low annual interest rate (3%). Finally, the model C was an example of co-operative wind energy investment without loans and interest rates paid. Most realistic to be tested in nowadays economic conditions in Estonia was chosen the model B. According to calculations based on the model B the annual costs for the first 10 years in Pakri find farm are 3.75 EUR/100kWh and the next 10 years 3.85 EUR/100kWh.

The study reveals an important energy policy and economical result - the oil shale and wind energy based electricity prices could be comparable already at present. If the level of pollution charge rates in Nordic countries would be taken for basis of oil shale based power production cost calculations, the results are rather surprising - the wind energy based electricity production used in present Feasibility Study by model B will have higher cost-efficiency compared with today’s oil shale based electricity production. This reflects the increasing competitiveness of wind energy in the future in accordance with the development of national system of environmental charges. The competitiveness will further increase, also, in accordance with the changes to be done in the state energy strategy and policy towards RES wider promotion. In case when many other environmental externalities will be internalised into calculation of the oil shale based electricity production cost on fair basis, the comparison between RES and fossil based electricity costs may show up challenging results.

Some conclusions and remarks of generic policy character as the result of the study to be recommended to Government and policy-makers were made. The authors of present study have reached the consensus that the minimum programme for Estonia’s wind energy development in near-term future should include initiating the following supportive measures:

- introduction of fixed feed-in tariff for wind-generated electricity supplied to national grid (transmission or distribution network), the continuation of purchase obligation for networks is assumed;

- providing the long-enough duration of the fixed feed-in tariff (e.g. for the first 10 years from the installation of wind turbine);
- restructuring of the electricity sector of Estonia to avoid monopolistic character of electricity market based on vertically integrated utility;
- unbundling generation, transmission and distribution into separate enterprises.

The mid-term measures should include:

- the substantial increase of pollution charge rates, in particular the rate on CO_2 emission;
- use part of revenues from pollution charges for supporting of renewable energy research and development (e.g. design of wind farms, mapping of wind resources, preparing technical infrastructure, assistance in grid connection, etc.).

The long-term measures should include:

- The target to be reached in a more distant time scale could be the objective for complete internalization of all kind of externalities for all energy resources.

At present a fair basis for the adequate comparison of fossil fuel based and RES based electricity production price is requested in Estonia. The need to follow the EU new strategic directions in energy strategy will urge government to pay more attention to the high potential of local renewable energy sources including wind energy. It is also important from point of view of responsibility of Estonia as an Annex I Party to UN FCCC and the signatory of Kyoto Protocol in international climate change mitigation co-operation.

The yearly output of electricity based on Paldiski region wind energy forms rather significant share in the total consumption of the country. Assuming the yearly average consumption of electricity in Estonia of 5500 GWh the present test area’s share electricity production reaches approximately 3.5%.

From the point of view of climate change mitigation and Joint Implementation foreseen in Kyoto Protocol the avoided yearly amount of CO_2 reaches the value of approximately 0.25-0.3 million tonnes. This is rather considerable amount of reduction which contributes to mitigation of global climate warming.