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The Implementation of a Wind Energy System at Constanţa Maritime University

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Abstract

The environmental problems caused by the urbanization are represented by significant impacts on the environment. In the recent time, the generation of electrical energy using renewable energy sources registers a considerable growth in many parts of the world.

This work presents a study dealing with the possibility of supplying electric energy coming from wind system implemented at Constanta Maritime University. It was considered that lighting for classrooms and administrative offices operates 8 h/day, but no air conditioning system was considered.

The environmental benefit resulting from the use of such a technology is met in the reduction of the pollution released in the town of Constanta.

Key words: *renewable, wind, electrical energy, environment*

Introduction

In many countries energy sector is highly dependent of fossil fuels. Several assessments of resources indicate that they are close to the end, especially the oil resources. More over, problems related to sustainability appear, due to the global heating and pollution problem.

Having in view that the need for energy production and consumption constantly rises all over the world, in the frame of improvement in energy efficiency, renewable energy technologies can help to diminish the negative effects of electricity consumption correlated with economic growth.

In Romania, wind energy can be available in many regions, especially in the S–E of the country, where the solar energy can be also well used due to the high solar radiation.

Biomass resources are more difficult to be assessed, but the climate, the land diversity and the agricultural activities lead to need of exploitation of the biomass potential.

Not at last, the major hydroelectric potential needs to be used in order to generate electricity in a conventional way. Table 1 indicates the installation cost values and capacity factor for electricity generation of several alternative sources of energy.

The wind power capacity and produced electricity in Europe varies by orders of magnitude among different countries. The situation does not reflect the correlation between the wind potential of a country and the installed capacity. As seen in Table 2, Germany is the leader from this point of view, despite the fact that it has a modest wind potential.

Table 1. Values for installed costs and capacity factors for some renewable energy sources

Energy source	Installed cost (Euro/kW)	Capacity factor (%)
Wind	931	40
Solar	6650	22
Biomass	1330	85
Micro Hydro Power	1995	70

Table 2. Wind power in some European countries

Country	Capacity (MW) in 2008	Electricity (GWh) in 2008
Germany	1,656	41,923
France	950	5,654
Netherlands	478	4,200
Italy	1,010	5,957
Czech Republic	34	140
Poland	196	723
Hungary	62	230
Bulgaria	88	157
Romania	2	18
Greece	114	2,159
Estonia	20	121
Lituania	3	104

Wind Power Obstacles

It is true the fact that the wind power development is in a modest stage in Eastern Europe where nuclear power and fossil fuels are in the top of electricity mix. In this part of Europe the main technical issues for wind power are in connection with the need for proper resource assessment and reliable grid connection.

Generally speaking, the penetration of wind power may be delayed by systems problems in relation to wind as a fluctuating and non-controllable source of electricity production. Obstacles in front of the wind power penetration have economic, environmental and technical aspects.

The economic aspect: the production cost of wind power on sites with high wind intensities is comparable with the level of fossil plants. Wind power is not competing on a level playing field as negative environmental and health externalities from fossil fuel plants are not fully internalized.

The environmental aspect: is represented by noise and visual pollution. If old wind turbines generation were quite noisy, modern turbine design over passed this inconvenient. Moreover the majority of EU countries have severe conditions regarding the distance from dwellings to a wind turbine. Regarding the visual impact, this is a matter of taste. Any way, most people enjoy the view offered by wind turbines and only a few dislike this image.

The technical aspect: is given by the fact that wind intensity can be predicted with 1-2 days in advance, but it is impossible to adjust it by human intervention in order to satisfy the demand, in a similar way as traditional power plants.

Calculation of the Energy Source

The analysis of general characteristics of the wind resource imposes the involvement of issues like global origins of the wind resource, that general characteristics of the wind, or the wind resource potential.

A major challenge is the placement turbines at the best location for the energy production with minimum losses, having in view that the energy production depends on the position of the wind turbine. That is why terrains characterized by height differences offer larger energy potentials than the flat ones. This is related to the speed-up effect which also depends on the main wind directions.

In order to simplify the engineering study, an expression like the power law might offer reasonable results [3; 4]:

$$\frac{\bar{v}}{v} = \frac{1}{k} \ln\left(\frac{z}{z_0}\right), \tag{1}$$

where:
v – wind speed [m/s];
$\bar{v}$ – average wind speed [m/s];
k – Weibull shape factor;
z – height at which a wind speed estimate is desired;
z_0 – height of measurement (10 m) [m].

The factor *k* depends on the height, time of day, period of the year, type of the terrain, wind speeds and temperature. This factor can be calculated using the formula:

$$k = a - b \lg v(z_1) \tag{2}$$

In the above equation $v(z_1)$ is a function giving the wind speed depending on the height.

In this paper it is analysed the possibility of the implementation of a wind turbine as a way of supplying electric energy using renewable technologies at Constanta Maritime University. It was considered that the lighting in the classrooms and administrative offices operates 8 h/day. The wind data needed for such a study are given in Table 3

Table 3. Average monthly wind speed data [m/s]

Month	Measured monthly wind speed	Calculated monthly wind speed
January	5.55	9.71
February	5.55	9.71
March	5	8.75
April	4.44	7.81
May	3.88	6.98
June	3.88	6.98
July	3.61	6.5
August	3.61	6.5
September	4.16	7.36
October	4.72	8.4
November	4.72	8.4
December	5.28	9.24

According the above values, a wind turbine with a maximum power corresponding to an wind velocity of 10 m/s should be selected. Results useful for the renewable energy study are shown bellow.

Table 4. Data of the wind system

Daily power demand (kW/day)	Daily electric demand (kWh/day)	Total wind power installed (kW)	Daily energy yield (kWh/day)	Annual energy yield (MWh/year)
33	264	114	270,346	98,676

The total wind power installed value indicates the estimated power supplied by the renewable technology, being also given the daily and annual energy yield.

Life Cycle Analysis (LCA)

The city is considered to be the cell of a country. Having in view the population centralization during the last decades, environmental problems consequent to the urbanization arise.

The environmental benefit of the wind system use in Constanta Maritime University consists in the reduction of the pollution released in the city. On the other hand, involving an academic institution in such a study will lead to a faster dissemination of such kind of technology, having in view that students are aware of the importance of renewable technologies.

LCA is an analysis dealing with all the effects on the environment of product during its life, “from cradle to the grave”, meaning from the production to the consumption and recycling, taking into consideration even the transport process. LCA implies four steps: goal and scope definition, inventory analysis, impact assessment, interpretation of results.

Goal and scope definition – in this phase is defined the goal of the study, the functional unit, the boundaries of the system under evaluation, the data required, the assumptions and the limits.

Inventory analysis – this step is devoted to data collection and calculation procedures to quantify relevant inputs and outputs of a product system. These inputs and outputs may include the use of resources and releases to air, water and land associated with the system.

Impact assessment – aims the evaluation of the environmental impact given by the process; aims to point out the extend of the alterations generated by the material and flux releases into the environment and the consumption of resources, as assessed in the inventory analysis. In this third step the objective data previously calculated are transformed into an environmental risk assessment.

Interpretation of results – is the final stage of the analysis, when findings from the inventory analysis and the impact assessment are combined together. The interpretation takes the form of conclusions and recommendations to decision-makers, in order to reduce the environmental impact of the processes considered.

Regarding LCA, a difficult step is gathering data and information about the products and production processes.

The alternative sources of energy contribute to the reduction of the global warming. With the ratification of the Kyoto Protocol is stipulated an intensive growth of investments in alternative sources of energy aiming to the reduction of gases emissions which causes the greenhouse effects.

Tables 5, 6 and 7 present values of gases emissions during the whole process, from the production of the equipment to its final, for different types of renewable and conventional sources, by the help of LCA [7].

Table 5. LCA for emissions of renewable sources, [kg/(kWh)]

Source	CO_2	SO_2	NOx
MHP	0.009	0.00003	0.00007
Hydro	0.0036 - 0.0116	0.000009 - 0.000024	0.000003 - 0.00006
Wind	0.007 - 0.009	0.00002 - 0.00009	0.00002 - 0.00006
Photovoltaic	0.0098 - 0.167	0.0002 - 0.00034	0.00018 - 0.00030
Solar	0.026 - 0.038	0.00013 - 0.00027	0.00006 - 0.00013

Table 6. Life Cycle for emissions of conventional sources, [kg/(kWh)]

Source	CO_2	SO_2	NOx
Coal	0.955	0.0118	0.0043
Petroleum	0.818	0.0142	0.0040
Gas	0.430	-	0.005
Diesel	0.772	0.0016	0.0123

Table 7. Emission factors [kg/kWh] by LCA of technologies in conversion to electric power generation

Technology	CO_2	SO_2	NOx
Gasification of biomass-wood	0.005 - 0.0010	0.00005 - 0.00010	0.0005 - 0.0006
Coal-powered integrated gasification combined cycle	0.190 - 0.220	0.011 - 0.012	0.004 - 0.0045
Natural gas-cycle combined of gas turbine	0.090 - 0.120	0	0.0005 - 0.0006
Decentralized photovoltaic	0.010 - 0.015	0.00005 - 0.00010	0.00001 - 0.00003
Wind power	0.150 - 0.170	0.0016 - 0.0019	0.0005 - 0.0006

These tables indicate a decrease of gas emission values when renewable sources are used. This is an important result for a dynamic city like Constanta, which will stimulate their more intensive spreading in the future.

The values of LCA vary according to the used technologies and the place of installation.

Conclusions

This paper suggests the generation of electrical energy to an academic establishment (Constanta Maritime University) using wind power resources.

Such a technology presents two types of benefits. Its implementation will contribute to sustainable development, mainly by the reduction of the pollution released in the town of Constanta. In the same time, the development of such a project in this kind of building will allow the fast dissemination of the technology, due to the fact that students are aware of the environmental issues.

Values of the total wind power installed, daily and annual energy yield were found. Results of LCA indicate the amount of emissions avoided.

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Implementarea unei instalații eoliene la Universitatea Maritimă din Constanța

Rezumat

Problemele de mediu cauzate de urbanizare sunt reprezentate de un impact negativ semnificativ asupra mediului. În prezent, producerea energiei electrice utilizând sursele neconvenționale cunoaşte un avânt impresionant în multe zone ale lumii.

Această lucrare prezintă un studiu care tratează posibilitatea furnizării enegiei electrice utilizând un sistem eolian la Universitatea Maritimă din Constanța. S-a considerat că iluminatul sălilor de curs şi a spațiilor administrative se realizează zilnic, timp de 8 h, fără a se lua în calcul sistemele de condiționare a aerului.

Beneficiile utilizării unei astfel de tehnologii constau în reducerea emisiilor poluante la nivelul oraşului Constanța.