Journal of Naval Science and Engineering
2010, Vol. 6 , No.3 , pp. 88-108

MAKING USE OF RENEWABLE ENERGY SOURCES IN THE ELECTRICITY MARKET OF TURKEY

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Abstract

Electricity powers the machinery, the computers, and all the other components of modern society. In Turkey particularly the firms, that are responsible for electrical energy generation and distribution, are planned to be privatized. At this stage, covering some portion of electricity consumption by the help of renewable energy sources, is accepted as a good option for high capacity consumers. In this study, current issue about installing wind and/or solar energy conversion systems for satisfying high amount of electrical energy demand, is investigated.

TÜRKİYE ELEKTRİK PİYASASINDA YENİLENEBİLİR ENERJİ KAYNAKLARINDAN FAYDALANABİLME

Özetçe

Elektrik enerjisi; makinelere, bilgisayarlara ve modern toplumun diğer tüm unsurlarına hayat verir. Türkiyede elektrik enerjisinin özellikle üretim ve dağıtım işlerini yapan şirketlerin özelleştirilmesi planlanmaktadır. Bu aşamada yüksek elektrik enerjisi ihtiyacı bulunan tüketim tesislerinin, ihtiyaç duydukları elektrik enerjisinin tamamını ya da bir kısmını yenilenebilir enerji kaynaklarından faydalanarak karşılaması bir seçenek

olarak değerlendirilebilmektedir. Bu çalışmada, rüzgar ve güneş enerjisi kullanılarak yüksek miktarda elektrik enerjisi ihtiyaçlarının karşılanması için enerji dönüşüm sistemleri kurulması ile ilgili mevcut durum incelenmiştir.

Anahtar Kelimeler: *Enerji Dönüşüm Sistemleri,Rüzgar Enerjisi Potansiyeli.*
Keywords: *Energy Conversion Systems, Wind Energy Potential .*

1. INTRODUCTION

The use of electrical energy is an indispensable element of modern life. Table 1 illustrates the annual increase in the installed capacity of Turkish electrical power system, which is comprised of residental, commercial and industrial loads. Natural gas combined cycle plants are included in the thermal power plants.

	2001	2002	2003	2004	2005	2006	2007	2008	2009
Thermal	16623	19568	22974	24144	25902	27420	27271	27580	29348
Hydrolic	11672	12240	12578	12645	12906	13062	13394	13828	14553
Geotermal + Wind	36.4	36.4	33.9	33.9	35.1	81.9	169.2	393.5	880
Total	28332	31845	35587	36824	38843	40564	40835	41802	44782
Increase(%)	3.9	12.4	11.7	3.5	5.5	4.4	0.7	2.4	7.1

Table 1. The Distribution of the Installed Capacity(MW) of Turkish Electrical Power System for the Sources and the Increase of Installed Capacity.

Transmission system; which connects power plants with the consumers, is managed by Turkish Electricity Transmission Incorporated(TEIAS) and it is not planned to be privatized. Previously, distribution systems on the consumer side had been managed by Turkish Electricity Distribution Incorporated(TEDAS). Since the privatization process, which has begun recently, these systems have been separated on a regional basis and management has been divided under different names.

The investments and planning of the aforementioned private companies which undertook the task of providing electrical energy to the

consumers, should supply this energy with high quality, consistency, and security. However, it has been acknowledged by almost all segments of stakeholders that shortcomings are expected in meeting the increasing demand of electrical energy in the near future, and the search for solutions are continued. Due to the economic crisis of 2008, which has a continued effect at the present, the estimated increase in the demand has been postponed for a while. However, if no precautions are taken, the present state of production might not be sufficient for further consumption.

Besides the planning of investment on nuclear power plants, dissemination of electricity production via renewable energy sources, seems to be another type of solution for meeting the increasing demand. Approximately 45 GW of installed production capacity provides for our economy, which has an annual growth rate of 8%. One third of the production capacity is provided by hydroelectric power plants. Another third is provided by natural gas plants, one fourth is provided by coal plants, and the rest is comprised of other sources. Since our national reserves of petroleum and natural gas are too limited to meet the demand for electricity, our foreign-dependence in energy can be reduced by a widespread and effective utilization of renewable energy sources. It has also become an obligation to diversify resources and a necessity to reach the targets of electrical production with renewable sources on the basis of European Union regulations and the Kyoto Protocol. Wind power plants, solar energy plants, small-capacity hydro-electric plants, and geothermal power plants are prominent among the types of electrical production plants using renewable energy sources. The figures on the electrical power plants that are newly established or closed down at the European Union in 2009, provided on Table 2, gives critical information with respect to the final situation on the subject.

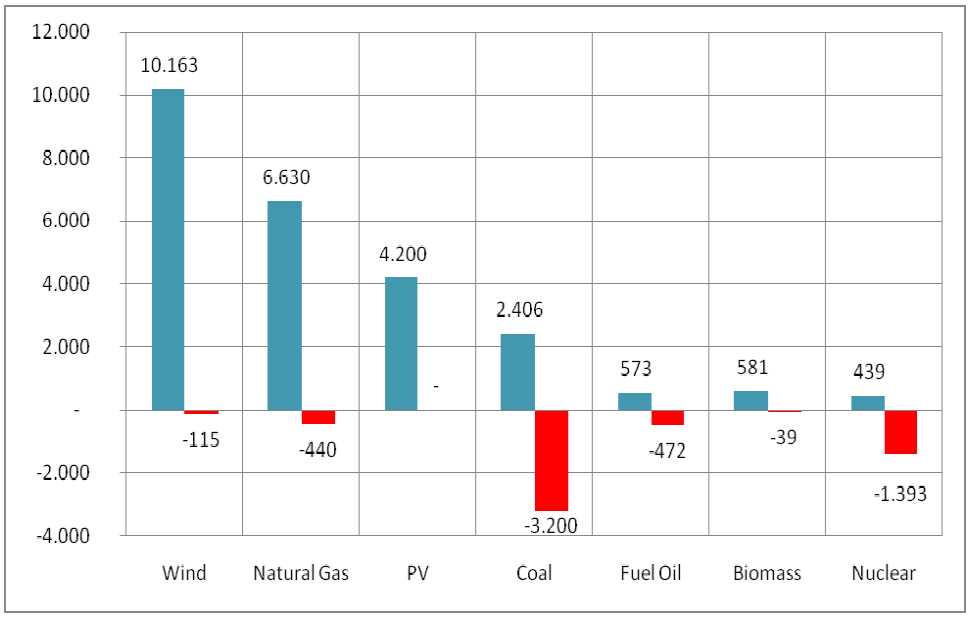

Table 2. New Installed Capacities of Electrical Power Plants(+) and Decomissioned Capacity(-) at European Union Countries in the year 2009 (PV=Photovoltaics – Solar)

An underlying motivation in the planning of the establishment of wind and solar energy plants on suitable land with potential, is austerity. Widespread dispersal of such plants would enable savings from electricity consumption and investments on long energy transmission lines. In addition, it would provide protection from the effects of possible shortages of the supply of electrical energy in our country, which seems likely in the future. Provision of new employment fields and country-wide effects in the case of the construction and management of efficient systems are other benefits.

At the planning phase of electrical energy systems based on renewable energy sources, decisive factors are the characteristics of the demand for electrical energy and the natural potential of the region. Another important criterion is the distance to the transmission grid.

2. REGIONAL RENEWABLE ENERGY POTENTIAL

Of the renewable energy sources, wind and solar energy are considered in this study. Studies conducted on the wing and solar energy potential of our country are summarized below. It has been conferred that these two sources may be utilized separately or in combination in Western Anatolia. Point analyses are needed in order to determine the exact place of establishment for the systems.

2.1 Wind Energy Potential

It was stated that Turkey's technical wind energy potential is 88,000 MW, economical potential is approximately 10,000 MW depending on the technical condition[1]. In order to exhibit the wind power potential and wind characteristics of the land and sea areas of Turkey, to contribute to energy planning and to evaluate the possibilities for the future development of wind power; General Directorate of Electrical Power Resources Survey and Development Administration(EIE) has developed the "Atlas of Turkish Wind Power Potential" (REPA). Below, Figure 1 and Figure 2 show the Turkish Wind Map and Izmir Province Wind Speed Distribution at 50 meters of height as examples created from REPA.

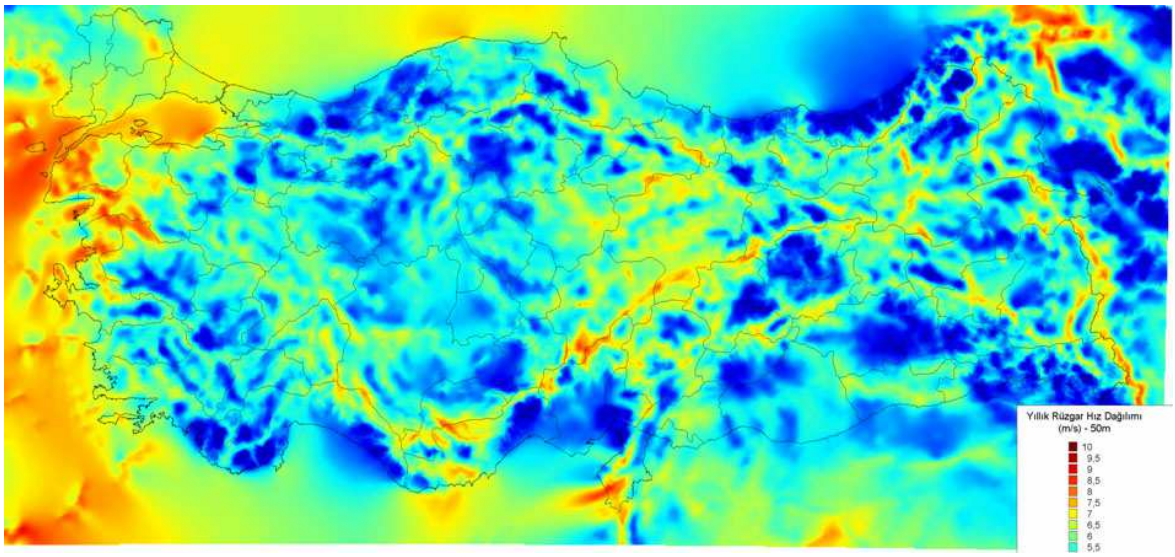

Figure 1. Turkish Wind Force Map; annual average at 50 m of height.

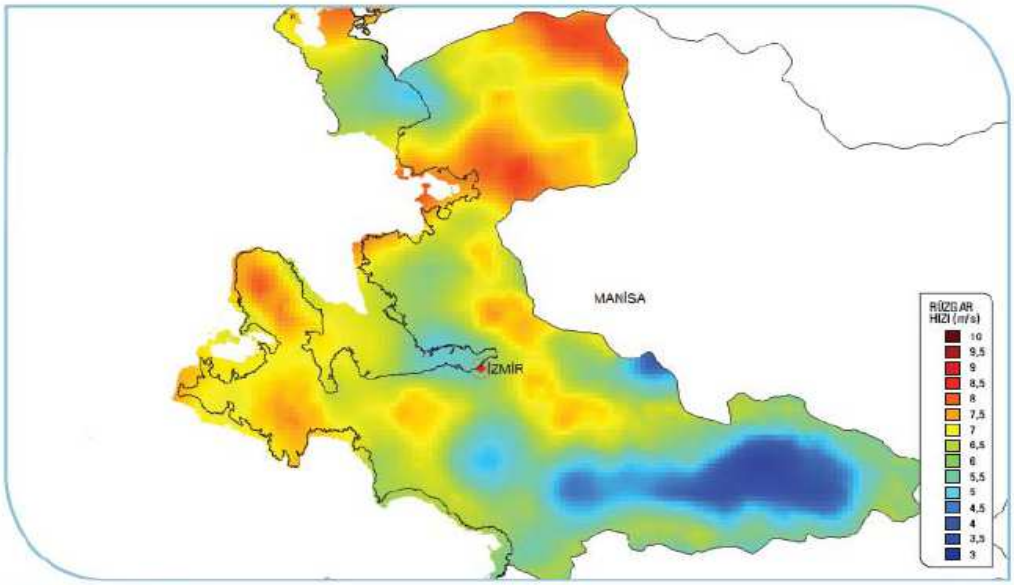

Figure 2. Izmir Province Wind Speed Distribution: 50 meters of height.

Reliable preliminary surveys and wind source evaluation provide the basis for an investment in wind energy; determining investment return and feasibility. The following steps are recommended in the investment decision [2]:

- Choice of the field: The first task in the construction of a wind energy plant is the choice of a field with sufficient potential. REPA could be used in the choice of field. The field chosen by the use of REPA, should be verified by examining wind measure indicators. If available, data on wind and other wind measurements - intended for wind energy - of the area around the chosen field, should be taken into account. Such data could be obtained from the Directorate General of State Meteorology Affairs Station.

- Investigation of the present situation on license application for the chosen field.

- Determination of parameters of the chosen field, such as land structure, land ownership, transportation facilities and distances from transformer stations.

- At least 1 year of wind force measurements intended for energy, in line with the standards, determined by an expert at a point within the chosen field.

- Decision on investment following the analysis and required reports of the wind data provided by wind measurements.

- Application for license to EPDK.

Nature itself is a real guide in field choice. Biological indicators such as trees and bushes, geological indicators such as wearing of the rocks and erosion that were formed by the wind, observations by the local people, wind applications such as windmills, cultural indicators such as local names, folk songs and poems associated with the wind, all provide supportive information on the wind source. There are certain standard charts prepared

according to the effects of wind on physical objects and used in field investigation for a rough projection of the wind source: Griggs-Putnam and Beaufort scale. Despite the availability of the energy source, it might not be physically, environmentally, technically or legally possible to establish a wind energy plant in the chosen field. Therefore, the following criteria should be taken into account:

- Convenience of transportation to the field,
- Power capacity of energy transmission lines and transformer stations,
- Distance from transformer stations for the transportation of produced energy,
- Convenience of the field for operations - building roads and other practices,
- Slope of the field,
- Sufficiency of the area of the field,
- Land usage and ownership at the field,
- Vegetation cover at the field,
- The position of the field with respect to dominant wind direction,
- Distance of the field to settlement units,
- Zoning situation of the field,
- Proximity of the field to military or civilian radars and other similar establishments,
- Whether the field is included in an archeological, natural park, forest or other protected areas,
- The importance of the field for natural life activities and the ecology,
- Geological structure of the field,
- Analysis of subterranean water resources,
- Stance of inhabitants nearby towards wind plants,
- The situation of the field with respect to icing, rain, lightning and atmospheric stability,
- Detection of GSM service area,
- Legal obligations,
- Results of meetings with local electricity distribution companies.

2.2 Solar Energy Potential

The map on the solar energy potential of our country, prepared by European Union Joint Working Group, is presented with Figure 3. Turkey has a high potential of solar energy due to its geographic position. It was determined that Turkey's average period of sunlight is 2.640 hours per year (7.2 hours per day). The average annual radiation force amounts to 1.311 kWh/m²-year (3.6 kWh/m²-per day). The solar energy potential was calculated to be 380 billion kWh/year. As shown in Figure 3, the provinces of Karaman, Antalya, Konya, Mugla, Burdur and Mersin have a potential for solar energy of striking magnitude.

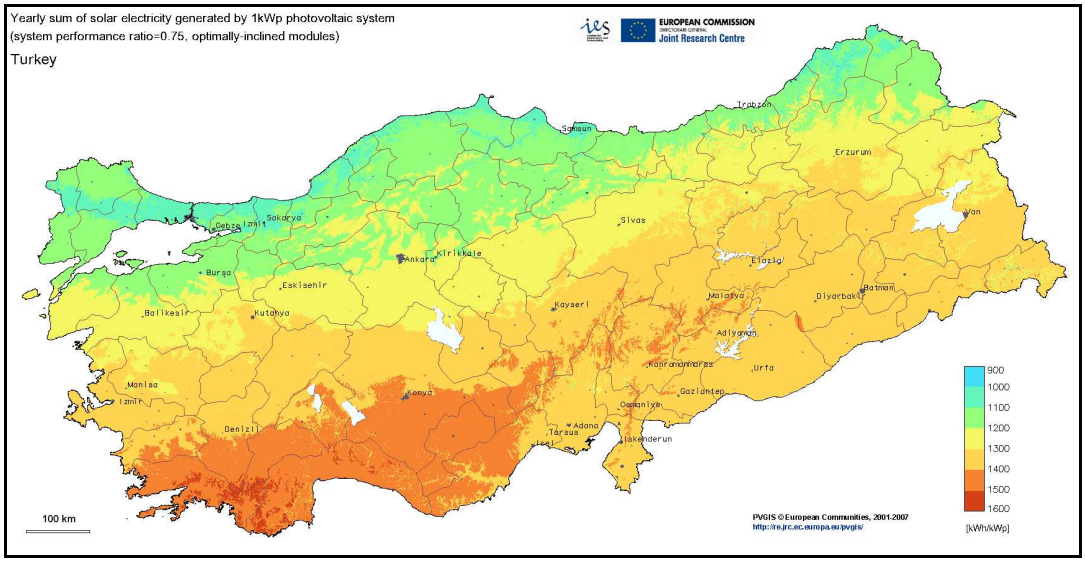

Figure 3. The Solar Energy Potential of Turkey(with photovoltaic system of 1kWp).

3. PLANNING AND FEASIBILITY STUDIES

Figure 4 presents the model work flow diagram prepared for investment companies. It is essential that similar planning is made and the project is realized. It is necessary that the goals of the plan are verified to be beneficial. The steps required for reaching the targets should be correctly

determined. Correct solutions should be found for overcoming the obstacles. It is also necessary that the disadvantages are determined, so that projects that are not beneficial for the society may be cancelled, and highest productivity levels are provided by the planned investments in the end.

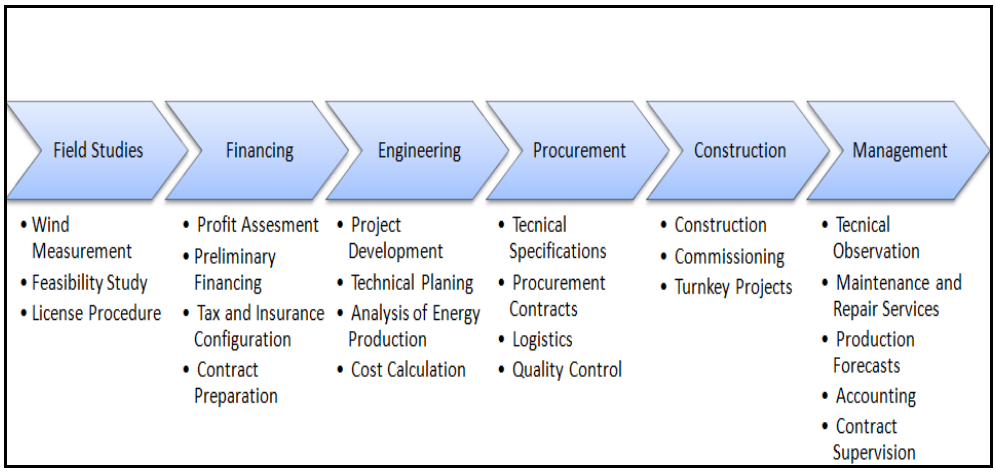

Figure 4. Model work flow diagram prepared for renewable energy investments of companies [3].

In order for measurements related to wind to be used in the technically correct planning of a Wind Energy Conversion System (WECS) investment and in licensing procedures, it is obligatory that they have been made for at least 1 year prior to the planning phase. It is mandatory for WECS applications with license requirement that wind measurements are made for at least one year, using a system similar to the wind observatory station (WOS) shown in Photo 1. The data resulting from the measurements are then put together in a technical feasibility report for establishing a WECS at a certain field. This report includes the capacities, placements and characteristics and the working situation of prospective turbines.

It is essential for increasing WECS productivity that the wind measurements, which give the most critical information in WECS planning, are made with reliable and certified hardware and the raw data are processed

correctly. Table 3 gives information on the available support services provided by the public institution; EIE.

No	TYPE OF SUPPORT SERVICE	PRICE(VAT INCLUDED)
1	Determination of the wind source information on a designated point representing the project field, by using REPA.	2.000 TL/point
2	Determination of the wind source information on the area of the project field, by using REPA.	5.000 TL/50km^2
3	At the project field: - preliminary surveys for wind energy applications, - determination of the coordinates of the optimal wind measurement points, - determination of the optimal heights for wind measurement, - provision of the technical characteristics of the Wind Observatory station (WOS), which will be purchased and constructed by public corporation, and the equipment list needed for its construction.	1.000 TL/Project
4	Presence of EIE technical personnel during the construction process of the Wind Observatory Station (WOS) which will be purchased and constructed by the public corporation, and the preparation of “WOS Installation Report”	1.000 TL/WOS

5	Operation of the WOS, reporting of the technical problems during its operation to the public corporation, gathering of the raw data from the station and conversion of the data into a usable form.	3.000 TL/WOS
6	Preparation of the RES technical feasibility report (preliminary feasibility) for foreseeing the prospect of an economic investment at the project field, or at the area represented by a single WOS in case demanded by the related public corporation.	18.000 TL/Project

Table 3. Information on the Available Support Services Provided by EIE for Wind Energy.

Photo 1. Wind Measurement Pole and Equipment(WOS).

It is a technical obligation for wind plants to be connected to the transmission grid. This connection provides voltage and frequency stability. However, there are technical and procedural requirements for realizing a reliable and correct connection between the plant and the grid. These requirements are called "grid connection criteria for wind plants (grid codes)" in the literature. Information on the current connection criteria are presented in [4].

In Turkey, a sizeable and powerful application in connecting solar energy conversion systems to the transmission grid is yet to be done. Photovoltaic units producing direct current are commercially widespread. However, they require inverters with equivalent power, in order to connect to the grid - which works with alternative current. The need for transformer and accumulator systems increase the investment and operation costs. As a result, there has not yet been any construction of solar plants that connect to the transmission grid in our country. Nonetheless, it is foreseen that by the realization of planned projects and availability of different technologies (such as Concentrating Solar Power-CSP) for commercial use, plants resting solely on solar energy, will be established in the coming period.

3.1 License Procedures

According to Electricity Market Law no. 4628 and Electricity Market License Regulation, a corporate body has to obtain a license from EPDK in order to operate in the electricity market. License can be defined as a certificate of authorization for operations. A "license application" is required in order to obtain such a license from EPDK. The periods open for license applications are declared by this institution. However, only on November 1st, 2007, license applications for wind plants amounted to a considerably high installed capacity.

According to Turkish Commercial Law no. 6762, the corporate bodies eligible for license application to EPDK, are joint-stock companies or limited liability corporations. There are not any board decisions for accepting new license applications.

Following from Article 5 of the aforementioned license regulation stating that "Matters related to the unlicensed operation of production facilities based on renewable energy sources, of maximum 500 kW of installed capacity, are set out with regulation.", conversion systems under 500 kW of power may be connected to the transmission grid without license procedures. The relevant laws and regulations which have to be examined and considered during the project phase of systems connecting to the transmission grid are as follows:

- Law no. 5346 on the Utilization of Renewable Energy Sources for the Production of Electrical Energy,
- Electricity Market Law no. 4628,
- Electricity Market Grid Regulation,
- Electricity Transmission System Reliability and Quality Regulation,
- Regulation about Technical Assessment of License Applications Based on Wind Power,
- Electricity Market License Regulation,
- Electricity Market Stabilization and Conciliation Regulation,
- Electricity Facilities Project Regulation.

Matters included in the legislation listed above are continuously updated. Therefore, applicants should be prepared according to the latest requirements.

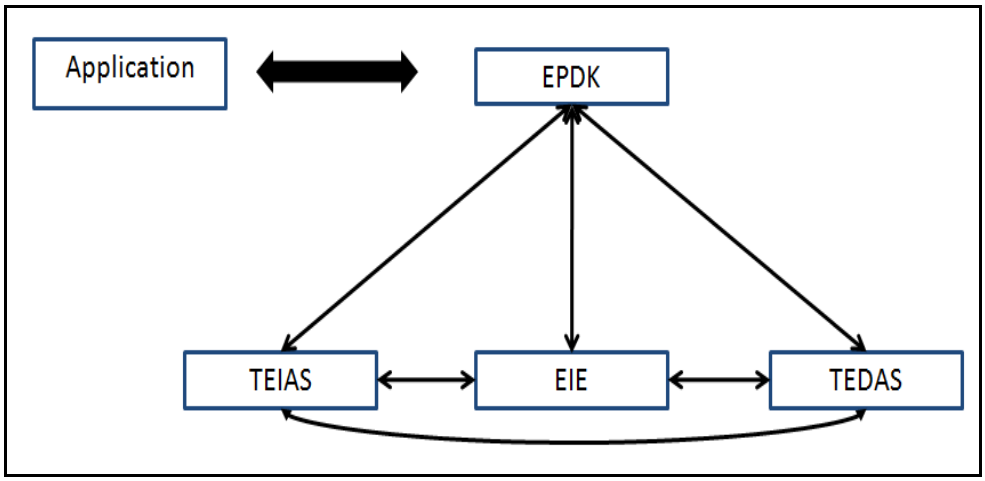

Figure 5. Task Connections of the Institutions Related to WECS License Application.

Applications during the designated time period by corporate bodies based on the "Regulation on the Technical Assessment of License Applications based on Wind Power", are concluded by EPDK, in coordination with TEIAS, EIE and TEDAS. The result is communicated to the applicant by EPDK. Detailed information on the licenses which were assessed, rejected or concluded, are published on the www.epdk.gov.tr web address. Procedures between the related institutions are shown in Figure 5.

The application information is examined by TEIAS in terms of grid connection point and grid connection requirements. TEIAS position is then communicated to EPDK. Details covered by the application, such as the productivity situation of the turbines, power concentration of the plant field, the effects of geographical positioning on other wind plants, are examined by EIE. The position of this institution is similarly communicated to EPDK. Projects which have received negative opinion are rejected if there are no possibilities for correction. The position of TEDAS is also sought and possible problems are tried to be avoided with this process.

3.2 Effect of WECS on Radars

Another subject that has to be considered is the effect of the wind turbines of military and civilian radars. This matter has to be taken into account in order to avoid problems during the licensing and permission process. British Ministry of Defence was the first to report the effect of wind turbines on radars. This was followed by the setting up of a working group - SET-128 RTG-070 "Impact of Wind Turbines on Radar" - by NATO Research Technology Organization for determining such impacts. The working group holds meetings twice a year, in order to analyze the effects of turbines on military and civilian radars, share experiences in this field, and determine the effects of turbines on different types of radars. Member states share their findings to a certain extent. At the same time, they provide resources for their national research institutions and corporations for projects on the subject.

Members of this working group are the USA, the United Kingdom, France, Canada, the Netherlands, Germany, Greece, Belgium, Italy and Turkey. Marmara Research Center of the Turkish Scientific and Technical Research Institution (TUBITAK-MAM), participates in the meetings as the institution representing Turkey[5].

3.3 Environmental Impact Assessment (CED)

Before the establishment of wind or solar energy conversion systems, the environmental impacts of the planned power plant should be examined with respect to the criteria set by Environmental Impact Assessment Regulation. According to this regulation, certified companies should apply for permission from the Ministry of Environment and Forestry with certain documents. Examples of explanations can be seen in [6].

With respect to environmental impact, wind plants should be at a certain minimum distance from settlement (due to sound volumes) and they should not be set on bird migration routes. Solar energy conversion systems should be outside forest areas (because that such systems block sun rays

from the ground, it is held that natural life in forests could be harmed by these systems).

3.4 Other Permits and Approvals

Table 4 shows the permission procedures of, and approval bodies responsible for a WECS project with grid connection. These procedures have to be repeated for every project and additional procedures also have to be taken into account. The institutions responsible for receiving the applications may communicate these to other related bodies and require their authorization as well.

Dimensions of poles and wings used in WECS have increased due to improvements in manufacturing technology. With respect to proximity criteria, this could cause an obstacle for project applications for fields close to military or civilian airports. In such events, project applications may be rejected.

PROCEDURAL STEP		**INSTITUTION FOR PERMISSION**
1	Energy Production License	EPDK
2	Certificate of Renewable Energy Source	EPDK
3	Wind Measurement Pole Installation Permit	Ministry of Forestry
4	Land Use Permit	Ministry of Forestry and/or Land Registry
5	High Voltage Connection and Usage Agreement	TEIAS
6	Document stating that “Environmental Impact Assessment” (CED) Report is not Necessary	Ministry of Envoriment
7	Zoning Plan Approval	Municipal Authority
8	"Public Benefit" Decision	EPDK

PROCEDURAL STEP		INSTITUTION FOR PERMISSION
9	Investment Incentive Document (YTB)	Undersecretariat of Treasure
10	"Exempt from VAT" Permit (Connected to YTB)	Ministry of Finance
11	Construction Permit	Municipal Authority
12	Carbon Credit Certificate	TUV
13	High Voltage Transformer and Connection Line Project Approval	TEIAS
14	Expropriation Permit (for Private Real Estate)	EPDK

Table 4. List of bureaucratic procedures required for WECS projects.

4. CONSTRUCTION OF THE PLANT

The phase of obtaining required permits and approvals for a large scale wind or solar energy conversion system, is followed by the construction phase. In the case of large scale, grid-connected plants subjected to license (above 500 kW), construction of the plant with single source is the rule. However, as installed capacity decreases, the grid connection and resource diversity may be brought into question.

At points where grid connection costs are high compared to the installed capacity, hybrid systems with accumulator, such as the one shown in Figure 6, are considered as appropriate options. Such systems do not require grid connections, therefore they are not subject to permits or approvals.

Figure 6. Hybrid System Independent from Transmission Grid

Factors affecting in the determination of the installed capacity of the planned plant are as follows: the amount and characteristics of the need, situation of the land, wind-solar measurement results, budget resources, grid connection requirements, other permission-approval conditions, national equipment production capacity (local procurement possibilities) and the final situation of the turbine technology.

To give an example of investment costs, it is reported that at European Union countries, the total cost of a WECS with 2 MW grid connection is comprised of turbines –more than 75%, grid connection -9%, basic manufacturing -6,5%, land expenditure -4%, and other supplementary costs –the rest [7].

Compared with conventional power plants, the capacity factor of wind plants with grid connection is relatively small; for example, 0.25 at medium-slow wind force regions and 0.40 at high wind force regions. This connotes that in order to acquire the same energy with a conventional plant, the wind plant has to have a much higher power.

$$\text{Capacity Factor} = \frac{\text{Total Energy Produced per Year(kWh)}}{\text{Installed Power (kW)} \times 8760}$$

Resource diversification is also an appropriate option for conversion systems that are exempt from license and used solely for saving purposes. In such case, in line with the connection agreement with the distribution company, a two-way current meter could be used, so that energy could be transmitted to the grid during the hours when energy is expensive, and brought in when it is cheap.

5. CONCLUSIONS

Obtaining electrical energy from renewable energy sources, especially by the usage of wind energy, is becoming more and more widespread in our country. In the context of privatization, where electricity supply shortages are expected, it seems to be a convenient option for large or medium scale production facilities to fulfill their electricity needs with grid-connected wind and/or solar conversion systems.

For planned systems to be productive, meet the needs, and operate consistently with the grid, both delicate engineering work that requires attentiveness and expertise, and considerable knowledge on relevant legislation are needed.

The required activities for the construction of grid-connected conversion systems were defined and the procedures that need to be fulfilled were stated in this study. It is necessary that all of these activities are concluded and the required changes are made. A detailed planning is

obliged, since the project takes its form with each result. Otherwise, it is inevitable that efforts and money are spent in vein, for facilities that cannot obtain permission-approval. Numerous WECS applications in our country have been rejected due to their lack of detailed technical feasibility reports.

The approving authorities such as TEIAS and EIE request detailed studies such as calculations of the grid connection and load flow of the planned power plant, information on the power concentration at the plant field, and the environmental impact assessment report. For a correct investment planning, surveys have to be made on every topic and step of approval mentioned in this study.

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