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Offshore Wind Power Economics

Analysis on the economic utilization of Turkey's offshore wind power potential under the current support mechanisms

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Abstract

Climate change and the energy supply security concerns supported the development of wind power growth in the world, which made wind power as one of the fastest growing renewable energy sources. Offshore wind energy attracts more investments day by day with its advantages such as higher wind speeds, larger wind turbines and lower GHG emissions. In order for developing projects that will power the grids with renewable electricity extracted from wind, governments provide extensive policy supports primarily as feed in tariffs (FiTs). To address its energy challenges, Turkey also encourages wind power development primarily with FiT support mechanism. This paper investigates whether profitable utilization of Turkey's offshore wind power potential is possible under the current support mechanisms and, if possible, how much of it is in fact economically viable. A model is built in Excel to calculate the free cash flows and NPV for economic analysis. Results show that none of the wind classes are able to produce a positive NPV. A sensitivity analysis on capital costs shows that wind class 7 (with a total potential of 142.7 MW) can produce positive NPV at the lowest level of 1.9 M USD. Recommendations are provided for students and researchers, wind power producers and the Turkish government based on the results of the analysis in this paper.

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1. INTRODUCTION

This paper is about offshore wind power economics with a particular focus on Turkey. The objective of this paper is to investigate whether profitable utilization of Turkey's offshore wind power potential is possible under the current support mechanisms and, if possible, how much of it is in fact economically viable. This chapter covers the energy challenges as the drivers of wind power growth around the world as well as in Turkey, and brief domain knowledge in wind power and support mechanisms. The research motivation and the structure of the thesis are also covered in this chapter.

1.1 Turkey: Energy Challenges and Renewable Energy Policies with Focus on Wind Power

Global renewable electricity installations[1] have more than quadrupled from 2000–2010 (NREL, 2011). The concerns over the climate change and the energy supply security are the two key motivations for the development of renewable energy systems around the globe (IEA, 2010a). With the extensive policy support over the last decade, these two motivations have increased the efforts to reduce greenhouse-gas (GHG) emissions and to diversify the energy supply mix (IEA, 2010a).

Energy supply security has become a greater motivation for the development of renewable energy which helps to diversify the energy supply mixes of different regions and decrease dependency on other resources around the world (MacKay, 2009). With the recent political unrest in the Middle East and North Africa, energy supply security concerns have been triggered at a greater extent (Ratner and Nerurkar, 2011). Limited short-term energy policy options, such as oil exporters' auxiliary production capacities to slow down the oil prices, are often based on the domestic decisions of resource rich countries (Ratner and Nerurkar, 2011). Therefore, unequal distribution of fossil fuels threatens the energy supply security of resource poor regions. Moreover, the finite character and rising consumption of fossil fuels results in the development of capital-intensive, costly and harder to mine 'unconventional' fossil reserves (IEA, 2010a).

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[1] Excluding hydropower

Similar challenges also apply to The Republic of Turkey (population around 75 million[2], area 783 562 km^2, in 2011) geopolitically located as a bridge between Europe and Asia. Turkey has a young population, grown by more than 10% between 2000 and 2009 (IEA, 2009). The capital Ankara has more than 4 million inhabitants. Istanbul is the most populated city of the country with a population of more than 13 million, also one of the largest cities in Europe.

Moreover, Turkey is the 17th largest economy in the world and one of the fastest growing nations around the world. The country is expected to see the fastest medium-to-long term growth in energy demand among the IEA countries (IEA, 2009). Deriving from its economic growth, energy use of Turkey is likely to approximately twofold over the next decade, and electricity demand is expected to boost (Saygın, 2011). The electricity demand increased by 5.3% annually during the period of 2000-2009 (TEIAS, 2010). This entails not only the needs for large energy investments but also policies for ensuring energy security, particularly in electricity sector (IEA, 2009).

The relative insufficiency of the domestic fossil resources (e.g. oil and natural gas) of Turkey with respect to its rising energy demand causes importation of these resources. It can easily be observed in Figure 1 - Primary Energy Consumption of Turkey by Energy Sourcebelow that the fossil fuels are dominant in the primary energy consumption of the country. This results in the current rate of foreign dependence on energy to be 73 % (MENR, 2010). This dependency is one of the most vital issues threatening country’s energy supply security and economy.

[2] Based on data from Turkish Statistical Institute

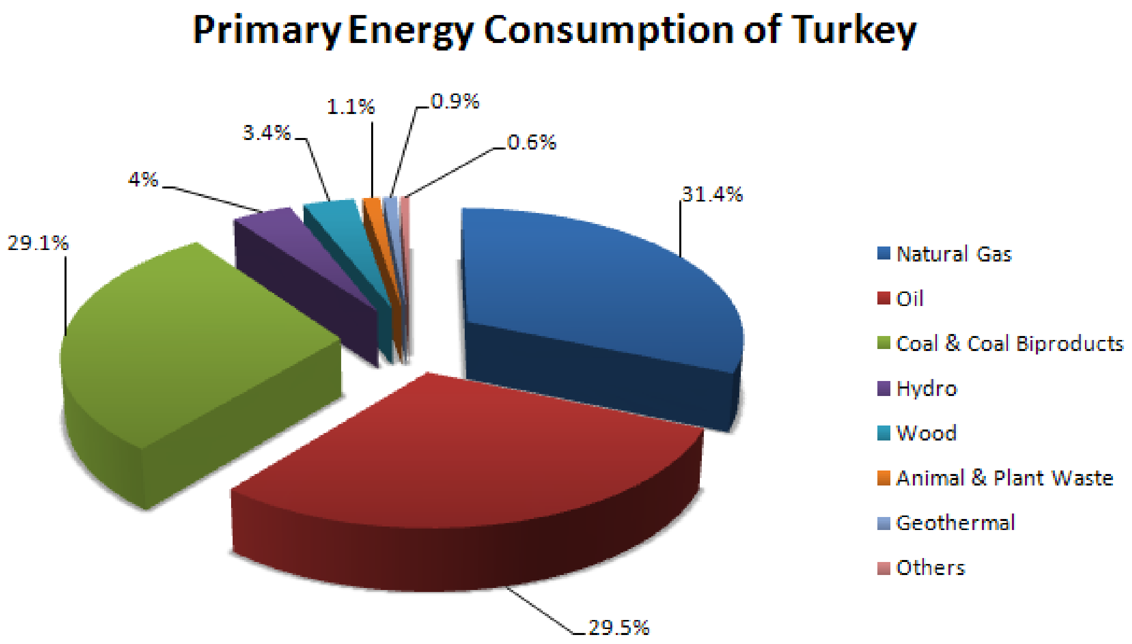

Figure 1 - Primary Energy Consumption of Turkey by Energy Source[3]

Climate change is defined by Intergovernmental Panel on Climate Change (IPCC) as "any change in climate over time, whether due to natural variability or as a result of human activity." (IPCC, 2007a) From this definition, it is a challenging task for researchers to state a clear distinction between natural and man-made causes of climate change. However, IPCC marks the increase in global atmospheric concentration of carbon dioxide (CO_2), methane (CH_4) and nitrous oxide (N_2O) since 1750s, caused by human activities (IPCC, 2007a). CO_2 emissions have grown by around 80% between 1970 and 2004, while representing 77% of total man-made GHG emissions in 2004 (IPCC, 2007b).The raise in CO_2 concentration over the globe is largely due to fossil fuel use (which release carbon dioxide upon combustion) and change in land use, while those of CH_4 and N_2O are primarily due to agriculture (IPCC, 2007a).In addition, the highest increase in global GHG emissions during the period of 1970-2004 has originated from the energy supply sector with an increase of 145% (IPCC, 2007a). Given these facts, the distinction between human and natural factors of climate change partly exists. Making such a distinction could serve for the purpose of directing & prioritizing the resources on both adaptations to natural causes and mitigating the man made ones.

[3] Source: MENR, 2010

In this regard, Turkey's large dependence on fossil fuels is also resulting in the rapid growth of GHG emission despite of Turkey being one of the countries declared to sign the Kyoto Protocol (Ilkilic, 2012). Even though Turkey has relatively less GHG emission per capita among both OECD and transition countries, it has a high growth rate of 119%[4] in GHG emissions between 1990 and 2007 (IEA, 2009). CO_2 emissions account for 82% of the total GHG emissions (IEA, 2009).

Looking at the energy related emissions in 2007, given in Figure 2 below, heat generation, manufacturing and transportation already accounts for around 80% of Turkey's energy related CO_2 emissions. In addition, the CO_2 emissions from power and heat generation have tripled since 1990, which generates concerns over the man-made contribution of the country on climate change.

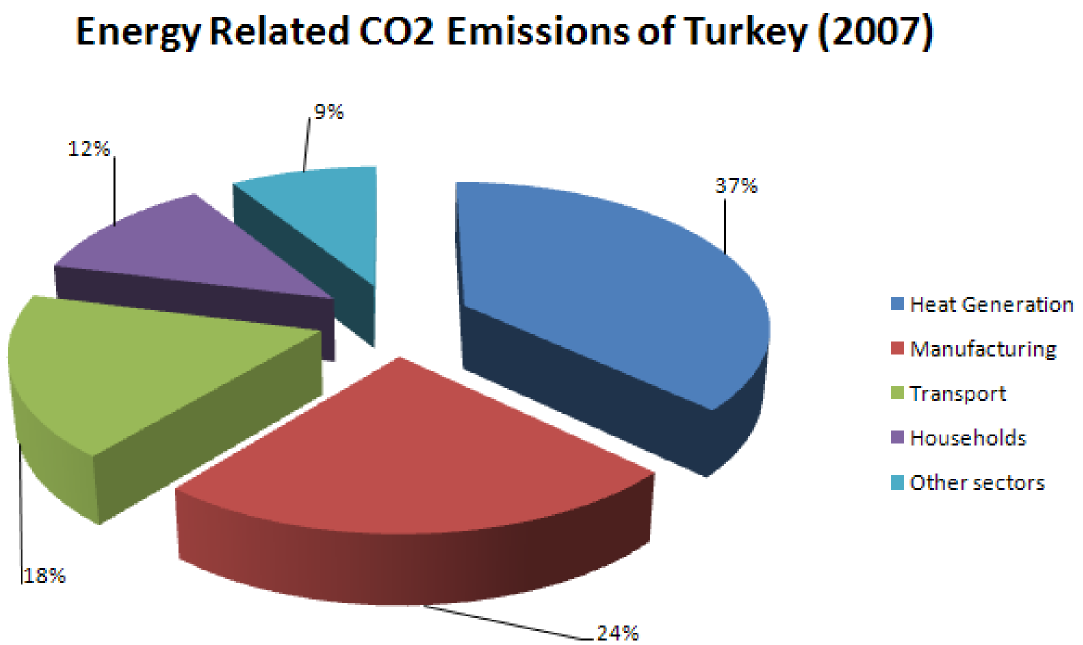

Figure 2 - Energy Related CO2 Emissions of Turkey by sector, 2007[5]

[4] Based on IEA figures

[5] Source: IEA, 2009

In light of these challenges, renewable energy technologies such as wind, solar, hydro and wave have become more attractive in addressing the concerns with climate change and energy supply security.

Wind and solar energy are the fastest growing renewable energy sources around the world during the period between 2000 and 2010 (NREL, 2011). Over the last decade, global wind power capacity has been growing at an average cumulative rate of over 30% which can be clearly observed in Figure 3 and Figure 4 below (GWEC, 2011).

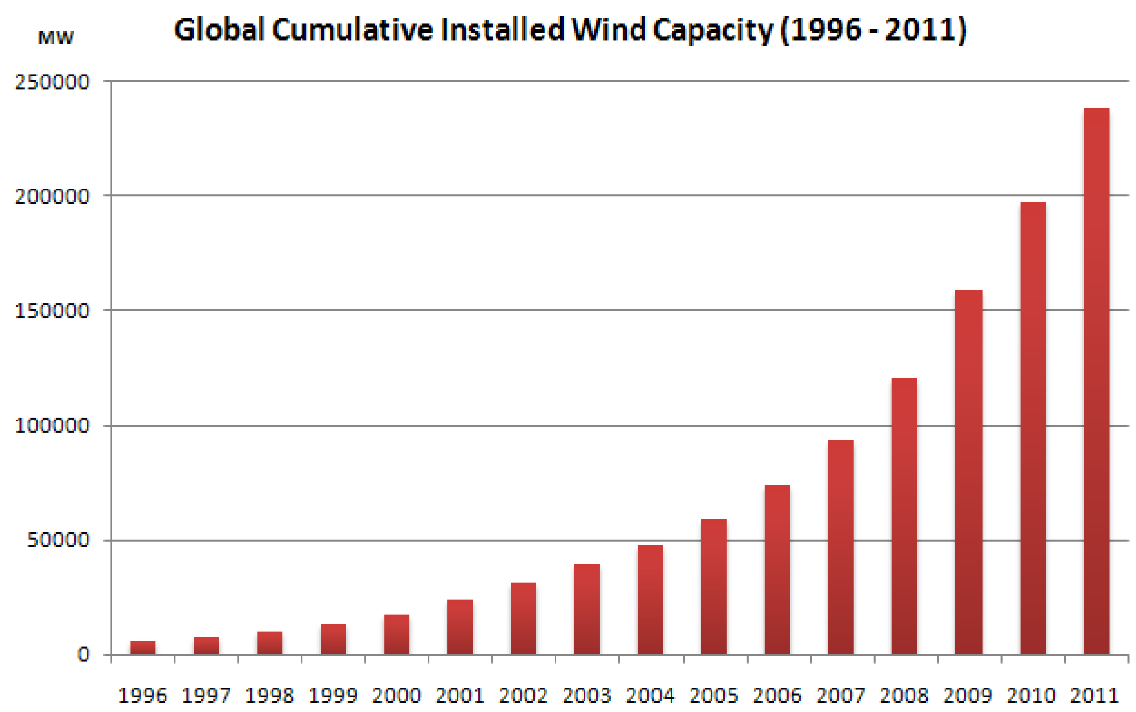

Figure 3 - Global Cumulative Installed Wind Capacity (1996 - 2011)[6]

[6] Based on the data from GWEC, 2012

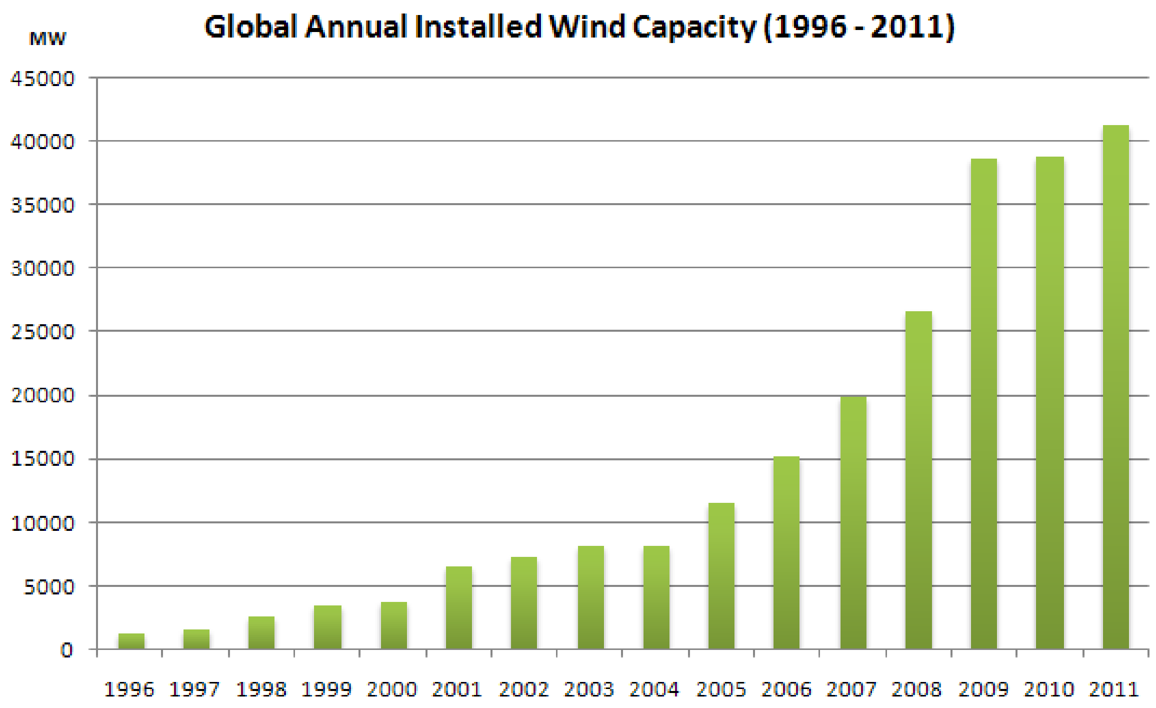

Figure 4 - Global Annual Installed Wind Capacity (1996 - 2011)[7]

The preceding challenges are also putting Turkey's energy mix in an unsustainable position and may result in loss of competitive advantages in the global arena. Therefore, parallel to the global trend mentioned above, it is clear that the utilization of its existing renewable energy potential will be helpful in addressing Turkey's energy issues.

Turkey has large renewable potential for its increasing power generation (IEA, 2009). In regards to utilizing its domestic renewable potential, Turkish government set an overall target of 30% in electricity production generated from renewable sources by 2023 (MENR, 2009). In this light, Turkey's status of possessing the highest wind energy potential in Europe strengthens the assertion that utilizing its wind power sources is Turkey's best opportunity to construct a more sustainable energy mix for addressing its energy challenges in future (Kenisarin et. al., 2006).

[7] Based on the data from GWEC, 2012

1.2 Investing in Wind Power

The power of the wind has been exploited for at least 3000 years, while it was used to provide mechanical power to pump water or to power mills for grinding grain until the early twentieth century; as seen in Figure 5 (Ackermann, 2005). At the beginning of modern industrialization, the use of wind power started to substitute by fossil fuel fired engines (Ackermann, 2005).

The first wind turbines for electricity generation had already been developed at the beginning of the twentieth century. The technology improved progressively from the early 1970s. By the end of the 1990s, wind power has become one of the most important renewable energy resources (Ackermann, 2005).

Figure 5 - Wind turbine for grinding grain (left), Wind turbine for pumping water (right) [8]

[8] Photos taken from Hau, 2006

Energy available in wind is fundamentally the kinetic energy of large masses of air moving over the earth's surface (Mathew, 2006). The electricity from wind is produced by extracting the kinetic energy from a stream of moving air with the help of a disk-shaped, rotating wind energy converter; which transforms the kinetic energy contained in the moving air, into mechanical energy (Hau, 2006).

The maximum extractable portion of the incoming energy by a wind turbine was studied by a German physicist called Albert Betz in 1919 (MacKay, 2009). 'Betz' Law' demonstrates that even without any power extraction losses, only 59 % of the wind power can be exploited by a wind turbine (Ackermann, 2005).

Considering a wind rotor of cross sectional area *A* exposed to an air mass that flows at speed V, the power extractable from wind can be calculated as follows (Ackermann, 2005):

$$P_{Betz} = \frac{1}{2}\rho A V^3 \cdot 0.59$$

Where,

ρ = air density, unit of kg / m^3

A = rotor cross sectional area, unit of m^2

V = wind speed, unit of m / second

Therefore, this relationship represents that the power generated from a wind turbine fundamentally depends on the rotor swept area and the wind speed.

Electricity generated from wind can be highly variable due to the natural fluctuations in wind speed over time. This can easily be observed by the following graph in Figure 6. Figure 6 shows the hourly wind power production (MW) in East Denmark during April 2012. The graph clearly illustrates how much the wind power varies hourly.

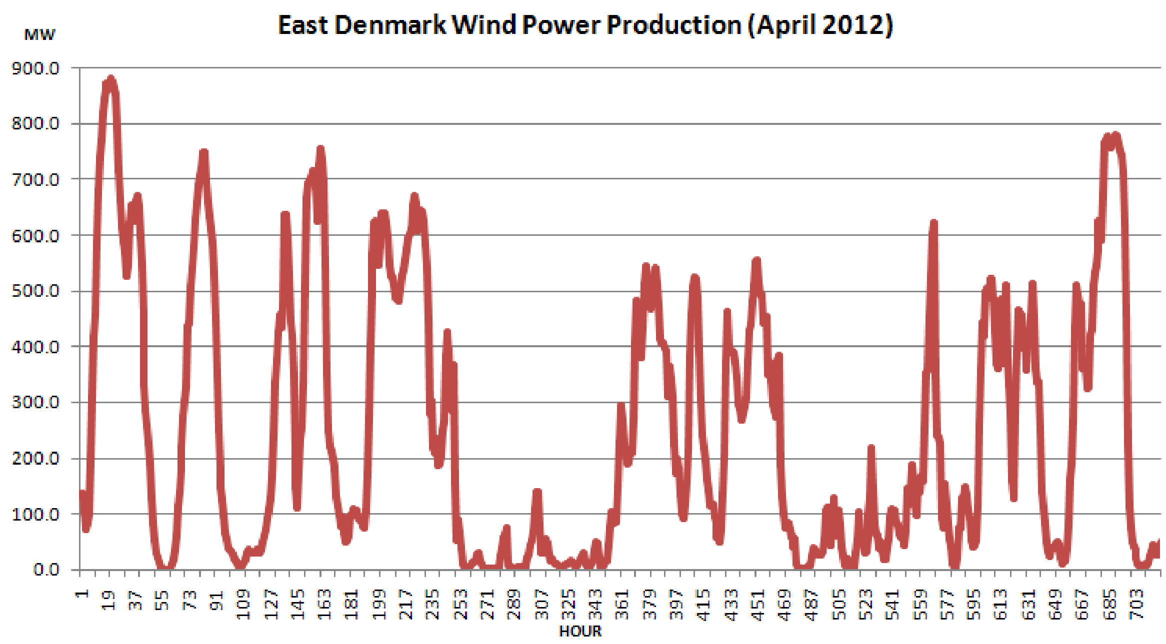

Figure 6 - East Denmark Wind Power Production (April 2012)[9]

This inherent characteristic of wind power makes the concept of capacity factor important for wind power producers as it is used to measure the utilization of wind energy, while variable wind speed can occasionally result in significantly lower utilization rates for wind farms. Capacity factor (CF) can be calculated (both for an individual turbine and a wind farm) as follows (Ackermann, 2005):

$$CF = \frac{Annual\ Wind\ Energy\ Production\ (in\ MWh)}{Installed\ Wind\ Power\ Capacity\ (in\ MW) \cdot 8760}$$

The CF is subject to the wind resources and the wind turbine specifications, yet often ranges between around 0.25 to 0.4 with low and high wind speed locations respectively; lesser than those of base load power plants (e.g. nuclear and coal) (Ackermann, 2005). This is why the installed capacity of a wind farm should be higher than a base load plant to extract the same amount of energy from both (Ackermann, 2005).

[9] Based on the data from energinet.dk

Wind power plants can either be sited onshore or offshore. Onshore wind energy has been utilized for a couple of thousand years. Yet, offshore wind energy history is quite recent.

The lowest lifecycle emissions in the power sector belong to offshore wind power, estimated to produce 2% of the lifecycle emissions of the best performing fossil fuel (Sovacool, 2008). Apart from its CO_2 emission advantage, offshore wind power attracts investments with its tendency to have higher wind speeds than onshore, thus resulting in turbines to produce more electricity (Bilgili et. al., 2010).

Europe is the leading region for offshore technology worldwide by possessing more than 99% of global offshore wind power capacity (Bilgili et. al., 2010). As illustrated in Figure 7, the development of offshore wind has mainly been in northern European countries, around the North Sea and the Baltic Sea, totaling around 3,813 MW by the end of 2010 (EWEA, 2012 and EWEA, 2009). UK and Denmark are the leading countries in offshore wind with a total capacity installed of 2,951 MW for both countries.

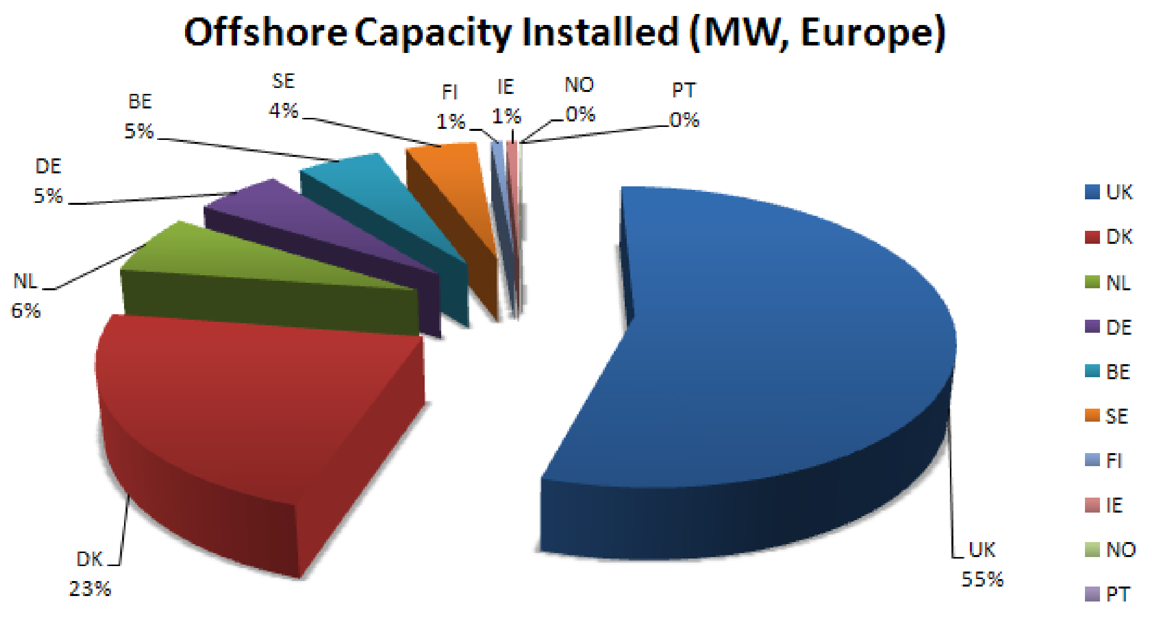

Figure 7 - Offshore Wind Capacity Installed in Europe – Percentage Distribution by Country

Offshore wind power is more complex and costly to install and maintain but also has several key advantages (Bilgili et. al., 2010):

- ✓ Winds are naturally stronger and more stable at offshore, resulting in higher capacity factors,
- ✓ Wind turbines can also be larger than onshore land as the transportation is relatively easier,
- ✓ Offshore installations can eliminate the issues of visual impact and noise,
- ✓ There is more availability of greater areas suitable for projects,
- ✓ Offshore installations can be close to major urban centers with high energy demand and costs, also resulting in shorter transmission lines.

On the other hand, the major disadvantages can be summarized under the title of investment costs as follows (Bilgili et. al., 2010):

- ✗ Offshore wind power needs more expensive marine foundations and integration into the grid electrical network,
- ✗ Installation procedures are also more expensive and access to construction site is limited due to unfavorable weather,
- ✗ The similar access restriction also occurs for operations and maintenance during operation.

Renewable energy technologies (primarily wind) are not the cheapest sources of producing electricity, whereas they are still developing day by day; therefore, supporting wind as a power source is critical.

Support mechanisms for renewable energy sources are widespread and diverse in different regions around the world. These mechanisms are crucial for wind power deployment as they aim not only to stimulate the immediate installation of the technology but also to improve the long-term framework conditions for investors in the sector (EWEA, 2009). Support instruments can be set either as a general rule for all renewable sources or as a rule for a specific renewable source.

As a key step for strengthening its renewable energy potential, Turkey enacted its first law specific to renewable energy, " Law on the Utilization of Renewable Energy Sources for the Purpose of Generating Electrical Energy" (also referred as "Renewable Energy Law") in 2005 (TUR, 2005). With the enactment of the Law, wind power has been increasingly attracting new investors (Saygın, 2011).

According to EWEA, 2009, the different types of support mechanism can be classified as direct and indirect policy instruments, where these two broad categories involve both regulatory and voluntary approaches.

Direct instruments primarily focus on the short term outcomes of the wind power industry, whereas indirect mechanisms tend to oversee a longer time horizon. As one of the fastest growing energy technologies, wind power significantly affects and is affected from these policy instruments.

The classification of various support mechanisms can be summarized in Table 1as follows:

		Direct		Indirect
		Price-driven	*Quantity-driven*	
Regulatory	*Investment-focused*	✓ Investment incentives ✓ Tax credits ✓ Low interest / Soft loans	✓ Tendering system for investment grant	✓ Environmental taxes ✓ Simplification of authorization procedures
Regulatory	*Generation-based*	✓ (Fixed) FiT ✓ Fixed premium system	✓ Tendering system for long-term contracts ✓ Tradable Green Certificate system	✓ Connection charges ✓ Balancing costs
Voluntary	*Investment-focused*	✓ Shareholder programs ✓ Contribution programs		✓ Voluntary agreements
Voluntary	*Generation-based*	✓ Green tariffs		

Table 1 - Support Mechanisms[10]

[10] Source: EWEA, 2009

It is fairly obvious to observe that feed-in tariff (FiT) mechanism is one of the most wide-spread supporting instruments around Europe (EWEA, 2009). FiTs can be classified as direct (price-driven) regulatory policy instruments based on generation[11].

Generation based methods are financial subsidies in terms of a payment per kilowatt-hour (kWh) energy produced and sold. It can either be a fixed regulated FiT or a fixed premium (on top of the electricity price) that government, utility or supplier is legally obliged to give for renewable electricity.

The difference between fixed FiTs and premiums scheme is as follows:

Regarding fixed FiTs, the total feed-in price is fixed; whereas for premium systems, the amount to be added on top of the electricity price is fixed (EWEA, 2009). Concerning the total price received per kWh by the wind power producer, one can conclude that the premium method is less predictable than a fixed FiT as it adds a premium on an unstable electricity price.

In principal, one can logically question why the premiums are not based on an environmental bonus reflecting the environmental benefits of wind as an energy source. However, in practice, the task of applying a mechanism based on the environmental benefits of a renewable energy source is challenging and tricky (EWEA, 2009). As a result, fixed premiums for wind power and other renewable energy technologies (e.g. Spanish model) are currently based on estimated production costs and are fixed based on the electricity price, rather than on the environmental benefits.

In light of EWEA's classification, Renewable Energy Law[12] in Turkey supports renewable energy sources with FiT mechanisms and some other indirect methods (TUR, 2005).The incentives (particularly the FiT), has played an important role in increasing the installed wind power capacity of Turkey from 0.01GW in 2005 to 1.7 GW in 2011 (TWEA, 2012). Considering that there are currently no offshore wind power projects in Turkey, the installed wind power capacity only represents 3% of the total wind power potential, therefore, leaving a large room for development (TWEA, 2012).

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[11] Based on Table

[12]Details will be provided in the following sections

Analysis of the FiT mechanisms applied in different countries; therefore, it becomes critical in understanding how the policy instruments affect the wind power deployment in a particular region. This would help directing and prioritizing resources accordingly.

1.3 Research Motivation

Given Turkey's energy challenges and the country's recent efforts to support renewable energy sources (particularly wind power); it becomes essential to assess the success of the country's support mechanisms for renewable energy sources. European Wind Energy Association (EWEA) assesses the success of a support mechanism with two major aspects as effectiveness and economic efficiency. Each aspect of assessment considers the following questions (EWEA, 2009):

- ✓ **Effectiveness:** Did the support mechanisms lead to a significant increase in deployment of capacities from the renewable source?

- ✓ **Economic efficiency:** What was the level of support compared to the generation costs of renewable generators?

Considering the fact that Turkey has no offshore wind power deployment, effectiveness of the current policy instruments on the offshore wind power deployment is hard to measure. However, it would be logical to assert that the situation of offshore development in the country could be an indicator for the ineffectiveness of the current policy instruments such that they do not lead to an increase in the deployment of offshore wind capacity. This can be due to many factors, yet, economic efficiency could be considered as one of the primary aspects (EWEA, 2009). Therefore, the objective of this paper is to investigate whether profitable utilization of Turkey's offshore wind power potential is possible under the current support mechanisms and, if possible, how much of it is in fact economically viable. The outcome will be the total economic potential of offshore wind power in Turkey with respect to each wind class.

The targeted audience of this paper includes researchers and students interested in Turkish wind power market, renewable energy corporations considering investments in offshore wind power in Turkey and government executives at The Republic of Turkey Ministry of Energy and Natural Resources (MENR) seeking for third party insights into the current renewable energy support mechanisms. The paper is believed to be the first in the field of offshore wind power economics in Turkey, which strengthens its beneficiary function to the targeted audience.

The outcomes of the paper are expected to benefit the targeted audience in the following aspects:

- ✓ Researchers and students will be provided with insights for understanding the Turkish wind power market. The paper can also be helpful in creating a platform for discussing offshore wind power in Turkey and further research possibilities in various countries and/or with different energy sources. It may also propose framework for conducting economic analysis in other research topics.

- ✓ Corporations will be provided with support for screening feasible offshore locations in Turkey as well as with insights for conducting economic feasibility analysis which may help in finalizing investment decisions.

- ✓ Government executives will be provided a third party perspective into current policies, which may develop into insights for prioritizing and reshaping the existing policies. The paper can also be a triggering factor for the prospective regulatory actions for supporting offshore wind power in Turkey.

All these factors have captured the interest and encouraged the motivation in researching in this topic.

1.4 Research Methodology and Structure of Thesis

This paper will investigate the impact of the current economic incentives on the profitable utilization of offshore wind power in Turkey for each wind class. The paper will treat the total technical potential of each offshore wind class in Turkey as one giant wind power project and construct a complete model on Excel which is used to calculate cash flows and net present value (NPV) for each wind class. The data used for assumptions, costs and analysis are based on secondary sources such as government statistics and reports, databases, company reports and literature.

There has been numerous studies conducted in the literature providing economic analysis of wind power in Turkey, however, most of them either focus on specific site or give only a statistical overview of the country's potential. Alternatively, the study of Erturk in 2011 appears to be the first and the only study attempting to provide a successful economic analysis of the country's onshore wind power potential as a whole.

Erturk's (2011) methodology follows an economic analysis of onshore wind energy potential of Turkey based on an NPV model in Excel for each wind class based on the cost data collected from the literature.

The tools and methods used for analysis (e.g. Excel and NPV) in this paper are similar to Erturk's study, however, the research and the analysis in this paper is done independently. The source in question (offshore), the assumptions for all calculations and most of the data are different than that of Erturk's work. Therefore, the originality of the paper and its status of being the first in the field still hold a valid assertion.

The structure of the paper will be as follows:

- ✓ Chapter 2 will present the findings on the research review about the offshore wind power business including potential of Turkey and regulatory environment as well as the characteristics of offshore wind power economics.

- ✓ In chapter 3, economic analysis of offshore wind power in Turkey will be conducted. Literature review about the analysis method and modeling will be presented. In addition, the assumptions will be provided together with the design of the model. Results of the model will also be shown in detail.

- ✓ Chapter 4 will explain the conclusions drawn from the results of the model and provide recommendations for various stakeholders that are expected to be interested in the conclusions of the paper. This chapter will conclude the whole paper with suggestions for further research.

1.5 Summary

Climate change and the energy supply security concerns are the two key motivations for the development of wind power growth in the world, which made wind power as one of the fastest growing renewable energy sources.

Offshore wind energy attracts more investments day by day with its advantages such as higher wind speeds, larger wind turbines and lower GHG emissions. In order for developing projects that will power the grids with renewable electricity extracted from wind, governments provide extensive policy supports primarily as FiTs.

The energy situation of Turkey is characterized by high rate of import dependence and rapidly rising GHG emissions. This situation is clearly unsustainable and in conflict with the current global energy trends.

To address this by realizing its renewable potential, Turkey has taken some steps in terms of renewable support mechanisms particularly as FiT. These instruments supported the deployment of wind power in Turkey. This paper will investigate the impact of the current economic incentives on the profitable utilization of offshore wind power in Turkey for each wind class.

2. RESEARCH REVIEW: OFFSHORE WIND POWER BUSINESS

This chapter introduces the findings from various secondary sources in the literature including articles, institutional reports, government statistics and company reports to name a few. The major aspects covered in this chapter are the official figures for Turkey's offshore wind power potential, the country's regulatory environment for wind projects and some major concepts in offshore wind power economics.

2.1 Offshore Wind Power Potential of Turkey

Turkey has long seashore surrounded along the three sides (Anatolian peninsula) by the Mediterranean Sea in south, the Aegean Sea on the west and the Black Sea in the North (Hepbasli, 2004). This makes Turkey to appreciate the good wind potential owing to its windy shores.

For the purpose of determining the characteristics and the distribution of the wind resources in Turkey, a very accurate Wind Energy Potential Atlas of Turkey (REPA) is produced by the General Directorate of Electrical Power Resources (EIE) in 2006, using numerical weather prediction methodology at 200 x 200m resolution for various heights (Malkoc[13], 2007).

The detailed mapping of wind resources and other information provided in REPA forms a basis for determining the potential regions for wind power production. The wind speed map showing the yearly average at 50m height is given below in Figure 8 (Malkoc, 2007).

Observing the map, it is obvious that the majority of the high wind potential shores are along the Aegean Sea shore, partly in the central Black Sea and eastern Mediterranean Sea.

[13] The data cited from Malkoc's article are from REPA

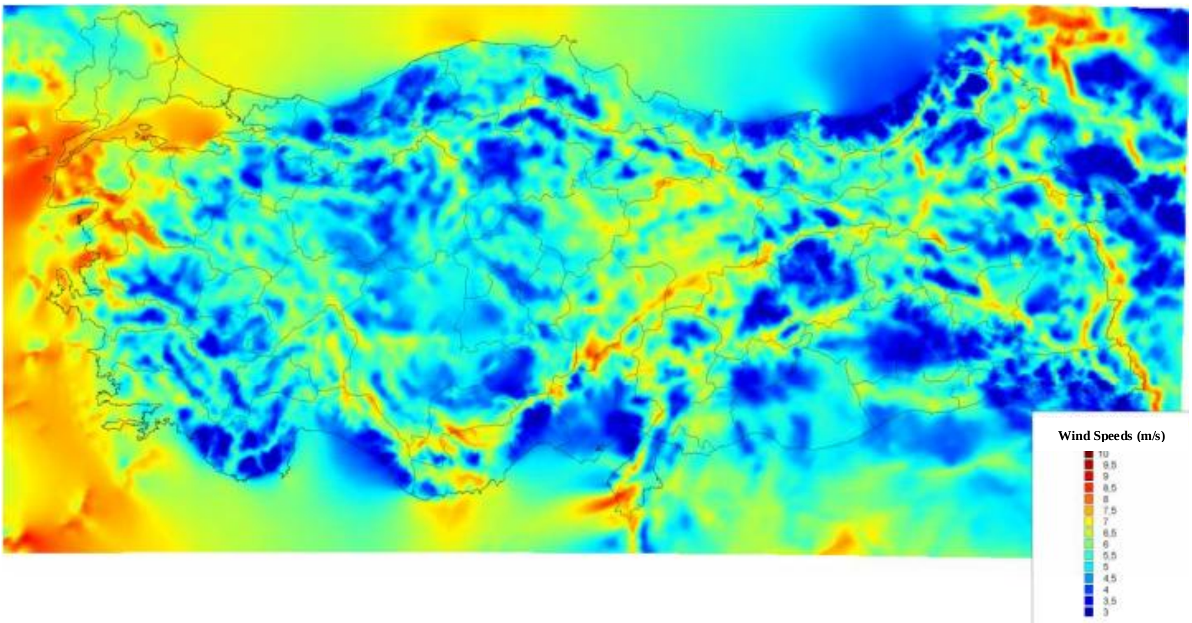

Figure 8 - Wind Distribution of Turkey at 50m Altitude

Below is Table 2 presenting the wind power capacity in Turkey (based on REPA) with respect to different degrees of wind resources, wind classes, power densities per m^2 and wind speeds.

Wind Resource Degree	**Wind Class**	**Power (MW/m^2)**	**Wind Speed (m/s)**	**Total Power Potential (MW)**
Good	4	400 - 500	7.0 – 7.5	29,259
High	5	500 - 600	7.5 – 8.0	12,994
Excellent	6	600 - 800	8.0 – 9.0	5,399
Extraordinary	7	> 800	> 9.0	195
Total				47,849

Table 2 - Turkey's Total Wind Power Capacity[14]

[14] Based on the real figures from REPA presented on Malkoc's article

The total technical potential of Turkey is estimated to be more than 47 GW at 50m altitude, given in Table 2. This figure is the total capacity of sites having wind speed greater than and equal to 7.0 m/s (with 400W/m^2 power density) (Malkoc, 2007).

In REPA, seven wind classes are determined as weak, low, medium, good, high, excellent and extraordinary. This paper takes into account the wind classes of good, high, excellent and extraordinary.

The sites that are not included for the calculation of the potentials in REPA, as part of the assumptions related to offshore potential, are as follows:

- ✓ The areas inside the 100 m coastal protection line
- ✓ Areas having higher than 50 m depth below the sea surface

Based on the official figures, the offshore wind power potential of Turkey is above 10GW representing around 22% of the total wind capacity (onshore and offshore) (Malkoc, 2007). The table showing the offshore wind power potential of Turkey based on different wind classes is given Table 3 below.

Wind Resource Degree	Wind Class	Power (MW/m^2)	Wind Speed (m/s)	Total Power Potential (MW)
Good	4	400 - 500	7.0 – 7.5	5 133
High	5	500 - 600	7.5 – 8.0	3 444
Excellent	6	600 - 800	8.0 – 9.0	1 742
Extraordinary	7	> 800	> 9.0	142
Total				10 463

Table 3 - Offshore Wind Power Potential of Turkey

2.2 Support Mechanisms and Regulatory Environment in Turkey

MENR specified wind power goals for 2015 in the ‘Strategic Plan 2010-2014’, aiming 10 GW of installed wind power capacity. Electricity Market and Security of Supply Strategy presents broader goals targeting for a share of 30% renewable energy sources in the electricity production and capacity target for wind power as high as 20 GW by 2023 (MENR, 2009). These targets are essential in shaping the support mechanisms and the regulatory environment for wind power producers (WPPs) in Turkey.

There are two main regulations important for WPPs: the Renewable Energy Law No. 5346 and the Electricity Market License Regulation (under the Energy Efficiency Law No. 26510) (TWEA, 2012). The overview of the regulations and supports based on these two major documents is as follows (TWEA, 2012 and Erturk, 2011):

- ✓ Legal entities holding generation licenses for energy production facilities from renewable resources are entitled to Renewable Energy Resource Certificates (RERC) can be taken with applications to Energy Market Regulatory Authority (EMRA).

- ✓ The fixed feed-in tariff with different prices for each renewable source is applied for the first 10 years of operation.

- ✓ Local equipment bonuses are available for the projects using mechanical or electronic equipment manufacture in Turkey.

- ✓ The rental fee for land (intended for onshore projects) is reduced by 85% (valid only for areas that are considered to be forests by the government or belongs to Prime Ministry Undersecretaries of Treasury or belongs to the government) for the renewable energy sources during the first 10 years of operation.

- ✓ During the first 8 years of operation, the renewable plant owners are not liable for their annual license fee and exempted from 99% of the license application fee.

- ✓ Renewable energy projects are given priority for connection to the grid.

Based on the figures in Renewable Energy Law, the level of FiT applied to wind power projects in Turkey is given in Table 4 below. The base FiT is 7.3 USD cents / kWh where the total FiT level may reach up to 11 USD cents / kWh if the equipments listed in Table 4 are locally sourced.

	Maximum price including the local equipment bonus (USD cent / kWh)	
	Feed-in-tariff	7.3
Equipment bonus (3.7 USD cent)	✓ Blade	0.8
	✓ Generator and power electronics	1.0
	✓ Turbine tower	0.6
	✓ All of mechanical equipment in rotor and nacelle groups (without payments made for the wing group and the generator and power electronics)	1.3
	Total	11.0

Table 4 - FiT for Wind Power in Turkey[15]

In understanding the structure of the electricity market, summarizing the trading opportunities for a WPP is essential. The summary of these options with respect to the price risk, sales risk and revenue expectation is given in Table 5 below.

According to Table 5, there are three options for a WPP to sell its electricity production: through organized markets (day-ahead), bilateral contracts and FiT. Regarding profitability, WPPs are subject to three major risks such that price risk, sales amount risk and revenue risk.

[15] Source: TWEA, 2012 and EMRA

	Organized Markets ✓ Day Ahead Market	Bilateral Contracts ✓ Wholesale companies ✓ Distribution Companies ✓ Eligible Customers	Feed-in-tariff ✓ Suppliers via Market Financial Settlement Center
Price Risk	**High:** Exposed to hourly and seasonal price variations	**Medium:** Price is subject to negotiations. Possibility of hedging middle/long term price	**None:** Constant price linked to USD
Sales (amount) Risk	**None:** Can sell the whole proposed amount as proposal is price independent	**Low:** Amount is subject to negotiations too. There is a chance to unsold amount of bilateral contracts in day-ahead market	**None:** Can sell all generation amount
Revenue Expectation[16]	**High Variability:** due to price fluctuations and imbalance costs	**Low/Middle Variability:** Possibility of guaranteeing a revenue with middle/long term contracts	**Constant:** Constant revenue flow and imbalance cost is not on the producer.

Table 5 - Trading Opportunities for a Wind Power Producer in Turkish Electricity Market[17]

WPPs can sell their power over the day ahead market which includes day-ahead planning and balancing power market regulated by market financial settlement center. Bilateral contracts via wholesale companies or distribution companies or eligible consumers[18] are also available as a way to sell electricity for WPPs. The final option is involving in the FiT support scheme which is selling the electricity produced to the suppliers via market financial settlement center.

[16] Comparing for the same generation amount

[17] Source: TWEA, 2012

[18] If the annual electricity consumption of a consumer is high enough, regulated by law, then it becomes eligible to freely choose its electricity supplier

2.3 Offshore Wind Power Economics

The long-term trends for wind energy costs have seen a significant decrease. Today, a wind turbine produces 180 times more electricity, at less than half of the cost per kWh 20 years ago (Blanco, 2009). However, offshore wind suffers from high installation and connection costs, making government support essential (Green, 2011).

Offshore wind power economics is affected by numerous aspects such as investment costs (e.g. foundation, grid connection), operation and maintenance costs, electricity production (capacity factor) and turbine lifetime. Exploiting offshore wind is still around 50% more expensive than onshore wind (EWEA, 2009). On the other hand, considering its advantages of stronger winds and lower visual impact, offshore wind power is trending (EWEA, 2009). In recent years, offshore wind costs have climbed rather than falling, driven partially by increase in commodity prices (e.g. steel) and partly by excess demand in relation to limited supply capacity (Green, 2011).

Figure 9 shows that the fundamental concepts of “Revenues” and “Costs” also apply for the offshore wind projects. The profitability breakdown of a typical offshore wind project can be illustrated as follows (Praessler, 2012):

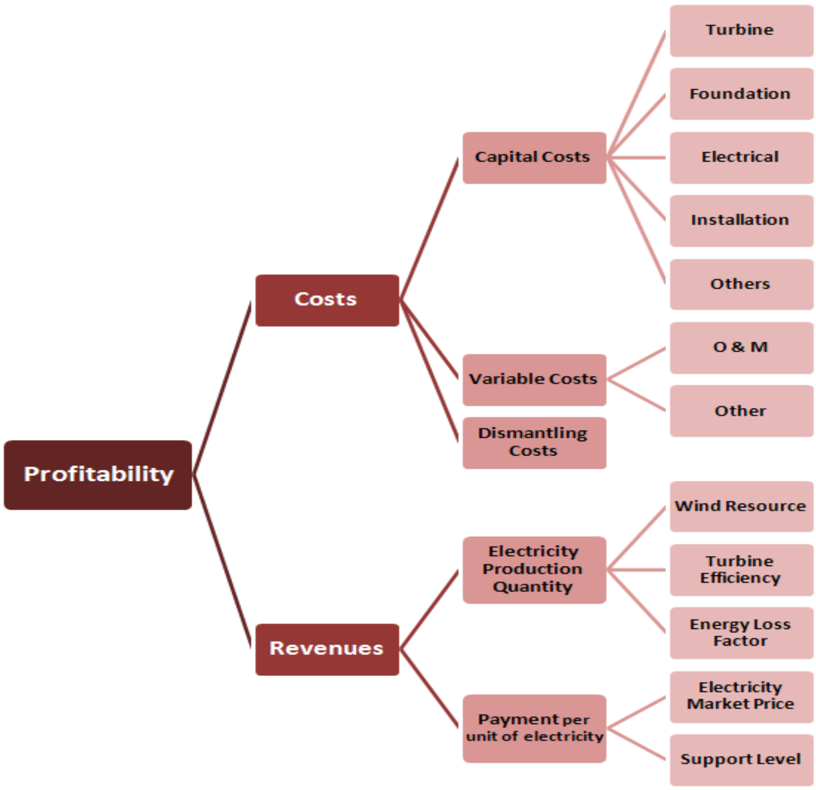

Figure 9 - Profitability breakdown of a typical offshore wind project

The revenues are primarily based on the amount of electricity generated (dependent on capacity factor) and the payment (e.g. market price and FiT) it receives per unit of electricity production. With regard to remuneration, support mechanisms become the critical component, as offshore wind power is still more expensive than conventional energy production, making it less competitive (Praessler, 2012). Therefore, it is clear that there would be limited investment in offshore wind in the absence of support mechanisms unless there are very high fossil fuel prices which would be needed to make offshore wind competitive against conventional sources (Green, 2011).

On the cost side, there are three major aspects as initial capital costs, annual variable costs and the dismantling costs occurring at the end of the project lifetime.

Capital costs are for planning and building the project and can be majorly divided into five types as follows (Praessler, 2012):

- ✓ ***Turbine***, including the turbine itself, the hub, tower and the electrical components (without installation and transportation)

- ✓ ***Foundation***, considering the construction of the foundation (without installation and transportation)

- ✓ ***Electrical***, indicating inner project and shore linkage cabling as well as offshore substations (without installation)

- ✓ ***Installation***, concerning the installation and transportation of components (e.g. turbine, electrical components, foundations)

- ✓ ***Others***, regarding different administrative tasks (e.g. environment assessment, engineering studies and legal advice)

Praessler (2012) presents an up to date overview of the capital cost split for offshore wind farms collected from various well-known sources in the literature and proposes a basis for assumptions, which is illustrated in Figure 10 below.

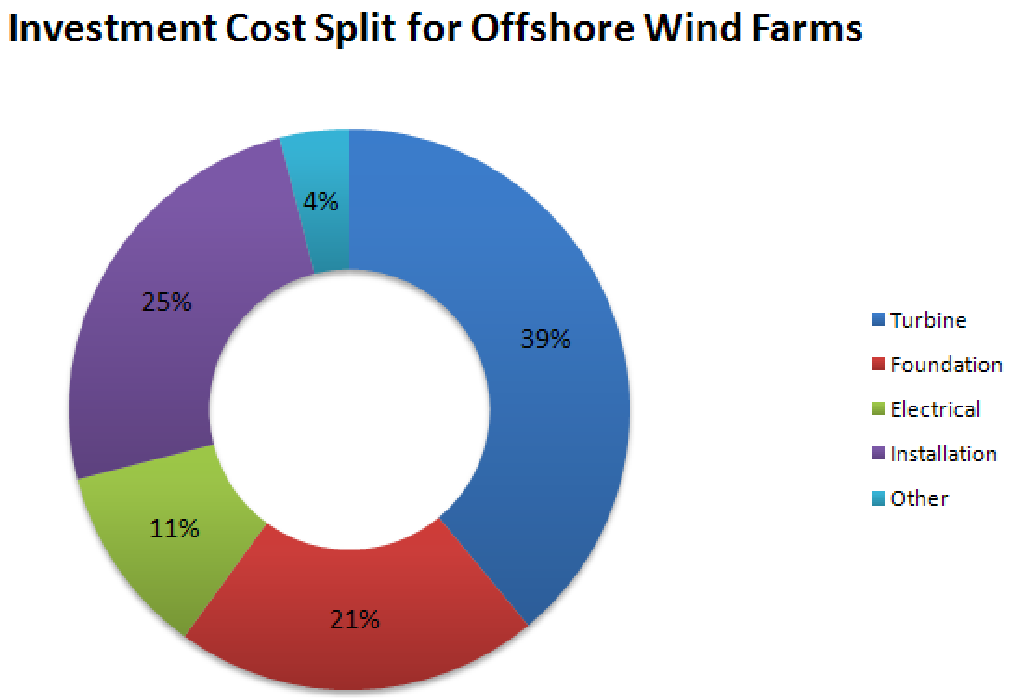

Figure 10 - Investment Cost Split for Offshore Wind Farms

It is important to note that the breakdown of the capital costs is dynamic and changes with respect to the configurations and the specifications of the project location so that Figure 10 only represents a simplified indication as to the distribution of the costs.

Variable costs of offshore wind projects are lower relative to fossil fuel based electricity generation as there is no fuel costs exist for wind power. Nevertheless, variable costs still account up to 30% of the total cost over the lifetime of a wind turbine (Blanco, 2009). The most crucial elements in variable costs are the operation and maintenance (O&M) costs concerning factors such as repairmen and spare parts. Moreover, reliable long-term track records of variable costs are not publicly available as yet, and the available estimates differ widely (Levitt et al., 2011). Also, a dominant O & M concept has not yet emerged (Praessler, 2012). This brings up the necessity to calculate the variable costs of offshore wind with a top-down approach. In that approach, therefore, O & M costs are calculated either by assigning a certain percentage of the initial investment costs as annual O & M costs or by assigning a fixed O & M cost per unit of energy produced (Praessler, 2012).

Dismantling costs are associated with the necessity of the wind turbines to be dismantled at the end of the project lifetime. Some studies prefer not to reflect the dismantling costs by assuming that the salvage value of the turbines will compensate for it (Praessler, 2012). According to IEA (2010c), the residual value of a wind farm is assumed as 20% of the initial capital costs.

2.4 Summary

Observing the wind potential map in Figure 8, it is obvious that the majority of the high wind potential shores are along the Aegean Sea shore, partly in the central Black Sea and eastern Mediterranean Sea. The total technical potential of Turkey is estimated to be around 47 GW. The offshore wind power potential of Turkey is above 10GW representing around 22% of the total wind capacity (onshore and offshore) (Malkoc, 2007).

To support wind power, Turkey provides fixed feed-in tariff for the first 10 years of operation. There are also supports such as local equipment bonus and license fee exemption.

Offshore wind business is capital intensive and turbines are making up the important share of the initial capital requirements. On the other side, the revenues are primarily based on the amount of electricity generated (dependent on capacity factor) and the payment (e.g. market price and FiT) it receives per unit of electricity production. Therefore, support mechanisms are significant in improving the competitiveness of offshore wind power economics.

3. ECONOMIC ANALYSIS OF OFFSHORE WIND POWER IN TURKEY

This chapter describes the economic analysis conducted on the offshore wind potential in Turkey and its results. A literature review on the methodology used in the model is presented first, followed by the assumptions, data and the results of the model.

3.1 Literature Review: Investing in Long-Term Assets - Capital Budgeting and Net Present Value Method

This paper considers the offshore wind power projects' profitability from independent power producers' point of view. Therefore, utilization of the offshore wind resources in Turkey will be based on a perspective such that a power producer's primary objective is to maximize its shareholder value by investing in projects that earn more than it costs (Brigham, 2004). Simply, projects that bring more returns than their costs are preferable.

Here, the concepts of capital budget and capital budgeting, therefore, become important to mention. Capital budget is defined as "an outline of planned investments in fixed assets" and capital budgeting as "the whole process of analyzing projects and deciding which ones to include in the capital budget" (Brigham, 2004).

As the offshore wind projects are capital intensive, the cost of capital becomes an essential component of the investment decision. In the case of financing a project completely with equity, the cost of capital for the project profitability analysis will be the firm's required return on its equity.

On the other hand, firms also raise an extensive portion of the capital needed for their projects as debt. In that case, the cost of capital should reflect the average cost of the debt and equity.

Therefore, managers use the weighted average cost of capital (WACC) to evaluate the investment projects and decisions. WACC could also be seen as the required rate of return that the debt and equity holders expect from a project that they invested.

WACC is calculated by using the equation below.

$$WACC = w_d r_d (1 - t) + w_e r_e$$

Where,

w_d = weight of debt

r_d = cost of debt

t = tax rate

w_e = weight of equity

r_e = cost of equity

The after tax cost of debt, $r_d(1-t)$, is used in calculating the WACC because the interest is a deductable expense which generates tax savings, therefore, lowering net cost of debt.

The cost of debt (r_d) is calculated based on the equation below (Ertürk, 2012).

$$r_d = r_f + DRP + CRP$$

Where,

r_f = risk free rate

DRP = debt risk premium

CRP = country risk premium

Debt risk premium and country risk premium are widely used in the literature to account for the additional risks in developing countries like Turkey compared to the developed economies like the US.

The cost of equity (r_e) is calculated based on the capital asset pricing model (CAPM) with the equation below.

$$r_e = r_f + \beta r_m + CRP$$

Where,

r_f = risk free rate

β = levered beta (equity beta)

r_m = market risk premium

CRP = country risk premium

Beta reflects the tendency of a stock to move up and down with the market (Brigham, 2004). Therefore, beta somehow measures the volatility with respect to changes in the market. Here, the beta in the equation measures the risk of levered company relative to the market.

In light of the detailed explanations on calculating the cost of capital (WACC), the shareholders' of a firm prefers to be better-off by investing in projects where the difference between a project's value and its costs are positive (Brealey et. al., 2001). This difference is simply called Net Present Value (NPV). NPV is one of the key methods used to decide whether or not a project should be accepted.

NPV method relies on the discounted cash flow techniques used for ranking investment proposals by considering the time value of money. NPV is simply the present value (PV) of future cash flows discounted at the cost of capital (Brigham, 2004 and Brealey et. al., 2001). The method works for projects of any length. The application of the method can be summarized as below:

- ✓ Find the PV of each free cash flow (both inflows and outflows) by discounting with the project's cost of capital.

- ✓ Sum these discounted free cash flows to calculate the NPV.

The equation for calculating the NPV is below (Brigham, 2004 and Brealey et. al., 2001).

$$NPV = CF_0 + \frac{CF_1}{(1+r)^1} + \frac{CF_2}{(1+r)^2} + \cdots + \frac{CF_n}{(1+r)^n} = \sum_{t=0}^{n} \frac{CF_t}{(1+r)^n}$$

Where,

n = total number of periods[19]

r = discount rate

CF_t = cash flow in period t[20]

A straightforward illustration is given in Figure 11 below for better understanding of how the method works (Brigham, 2004 and Brealey et. al., 2001).

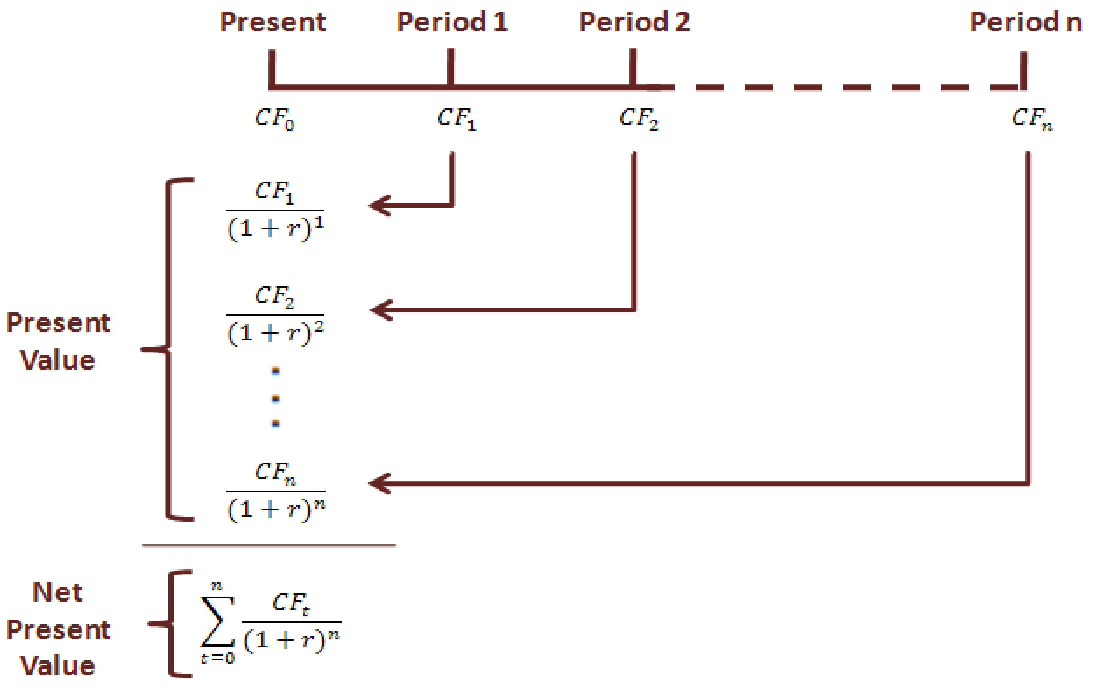

Figure 11 - Net Present Value Calculation

[19] Usually equals to the economic lifetime of the project

[20] t is between 0 and n

The investment decision criteria for the NPV method can be summarized as follows:

- ✓ If the NPV is positive, the project should be accepted.
- ✓ If the NPV is negative, the project should be rejected.
- ✓ If there are two mutually exclusive projects with positive NPVs, the one with the higher NPV should be accepted.

The rationale for the zero NPV projects is that the project's cash flows are exactly sufficient to repay its costs given the project's cost of capital. Therefore, the investor is indifferent between accepting and rejecting the project.

NPV is one of the most commonly used methods to evaluate a project because of its many advantages. Some of these advantages listed by Erturk (2012) are as follows:

- ✓ It shows the overall profitability of a project.
- ✓ It provides a clear-cut criterion to accept or reject a project.
- ✓ It is helpful to figure out the profitability impact of the rest of the cash flows after the payback period.

3.2 Data and Assumptions for Modelling and Analysis

This section describes the parameters and assumptions used in the analysis. A model will be built in Excel to calculate the free cash flows for economic analysis based on these assumptions. The detailed explanations of the major aspects in the model are provided later in this section.

In addition, the summary of the major assumptions are illustrated in Table 6 below.

Parameter	Assumption
Capital Cost ($/MW installed)	4,492,500
O & M Cost (%)	Year 1 to 2: 2.5% of capital cost Year 4 to 20: 4% of capital cost
Dismantling Cost	Compensated by the salvage value
Capacity Factor (%)	Highest: 41.34 / Lowest: 31.03
Lifetime	20 years
Tax Rate	20%
FiT ($/MWh)	78
Market Price ($/MWh)	79.88
Debt Payment Period	10 years
Cost of Debt (%)	7.2
Cost of Equity (%)	13.5
Weight of Debt (%)	60
Weight of Equity (%)	40
WACC (%)	8.8
Depreciation Period / Type	20 years / Straight line

Table 6 - Assumptions for Inputs

Capacity factor is one of the most vital factors in offshore wind power projects. It is very influential on the amount of energy extracted from the wind on a specific site. On the other hand, this paper does not conduct an analysis on a specific site, but rather the country as a whole. Therefore, estimations of capacity factors for each offshore wind class in Turkey based on the average annual wind speed are made.

The estimations are derived from linear regression model in Excel with samples collected from various sources that are (Manwell et. al., 2009), (Mathew, 2006), (Akdag and Guler, 2010), (Hau, 2006), (Ackermann, 2005), (Kenisarin et. al., 2006), (EWEA, 2009), (Redlinger et. al., 2002), (NREL, 2010), (Li, 2000), (Levitt et. al., 2011) and (Kempton et. al., 2010). The result of the regression as well as the scatter diagram of observations with linear regression trend-line is presented in Table 7 and Figure 12, respectively.

Regression Statistics	
Multiple R	0.935454
R Square	0.875075
Adjusted R Square	0.872577
Standard Error	3.832108
Observations	52

ANOVA					
	df	*SS*	*MS*	*F*	*Significance F*
Regression	1	5143.294472	5143.294472	350.2401975	3.12111E-24
Residual	50	734.2524514	14.68504903		
Total	51	5877.546923			

	Coefficients	*Standard Error*	*t Stat*	*P-value*	*Lower 95%*	*Upper 95%*	*Lower 95.0%*	*Upper 95.0%*
Intercept	-2.195213423	2.261463957	-0.970704581	0.336367969	-6.73749737	2.347070524	-6.73749737	2.347070524
X Variable 1	4.582291408	0.244849775	18.71470538	3.12111E-24	4.09049617	5.074086646	4.09049617	5.074086646

Table 7 - Regression Statistics and Results

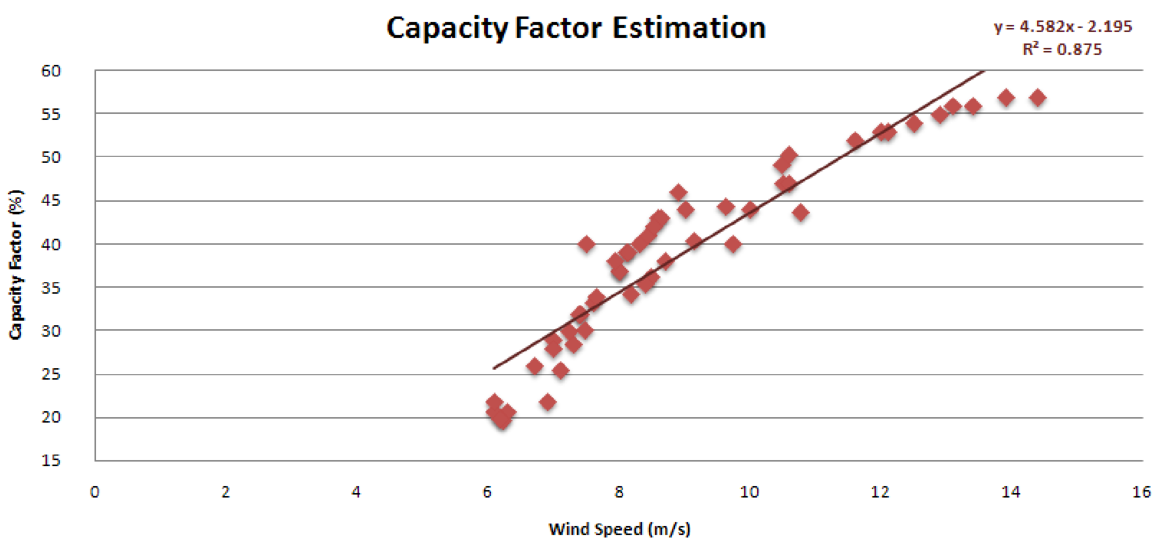

Figure 12 - Scatter Diagram and Regression Line

Based on the regression model above, the estimated capacity factors for each wind class in Turkey are illustrated in Table 8 below.

Estimated Capacity Factors		
Wind Class	*Wind Speed (m/s)*	*Capacity Factor (%)*
4	7.0 - 7.5	31
5	7.5 - 8.0	33
6	8.0 - 9.0	37
7	> 9.0	41

Table 8 - Estimated Capacity Factors for each Wind Class

An example to clarify the figures in Table 8 can be such that the wind resources classified between 7.0 and 7.5 m/s speed (wind class 4) are expected to experience around 31% of capacity factor over its economic lifetime.

Revenue calculations are primarily based on two factors: FiT and annual energy production. As discussed in previous chapters, FiT for wind power in Turkey is 7.3 USD cents / kWh with additions of local equipment bonus. However, the offshore wind power technology is not developed in Turkey; therefore, all turbines are assumed to be imported. Some parts related to power electronics in the projects are assumed to be locally supplied, therefore, adding a local equipment bonus of 0.5 USD cents / kWh. As a result the remuneration for the energy produced becomes 7.8 USD cents per kWh (78 USD/MWh) energy produced.

The FiT is valid only for the first 10 years of the projects, thus leaving the projects being subject to the rates in the electricity market. As the economics life time of the project is assumed to be 20 years, the last 10 years of the projects are assumed to face a market price with 2.5% constant annual inflation in price. The price in 10th year is calculated as 102.67 based on the last 3 year (2010-2012) data from Market Financial Settlement Center (MSFC, 2012). For simplicity, it is also assumed that the wind power producers are not subject to any balancing costs.

Construction of the projects is assumed to take two years where 50% of the capacity will be available in the first year. Full capacity will become available in the second year and the model assumes the same annual energy production over the economic lifetime. The annual energy production is calculated by multiplying the estimated capacity factor with the technical available capacity for a specific wind class and total hours in a year (assumed to be

8760 hrs.). The estimated annual energy production for each wind class in Turkey is illustrated in Table 9 below.

8760 HRS / YEAR			
Estimated Annual Production			
Wind Class	*Available Capacity (MW)*	*Estimated Capacity Factor (%)*	*Annual Production(MWh)*
4	5,133	31	13,951,589
5	3,445	33	10,054,052
6	1,743	37	5,610,474
7	143	41	516,801

Table 9 - Estimated Annual Offshore Energy Production in Turkey

Revenues are, then, calculated by multiplying the annual energy production with FiT for the first 10 years and average market price for the rest of the economic lifetime.

Costs, as discussed in previous chapters, are primarily divided into three major components as capital, maintenance (O&M) and dismantling costs. Capital costs are calculated as USD/MW installed capacity, based on the data collected from various sources in the literature which are (Junginger, 2005), (EWEA, 2009), (MacDonald, 2010), (RenewableUK, 2011), (Praessler, 2012), (Bilgili et. al., 2010), (Esteban et. al., 2011), (Levitt et. al., 2011), (BWEA, 2009), (Gross et. al., 2010), (Ernst & Young, 2009), (KPMG, 2010) and (Blanco, 2009). The capital costs are, therefore, assumed to be 4.492 million USD /MW installed capacity which is very much in line with the assumptions of Praessler's paper based on rich literature review about offshore wind (2012).

O&M costs include both fixed costs such as insurance and variable costs such as spear parts. Fuel cost is assumed to be zero for the model. As mentioned before, O&M costs are generally calculated as a fraction of total capital costs of the projects (Praessler, 2012). Therefore, the fractions in the literature are collected from various sources; that are (Junginger, 2005), (RenewableUK, 2011), (EWEA, 2009), (MacDonald, 2010), (KPMG, 2010), (Praessler, 2012) and (EEA, 2009). As a result, the O&M costs are assumed to be 2.5% of the capital costs for the first two years of operation and 4% for the rest of the economic lifetime (subject to 2.5% annual inflation). Lastly, it is assumed that the dismantling costs are compensated by the salvage value of the project equipments (Praessler, 2012).

Discount rate used in the model is based on WACC. The firm investing in the project is assumed as it invests in an expansion of its regular business of offshore wind power production. Therefore, there are no extra risks, which may derive from investing in a new business area, to be accounted for in the discount rate. WACC is calculated by using the formula presented in the beginning of this chapter. Weight of debt is assumed to be 60% based on the data from the presentation made by the general manager of Zorlu Energy Group (a leading energy firm in Turkey) at the conference organized by European Investment Bank (Ak, 2012). Weight of equity, therefore, becomes 40%. The corporate tax rate in Turkey is 20% (Erturk, 2012).

Regarding the cost of debt, a risk free rate is calculated by using the average of daily indices of the 10-year US Treasury bond between 03.01.2011and 30.12.2011as 2.78%. Moreover, country risk premium is collected from Damodaran's paper as 2.39% (2011a). Debt risk premium is assumed to be 2% (Erturk, 2012). CAPM model is used for estimating the cost of equity. In addition to cost of debt assumptions, sector beta and market risk premium is assumed. Sector beta is assumed as 1.04 (Erturk, 2012 and Damodaran, 2011b). Market risk premium is taken as 8% based on a survey study with more than 6000 answers (Fernandez et. al., 2011). Given the assumptions, the weighted average cost of capital (used as discount rate in the model) is calculated as 8.8%.

3.3 Results and Sensitivity Analysis

In light of the data and assumptions for the model, free cash flows are computed and discounted based on the calculated WACC in order to obtain the net present value for each offshore wind class in Turkey.

The calculations are done by using Microsoft Office Excel 2007 and spreadsheets are created for each input (including assumptions) as well as for cash flow calculations. The outputs of the model for each wind class are illustrated in Table 10, Table 11 and Table 12 below.

Revenues & Costs					
Wind Class	Annual Production (MWh)	Annual Revenue ($ / 1st Year)	Annual Revenue ($ / 11th Year)	Annual Revenue ($ / 20th Year)	Capital Cost ($)
4	13,951,589	544,111,965	1,432,382,522	1,788,849,490	23,060,901,000
5	10,054,052	392,108,014	1,032,229,949	1,289,113,760	15,475,764,000
6	5,610,474	218,808,495	576,016,489	719,365,664	7,828,450,800
7	516,801	20,155,233	53,058,940	66,263,345	641,169,600

Table 10 - Estimated Revenues & Costs

Cash Flows ($)						
Wind Class	Period 0	Period 1	Period 2	Period 5	Period 11	Period 20
4	-23,060,901,000	204,680,562	628,439,683	286,630,720	431,878,133	481,966,565
5	-15,475,764,000	158,928,771	464,877,300	235,495,333	346,612,437	394,357,992
6	-7,828,450,800	96,762,288	267,894,859	151,861,463	218,423,176	253,298,501
7	-641,169,600	9,712,491	25,516,092	16,012,669	22,594,806	26,622,183

Table 11 - Estimated Free Cash Flows

Net Present Values		
Wind Class	Technical Power Potential (MW)	Net Present Value ($)
4	5,133	-19,849,468,720
5	3,445	-12,888,312,202
6	1,743	-6,191,550,124
7	143	-471,281,153

Table 12 - Estimated Net Present Values for each Wind Class

In Table 10, the 1st, 11th and 20th years are selected. The 1st year and the 20th year values are displayed since they represent the start and the end of the projects, respectively. The 11th year is also selected as FiT only lasts for 10 years and the revenues start to be dependent on the market prices.

As it can be clearly observed from Table 11, the projects start to produce positive cash flows at the first year of operation, whereas these positive cash flows are eventually not enough to cover the costs. According the figures in Table 12, none of the wind classes were able to produce a positive net present value which may be due to various factors such as FiT level, discount factor and high capital costs to name a few. Therefore, a sensitivity analysis on these variables may help to investigate the reasons for the negative NPVs.

Sensitivity analysis serves for the purpose of freezing all the variables except the one(s) investigated and testing how sensitive the NPV is to changes in variable(s) in question. In this respect, sensitivity analysis is performed on the NPVs of different wind classes in order to determine the impact of FiT level, discount factor (WACC) and capital cost assumption per MW capacity installed.

The FiT used in the preceding analysis is 78 USD / MWh. One would expect that the NPV varies in relation to the FiT level, such that higher FiT results in higher NPV and vice versa. This relationship is verified by the model which is shown in the Figure 13 below. Figure 13 clearly illustrates that the NPVs increase and eventually become positive as the FiT level increases.

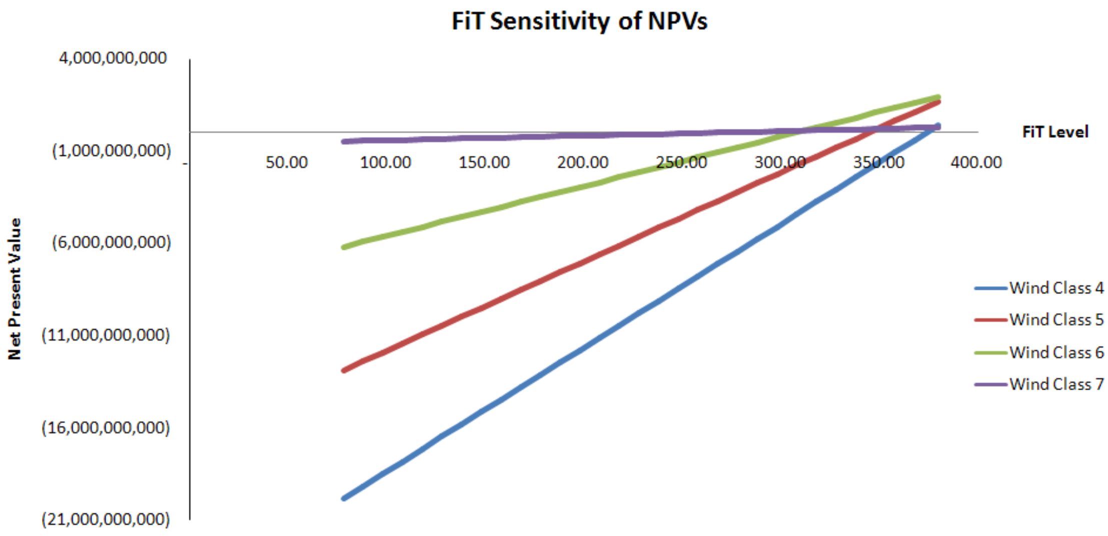

Figure 13 - NPVs with different FiT Levels

According to the shape of the NPV line for Wind Class 7 in Figure 13, one could think that Wind Class 7 is so much less sensitive to the FiT than the other wind classes. However, the shape of the line is flat due to high scale interval on the y-axis (NPV). The size of the Wind Class 7 is significantly smaller than other wind classes[21], resulting in a flat looking line in a broad scale graph.

[21] This is due to the considerably lower potential capacity in Turkey for Wind Class 7

Inserting the data only for Wind Class 7 on a single graph, which is in Figure 14, clearly shows the sensitivity of this wind class to be as high as others.

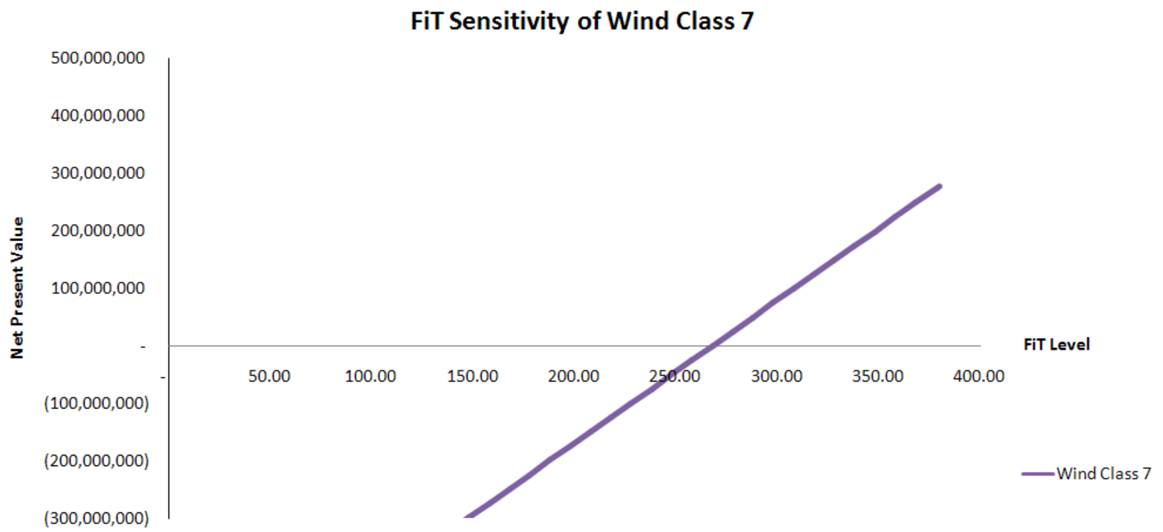

Figure 14 - FiT Sensitivity of Wind Class 7

It is also key to note that the break even FiT levels for each wind class is different such that higher wind class (better wind and capacity factor conditions) leads to lower break-even point for NPV and vice versa. The break-even FiT levels for each wind class are given in the Table 13 below.

Break Even FiT Level				
	Wind Class 4	*Wind Class 5*	*Wind Class 6*	*Wind Class 7*
FiT ($/MWh)	374	345	308	268

Table 13 - Break-Even FiT Levels for each Wind Class

The FiT levels in Table 13 are the minimum amounts of remuneration (price) required to pay exactly the same amount of return that is expected from the equity and debt holders. In other words, any FiT level higher than those of Table 13 will produce positive NPVs for each wind class, therefore, make it an attractive investment. Some of the projects in the US made power purchase agreements (PPAs) over their lifetime with price of 240 USD / MWh (NREL, 2010). Considering fact that FiT level is only valid for 10 years, the figures in Table 13 are considered as reasonable and supportive of model’s consistency.

Another variable of interest for the sensitivity analysis is the discount factor (WACC). However, it has been observed that even with zero discount rate (equals to nominal sum of all free cash flows); none of the wind classes can produce a positive NPV. This may be due to low FiT level and high investment costs.

The need for sensitivity on the capital cost assumption is critical as the figures deviate widely among different sources in the literature. Therefore, a range between 1.9 M USD and 4.9 M USD / MW installed capacity (the lowest and the highest capital cost figures taken from the literature respectively) is considered for the analysis. It is observed that at 1.9 M USD / MW installed capacity, wind class 7 produces an NPV of around 4.6 M USD. The break-even capital cost level for wind class 7 is calculated as around 2 M USD / MW installed capacity.

On the other hand, the minimum capital cost of 1.9 M USD / MW is not low enough to produce positive NPVs with the current WACC of 8.8% for the other wind classes (4, 5 and 6). Alternatively, Wind Class 6 can also be considered as economically viable as its break-even level is very close to 1.9 M USD. The break-even capital cost values for each wind class are given in Table 14 below.

Break-Even Capital Cost Levels				
	Wind Class 4	*Wind Class 5*	*Wind Class 6*	*Wind Class 7*
Capital Cost (USD/ MW installed)	1,588,077	1,682,339	1,823,732	2,012,256

Table 14 - Break-Even Capital Cost Levels for each Wind Class

The figures represent the highest amount of capital cost that each wind class can handle and any value lower than those in Table 14 will produce positive NPVs. It is important to note that these figures are based on the current FiT level of 78 USD / MWh.

3.4 Summary

This paper considers the offshore wind power projects' profitability from independent power producers' point of view. Therefore, utilization of the offshore wind resources in Turkey will be based on a perspective such that a power producer's primary objective is to maximize its shareholder value by investing in projects that earn more than it costs (Brigham, 2004). For determining this, NPV method is widely used in the literature which relies on the discounted cash flow techniques used for ranking investment proposals by considering time value of money (Brigham, 2004 and Erturk, 2012). NPV is simply the present value (PV) of future cash flows discounted at the cost of capital (Brigham, 2004 and Brealey et. al., 2001).

A model is built in Excel to calculate the free cash flows and NPV for economic analysis based on detailed assumptions. Results show that none of the wind classes are able to produce a positive NPV. Based on a sensitivity analysis, the model behaves as expected. Some of the results obtained in this paper are similar to those found in the literature. A sensitivity analysis on capital costs shows that wind class 7 can produce positive NPV at the lowest level of 1.9 M USD according to the capital cost range based on the literature findings.

4. CONCLUSIONS AND RECOMMENDATIONS

4.1 Conclusions

Renewable energy has become attractive recently due to the energy security and environmental concerns both in the world and in Turkey. This paper has developed a model for offshore wind power economics in Turkey. The model was used to investigate the profitable utilization of offshore wind power in Turkey based on the current FiT levels.

Based on the literature findings, official statistics and domain knowledge available in the field, the model is developed in Microsoft Office Excel 2007 with detailed assumptions in order to calculate free cash flows of four wind classes in Turkey. Then, NPVs for each wind class is calculated to determine the profitability. Critical components of the model are FiT levels and the capital costs per MW installed offshore capacity, which are primary determinants of offshore wind power in Turkey.

Finally, a sensitivity analysis is conducted which compared the impact of, FiT levels, discount factors and capital cost levels on profitability of offshore wind power in Turkey.

The conclusions of this paper are presented below, which will provide the basis for the recommendations in the following chapter.

- ✓ ***Offshore wind power cannot be profitably utilized under the current FiT support provided by the government.*** Given the assumptions made in the model, none of the wind classes have produced economically viable NPV values. The NPV results are in line with what is expected. There are currently no offshore wind power projects in Turkey; therefore NPV results in the model are clearly supporting this situation. It is very likely that there has not been any investors that have found offshore attractive enough to invest in Turkey as yet.

- ✓ ***Current FiT level is far away from enabling offshore wind power as an economically utilized renewable source in Turkey and making it an attractive investment.*** This may be considered as Turkish government’s intentional choice to encourage the utilization of the wind resources with the lowest costs at the first stage. Yet, one can also claim that no matter what the government sets as an FiT level, the market itself will naturally tend to utilize the resources with the lowest costs for profit maximization. One can also think that the low level of FiT is the reflection of how much priority that the government puts into offshore wind power deployment.

- ✓ ***There is a minimum FiT level that is necessary for offshore wind power to be economically feasible in Turkey.*** The existence of these break-even FiT levels can go up to four times more than that of Turkish government's current offer. These levels can be decreased by extending the current support period of 10 years.

- ✓ ***Local equipment bonus is more attractive for onshore wind power projects than offshore projects in Turkey.*** The turbine technology for offshore projects is not available in Turkey; therefore, the turbines have to be imported. This puts offshore wind power in a disadvantageous position against onshore where the technology can be locally supplied.

- ✓ ***There is a maximum level of capital cost per MW installed capacity that makes offshore wind power to be economically feasible in Turkey.*** The results are in line with the argument that offshore wind power economics is capital intensive and profitability is significantly affected with the changes in the capital costs.

- ✓ ***Wind Class 7 with an available capacity of 142.7 MW becomes economically feasible in cases where capital costs per MW installed capacity are below 2.1 M USD / MW.*** The capacity cost figures are deviating significantly in the literature where the range is between 1.9 M and 4.9 M USD / MW. This is expected as the costs are very specific to features of the sites. Therefore, there is hope that offshore wind power can economically viable in Turkey if the sites with the lowest cost can be identified.

- ✓ ***Wind Class 6 with an available capacity of 1,742.6 MW is also considered as economically feasible in cases where capital costs per MW installed capacity are below 1.8 M USD / MW.*** There could be sites where the capital cost numbers can be below the stated level and offshore wind power can be utilized in Turkey.

4.2 Recommendations and Suggesstions for Further Research

The recommendations are primarily directed to the audience of this paper such that students, researchers, wind power producers and Turkish government for supportive and thought triggering purposes. It is important to note that these are independent thoughts reflecting only those of the author and do not have any obligatory implication on any of the audience.

The recommendations for students and researchers are related to the possibilities of a further research, therefore, left to be discussed in the following section.

Wind power producers are recommended not to take the results of this paper for granted. The paper concludes as there is no economically feasible market for offshore wind power in Turkey. This is still holding true, however, it is important to note that the conditions (primarily cost factors) are very specific to the site under investigation. Considering the result that wind class 7 and 6 becomes economically viable under certain cost levels, there could be project sites where economic utilization of offshore wind power is possible in Turkey. Therefore, site specific research is recommended. It is also recommended to follow the trends in the Turkish wind power market as the conditions may turn the market status in advantage of offshore wind power.

Considering government’s goals of 10 GW wind power installed by 2015 and 30% share of renewable in electricity production by 2020, Turkish government should not ignore the potential of the country’s offshore wind power.

To enable profitable utilization of offshore wind power in Turkey, either the remuneration that a WPP receives should increase or the costs of deploying offshore wind power should decrease. Obviously, application of both solutions is expected to lead to better profitability figures.

In attempt to produce economic viability of offshore wind power in Turkey (assuming that offshore wind is one of the priorities for Turkish energy policy), the government can consider the following recommendations:

- ✓ ***Increasing the FiT level*** for offshore wind energy would lead to a better remuneration for WPPs. Increased FiT can be made valid only for offshore wind energy, therefore, minimize the risk of abuse by other renewable resources. However, the required increase for making offshore wind economically viable is very unlikely to occur as it will burden significant costs to government's budget.

- ✓ ***Extending the duration of FiT*** would also be supportive in the profitability of offshore wind power.

- ✓ ***Deployment of fixed premium or tendering systems*** can be used as alternative policies. Fixed FiT may not be the correct way to support offshore wind energy, as it has not triggered the interest in offshore energy in Turkey.

- ✓ ***Direct capital investment subsidies (even as cash subsidies) and/or low interest loans*** for cheaper financing would be helpful in addressing the capital intensive nature of the offshore wind power.

- ✓ ***Corporate tax exemptions*** can be applied to decrease expenses which would support WPPs.

- ✓ ***Subsidies for R&D projects*** would support the country in developing its own technology, therefore, limiting the dependence on turbine imports. R&D support would also help Turkey to decrease the cost of offshore wind energy.

- ✓ ***Investing in technologies that will enable offshore turbines to last longer***, which would improve the economic lifetime of the projects, therefore, support profitability.

A number of extensions and improvements for the paper are recommended as follows:

- ✓ More accurate numbers collected from primary sources can be used for calculations to get more accurate results.

- ✓ The market price calculations for the last 10 years of the project could be calculated with sophisticated professional forecasting tools by including more historical data of electricity prices.

- ✓ Assuming a longer project lifetime (e.g. 30 years) would also be a realistic extension option to the model. Longer lifetime would also lead to higher NPVs.

Some recommendations concerning suggestions for further research are given as follows:

- ✓ The model could be based on a data for a specific site, and will therefore, provide profitability for an offshore wind power project in development.

- ✓ The model could be applied to different countries around the world by changing the country specific assumptions.

- ✓ The model could be also used to evaluate other types of support mechanism with minor modifications.

- ✓ The results of this paper can be used as an input for an extensive research on the success of Turkish renewable energy policy.

- ✓ A study comparing the profitability of WPP in cases of FiT or market price based remuneration could be conducted, which would deliver important insights for policy makers.

References

Ackermann, T. ed., (2005), *Wind Power in Power Systems*, England: J. Wiley & Sons.

Ak, S. (2012), *Challenges & Opportunities of Developing Renewable Energy Projects in Turkey*, General Manager of Zorlu Energy Group, The Athens Regional Forum by EIB (European Investment Bank). [Online] Available at: http://www.eib.org/projects/events/tackling-climate-change-athens.htm

Akdag, S. A. and Guler, O. (2009), *Evaluation of wind energy investment interest and electricity generation cost analysis for Turkey*. Applied Energy, Vol. 87, p.2574-2580.

Bilgili, M., Yasar A. and Simsek E. (2010), *Offshore wind power development in Europe and its comparison with onshore counterpart*, Renewable and Sustainable Energy Reviews, Vol. 15, 2011, p. 905-915. [Online] Available at: http://www.sciencedirect.com/science/article/pii/S1364032110003758

Blanco, M.I. (2009), *The economics of wind energy*. Renewable and Sustainable Energy Reviews, Vol. 13, 2009, p. 1372–1382 [Online] Available at: http://anakena.dcc.uchile.cl/~mnmonsal/sdarticle03.pdf

Brealey, A. R., Myers, C. S. and Marcus J. A. (2001), *Fundamentals of Corporate Finance*, United States of America: The McGraw-Hill Companies, Inc.

Brigham, F. E. and Houston, F. J. (2004), *Fundamentals of Financial Management*, Ohio: Thomson Learning.

BWEA (British Wind Energy Association), (2009), *UK Offshore Wind: Charting the Right Course*. United Kingdom. [Online] Available at: http://www.bwea.com/pdf/publications/ChartingtheRightCourse.pdf

Damodaran, A. (2011a), *Equity Risk Premiums (ERP): Determinants, Estimation and Implications – The 2011 Edition*. [Online] Available at: http://ssrn.com/abstract=1769064

Damodaran, A. (2011b), *Betas by Sector*. [Online] Available at: http://pages.stern.nyu.edu/~adamodar/New_Home_Page/datafile/Betas.html

EEA (European Environment Agency) (2009), *Europe's Onshore and Offshore Potential - An assessment of Environmental and Economic Constraints*. Denmark. [Online] Available at: http://www.energy.eu/publications/a07.pdf

Erturk, M. (2012), *The evaluation of feed-in-tariff regulation of Turkey for onshore wind energy based on the economic analysis*. Energy Policy, Vol. 45, 2012, p. 359-367 [Online] Available at: http://www.sciencedirect.com/science/article/pii/S0301421512001619

Ernst & Young (2009), *Cost of and Financial Support for Offshore Wind*. Department of Energy & Climate Change. United Kingdom. [Online] Available at: http://webarchive.nationalarchives.gov.uk/+/http://www.berr.gov.uk/files/file51142.pdf

Esteban, M. D., Diez, J. J., Lopez, S. J. and Negro V. (2011), *Why Offshore Wind Energy?*, Renewable Energy, Vol. 36, 2011, p. 444-450. [Online] Available at: www.sciencedirect.com/science/article/pii/S0960148110003332

EWEA (European Wind Energy Association) (2009), *The Economics of Wind Energy*, Brussels. [Online] Available at: http://www.ewea.org/fileadmin/ewea_documents/documents/00_POLICY_document/Economics_of_Wind_Energy__March_2009_.pdf

EWEA (European Wind Energy Association) (2012), *The European offshore wind industry key 2011 trends and statistics*, Brussels. [Online] Available at: http://www.ewea.org/index.php?id=1861

EWEA (European Wind Energy Association), (2009), *Wind Energy – The facts*, London: Earthscan.

Fernandez, P., Aguirreamalloa, J. and Avendano, C. L. (2011), *Market Risk Premium Used in 56 Countries in 2011: A Survey with 6,014 Answers*, [Online] Available at: http://papers.ssrn.com/sol3/papers.cfm?abstract_id=1822182

Green, R. and Vasilakos, N. (2011), *The economics of offshore wind*, Energy Policy, Vol. 39, 2011, p. 496-502 [Online] Available at: http://www.sciencedirect.com/science/article/pii/S0301421510007615

Gross, R., Greenacre, P. and Heptonstall, P. (2010), *Great expectations: The cost of offshore wind in UK waters – Understanding the past and projecting the future*. UK Energy Research Center. United Kingdom. [Online] Available at: www.ukerc.ac.uk/support/tiki-download_file.php?fileId=1112

GWEC (Global Wind Energy Council) (2012), *Global Wind Statistics 2011*, Brussels. [Online] Available at: http://www.gwec.net/fileadmin/images/News/Press/GWEC_-_Global_Wind_Statistics_2011.pdf

GWEC (Global Wind Energy Council), (n.a.), *Wind is a global power source*. Accessed on 20.04.2011, [Online] Available at: http://www.gwec.net/index.php?id=13

Hau, E. (2006), *Wind Turbines: Fundamentals, Technologies, Applications*, Economics, Germany: Springer-Verlag

Hepbasli, A. and Ozgener, O. (2004), *A review on the development of wind energy in Turkey*. Renwable and Sustainable Energy Reviews, Vol. 8, p. 257-276. [Online] Available at: http://www.sciencedirect.com/science/article/pii/S1364032103001199

IEA (International Energy Agency) (2010a), *World Energy Outlook*, OECD/IEA, Paris. [Online] Available at: http://www.iea.org/

IEA (International Energy Agency) (2010b), *Energy Technology Perspectives*, OECD/IEA, Paris. [Online] Available at: http://www.iea.org/

IEA (International Energy Agency) (2010c), *Projected Costs of Generating Electricity*, OECD/IEA, Paris. [Online] Available at: http://www.iea.org/

IEA (International Energy Agency) (2009), *Energy Policies of IEA Countries – Turkey 2009*, OECD/IEA, Paris, [Online] Available at: http://www.iea.org/

Ilkilic, C. (2012), *Wind energy and assessment of wind energy potential in Turkey*, Renewable and Sustainable Energy Reviews, Vol. 16, p. 1165-1173. [Online] Available at: http://www.sciencedirect.com/science/article/pii/S1364032111005570

IPCC (Intergovernmental Panel on Climate Change) (2007a), *Climate Change 2007: The Physical Science Basis. Contribution of Working Group I to the Fourth Assessment Report of* *the Intergovernmental Panel on Climate Change*, Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA. [Online] Available at: http://www.ipcc.ch/

IPCC (Intergovernmental Panel on Climate Change) (2007b), *Climate Change 2007: Mitigation. Contribution of Working Group III to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change*, Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA. [Online] Available at: http://www.ipcc.ch/

Junginger, M. (2005), *Learning in Renewables Energy Technology Development*. University of Utrecht. [Online] Available at: http://nws.chem.uu.nl/publica/Publicaties2005/E2005-16.pdf

Kenisarin, M., Karslı, M. V. and Caglar, M. (2006), *Wind power engineering in the world and perspectives of its development in Turkey*. Renewable and Sustainable Energy Reviews, Vol. 10, p. 314-369. [Online] Available at: http://www.sciencedirect.com/science/article/pii/S1364032107001219

Kempton, W., Pimenta, M. F., Veron E. D. and Colle, A. B. (2010), *Electric Power from Offshore Wind via Synoptic-Scale Interconnection,* PNAS (Proceedings of the National Academy of Sciences of the United States of America), Vol. 107, p.7240-7245. [Online] Available at: http://www.pnas.org/content/107/16/7240.full

KPMG (2010). *Offshore wind in Europe: 2010 Market Report*. [Online] Available at: http://powercluster.net/Portals/6/DGehring_Offshore_Wind_in_Europe_2010_Market_Report.pdf

Levitt, A.C., Kempto, W., Smith, P. A., Musial, W. and Firestone, J. (2011), *Pricing offshore wind power*, Energy Policy, Vol. 39, p.6408–6421. [Online] Available at: http://www.sciencedirect.com/science/article/pii/S0301421511005763

Li, G. (2000), *Feasibility of large scale offshore wind power for Hong Kong - a preliminary study*. Renewable Energy, Vol. 21, p.387-402. [Online] Available at: www.sciencedirect.com/science/article/pii/S0960148100000380

MacDonald, M. (2010), *UK Electricity Generation Costs Update*. United Kingdom: Mott MacDonald Consultancy. [Online] Available at:

http://www.decc.gov.uk/assets/decc/statistics/projections/71-uk-electricity-generation-costs-update-.pdf

MacKay, D., (2009), *Sustainable Energy – without the hot air*, Cambridge: UIT Cambridge Ltd. [Online] Available at: http://www.withouthotair.com/order.html

Malkoc, Y. (2007), *The place of wind energy in meeting the electrical energy needs of Turkey*. The Chamber of Electrical Engineers Publications, Vol. 3, p.45-50. [Online] Available at: http://www.emo.org.tr/ekler/259d9d7a8d528f5_ek.pdf?dergi=486 (in Turkish)

Manwell, J. F., McGowan, G. J. and Rogers, L. A. (2009), *Wind Energy Explained: Theory, Design, and Application*, United Kingdom: John Wiley & Sons Ltd.

Mathew, S. (2006), *Wind Energy Fundamentals, Resource Analysis and Economics*, Germany: Springer-Verlag

MENR (The Republic of Turkey Ministry of Energy and Natural Resources) (2009), *Electricity Market and Security of Supply Strategy*, Ankara, [Online] Available at: http://www.enerji.gov.tr/yayinlar_raporlar/Arz_Guvenligi_Strateji_Belgesi.pdf

MENR (The Republic of Turkey Ministry of Energy and Natural Resources) (2010), *Strategic Plan 2010-2014*, Ankara, [Online] Available at: http://www.enerji.gov.tr/yayinlar_raporlar_EN/ETKB_2010_2014_Stratejik_Plani_EN.pdf

NREL (National Renewable Energy Labratory) (2010), *Large-Scale Offshore Wind Power in the United States*, US Department of Energy, Washington DC. [Online] Available at: http://www.nrel.gov/docs/fy10osti/40745.pdf

NREL (National Renewable Energy Labratory) (2011), *Renewable Energy Data Book*, US Department of Energy, Washington DC. [Online] Available at: http://www.nrel.gov/analysis/pdfs/51680.pdf

MSFC (Market Financial Settlement Center) (2012), *Market Development Reports: Periodic System Marginal Price Averages*. [Online] Available at: http://dgpys.teias.gov.tr/dgpys/ (in Turkish)

Praessler, T. and Schaechtele, J. (2012), *Comparison of the financial attractiveness among prospective offshore wind parks in selected European countries*, Energy Policy, Vol. 45, p.86-101. [Online] Available at: http://www.sciencedirect.com/science/article/pii/S0301421512000894

Ratner, M. and Nerurkar, N. (2011), *Middle East and North Africa Unrest: Implications for Oil and Natural Gas Markets*, US Congressional Research Service, United States. [Online] Available at: http://www.fas.org/sgp/crs/mideast/R41683.pdf

Redlinger, Y., R., Andersen, D. P. and Morthorst, E. P. (2002), *Wind Energy in the 21st Century*, New York: Palgrave

RenewableUK, (2011), *Offshore Wind - Forecasts of Future Costs and Benefits*. United Kingdom. [Online] Available at: http://www.bwea.com/pdf/publications/Offshore_report.pdf

Saygın, H. and Cetin, F. (2011), *Recent Developments in Renewable Energy Policies of Turkey*, *Renewable Energy - Trends and Applications*, InTech, ISBN: 978-953-307-939-4, [Online] Available from: http://www.intechopen.com/books/renewable-energy-trends-and-applications/recent-developments-in-renewable-energy-policies-of-turkey

Sovacool, B. K. (2008), *Valuing the greenhouse gas emissions from nuclear power: A critical survey*, Energy Policy, Vol. 36, 2008, p. 2950. [Online] Available at: http://www.sciencedirect.com/science/article/pii/S0301421508001997

TEIAS (Turkish Electricity Transmission Company), (2010), *10 years Production Capacity Projection of Electrical Energy of Turkey (2010-2019)*. [Online] Available at: http://www.teias.gov.tr/projeksiyon/KAPASITE PROJEKSIYONU 2010.pdf

TUR (Republic of Turkey), (2005). *Law on Utilization of Renewable Energy Sources for the Purpose of Generating Electrical Energy*, Official Gazette, with No. 24335, dated 10.05.2005 (Law No.: 5346)

TWEA (Turkish Wind Energy Association) (2012), *Wind Business in Turkey*, [Online] Available at: http://www.deloitte.com/assets/Dcom-Turkey/Local%20Assets/Documents/turkey_tr_energy_windbusiness_150512.pdf