DOKUZ EYLÜL UNIVERSITY
GRADUATE SCHOOL OF NATURAL AND APPLIED SCIENCES

EXAMINING THE SITE SELECTION OF WIND POWER PLANTS IN TURKEY IN TIME: A GIS/SPATIAL STATISTICS-BASED APPROACH

by
Çiğdem ÇİÇEK ÖZ

October, 2015
İZMİR

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A Thesis Submitted to the
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We have read the thesis entitled **"EXAMINING THE SITE SELECTION OF WIND POWER PLANTS IN TURKEY IN TIME: A GIS/SPATIAL STATISTICS-BASED APPROACH"** completed by **ÇİĞDEM ÇİÇEK ÖZ** under supervision of **PROF.DR. K. MERT ÇUBUKÇU** and we certify that in our opinion it is fully adequate, in scope and in quality, as a thesis for the degree of Master of Science.

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Çiğdem ÇİÇEK ÖZ

EXAMINING THE SITE SELECTION OF WIND POWER PLANTS IN TURKEY IN TIME: A GIS/SPATIAL STATISTICS-BASED APPROACH

ABSTRACT

Energy requirement became one of the basic needs with machinery in agriculture and industralization. Energy had mainly supplied by fossil fuels until the reserves are reduced. Most countries are focused on renewable energy sources. Recently in Turkey and all over the world, wind energy utilization and technology is one of the blooming renewable energy source. Turkey has great potential because of wind speed and geography. Turkey hasn't achieved to use this potential comparing with developed countries, nevertheless there is significant progress, due to production licenses authorized by the Energy Market Regulatory Authority (EMRA). In this study, analysis and maps are created using geographic information system methods and various spatial analysis are made using spatial statistical methods with wind power plants turbine information is received from the Energy Market Regulatory Authority website. Wind power plants site selections are determined in which wind speed range with maps of wind speed is received from Renewable Energy General Directorate and Turkish State Meteorological Service.

This study aims at showing how wind power plants that are installed and have production licenses between the years 1998-2014 site selections is changed according to years, identifying how wind speed are affected site selections and which regions these plants are accumulated. Also, this study is to demonstrate the progress that the energy sector in Turkey displayed, to determine future policies concerning the portion of power generated through renewable resources and to signify the role of windmills amongst renewable energy policies and development plans.

Keywords: Wind power, wind power plant, wind speed range, geographical information system, spatial statistics, site selection

TÜRKİYE'DE RÜZGAR ENERJİ SANTRALLERİNİN MEKANSAL YER SEÇİMLERİNİN YILLAR İÇİNDEKİ DEĞİŞİM VE GELİŞİMİNİN CBS VE MEKANSAL İSTATİSTİK YÖNTEMİ İLE AÇIKLANMASI

ÖZ

Tarımda makineleşme ve sanayi devrimi ile birlikte sürekli olarak artan enerji ihtiyacı, önceleri fosil yakıtlardan karşılanmıştır. Fosil yakıt rezervlerinin hızla azalmasıyla, birçok ülke yenilenebilir enerji kaynaklarına yönelmeye başlamıştır. Günümüzde Türkiye'de ve tüm dünyada teknolojisi ve kullanımı en hızlı gelişen yenilenebilir enerji kaynaklarının başında rüzgâr enerjisi gelmektedir. Rüzgâr hızı ve coğrafyası bakımından şanslı bir ülke olan Türkiye, bu şansı kullanmakta gecikmiş olsa da son yıllarda, Enerji Piyasası Düzenleme Kurumu tarafından verilen Üretim Lisansları sayesinde ciddi ilerlemeler kaydedilmektedir. Bu çalışmada Enerji Piyasası Düzenleme Kurumu internet sitesinden edinilen rüzgâr enerji santralleri türbin bilgilerine yönelik coğrafi bilgi sistemi yöntemleriyle analizler ve haritalar oluşturulmuş, mekânsal istatistik yöntemleriyle çeşitli mekânsal analizler yapılmıştır. Yenilenebilir Enerji Genel Müdürlüğü ve Meteoroloji Genel Müdürlüğü internet sitelerinden edinilen rüzgar hızı haritaları ile rüzgar enerji santrallerinin hangi rüzgar hızı aralıklarında yer seçtikleri belirlenmiştir.

Bu çalışma 1998-2014 yılları arasında kurulan ve Üretim Lisansı verilen rüzgar enerji santrallerinin mekânsal yer seçimlerinin yıllara göre nasıl değişim gösterdiğini, rüzgar hızlarının yer seçimlerini nasıl etkilediğini ve Türkiye ölçeğinde bu santrallerin hangi bölgelerde yoğunlaştığını belirlemeyi hedeflemektedir. Ayrıca, Türkiye'de enerji sektörünün yıllar içinde nasıl gelişim gösterdiğini ve yenilenebilir enerji kaynaklarının ülkenin genel enerji politikası ve kalkınma planları içerisindeki yerini belirlemektir.

Anahtar kelimeler: Rüzgar enerjisi, rüzgar enerji santrali, rüzgar hız aralığı, coğrafi bilgi sistemi, mekânsal istatistik, yer seçimi

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CHAPTER ONE
INTRODUCTION

Energy is one of the basic requirements needed to sustain life. There is continuous social development in city and county. Due to technological advancements, energy requirement increases day by day for vital activities in people's life, work, transportation, recreation, entertainment.

Nomadic lifestyle of early tribes was converted to settled life form by early agriculture, therefore energy requirment was occured. Energy requirement became one of the basic needs with machinery in agriculture and industralization. Energy has been mainly supplied by fossil fuels (coal, oil, natural gas) until the reserves are reduced. Most countries are focused on renewable energy sources and have main policy to product electricity from renewable energy.

As Turkey has rich renewable energy sources, the potential sources can be used as a solution to future energy problems. Recently in Turkey and all over the world, wind energy utilization and technology has become one of the blooming renewable energy source (Kose, 2004). Turkey has great potential because of wind speed and geography. Turkey hasn't achieved to use this potential comparing with developed countries, nevertheless there is significant progress, due to production licenses authorized by the Energy Market Regulatory Authority.

1.1 Wind and Wind Energy

Renewable Energy Sources (RES) is defined as *'Hydraulic, wind, solar, geothermal, biomass, gas obtained from biomass (including landfill gas), waves, currents and tides which are non-fossil energy sources such'* in the 3rd article of 'Law on Utilization of Renewable Energy Sources with Purpose of Production Electrical Energy' which is published and enacted in Offical Gazette of Turkey with 25819 number on 18.5.2005. Renewable energy sources are explained as: *'Wind, solar, geothermal, biomass, derived from biomass gas (including landfill gas),*

waves, currents and tides with channel and or river type and the reservoir area of electricity generation sources appropriate to establish the hydroelectric plant less than fifteen kilometers.'

Wind occurs by varied temperatures which are created by solar radiation on the surface of the earth with different angles. These different temperatures cause humidity and pressure levels to vary as well, and the difference between the pressure levels causes the air to move. 2% of solar energy which reaches the Earth is converted into wind energy. The characteristics of the wind differ (in respect of time and region), based on local geographic differences and the non-homogenous temperatures of the surface of the earth. Wind is stated with two seperate parameters - speed and direction. The speed of the wind rises with the height, and its theoretical strength changes proportionately to its cubic speed (Directorate General of Renewable Energy [YEGM], 2015).

The average wind speed at the relevant location is:
6.5 m/s medium level in terms of wind speed energy,
7.5 m/s, good,
8.5 m/s and above speeds are evaluated as being very good (YEGM, 2015).

Wind turbines are used to produce electricity energy from wind energy. Kinetic energy in wind turbine blades is converted into mechanical energy via power transmission systems, then electrical energy is obtained from the generator. They are classified as horizontal axis and vertical axis wind turbines according to the axis of rotation (Senel & Koc, 2015). Nowadays, horizontal axis three-bladed 3000 kw – 3500 kw turbines are commonly used at windfarms, depending on technological development.

1.2 Turkey Electricity Generation and Shares by Energy Resources

Table 1.1 displays energy sources and their energy generation shares from 1970 to 2014. It is shown that energy production is increased 27.85 times in 43 years, while

coal's share diminished and liquid fuel share is almost zero. Power generation through natural gas has vastly increased and although it is less then desired, there is an increase in generation through renewable energy sources. The rise of power generation through natural gas indicates that Turkey is import dependent and that it does not sufficiently utilize its renewable energy source potential. Figure 1.1 shows electricity generation and shares by coal, figure 1.2 shows electricity generation and shares by liquid fuels, figure 1.3 shows electricity generation and shares by natural gas, figure 1.4 shows electricity generation and shares by hydraulics, figure 1.5 shows electricity generation and shares by renewable energy and wastes and figure 1.6 shows electricity generation and shares by energy resources.

Table 1.1 Electricity generation and shares by energy resources (%)

Year	Total	Coal	Liquid Fuels	Natural Gas	Hydraulics	Renewable Energy and Wastes (1)
1970	8623	32.8	30.2	-	35.2	1.9
1971	9781	30.5	41.2	-	26.7	1.7
1972	11242	26.0	44.0	-	28.5	1.6
1973	12425	26.1	51.4	-	21.0	1.6
1974	13477	28.7	44.8	-	24.9	1.5
1975	15623	26.3	34.5	-	37.8	1.4
1976	18283	23.7	29.6	-	45.8	0.9
1977	20565	23.8	33.5	-	41.7	1.1
1978	21726	25.6	30.8	-	43.0	0.6
1979	22522	28.6	25.1	-	45.7	0.6
1980	23275	25.6	25.1	-	48.8	0.6
1981	24673	24.9	23.5	-	51.1	0.4
1982	26552	24.3	22.4	-	53.4	0.0
1983	27347	31.4	27.2	-	41.5	0.0
1984	30614	33.1	23.0	-	43.9	0.1
1985	34219	43.9	20.7	0.2	35.2	0.0
1986	39695	49.0	17.6	3.4	29.9	0.1

Table 1.1 Electricity generation and shares by energy resources (%) (cont.)

1987	44353	39.8	12.4	5.7	42.0	0.1
1988	48049	26.0	6.9	6.7	60.3	0.1
1989	52043	38.9	8.2	18.3	34.5	0.1
1990	57543	35.1	6.9	17.7	40.2	0.1
1991	60246	35.8	5.5	20.9	37.7	0.2
1992	67342	36.5	7.8	16.1	39.5	0.2
1993	73808	32.2	7.0	14.6	46.0	0.2
1994	78322	36.0	7.1	17.6	39.1	0.2
1995	86247	32.5	6.7	19.2	41.2	0.4
1996	94862	32.1	6.9	18.1	42.7	0.3
1997	103296	32.8	6.9	21.4	38.5	0.4
1998	111022	32.1	7.1	22.4	38.0	0.3
1999	116440	31.8	6.9	31.2	29.8	0.3
2000	124922	30.6	7.5	37.0	24.7	0.3
2001	122725	31.3	8.4	40.4	19.6	0.3
2002	129400	24.8	8.3	40.6	26.0	0.3
2003	140581	22.9	6.5	45.2	25.1	0.2
2004	150698	22.9	5.1	41.3	30.6	0.2
2005	161956	26.7	3.4	45.3	24.4	0.2
2006	176300	26.5	2.5	45.8	25.1	0.2
2007	191558	27.9	3.4	49.6	18.7	0.4
2008	198418	29.1	3.8	49.7	16.8	0.6
2009	194813	28.6	2.5	49.3	18.5	1.2
2010	211208	26.1	1.0	46.5	24.5	1.9
2011	229395	28.9	0.4	45.4	22.8	2.6
2012	239497	28.4	0.7	43.6	24.2	3.1
2013	240154	26.6	0.7	43.8	24.7	4.2

Source: TETC, Electricity Generation - Transmission Statistics of Turkey

(1) Renewable energy and waste includes geothermal, wind, solid biomass, biogas and waste.

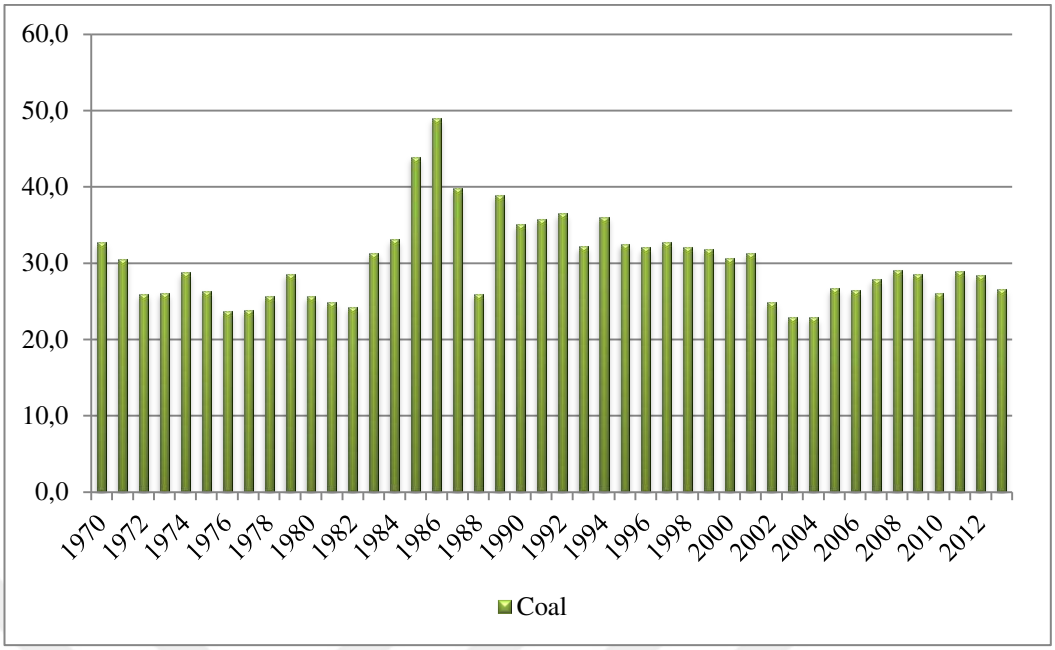

Figure 1.1 Electricity generation and shares by coal (%)

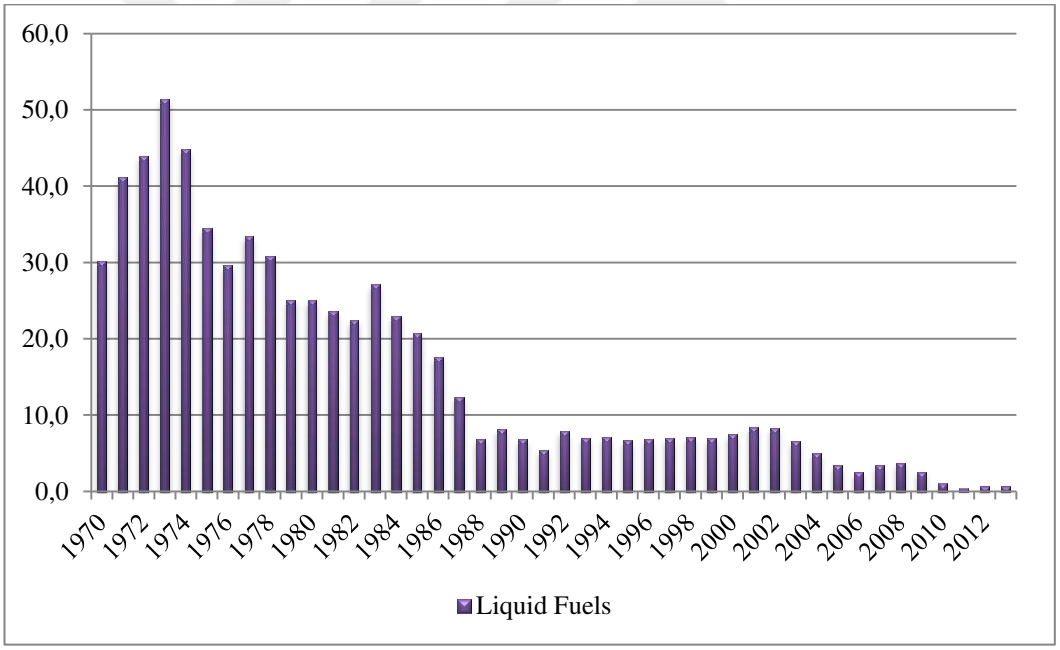

Figure 1.2 Electricity generation and shares by liquid fuels (%)

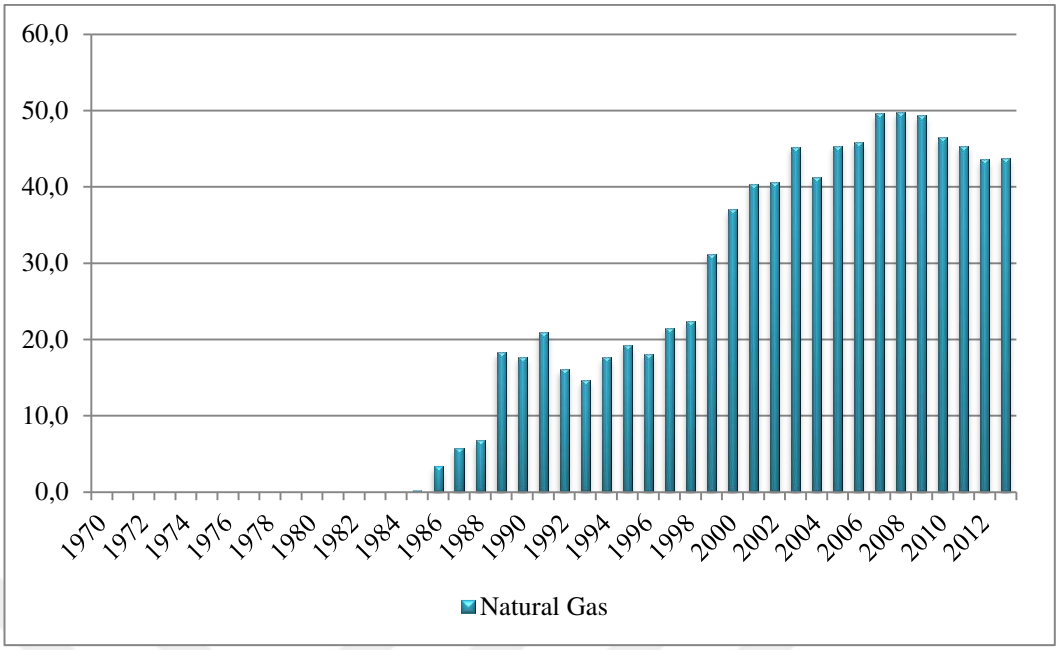

Figure 1.3 Electricity generation and shares by natural gas (%)

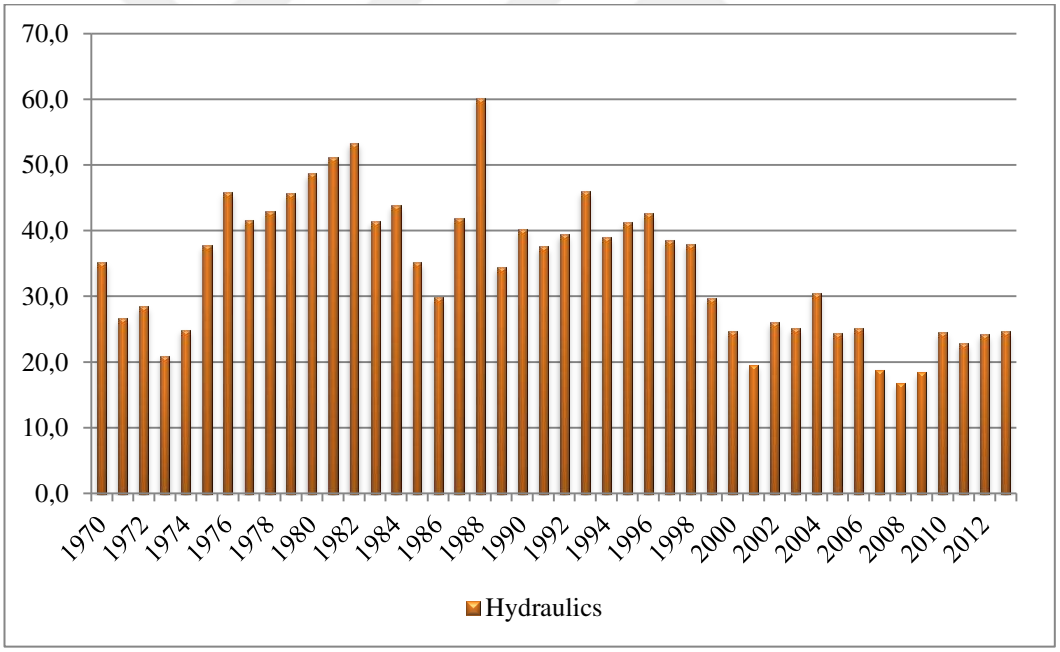

Figure 1.4 Electricity generation and shares by coal (%)

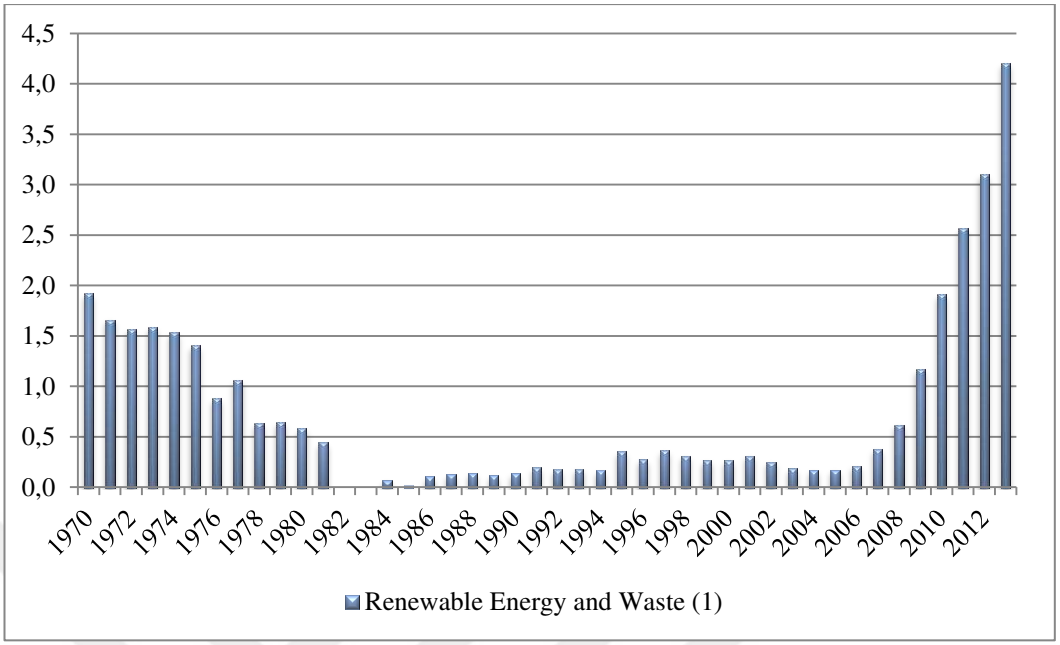

Figure 1.5 Electricity generation and shares by renewable energy and wastes (%)

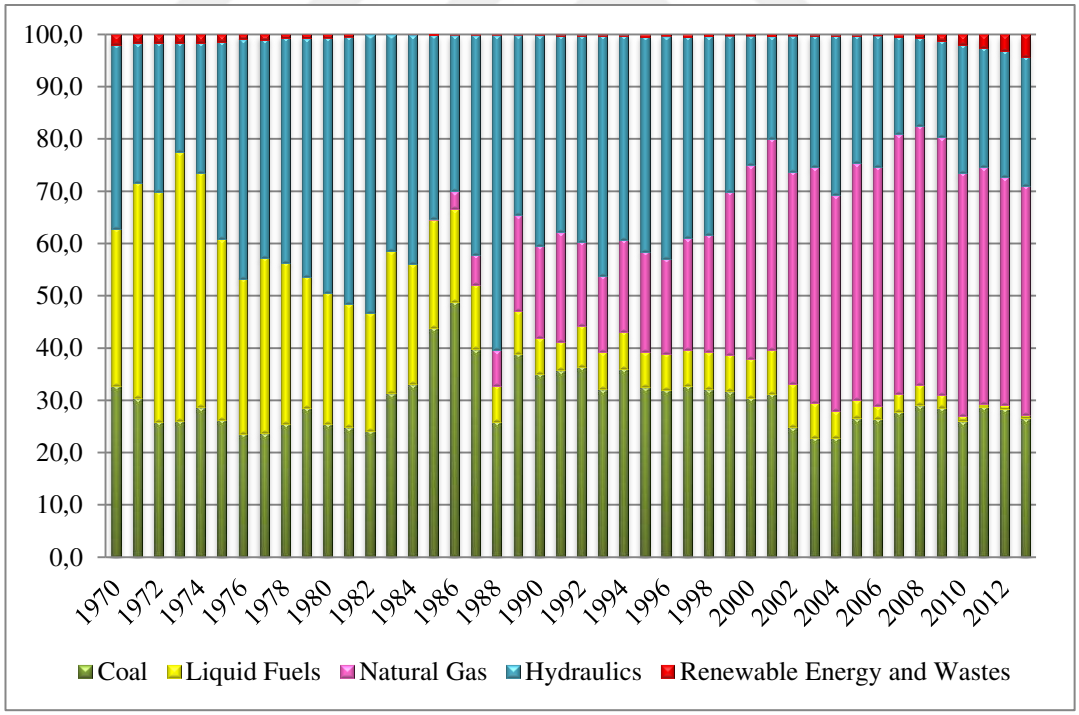

Figure 1.6 Electricity generation and shares by energy resources (%)

Table 1.2 presents the increase in established capacity from 4,186.6 MW in 1975 to 64,007.5 MW in 2013. It also shows that gross production has increased from

15,622.8 GWh to 240,154 GWh and net consumption has increased from 13,491.7 to 198,045.5.

Table 1.2 The power stations the total installed capacity, gross production, net electricity consumption

Year	Total installed capacity (MW)	Gross Generation (GWh)	Net Consumption (GWh)
1975	4186.6	15622.8	13491.7
1976	4364.2	18282.8	16078.9
1977	4727.2	20564.6	17968.8
1978	4868.7	21726.1	18933.8
1979	5118.7	22521.9	19633.1
1980	5118.7	23275.4	20398.2
1981	5537.6	24672.8	22030.0
1982	6638.6	26551.5	23586.8
1983	6935.1	27346.8	24465.1
1984	8461.6	30613.5	27635.2
1985	9121.6	34218.9	29708.6
1986	10115.2	39694.8	32209.7
1987	12495.1	44352.9	36697.3
1988	14520.6	48048.8	39721.5
1989	15808.2	52043.2	43120.0
1990	16317.6	57543.0	46820.0
1991	17209.1	60246.3	49282.9
1992	18716.1	67342.2	53984.7
1993	20337.6	73807.5	59237.0
1994	20859.8	78321.7	61400.9
1995	20954.3	86247.4	67393.9
1996	21249.4	94861.7	74156.6
1997	21891.9	103295.8	81885.0
1998	23354.0	111022.4	87704.6
1999	26119.3	116439.9	91201.9
2000	27264.1	124921.6	98295.7

Table 1.2 The power stations the total installed capacity, gross production, net electricity consumption (cont.)

2001	28332.4	122724.7	97070.0
2002	31845.8	129399.5	102948.0
2003	35587.0	140580.5	111766.0
2004	36824.0	150698.3	121141.9
2005	38843.5	161956.2	130262.9
2006	40564.8	176299.8	143070.5
2007	40835.7	191558.1	155135.2
2008	41817.2	198418.0	161947.6
2009	44761.2	194812.9	156894.1
2010	49524.1	211207.7	172050.6
2011	52911.1	229395.1	186099.6
2012	57059.4	239496.8	194923.4
2013	64007.5	240154.0	198045.2

Source: TETC Electricity Generation - Transmission Statistics of Turkey

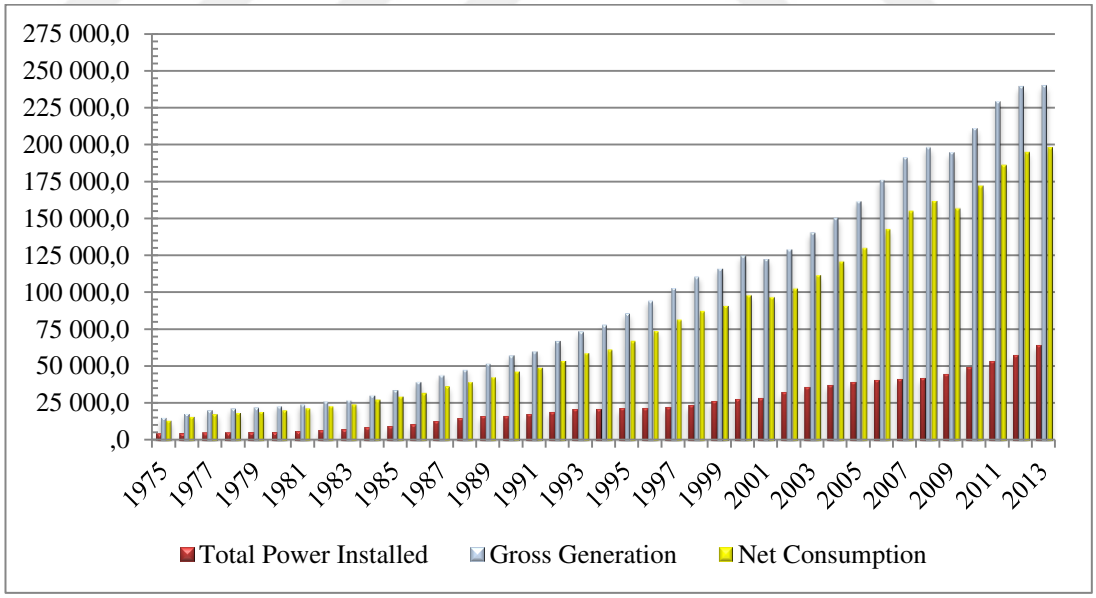

Figure 1.7 Power installed of power plants, gross generation and net consumption of electricity

The purpose of this study is to demonstrate the progress that the energy sector in Turkey displayed, to determine future policies concerning the portion of power generated through renewable resources and to signify the role of windmills amongst

renewable energy policies. It also aims to exhibit the location choices for windmills since 1998 and changes in these locations, cumulatively and on an annual basis. It will also try to reflect the effects of wind speed on locational selections for wind turbines.

CHAPTER TWO
LITERATURE REVIEW

The studies that use statistical methods for wind power plants in Turkey, are commonly intended to measure the efficiency of wind power plants and also to identify the most efficient locations for the new plants to be built in the future. Moreover, there are several studies which are conducted upon the importance of wind power plants in the renewable energy sector, progress in the world and Turkey, the impacts on natural life and ecology, and legal aspects as well. Literature review indicates that, geographical, technical and economic data are used in most of the analysis. In general, conducted studies ended up with having the results that can be transmitted through graphical/numerical analysis and interpretations. Studies conducted around the world mainly focus on possible problems that wind energy usage would cause, wind speed changes, ecological implications of wind energy, making essential revisions on geographical selections according to artificial and natural limitations and identifying the criterias that must be considered while determining locations for wind energy centrals.

In scope of the literature review, no other study, which analyse the changes and developments in years on site selection for the current and future wind power plants with GIS and Spatial Statistical Method, was observed in Turkey.

Baban and Parry (2004) pointed out that, wind energy is a popular and safe form of renewable energy, and it causes no environment pollution. In the UK, despite the fact that the demand for wind energy increases, expansions are inevitable to achieve the goals set by the USA. Also, in the UK, criteria on site selections for wind power plants were identified in the light of information gathered from various survey results and the studies published in this field.

Erkek (2004) examined the world's energy status in the last century and the search for alternative energy sources associated with future forecasts, energy history of Turkey, energy production and consumption with the search for alternative energy

sources and energy policies implemented in Turkey, structural formations of the organizations that had influence on forming these current policies as well.

Ramachandra and Shruthi (2005) highlighted that the demand for energy resources and the spatial mapping of availability would help integrated regional energy planning process through a suitable energy supply–demand matching. In their study, they used GIS for mapping the potential of renewable energy sources (solar, wind, bioenergy and small hydro) in Karnataka, India. As a result of mapping the regions which are suitable for wind energy based on wind speed data, they argued that Belgaum district holds a great potential especially during summer.

Ozturk and Celik (2006) noted that, our need and dependence of energy have increased significantly due to the increasing population, innovations of modern life, and the emergence of new areas as a result of technological developments where the most of the energy produced will be directed. Therefore, these factors in total, push authorities to search for alternative and renewable sources of clean energy. They furthermore discussed the current status of wind energy and their future expectations for wind energy in the world and in Turkey.

Bennui, Rattanamanee, Puetpaiboon, Phukpattaranont and Chetpattananondh (2007) emphasized that the site selection of large wind power plants is highly affected by wind speed, altitude, slope, highways and railways, urban areas, forests and natural areas.

Aydin (2009) identified a set of environmental goals which are based on site selection of wind power plants; acceptability in terms of noise level, bird habitats, safety, and aesthetics and also natural reserves. In such effort, they divided Usak, Aydin, Denizli, Mugla and Burdur provinces into 250 x 250 m grids to prepare an environmental suitability map based on the results of these criteria stated above.

Ozcan (2009) claimed that the demand for alternative and renewable energy resources increases because of exhaustion of fossil energy resources and pollution that these resources cause. In the study, financial aspects of constructing a plant are examined and to make it more specific, economical aspects of a wind plant that would possibly be constructed in Isparta province are analyzed.

Senkal and Cetin (2009) analyzed the amount of energy produced by the wind power plants in Turkey and their turbine capacity until 2009. They aimed to contribute to the increasing wind power plant investments in the recent years.

Janke (2010) noted that Colorado is the highest and the 11th most windy state of the USA and has more than 250 sunny days per year. As a result of the study, suitable areas for wind and solar farms are identified by using GIS modeling techniques. Interestingly, although mountainous areas are the most efficient locations for wind farms, ecosystem of these areas is so sensitive that easily be affected negatively by wind farms. On the other hand, the study also revealed that, federal lands and mountainous areas are the best for solar farms. However, it is not possible to construct any large-scaled farms in these areas.

Karamanlioglu (2011) pointed out that the most suitable areas for wind farm installation are in Aegea, Marmara and the Eastern Mediterranean Regions. He applied an analytic hierarchy process to determine the most suitable areas and wind speed in Mersin, Silifke and Anamur for wind plants.

Yilmaz (n.d.) explained the advantages and disadvantages of wind power plants, as renewable energy resources, and wind energy potential in Turkey.

Arici (2011) claimed that, renewable energy resources require high costs, long-term investment processes and have long-term return of investment ratios. It is also mentioned that, this kind of projects consist of a set of technical and managerial procedures which ought to be carried out meticulously. In the study, the prior and

posterior steps of obtaining production licenses, project procedures, and their impact on total cost and project process are explained in detail.

Nurbay and Cinar (n.d.) stated that, various types of wind turbines were used for centuries to cope with the energy needs of people. This progress was initiated with the first deployment of windmills and kept on developing to today's modern offshores. They explained that turbine varieties were determined by examining the advantages and disadvantages relative to one another.

Baran (2012) investigated the needs for renewable energy sources, historical development of methods to make use of the sun and wind energy, the structure of solar cells and wind turbines, working principles and advantages. He furthermore discussed the roles of renewable resources in energy production. Future expectations, the positive and negative aspects are also assessed.

Besides these studies, the transformation of energy production in Turkey was examined in Development Plans which were prepared by the State Planning Organization until 2011, and the Ministry of Development after 2012.

The First Five-Year Development Plan (1963-1967), which was discussed in Turkish Grand National Assembly, was approved on November 21, 1962; and has been declared in the Official Gazette No 11272 on December 3, 1962. In this plan, it was indicated that the total required energy was provided from 7 different fuel supplies which consist of 4 commercial (coal, lignite, petroleum products and hyraulic energy) and 3 noncommercial (wood, turd and agricultural waste) resources.

In the First Five-Year Development Plan, only hydraulic energy was mentioned as a renewable energy source and it has emphasized that this energy should be employed for a greater use. During this development plan, observed growth rate of energy production was 12.8%, whereas the desired growth rate of energy production was 83.3%. In order to implement a more systematic production of electricity, Turkish Electricity Authority was going to be established.

The Second Five-Year Development Plan, covering the period between 1968 and 1972, was merely focused on the need to increase energy production to meet the demand created by rapid industrialization and urbanization. This production growth has been based on using petroleum products. Interestingly, the idea of constructing nuclear power plants was first mentioned in this particular plan. During this development plan period, growth rate of energy production was targeted to be increased by 13.2%.

The Third Five-Year Development Plan (1973-1977) was approved on October 26, 1972 by The Grand National Assembly of Turkey. In this plan, it has been stated that, energy production of Turkey was relying on 6 main resources, which are lignite, hard coal, petroleum products, hydraulic power, commercial wood and dung. Furthermore, the idea of using natural gas, nuclear energy and geothermal energy as the main energy resources in Turkey was highlighted. This proposal was supported with the fact that these energy resources were already being used as primary energy resources in many countries around the world. Therefore, relying on hydropower and geothermal energy, besides fossil fuels, in order to cope with the increasing energy demand was highlighted in this plan. During this period, oil equivalent of primary energy consumption per capita was increased from 453 kg to 620 kg between the years of 1962 and 1972. Electricity consumption per capita was increased from 118 Kwh to 294 Kwh between the years of 1962 and 1972. In addition, annual electricity generation ratio was increased by 15%.

The Fourt Five-Year Development Plan (1979-1983), which was discussed in the Grand National Assembly of Turkey, had been declared in Official Gazette No 16393 on August 31, 1978. This plan indicated that the attempts of generating adequate and high quality energy were not capable of meeting the desired goals. It is also emphasized that, energy sector, including electricity in particular, has created a bottleneck in Turkish economy. Furthermore, energy demand was being maintained under a constant pressure since domestic production facilities were not developed as planned and consequently, these facilities were not capable of producing sufficient energy to meet demands in spite of all efforts. During this period, oil equivalent of

primary energy consumption per capita was increased from 611 kg to 798 kg between the years of 1972 and 1977. In addition, electricity consumption per capita was increased from 303 Kwh to 510 Kwh in between the years of 1972 and 1977.

The Fifth Five-Year Development Plan (1985-1989) was approved on July 13, 1984 by the Grand National Assembly of Turkey. According to this plan, significant portion of total investment in energy sector was going to be focused on production facilities. The plan also indicated that, developing geothermal energy resources was one of the prior aims. Construction of Ataturk Dam, which was the largest dam in Turkey was going to be completed and also Karakaya and Altinkaya Hydroelectric Power Plants and The Afsin-Elbistan Thermal Power Plant were going to operate with all of their units. Relying on domestic resources, using cheap and reliable resources were also encouraged in this plan. During this period, primary energy consumption was expected to be increased by 7.2% per year. However, primary energy production was increased 7.7% per year on average, secondary energy source coal and gas production was aimed to increase by 4.6% and 14.9%, respectively.

In the Fifth Five-Year Development Plan, solar energy has been firstly mentioned as one of the renewable energy sources. It was also highlighted that any investment that aim to increase energy production from renewable energy sources such as solar, geothermal, biogas which are reliable and cheap sources, will be supported.

The Sixth Five-Year Development Plan (1990-1994) was approved on June 22, 1989 by the Grand National Assembly of Turkey. This plan indicated the usage of natural gas was going to be increased in a planned way and necessary steps to utilize hydropower, solar power and geothermal energy more were going to be taken. Moreover, focusing on the transition to nuclear energy technology was also included in this plan.

The Seventh Five-Year Development Plan (1996-2000) was approved on July 18, 1995 by the Grand National Assembly of Turkey. Until the seventh plan period, the energy sector has not created a structure that operates a combination of public and private companies, the issues on the principles and mechanisms of which

competition will be carried on accordingly after privatization, were not resolved, and also the build-operate-transfer model made it difficult to form a system in which competition and the free market economy will be in charge.During this plan period, although wind energy was not mentioned as one of renewable energy resources, Turkey's first 7.2 MW capasity wind power plant has been installed by Ares Alacati Wind Power Plant Industry and Trade Joint Stock Company in 1998, in İzmir, Cesme, Alacati district. In 2000, the second plant with 10.2 MW capacity was installed by Bores Bozcaada Wind Power Plant Industry and Trade Joint Stock Company, in Canakkale. With the establishment of these two plants, wind energy has firstly been used in Turkey.

Long Term Strategy and the Eighth Five-Year Development Plan (2001-2005) was approved by the 119th plenary session of the Grand National Assembly of Turkey, on June 27, 2000. The main goals of this plan were to encourage minimum amount of use and cost of energy consumption, to promote environment friendly solutions and also to promote economic and social improvements within a sustainable development approach.

During the Eighth Five-Year Development Plan period, the Energy Market Regulatory Authority has been established. The main duties and responsibilities of this institution were published on the Official Gazette date 03.03.2001 and No 24335. The duties of this instutition were determined under 'The Law on the Organization and Duties of Energy Market Regulatory Authority'. The article 4 of this law highlights the importance of arranging the transactions of operating rights within the scope of existing contracts, monitoring market performance, preparation of performance standards, distribution and customer service regulations, amending, controlling and enforcing the production licenses and determining the pricing principles. According to this provision, building plants has become possible for private companies if they are granted with production license. The first and the second wind power plants of Turkey (ARES and BORES) have no Production Licenses since they had been installed before the establishment of Energy Market Regulatory Authority. After the date of 03.03.2001, excessive amounts of production

license were distributed to private sector. Majority of these licenses were granted to encourage constructing wind power plants.

The Ninth Development Plan (2007-2013), was approved during the 121st plenary session of the Grand National Assembly of Turkey, in 28.06.2006 in compliance with the provision of the Law No. 3067, dated 30.10.1984. One of the main objectives of this plan was to improve energy and transportation infrastructure. This plan indicated that, during the Eighth Plan period, with the declaration of the Electricity Market Law with No. 4628 and the Natural Gas Market Law with No. 4646, these two sectors were opened to competition. The plan also highlighted that Energy Market Regulatory Authority (EMRA) was established in order to regulate this competition environment.

In order to raise the overall share of renewable energy sources in power generation, No. 5346 Law on the Purpose of Generating Electrical Energy Renewable Energy Sources was put into force. Energy Efficiency Law has not yet been published. During the ninth development plan, there were more energy investments than eighth development plan period. EMRA, which was established in the previous period, distributed production licenses including wind energy. Most of these distributed production licenses are put into action. However, there are still some inactive centrals due to technical or bureaucratic procedures.

The Tenth Development Plan (2014-2018), that we are still in, was approved at the 127th plenary session of The Grand National Assembly of Turkey, on 1 July 2013, in compliance with the Law No. 3067, dated 30 October 1984. In this plan, The Ninth Development Plan period is accepted as a period in which marketization process is accelerated within the framework of the liberalization policy in the energy sector. Growing interest in energy investment by the private sector, the share of electric power installed capacity rose to 56.6% in 2012 from 41.5% in 2006. The private sector share in electricity production has been increased from 51.9% to 62%. By renewing the Electricity Market Law, establishment of energy market was foreseen, pre-licensing mechanism was put into service to accelerate investments and the duration of incetives provided to investors has been extended.

The pre-licensing mechanism, which took place in the Tenth Development Plan, was formed due to technical and bureaucratic obstacles encountered during projects and distributing production licenses and also cancellation rates of production licenses. All of the production licenses distributed after the Eighth Five-Year Development Plan were cancelled afterwards for they are granted just according to wind speeds and without taking geographical, ecological, technical or bureaucratic thresholds into consideration. In order to avoid this case to occur again, any obstacles that may occur during the construction of a project or unsuitable areas as well as wind speeds are to be measured by related institutions before granting production licenses.

Within this context, the main objective of the study is to investigate spatial distributions of the wind power plants that are installed after 1998 by using spatial statiscial methods and to examine how wind speed affects site selection process. Moreover, the other concern of the study is to examine the development progress of energy sector in Turkey and to generate discussions on wind energy, which is one of the renewable energy resources, within the political frameworks that are prepared under development plans.

CHAPTER THREE
DATA

In this section, the methods of obtaining the data, sources of the data, and the programs that are used is the analyses are presented.

3.1 Data Sources

For the data of wind turbines that formed the basis of the study, Energy Market Regulatory Authority (EMRA) and the General Directorate of Renewable Energy (YEGM) were consulted. The turbine points of wind energy plants in Turkey, which are granted production license from the Energy Market Regulatory Authority, have been categorized individually according to years. Turkey's spatial data are obtained from the ArcGIS 10.1 training program files. Wind speed data have been digitized from the Turkey Wind Energy Potential Atlas (REPA) maps. The preparation of the data gathered under the study can be summarized as follows. As for spatial data, administrative border provinces in Turkey have been obtained from a study of the ArcGIS 10.1 software files. Wind speeds were digitized using Turkey Wind Energy Potential Atlas (REPA).

Production license dates and numbers, plant names, establishment/intended to be installed dates, provincial and district information, total installed capacity (MW) of the 245 production licensed wind power plants, which are currently published on the Energy Market Regulatory Authority's (EMRA) website, were transferred into Excel format. This table is given in Appendix-1.

Installation dates of the centrals, the plant names, establishment/intented to be installed dates, provincial and district information, the total installed capacity of 2 power plants (MW) without production license, were transferred into Excel format. This table is also given in Appendix-1.

The coordinates of turbine points of 16 power plants out of 257, could not be reached. Therefore, the turbine points coordinates of 231 plants were transferred into Excel format in the 6 degrees of European Geographic Coordinate System Datum 1950 by X and Y coordinates. Under ID column, each plant has been given a code as A, B, C, … AA, AB, … and so on. Additionally, each turbine of every single plant has also been given a code form as A1, A2, ... AA1, AA2 and so on. Edited coordinates are arranged in 14 different categories which are based on years as 1998, 2000, 2003, 2004, 2005, 2006, 2007, 2008, 2009, 2010, 2011, 2012, 2013 and 2014. Overall capacities of power plant turbines are calculated from the total power, and this data is also included in the same table. The years of 1999, 2001 and 2002 are not included since there are no power plants established in these years.

Wind turbines that are organized by years, have been converted into vector point data in CAD format and point data is rearranged in ArcGIS 10.1 format. Is an example, Figures 3.1 and 3.2 show the wind turbines installed in 1998 and 2000 years and also figures 3.3, 3.4, 3.5, 3.6, 3.7, 3.8, 3.9, 3.10, 3.11, 3.12, 3.13 and 3.14 show the wind turbines which have production license in the following years. Figure 3.15 show all the wind turbines installed that had production licenses between 1998 and 2014.

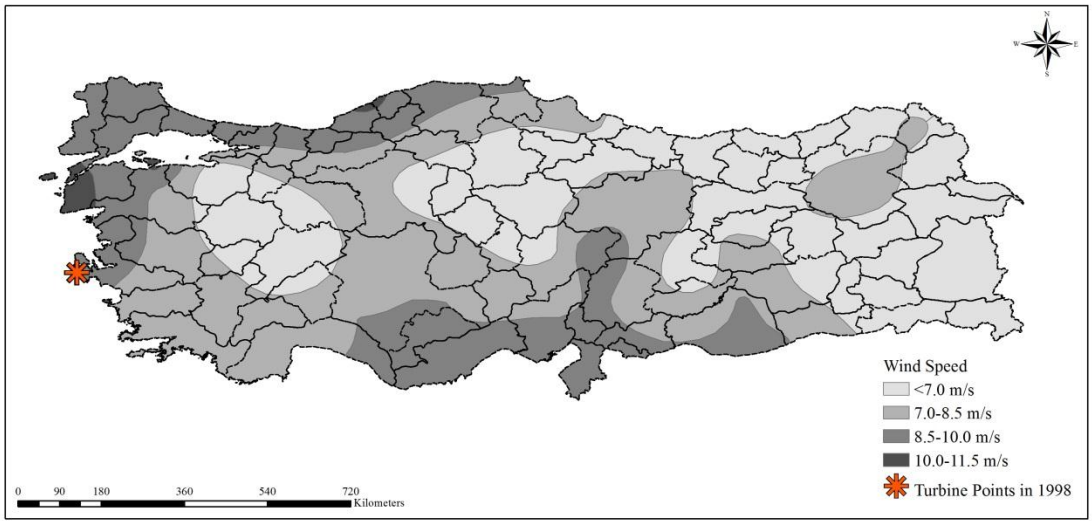

Figure 3.1 Wind turbines installed in 1998.

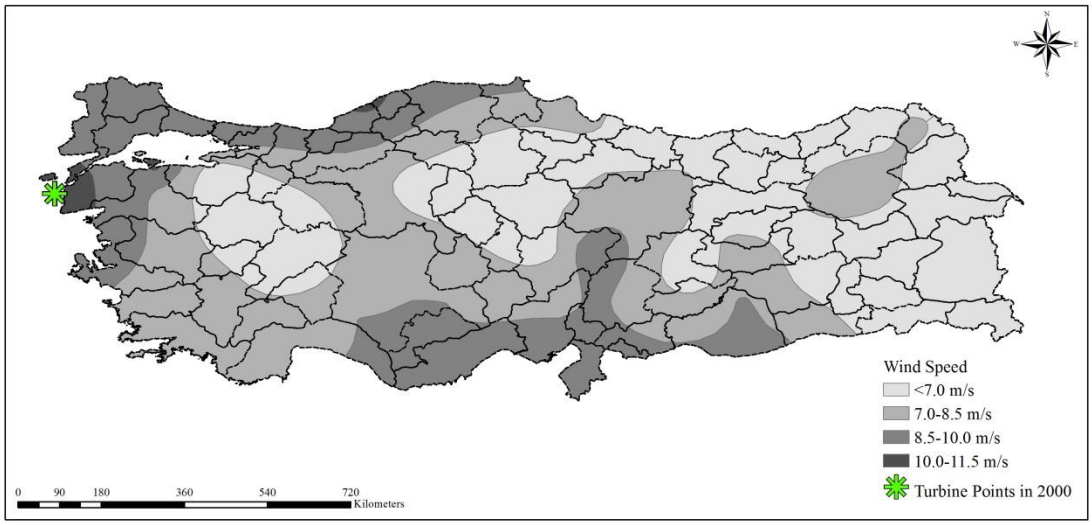

Figure 3.2 Wind turbines installed in 2000.

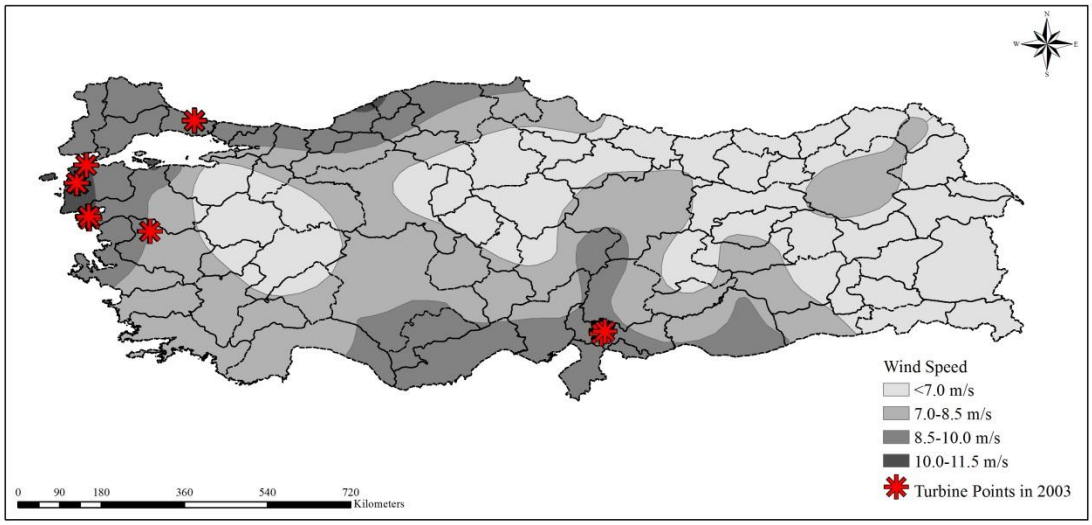

Figure 3.3 Wind turbines licensed in 2003.

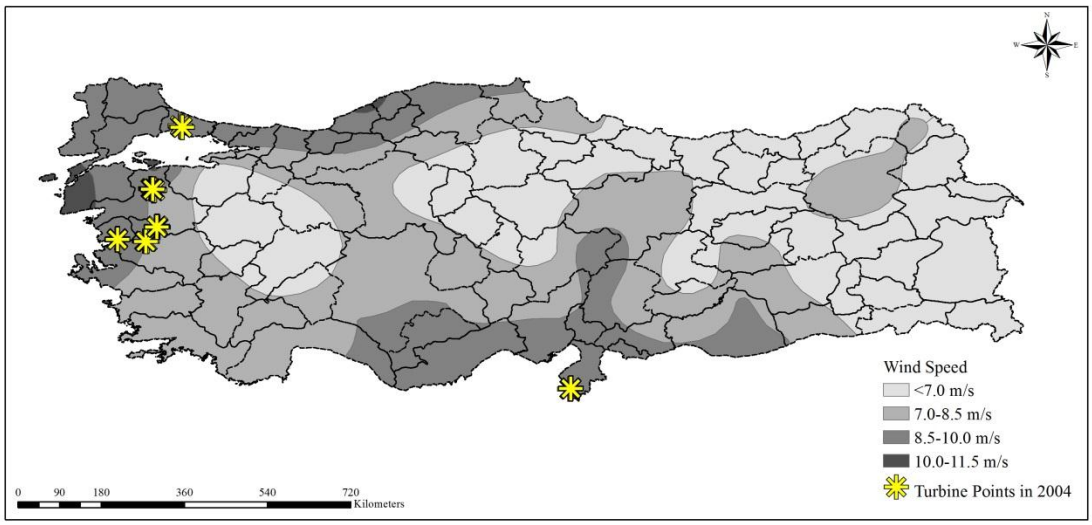

Figure 3.4 Wind turbines licensed in 2004.

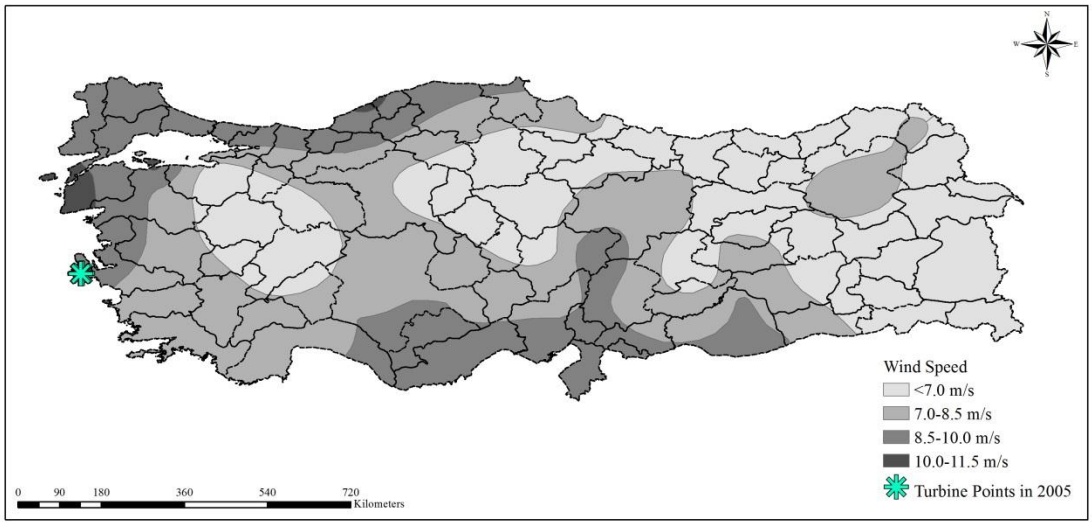

Figure 3.5 Wind turbines licensed in 2005.

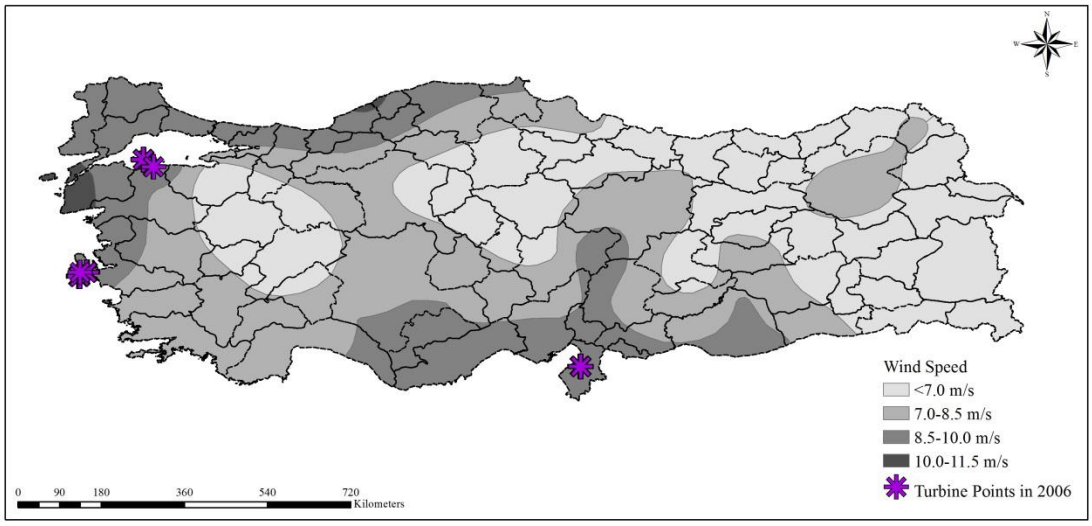

Figure 3.6 Wind turbines licensed in 2006.

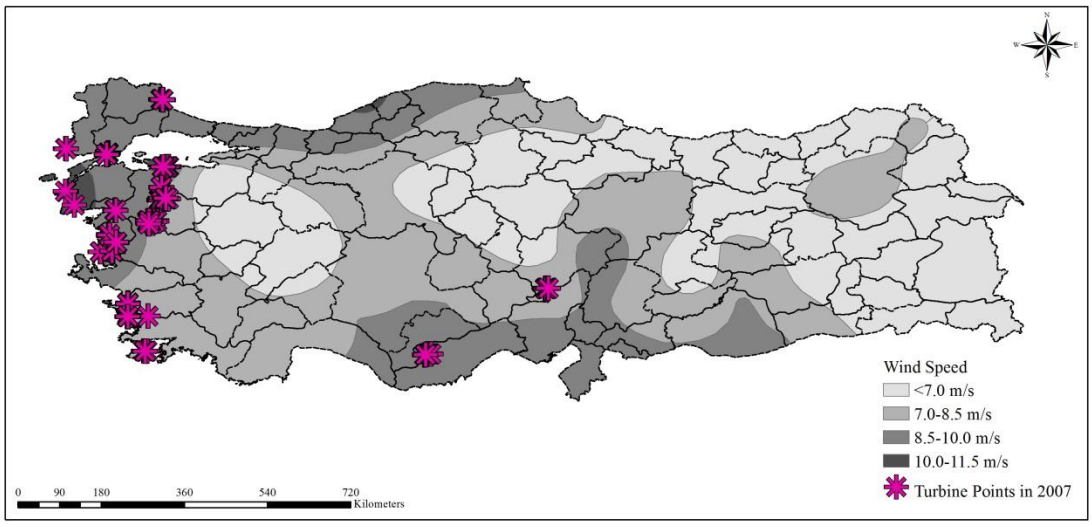

Figure 3.7 Wind turbines licensed in 2007.

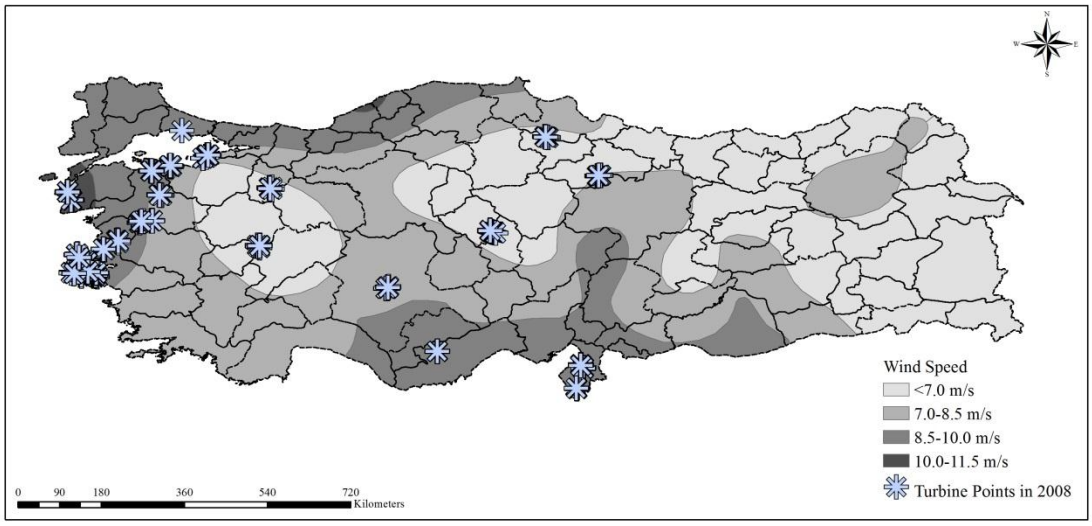

Figure 3.8 Wind turbines licensed in 2008.

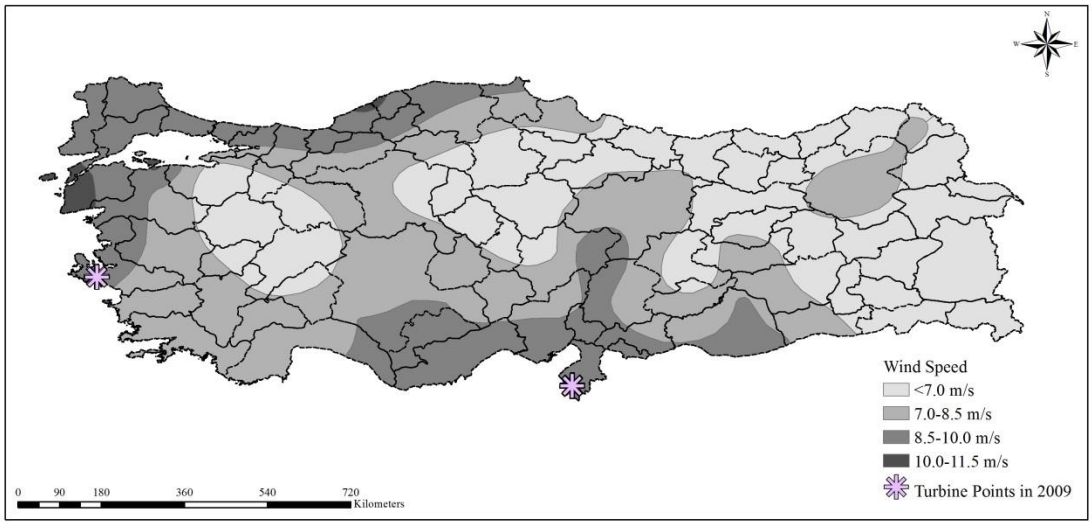

Figure 3. 9 Wind turbines licensed in 2009.

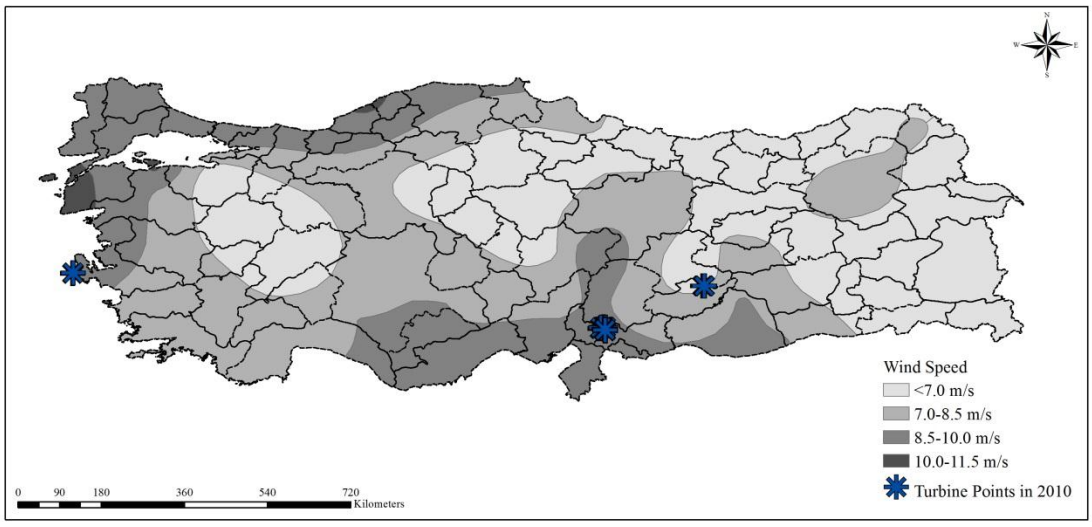

Figure 3.10 Wind turbines licensed in 2010.

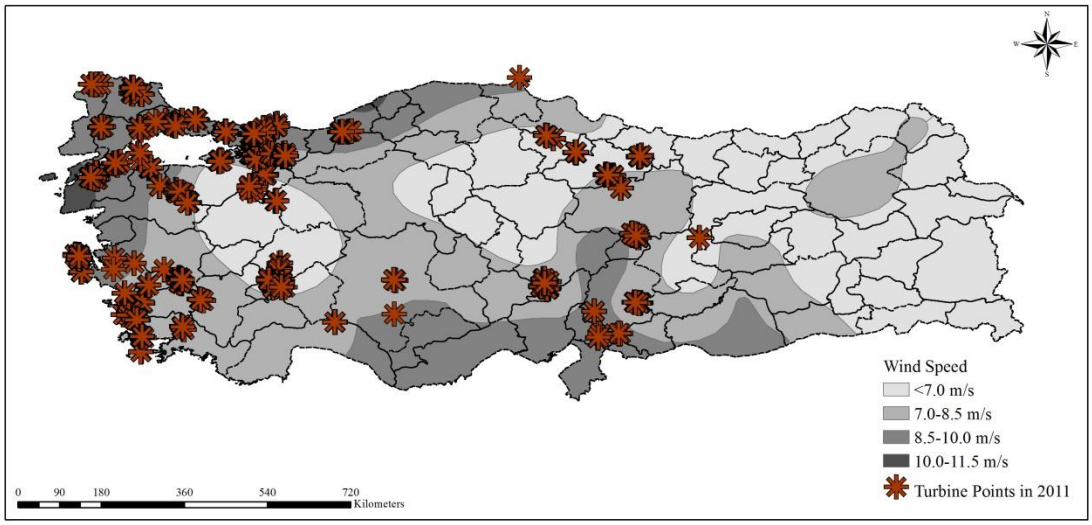

Figure 3.11 Wind turbines licensed in 2011.

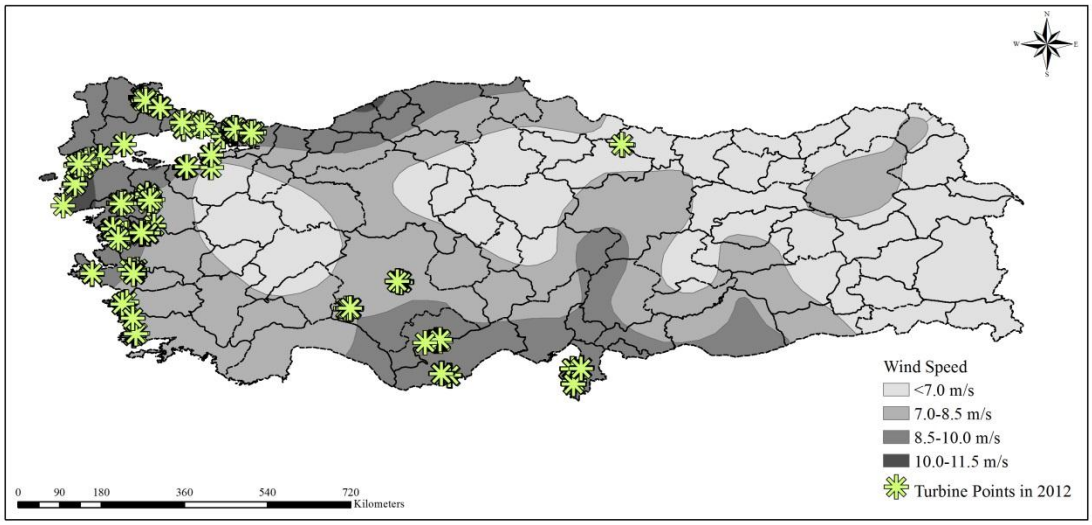

Figure 3.12 Wind turbines licensed in 2012.

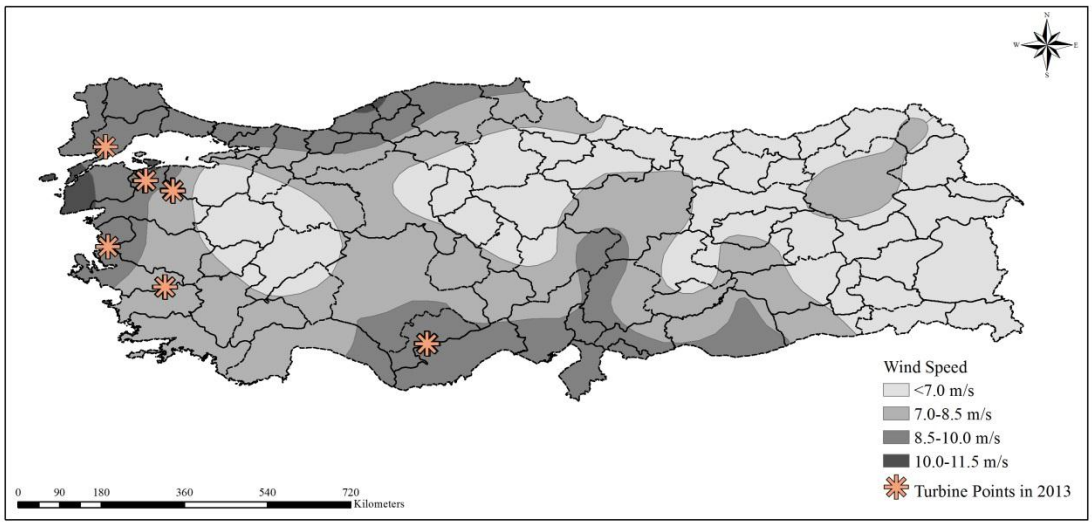

Figure 3. 13 Wind turbines licensed in 2013.

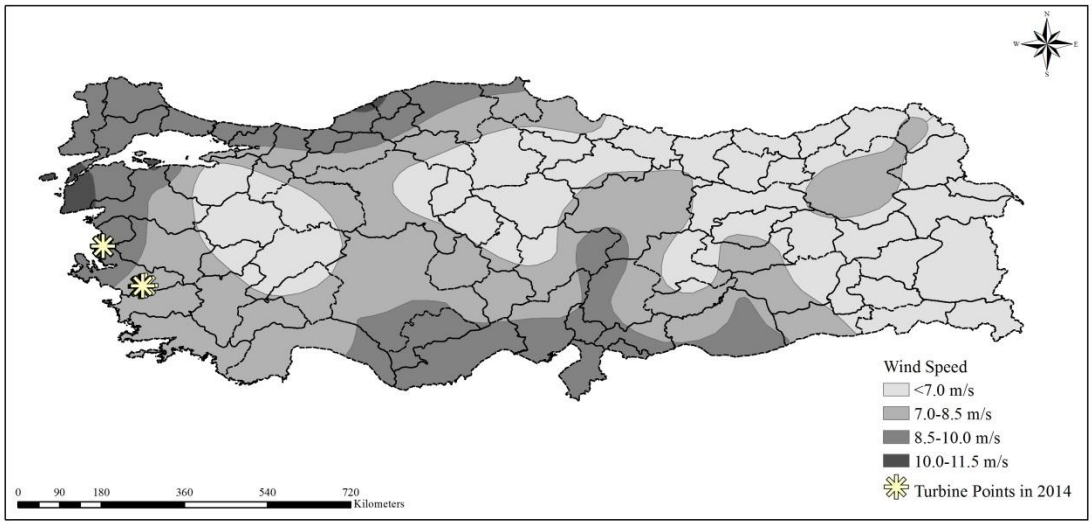

Figure 3.14 Wind turbines licensed in 2014.

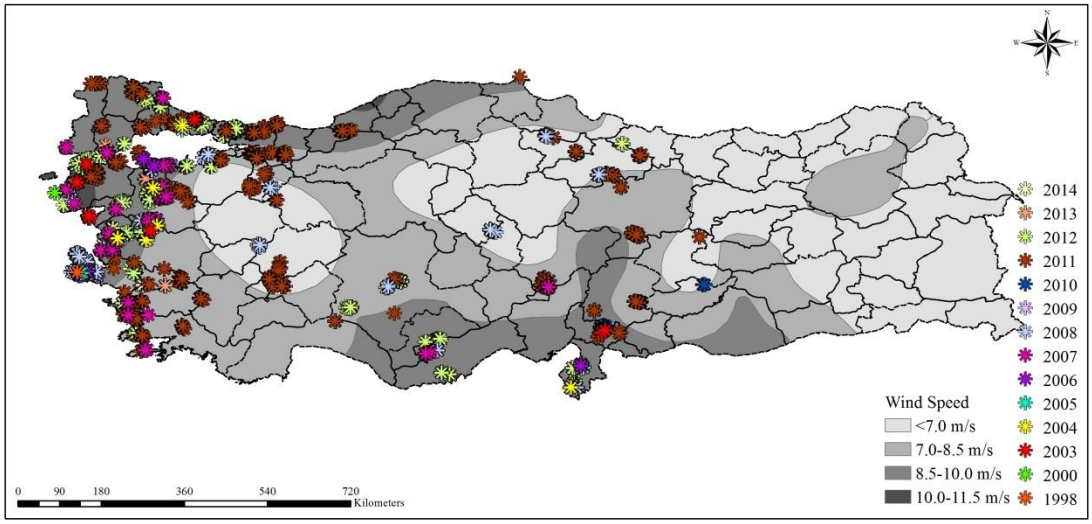

Figure 3.15 All wind turbines installed and have production licenses between 1998 and 2014.

3.2 Descriptive Statistics

By using spatial descriptive statistical methods, as one of spatial statistical methods, mean centers, weighted mean centers and standard deviational ellipses in time are calculated in Excel. The results of these calculations are shown in Table 3.1.

Table 3.1 Results of spatial descriptive statistical methods in years

Years	Mean Center		Weighted Mean Center		Standard Deviational Ellipse			Turbines
	Y Coor.	X Coor.	Y Coor.	X Coor.	Y Std. Dist.	X Std. Dist.	Rotation	n
1998	447335	4237822	447290	4237642	0.004066	0.001802	35.367591	12
2000	411848	4409730	411848	4409730	0.00042	0.00575	122.753726	17
2003	242855	4336207	514620	4224302	0.8739	6.761419	106.199202	168
2004	696603	4320140	683001	4336080	0.976475	4.724577	113.858985	176
2005	455160	4237417	455213	4237428	0.017214	0.003435	72.392159	55
2006	651176	4263417	580659	4285004	5.406163	1.45588	104.064494	82
2007	637517	4322139	614602	4347470	1.507993	3.536381	107.06128	539
2008	754736	4326961	256771	4325341	1.581757	5.114857	91.047702	677
2009	565006	4054219	611894	4041432	0.013852	5.814578	102.893355	40
2010	736902	4153616	762678	4150124	0.517143	5.16181	93.750567	63
2011	301684	4362209	281246	4357270	5.491025	1.971617	94.813123	1405
2012	677491	4359351	657385	4379183	1.777763	4.111264	112.905232	916
2013	724189	4264304	256295	4244798	1.009675	3.865434	115.074608	51
2014	534483	4241871	536928	4238709	0.031296	0.743484	134.961394	24

Followingly, cumulative mean centers, cumulative weighted mean centers and cumulative standard deviational ellipses in time are calculated in Excel with the wind turbine points. The results of these calculations are shown in Table 3.2.

Table 3.2 Results of spatial descriptive statistical methods in cumulative years

Years	Cumulative Mean Center		Cumulative Weighted Mean Center		Cumulative Standard Deviational Ellipse			Turbines
	Y Coor.	X Coor.	Y Coor.	X Coor.	Y Std. Dist.	X Std. Dist.	Rotation	n
1998	447290	4237642	447290	4237642	0.004066	0.001802	35.367591	12
2000	426311	4338497	426311	4338497	0.003649	1.118376	164.560441	17
2003	712074	4335758	467728	4233041	1.015666	6.524396	104.980013	168
2004	704785	4328389	275918	4299712	1.085119	5.732189	107.742102	176
2005	673010	4316255	247016	4295581	1.263563	5.483201	105.89609	55
2006	669526	4307752	246418	4296178	1.326243	5.470941	105.577062	82
2007	653065	4315132	670875	4328356	1.423578	4.58812	106.00575	539
2008	692968	4319616	717142	4327332	1.611328	4.830724	98.951336	677
2009	701946	4313866	728749	4319785	1.62895	4.960091	100.003237	40
2010	721056	4308824	754488	4312641	1.609063	5.241837	100.101961	63
2011	245192	4333541	256612	4333935	1.845851	5.400705	96.964617	1405
2012	744967	4339350	748572	4344819	1.885545	5.16118	99.051005	916
2013	744718	4338442	747113	4344495	1.883931	5.1463	99.155874	51
2014	743406	4337812	745319	4343561	1.88319	5.136517	99.072656	27

Maximum, minimum, mean, mod and standard deviation are calculated in Excel for the turbine capacities of 4228 wind turbınes. These calculations are shown in Table 3.3.

Table 3.3 Descriptive statistics (n=4228)

	Maximum	Minimum	Mean	Mode	Standard Deviation
Turbine capacities	6000	500	2118.36	2000	806.32

CHAPTER FOUR
ANALYSIS

In this section, mean centers, weighted mean centers and standard deviational ellipses 4228 wind turbines of the 231 wind power plants are calculated separately, including the years 1998, 2000, 2003, 2004, 2005, 2006, 2007, 2008, 2009, 2010, 2011, 2012, 2013 and 2014. Then, cumulative mean centers, cumulative weighted mean centers and cumulative standard deviational ellipses are calculated for 1998, and every year ofter 2000. At the end of these analyzes, mean centers, weighted mean centers and standard deviational ellipses of wind turbines according to separate years and the cumulative years are discussed.

The wind speed data which was collected from Turkey Wind Energy Potential Atlas (REPA) were analyzed on order to examine the relationship between turbine locations and wind speed.

4.1 Wind Power Plants in 1998

As an example to the calculations conducted, mean center, weighted mean center and standart deviational ellipse for wind power plants installed in 1998 are presented here.

In 1998, Turkey's first wind power plant ARES-YlD was installed in Cesme, Izmir. The total installed capacity of this plant is 10.2 MW and has 12 turbines. Plant information is given in Table 4.1, coordinate data of the turbine and turbine capacity are given in Table 4.2.

Table 4.1 Wind power plants in 1998

ID	Licence No	Start / Enforcement Date	Facility Name	Facility City	Facility Town	Installed Capacity (MW)	Title
KZ	NONE	28.11.1998	ARES-YID	IZMIR	ALACATI	7.2	ARES ALACATI WIND ENERGY PLANT INC.

Table 4.2 Coordinates informations of wind power plants turbine points and turbine capasities in 1998

ID	Y	X	Turbine Capacity (kW)
KZ1	447558.00	4237770.00	600
KZ2	447369.00	4237603.00	600
KZ3	447199.00	4237532.00	600
KZ4	447042.00	4237379.00	600
KZ5	447058.00	4237584.00	600
KZ6	447223.00	4237695.00	600
KZ7	447381.00	4238098.00	600
KZ8	447353.00	4238276.00	600
KZ9	447534.00	4238214.00	600
KZ10	447565.00	4238027.00	600
KZ11	447460.00	4237793.00	600
KZ12	447279.00	4237895.00	600

4.1.1 Mean Center in 1998

The mean center is a simple generalization of the arictmetic mean. It can be thought of as the 'center of gravity' of turbine points (Burt, Barber and Rigby, 2009) which is calculated by considering all of the 12 wind turbines that are located in Cesme, Izmir. X and Y coordinates of wind turbines are added and divided into the

total number of these turbines. The following formula is used during this process (Cubukcu, 2015).

$$(\bar{X}mc, \bar{Y}mc) = \left(\frac{\sum_{i=1}^{n} X_i}{n}, \frac{\sum_{i=1}^{n} Y_i}{n} \right) \quad (4.1)$$

n=number of turbines

$$\bar{X}mc = \frac{4237770.00 + 4237603.00 + 4237532.00 + ... + 423789\,5.00}{12} = 4237822.17$$

$$\bar{Y}mc = \frac{447558.00 + 447369.00 + 447199.00 + ... + 447279.00}{12} = 447335.08$$

In 1998, the mean center points of the turbines are located in the (4237822.17, 447335.08) coordinates.

4.1.2 Weighted Mean Center in 1998

The weighted mean center is obtained that the mean center generalized to include the variable for turbine points have an associated weight, which is turbines capacity. (Burt & etal., 2009) X and Y coordinates of wind turbines are added and divided into the total number of these turbines and multiplied to the turbine capacities. The following formula is used during this process (Cubukcu, 2015).

$$(\bar{X}wmc, \bar{Y}wmc) = \left(\frac{\sum_{i=1}^{n} w_i X_i}{\sum_{i=1}^{n} w_i}, \frac{\sum_{i=1}^{n} w_i Y_i}{\sum_{i=1}^{n} w_i} \right) \quad (4.2)$$

n=number of turbines w=turbine capacity

Table 4.3 Required values for turbine points to calculate the weighted mean center in 1998 (n=12)

ID	Y	X	Turbine Capacity (kw)	$w_i y_i$	$w_i x_i$
KZ1	447558.00	4237770.00	600	268534800	2542662000
KZ2	447369.00	4237603.00	600	268421400	2542561800
KZ3	447199.00	4237532.00	600	268319400	2542519200
KZ4	447042.00	4237379.00	600	268225200	2542427400
KZ5	447058.00	4237584.00	600	268234800	2542550400
KZ6	447223.00	4237695.00	600	268333800	2542617000
KZ7	447381.00	4238098.00	600	268428600	2542858800
KZ8	447353.00	4238276.00	600	268411800	2542965600
KZ9	447534.00	4238214.00	600	268520400	2542928400
KZ10	447565.00	4238027.00	600	268539000	2542816200
KZ11	447460.00	4237793.00	600	268476000	2542675800
KZ12	447279.00	4237895.00	600	268367400	2542737000
Total	5368021.00	50853866.00	7200	3220812600	30512319600

$$\bar{X}wmc = \frac{(4237770 \times 600) + (4237603 \times 600) + ... + (4237895 \times 600)}{(600 + 600 + ... + 600)} = 4237822.2$$

$$\bar{Y}wmc = \frac{(447558 \times 600) + (447369 \times 600) + ... + (447279 \times 600)}{(600 + 600 + ... + 600)} = 447335.08$$

In 1998, the weighted mean center points of the turbines are located in the (4237822.2, 447335.08) coordinates.

4.1.3 Standard Deviational Ellipse in 1998

When calculating standard deviational ellipse for determining the spatial distribution of the turbines of 1998 year, mean center, deviation from the x-axis, deviation from the y-axis, and angle of deviation the y-axis are calculated (Cubukcu, 2015). For this purpose, the following formula was utilized.

$$X_i^{'} = X_i - \bar{X}mc \tag{4.3}$$

$$Y_i^{'} = Y_i - \bar{Y}mc \tag{4.4}$$

Deviation from the x-axis;

$$Sx = \sqrt{2}\sqrt{\frac{\sum_{i=1}^{n}\left[\left((X_i - \bar{X}mc)\cos\theta\right) - \left(\left(Y_i - \bar{Y}mc\right)\sin\theta\right)\right]^2}{n}} \tag{4.5}$$

Deviation from the y-axis;

$$Sy = \sqrt{2}\sqrt{\frac{\sum_{i=1}^{n}\left[\left((X_i - \bar{X}mc)\sin\theta\right) - \left(\left(Y_i - \bar{Y}mc\right)\cos\theta\right)\right]^2}{n}} \tag{4.6}$$

While calculating the deflection angle from the y-axis, the inverse of the tangent value (arctan) is taken (Cubukcu, 2015).

$$\tan\theta = \frac{\left[\left(\sum_{i=1}^{n}(x_i^{'})^2\right)\right] - \left[\left(\sum_{i=1}^{n}(y_i^{'})^2\right)\right] + \sqrt{\left(\sum_{i=1}^{n}(x_i^{'})^2 - \sum_{i=1}^{n}(y_i^{'})^2\right)^2 + 4\left(\sum_{i=1}^{n}x_i^{'}y_i^{'}\right)^2}}{2\left(\sum_{i=1}^{n}x_i^{'}y_i^{'}\right)} \tag{4.7}$$

Table 4.4 Required values for calculation of the angle of standard deviational ellipse in 1998 (n=12)

ID	Y	X	y_i-y_{mc}	x_i-x_{mc}	$(y_i-y_{mc})^2$	$(x_i-x_{mc})^2$	(y_i-y_{mc}) (x_i-x_{mc})
KZ1	447558	4237770	222.92	-52.17	49691.84	2721.36	-11628.82
KZ2	447369	4237603	33.92	-219.17	1150.34	48034.03	-7433.40
KZ3	447199	4237532	-136.08	-290.17	18518.67	84196.69	39486.85
KZ4	447042	4237379	-293.08	-443.17	85897.84	196396.69	129884.76
KZ5	447058	4237584	-277.08	-238.17	76775.17	56723.36	65992.01
KZ6	447223	4237695	-112.08	-127.17	12562.67	16171.36	14253.26
KZ7	447381	4238098	45.92	275.83	2108.34	76084.03	12665.35
KZ8	447353	4238276	17.92	453.83	321.01	205964.69	8131.18
KZ9	447534	4238214	198.92	391.83	39567.84	153533.36	77942.18
KZ10	447565	4238027	229.92	204.83	52861.67	41956.69	47094.60
KZ11	447460	4237793	124.92	-29.17	15604.17	850.69	-3643.40
KZ12	447279	4237895	-56.08	72.83	3145.34	5304.69	-4084.74
Total	5368021	50853866			358204.92	887937.67	368659.83

$$\tan\theta = \frac{\left[887937.67 - 358204.92\right] + \sqrt{\left(887937.67 - 358204.92\right)^2 + 4\left(368659.83\right)^2}}{2 \times 368659.83}$$

$\tan\theta$=1,95

$\tan^{-1}\left(1.95\right)$=arctan(1.95)=62.85

The angle of deviation from y-axis of turbines is 62.85 degrees, in 1998. This angle is positive, which means that the ellipse is in the northeast - southwest direction. The angle of deviation from the y-axis is used to calculate the deviation of the turbine ellipse point from x-axis and y-axis.

$\sin\theta$=sin(62.85)=0.02

$\cos\theta$=cos(62.85)=1.00

Table 4.5 Required values for calculation of deviation from x-axis and y-axis belonging to standard deviational ellipse in 1998 (n=12)

ID	Y	X	SY	SX
KZ1	447558.00	4237770.00	50051.10	3104.56
KZ2	447369.00	4237603.00	1399.59	48259.38
KZ3	447199.00	4237532.00	17274.87	82919.42
KZ4	447042.00	4237379.00	81779.68	192222.21
KZ5	447058.00	4237584.00	74663.39	54621.80
KZ6	447223.00	4237695.00	12108.59	15715.43
KZ7	447381.00	4238098.00	1722.87	75660.86
KZ8	447353.00	4238276.00	113.84	205652.72
KZ9	447534.00	4238214.00	37108.73	151016.16
KZ10	447565.00	4238027.00	51355.49	40456.07
KZ11	447460.00	4237793.00	15716.72	970.76
KZ12	447279.00	4237895.00	3276.29	5434.54
Total	5368021.00	50853866.00	346571.15	876033.91

$$Sx = \sqrt{2}\sqrt{\frac{876033.91}{12}} = 382.11$$

$$Sy = \sqrt{2}\sqrt{\frac{346571.15}{12}} = 240.34$$

Using the calculated values to draw the cumulative standard deviational ellipse of turbines we achieve:

Mean center = (4237822.17, 447335.08) coordinates

Deviation from the x-axis = 382.11

Deviation from the y-axis = 240.34

Angle of deviation from the y-axis = 62.85

Figure 4.1 shows mean center, weighted mean center and standart deviational ellipse in 1998.

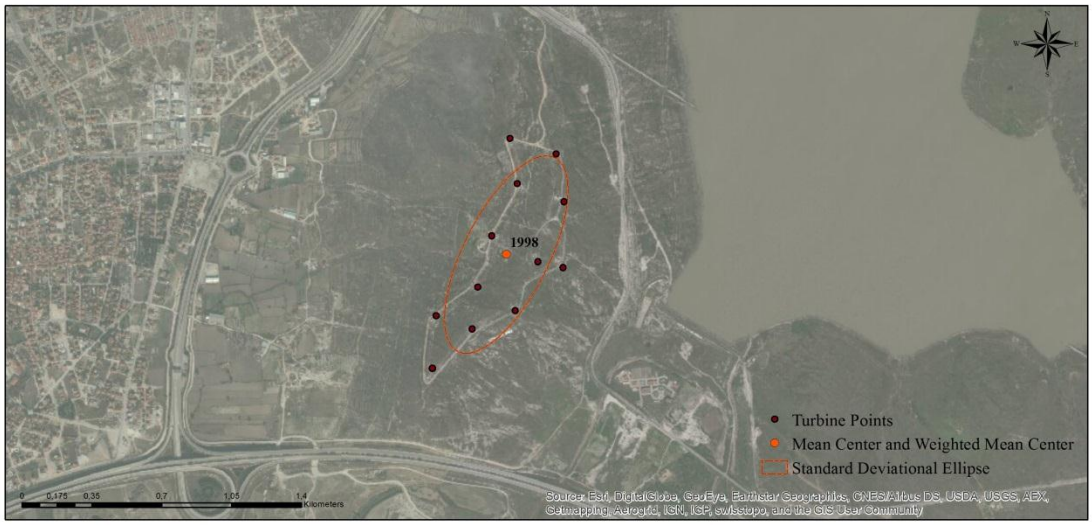

Figure 4.1 Spatial descriptive statistics in 1998

4.2 Wind Power Plants in 1998 and 2000

As an example to the calculations contucted though the study, the method of calculations for cumulative mean center, cumulative weighted mean center and cumulative standart deviational ellipses of wind power plants in 1998 and 2000 are described.

Cumulative mean center, cumulative weighted mean center and cumulative standard deviational ellipse are calculated for two wind power plants including the one wind power plant installed in 1998 and the other wind power plant installed in 2000. The facility information of these plants are provided in Table 4.6. Additionally, coordinates data of the turbines and turbine capacites are provided in Table 4.7.

Table 4. 6 Wind power plants in 1998 and 2000

ID	License No	Start / Enforcement Date	Facility Name	Facilty City	Facility Town	Installed Power (MW)	Title
KZ	NONE	28.11.1998	ARES-YID	IZMIR	ALACATI	7.2	ARES ALACATI WIND ENERGY PLANT INC.
KY	NONE	01.01.2000	BORES -YID	CANAKKALE	BOZCAADA	10.2	BORES BOZCAADA WIND ENERGY PLANT INC.

Table 4.7 Coordinates information of wind power plants turbine points and türbine capasities in 1998 and 2000

ID	Y	X	Turbine Capacity (kW)
KZ1	447558.00	4237770.00	600
KZ2	447369.00	4237603.00	600
KZ3	447199.00	4237532.00	600
KZ4	447042.00	4237379.00	600
KZ5	447058.00	4237584.00	600
KZ6	447223.00	4237695.00	600
KZ7	447381.00	4238098.00	600
KZ8	447353.00	4238276.00	600
KZ9	447534.00	4238214.00	600
KZ10	447565.00	4238027.00	600
KZ11	447460.00	4237793.00	600

Table 4.7 Coordinates information of wind power plants turbine points and türbine capasities in 1998 and 2000 (cont.)

KZ12	447279.00	4237895.00	600
KY1	412381.56	4409536.98	600
KY2	412318.14	4409576.95	600
KY3	412254.71	4409616.92	600
KY4	412191.28	4409656.89	600
KY5	412127.85	4409696.86	600
KY6	412064.42	4409736.83	600
KY7	412001.00	4409776.80	600
KY8	411937.58	4409816.77	600
KY9	411874.15	4409856.74	600
KY10	411858.27	4410014.79	600
KY11	411794.99	4410054.98	600
KY12	411731.70	4410095.18	600
KY13	411668.42	4410135.37	600
KY14	411605.13	4410175.56	600
KY15	411541.84	4410215.76	600
KY16	411478.56	4410255.95	600
KY17	411415.28	4410296.15	600

4.2.1 Cumulative Mean Center in 2000

Cumulative mean center is calculated for the 29 turbines of Turkey's first and second wind power plants, which are located in Cesme, İzmir and Bozcaada, Canakkale.

$$\bar{X}mc = \frac{4237770.00 + 4237603.00 + ... + 4410296.15}{29} = 4338702.81$$

$$\bar{Y}mc = \frac{447558.00 + 447369.00 + ... + 411415.28}{29} = 426560.89$$

For the years of 1998 and 2000, cumulative mean center points of these turbines are located on the (4338702.81, 426560.89) coordinates.

4.2.2 Cumulative Weighted Mean Center in 2000

Additionally, cumulative weighted mean center is calculated for the years of 1998 and 2000 after completing the calculations of cumulative mean center, that are based on the turbine capacities.

Table 4.8 Required values for calculate the cumulative weighted mean center in 1998 and 2000 (n=29)

ID	Y	X	Turbine Capacity (kw)	$w_i y_i$	$w_i x_i$
KZ1	447558.00	4237770.00	600	268534800	2542662000
KZ2	447369.00	4237603.00	600	268421400	2542561800
KZ3	447199.00	4237532.00	600	268319400	2542519200
KZ4	447042.00	4237379.00	600	268225200	2542427400
KZ5	447058.00	4237584.00	600	268234800	2542550400
KZ6	447223.00	4237695.00	600	268333800	2542617000
KZ7	447381.00	4238098.00	600	268428600	2542858800
KZ8	447353.00	4238276.00	600	268411800	2542965600
KZ9	447534.00	4238214.00	600	268520400	2542928400
KZ10	447565.00	4238027.00	600	268539000	2542816200
KZ11	447460.00	4237793.00	600	268476000	2542675800
KZ12	447279.00	4237895.00	600	268367400	2542737000
KY1	412381.56	4409536.98	600	247428936	2645722188
KY2	412318.14	4409576.95	600	247390884	2645746170
KY3	412254.71	4409616.92	600	247352826	2645770152
KY4	412191.28	4409656.89	600	247314768	2645794134
KY5	412127.85	4409696.86	600	247276710	2645818116
KY6	412064.42	4409736.83	600	247238652	2645842098

Table 4.8 Required values for calculate the cumulative weighted mean center in 1998 and 2000 (n=29) (cont.)

KY7	412001.00	4409776.80	600	247200600	2645866080
KY8	411937.58	4409816.77	600	247162548	2645890062
KY9	411874.15	4409856.74	600	247124490	2645914044
KY10	411858.27	4410014.79	600	247114962	2646008874
KY11	411794.99	4410054.98	600	247076994	2646032988
KY12	411731.7	4410095.18	600	247039020	2646057108
KY13	411668.42	4410135.37	600	247001052	2646081222
KY14	411605.13	4410175.56	600	246963078	2646105336
KY15	411541.84	4410215.76	600	246925104	2646129456
KY16	411478.56	4410255.95	600	246887136	2646153570
KY17	411415.28	4410296.15	600	246849168	2646177690
Total	12370265.88	125822381.5	17400	7422159528	75493428888

$$\bar{X}wmc = \frac{(4237770 \times 600) + (4237603 \times 600) + ... + (4410296.15 \times 600)}{(600 + 600 + ... + 600)} = 4338702.81$$

$$\bar{Y}wmc = \frac{(447558 \times 600) + (447369 \times 600) + ... + (411415.28 \times 600)}{(600 + 600 + ... + 600)} = 426560.89$$

In 1998 and 2000, cumulative weighted mean center points of the turbines are located on the (4338702.81, 426560.89) coordinates.

4.2.3 Cumulative Standard Deviational Ellipse in 2000

When calculating cumulative standard deviational ellipse for determining the spatial distribution of the turbines from 1998 and 2000, mean center, deviation from the x-axis, deviation from the y-axis, and angle of deviation the y-axis are also calculated.

Table 4.9 Required values for calculate the angle of cumulative standard deviational ellipse in 1998 and 2000 (n=29)

ID	Y	X	y_i-y_{mc}	x_i-x_{mc}	$(y_i-y_{mc})^2$	$(x_i-x_{mc})^2$	$(y_i-y_{mc})(x_i-x_{mc})$
KZ1	447558.00	4237770.00	20997.11	-100932.81	440878526.99	10187432064.89	-2119297063.31
KZ2	447369.00	4237603.00	20808.11	-101099.81	432977341.32	10221171512.31	-2103695716.25
KZ3	447199.00	4237532.00	20638.11	-101170.81	425931484.74	10235532726.28	-2087974054.25
KZ4	447042.00	4237379.00	20481.11	-101323.81	419475767.96	10266514403.04	-2075223846.59
KZ5	447058.00	4237584.00	20497.11	-101118.81	420131419.40	10225013666.08	-2072643120.49
KZ6	447223.00	4237695.00	20662.11	-101007.81	426922689.90	10202577611.34	-2087034230.14
KZ7	447381.00	4238098.00	20820.11	-100604.81	433476879.90	10121327725.75	-2094602960.71
KZ8	447353.00	4238276.00	20792.11	-100426.81	432311737.88	10085544097.52	-2088085030.89
KZ9	447534.00	4238214.00	20973.11	-100488.81	439871241.82	10098000865.91	-2107562616.11
KZ10	447565.00	4238027.00	21004.11	-100675.81	441172535.49	10135618649.72	-2114605537.33
KZ11	447460.00	4237793.00	20899.11	-100909.81	436772697.90	10182789684.64	-2108924968.49
KZ12	447279.00	4237895.00	20718.11	-100807.81	429239981.95	10162214487.47	-2088547045.97
KY1	412381.56	4409536.98	-14179.33	70834.17	201053467.70	5017479688.44	-1004381247.57
KY2	412318.14	4409576.95	-14242.75	70874.14	202855996.32	5023143769.62	-1009442833.47
KY3	412254.71	4409616.92	-14306.18	70914.11	204666855.26	5028811046.00	-1014510198.30
KY4	412191.28	4409656.89	-14369.61	70954.08	206485760.92	5034481517.58	-1019582633.73
KY5	412127.85	4409696.86	-14433.04	70994.05	208312713.32	5040155184.36	-1024660139.75
KY6	412064.42	4409736.83	-14496.47	71034.02	210147712.44	5045832046.35	-1029742716.37
KY7	412001.00	4409776.80	-14559.89	71073.99	211990467.10	5051512103.54	-1034829652.84
KY8	411937.58	4409816.77	-14623.31	71113.96	213841265.95	5057195355.93	-1039921659.10
KY9	411874.15	4409856.74	-14686.74	71153.93	215700402.73	5062881803.52	-1045019446.70
KY10	411858.27	4410014.79	-14702.62	71311.98	216167105.84	5085398540.70	-1048473120.59
KY11	411794.99	4410054.98	-14765.90	71352.17	218031874.09	5091132212.92	-1053579184.32
KY12	411731.70	4410095.18	-14829.19	71392.37	219904947.65	5096870543.45	-1058691196.72
KY13	411668.42	4410135.37	-14892.47	71432.56	221785734.60	5102610677.42	-1063807434.38
KY14	411605.13	4410175.56	-14955.76	71472.75	223674829.38	5108354041.85	-1068929473.22
KY15	411541.84	4410215.76	-15019.05	71512.95	225571935.41	5114102067.02	-1074056749.49
KY16	411478.56	4410255.95	-15082.33	71553.14	227476751.04	5119851893.21	-1079188247.93
KY17	411415.28	4410296.15	-15145.61	71593.34	229389575.39	5125606381.73	-1084324984.27
Total	12370265.88	125822381.48			8836219700.39	208329156368.59	-42901337109.30

$$\tan\theta = \frac{[208329156368.59 - 8836219700.39] + \sqrt{(208329156368.59 - 8836219700.39)^2 + 4(-42901337109.30)^2}}{2 \times (-42901337109.30)}$$

$\tan\theta$ = -4.86

$\tan^{-1}(-4.86)$ =arctan(-4.86)= -78.36

The angle of deviation from the y-axis of turbines for 1998 and 2000 is -78.36 degrees. This angle is negative, which means that the ellipse is in the northwest-southeast direction. For positive values should be used in the calculations, the angle of cumulative standard deviational ellipse to the y-axis is 90.00-78.36=11.64 degrees.

The angle of deviation from the y-axis is used for identifying cumulative standard deviational ellipse of turbine points in order to find the deviation from the x-axis and the deviation from the y-axis.

$\sin\theta$ =sin(11.64)=-0.80

$\cos\theta$ =cos(11.64)=0.60

Table 4.10 Required values for calculate of deviation from x-axis and y-axis belonging to cumulative standard deviational ellipse in 1998 and 2000 years (n=29)

ID	Y	X	SY	SX
KZ1	447558.00	4237770.00	4672761515.61	1892998118.77
KZ2	447369.00	4237603.00	4706572070.01	1914932566.68
KZ3	447199.00	4237532.00	4728351135.98	1930606234.37
KZ4	447042.00	4237379.00	4758173425.61	1949751201.42
KZ5	447058.00	4237584.00	4734212821.48	1937813799.64
KZ6	447223.00	4237695.00	4708429145.19	1920365895.43
KZ7	447381.00	4238098.00	4651305851.98	1888284741.94
KZ8	447353.00	4238276.00	4634142006.57	1880994253.34

Table 4.10 Required values for calculate of deviation from x-axis and y-axis belonging to cumulative standard deviational ellipse in 1998 and 2000 years (n=29) (cont.)

KZ9	447534	4238214	4626179889	1871635413
KZ10	447565	4238027	4644067841	1879165729
KZ11	447460	4237793	4678252204	1898641834
KZ12	447279	4237895	4681869917	1905979325
KY1	412381.56	4409536.98	2333434511	959766859.4
KY2	412318.14	4409576.95	2332867122	958098136.6
KY3	412254.71	4409616.92	2332299224	956430370
KY4	412191.28	4409656.89	2331731395	954764056.1
KY5	412127.85	4409696.86	2331163635	953099195.1
KY6	412064.42	4409736.83	2330595944	951435786.9
KY7	412001	4409776.8	2330028900	949774325.6
KY8	411937.58	4409816.77	2329461924	948114316.2
KY9	411874.15	4409856.74	2328894441	946455265.6
KY10	411858.27	4410014.79	2340220317	951492367.3
KY11	411794.99	4410054.98	2339677261	949845881.1
KY12	411731.7	4410095.18	2339134464	948200695.1
KY13	411668.42	4410135.37	2338591534	946557060.5
KY14	411605.13	4410175.56	2338048088	944914358.9
KY15	411541.84	4410215.76	2337505481	943273451.1
KY16	411478.56	4410255.95	2336962740	941634094.4
KY17	411415.28	4410296.15	2336420836	939996530.2
Total	12370265.88	125822381.5	95911355640	39015021862

$$Sx = \sqrt{2}\sqrt{\frac{39015021862.21}{29}} = 51871.87$$

$$Sy = \sqrt{2}\sqrt{\frac{95911355640.35}{29}} = 81330.05$$

Using the calculated values to draw the cumulative standard deviational ellipse of turbines we achieve:

Mean center = (4338702.81, 426560.89) coordinates

Deviation from the x-axis = 51871.87

Deviation from the y-axis =81330.05

Angle of deviation from the y-axis =11.64

Figure 4.2 shows cumulative mean center, cumulative weighted mean center and cumulative standard deviationsl ellipse in 1998 and 2000. In this figure, although the standard deviational ellipse seems as line, it is a narrow ellipse in fact. Its angle of deviation from the y-axis is 11.64 degrees.

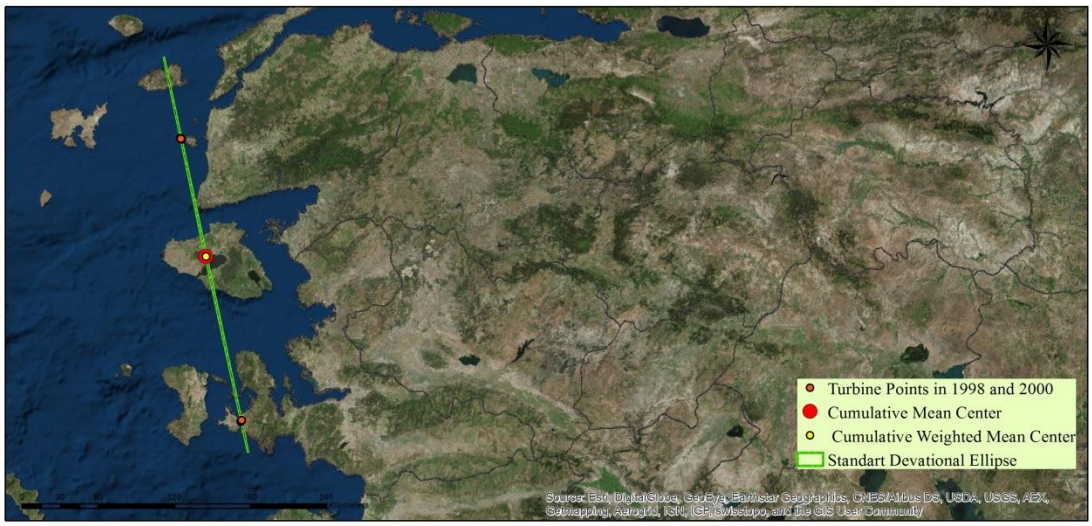

Figure 4.2 Spatial descriptive statistics in 1998 and 2000

4.3 Mean Centers

4.3.1 Mean Centers in Time

For every year since 1998, when the mean centers calculated by wind power plants turbines points, are compared. The mean center is located in Izmir in 1998 because the first plant was installed in Izmir; in 2000, the mean center is located in Canakkale. The second plant was installed in Canakkale followed by in Kutahya in 2003; in Kutahya in 2004; in Izmir in 2005; in Manisa in 2006; in Manisa in 2007; in

Kutahya in 2008; in Mersin in 2009; in Adana in 2010; in Eskisehir in 2011; in Kutahya in 2012; in Usak in 2013; and in Izmir in 2014. This finding shows that the wind power plants are mostly located in the Aegean, Marmara and Eastern Mediterranean Regions. Mean centers of turbine points of wind power plants according to seperate years are given in Figure 4.3.

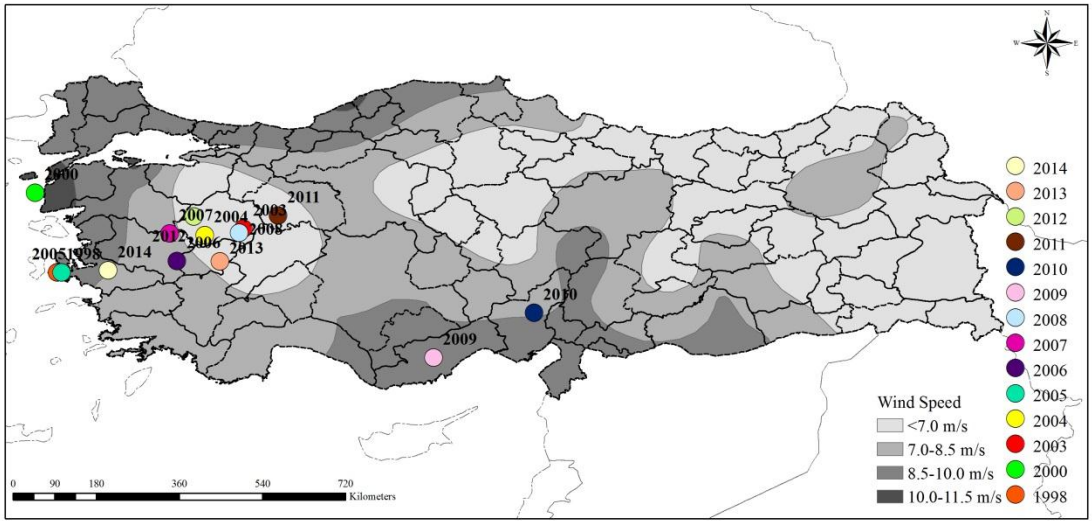

Figure 4.3 Mean centers in time

4.3.2 Cumulative Mean Centers in Time

For every year since 1998, when cumulative mean center calculated by wind power plants turbines points, are compared, the cumulative mean center is located in İzmir, in 1998. That is because it was the first and only plant in Izmir. In 2000, with the establishment of a second plant in Canakkale, the cumulative mean center moves into between Canakkale and Izmir. Since 2003, with an increasing number of wind power plants and the diversity of city selection, the cumulative mean center is located in the Central Anatolia Region. Since 2003, even though the position of the cumulative mean center has changed, it is observed that the cumulative mean centers are located in a certain region. Cumulative mean centers of turbine points of wind power plants, according to cumulative years, are presented in Figure 4.4.

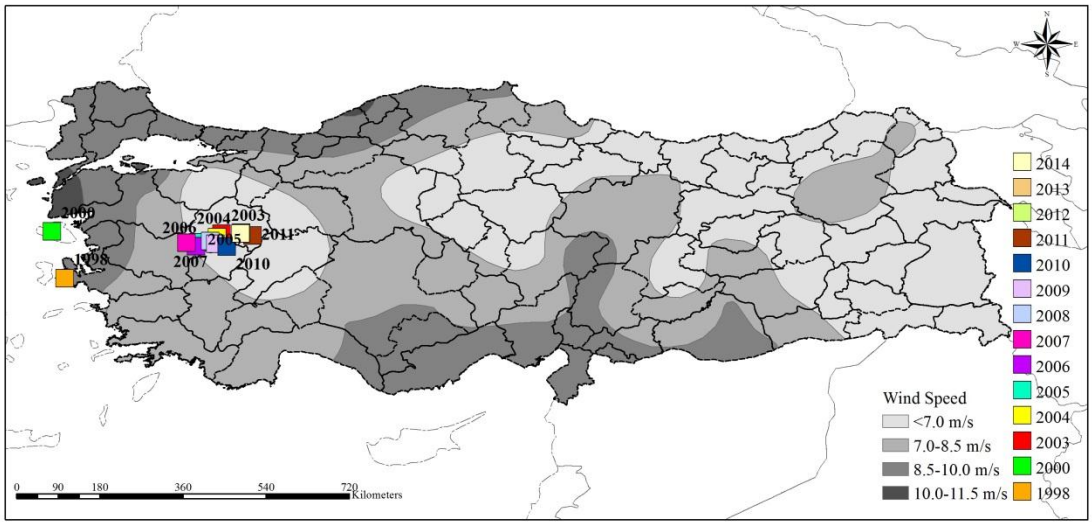

Figure 4.4 Cumulative mean centers in time

4.4 Weighted Mean Centers

4.4.1 Weighted Mean Centers in Time

For every year since 1998, when the weighted mean centers calculated by wind power plants turbines points and weighted by the turbine capacities, are compared, the weighted mean center is located in İzmir in 1998, That is because it was the first and only plant in Izmir; in Canakkale in 2000 because it was the second plant in Canakkale; in Konya in 2003; in Kutahya in 2004; in Izmir in 2005; in Manisa in 2006; in Balikesir in 2007; in Kutahya in 2008; in Mersin in 2009; in Osmaniye in 2010; in Eskisehir in 2011; in Balikesir in 2012; in Afyon in 2013; in Izmir in 2014.

The reason for the mean centers and the weighted mean centers are in different locations is that, the spatial mean centers based on the number of turbines and spatial weighted mean centers gain importance with the value of turbines capacities are different from each other. So, the turbines, even though they are collected in specific cities, turbine capacities which also plant capacities, affect the spatial location of mean centers. In figure 4.5 shows that weighted mean centers of turbine points of wind power plants, according to seperate years.

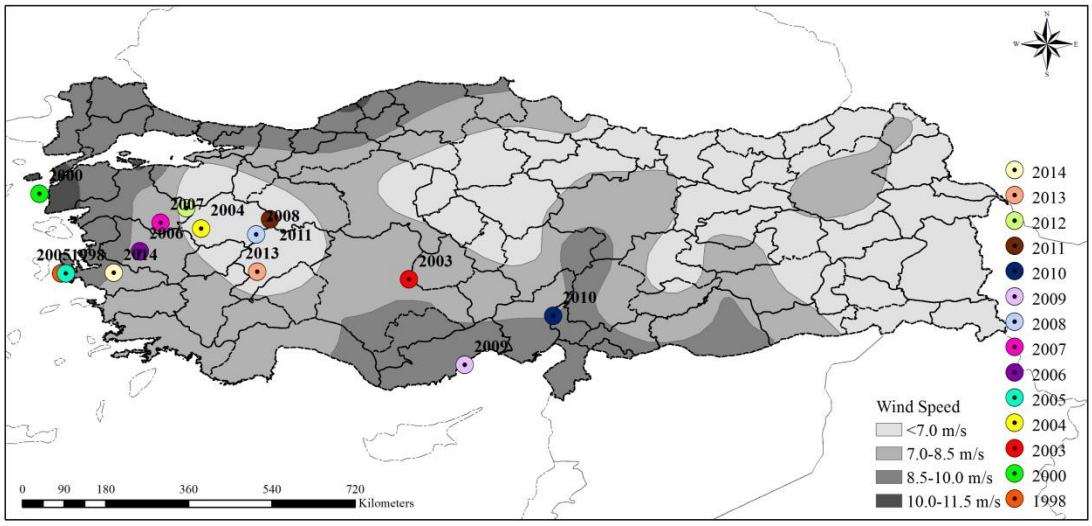

Figure 4.5 Weighted mean centers in time

4.4.2 Cumulative Weighted Mean Centers in Time

For every year since 1998, when weighted mean centers calculated by wind power plants turbines points, are compared, the cumulative weighted mean center is located in Izmir in 1998, that is because it was the first and only plant in Izmir. In 2000, with the establishment of the second plant in Canakkale, cumulative weighted mean center is moved to between Canakkale and Izmir. In 2003, the cumulative weighted mean center is located in Konya, because of the establishment of large-capacity power plants in the Southeastern Anatolian Region and the North Anatolian Region. After the emergence of diversity on site selection, cumulative weighted mean centers are spotted in Kutahya, located around the same area. In figure 4.6, weighted mean centers of turbine points of wind power plants, according to cumulative years, are provided.

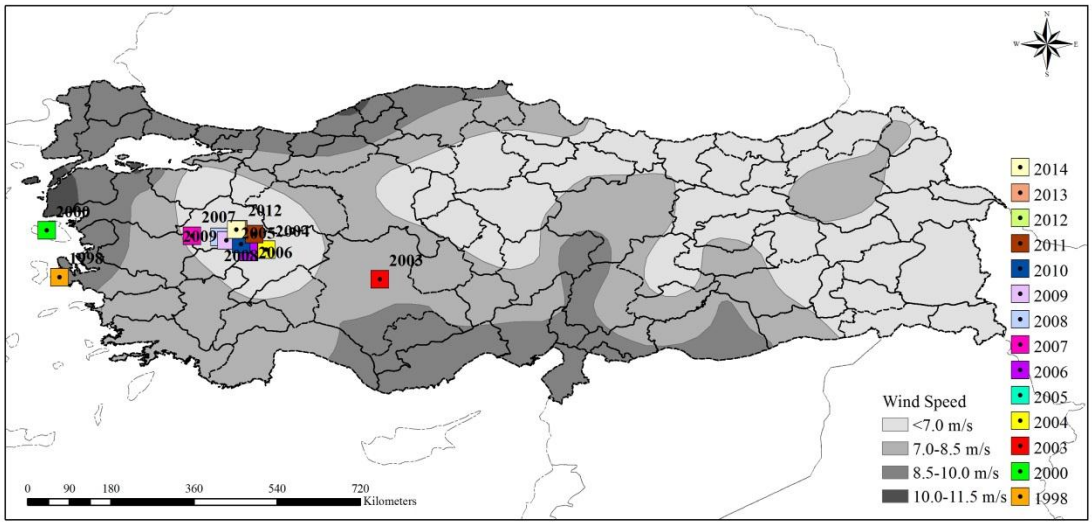

Figure 4.6 Cumulative weighted mean centers in time

4.5 Standard Deviational Elipses

4.5.1 Standard Deviational Elipses in Time

When standard deviational ellipses, that are drawn to describe the spatial distribution of turbine points according to years, are compared; the deviation angle from the y-axis of the standard deviational ellipse is on northeast-southwest direction in 1998 and 2005, because they are positive values. The deviation angle from the y-axis of the standard deviational ellipse is on northwest-southheast direction in 2000, 2003, 2004, 2006, 2007, 2008, 2009, 2010, 2011, 2012, 2013 and 2014, because they are negative values. This situation means that turbine points of wind power plants are usually distributed around the northwest-southeast direction. In figure 4.7, standard deviational ellipses of turbine points of wind power plants according to seperate years, are presented.

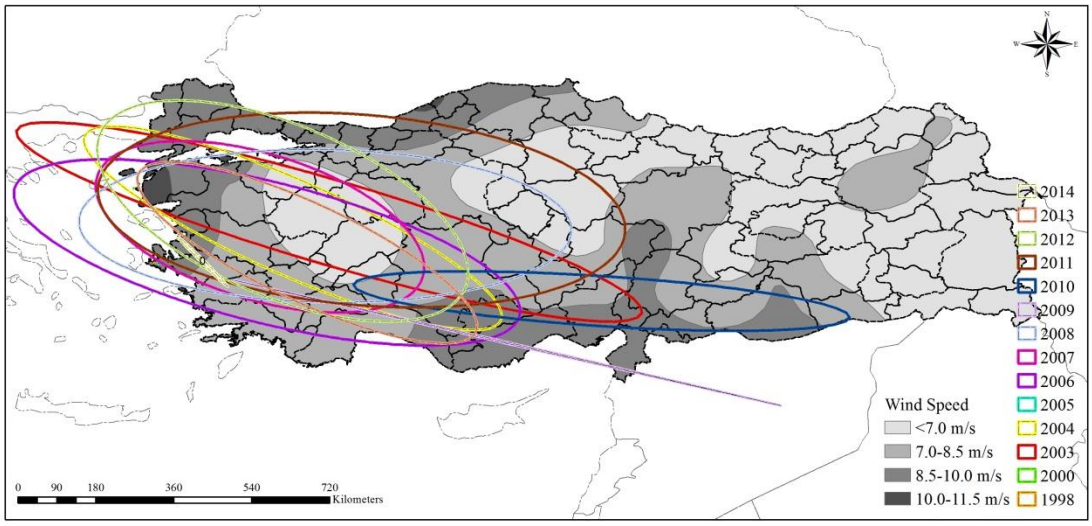

Figure 4.7 Standart deviational elipses in time

4.5.2 Cumulative Standard Deviational Elipses in Time

When the standard deviational ellipses are compared; the deviation angle from the y-axis of the standard deviational ellipse is on the northeast-southwest direction in 1998, because it is a positive value. The deviation angles from the y-axis of the cumulative standard deviational ellipses are on the northwest-southeast direction in 2000, 2003, 2004, 2005, 2006, 2007, 2008, 2009, 2010, 2011, 2012, 2013 and 2014, because they are negative values. This situation means that all of the turbine points of wind power plants are collected on the northwest-southeast direction according to the cumulative years. In figure 4.8, standard deviational ellipses of turbine points of wind power plants, according to cumulative years, are presented.

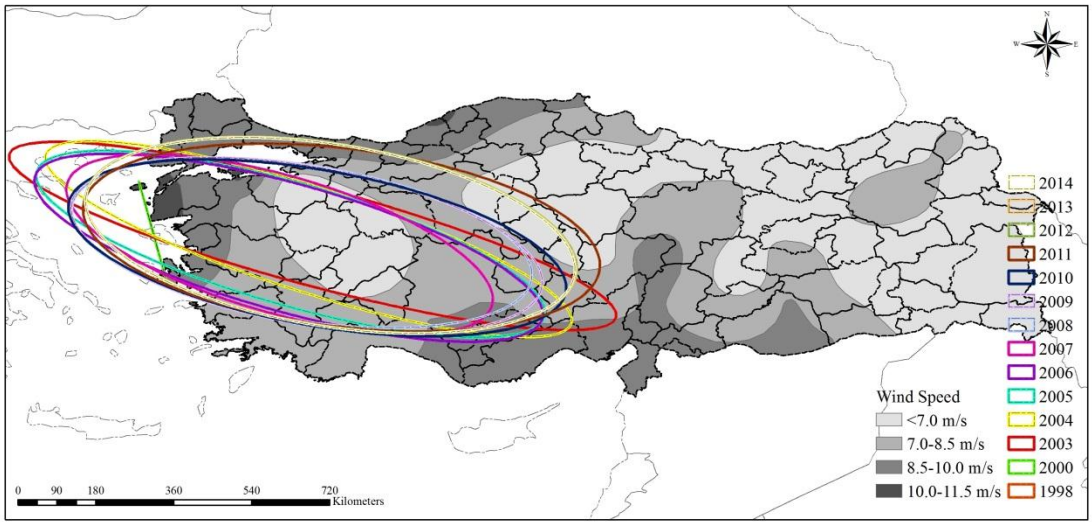

Figure 4.8 Cumulative standart deviational elipses in time

4.6 Analysis of Wind Speed

Renewable Energy General Directorate has prepared a wind energy potential atlas, taking the data of Turkey's wind speed at 50 meters height into consideration. This map has been coordinated by georeferencing in the ArcGIS 10.1 program and is overlaid with turbine points.

When the wind speed and turbine points are evaluated together; in Turkey, it is observed that the wind power plants site selection where wind speed of 7 m/s in the area. This case shows that, site selection of wind power plants are mainly influenced by wind speed of an area. The wind speed must at least be 7 m/h for an economic of RES investment (YEGM, 2015). Figure 4.9 includes wind energy potential atlas and turbine points.

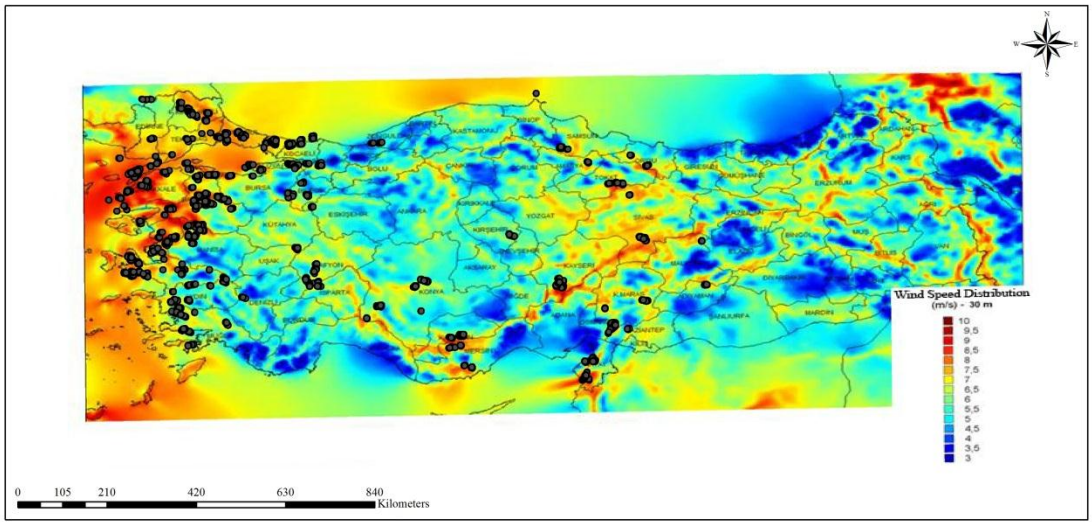

Figure 4.9 Wind speed and turbine points in Turkey

Turkish State Meteorological Service prepared a wind energy potential atlas considering five different topographic situations which are located 50 meters high from sea level. This map has been converted into digitized vector data in the ArcGIS 10.1 program and is overlaid with turbine points.

When the wind speed and turbine points are taken into consideration together; in Turkey, considering that wind power plants are more likely to be constructed on hills and ridges, wind speeds are divided into 4 categories. The table 4.11 given below, consists of these wind speed categories and those wind turbines which are granted production licenses according to years under these categories. In 1998, wind turbines were started to be built in areas with 8.5 - 10.0 m/h wind speed. Even though the wind turbines were constructed in different wind speed category areas since 2007, it is observed that wind turbines are more likely to be collected in areas with 7.0 - 8.5 m/h and 8.5 – 10 m/h wind speed. Figure 4.10 includes wind energy potential atlas and turbine points together.

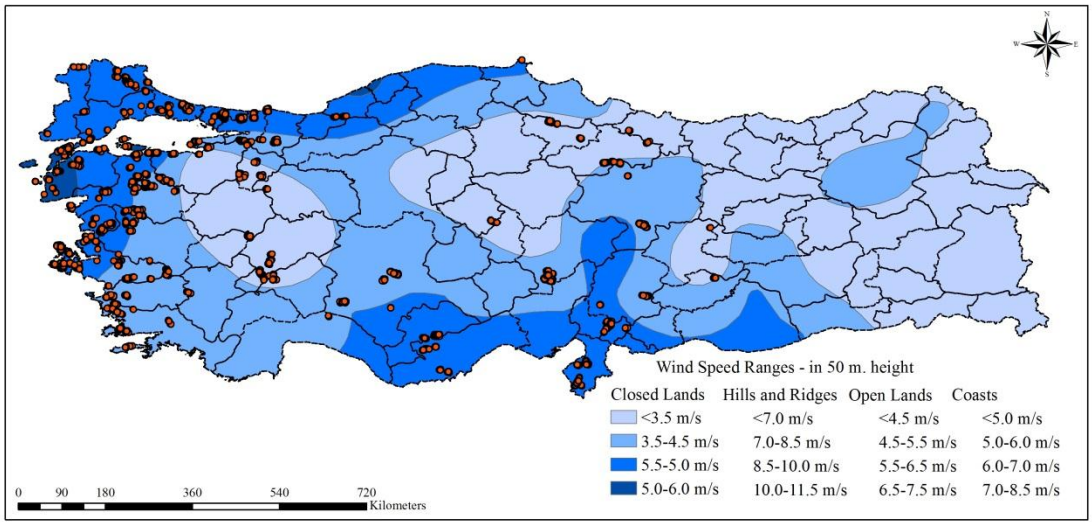

Figure 4.10 Wind speeds and turbine points in Turkey

Table 4.11 Wind turbines in wind speed categories areas in time

Years	<7.0 m/h	7.0 - 8.5 m/h	8.5 - 10.0 m/h	10.0 - 11.5 m/h	Total
1998	0 (0%)	0 (0%)	12 (100%)	0 (0%)	12
2000	0 (0%)	0 (0%)	0 (0%)	17 (100%)	17
2003	0 (0%)	6 (3.57%)	89 (52.98%)	73 (43.45%)	168
2004	0 (0%)	58 (32.95%)	118 (67.05%)	0 (0%)	176
2005	0 (0%)	0 (0%)	55 (100%)	0 (0%)	55
2006	0 (0%)	0 (0%)	77 (93.90%)	5 (6.10%)	82
2007	0 (0%)	299 (55.47%)	226 (41.93%)	14 (2.60%)	539
2008	195 (28.80%)	108 (15.95%)	351 (51.85%)	23 (3.40%)	677
2009	0 (0%)	0 (0%)	40 (100%)	0 (0%)	40
2010	11 (17.46%)	0 (0%)	52 (82.54%)	0 (0%)	63
2011	191 (13.59%)	639 (45.48%)	535 (38.08%)	40 (2.85%)	1405
2012	18 (1.97%)	255 (27.84%)	586 (63.97%)	57 (6.22%)	916
2013	0 (0%)	23 (45.10%)	28 (54.90%)	0 (0%)	51
2014	0 (0%)	17 (62.96%)	10 (37.04%)	0 (0%)	27
Total	415 (9.82%)	1405 (33.23%)	2179 (51.54%)	229 (5.42%)	4228

As Figures 4.11 and 4.12 indicate, wind turbines in Turkey are commonly installed within the locations with 7.0 – 8.5 m/h and 8.5 – 10.0 m/h wind speed

ranges. Additionally, figure 4.11 shows that production licenses are mostly granted in 2011 and 2012 years.

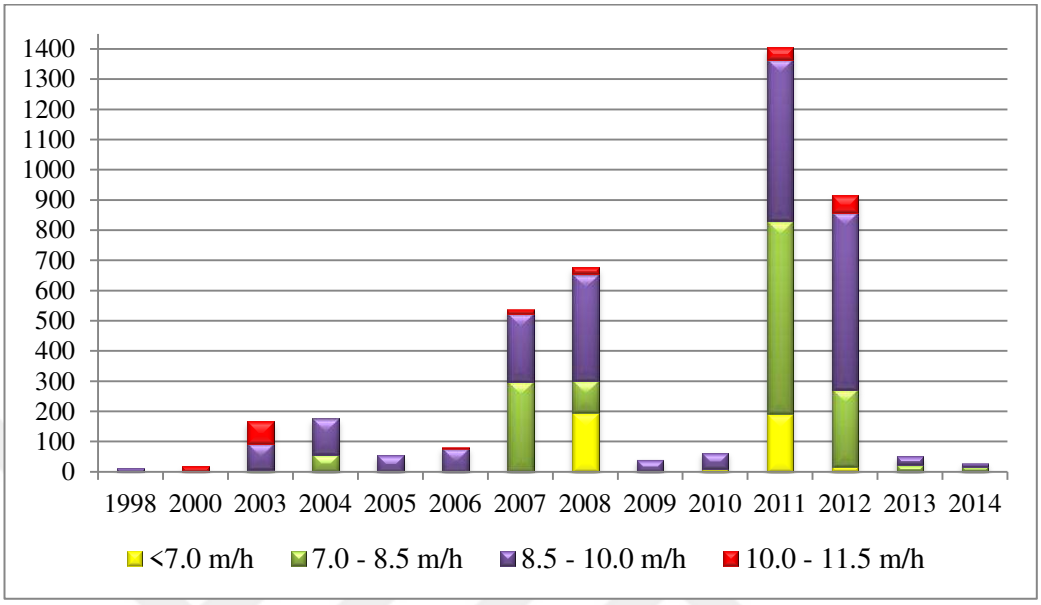

Figure 4. 11 Wind turbines in wind speed categories areas in time

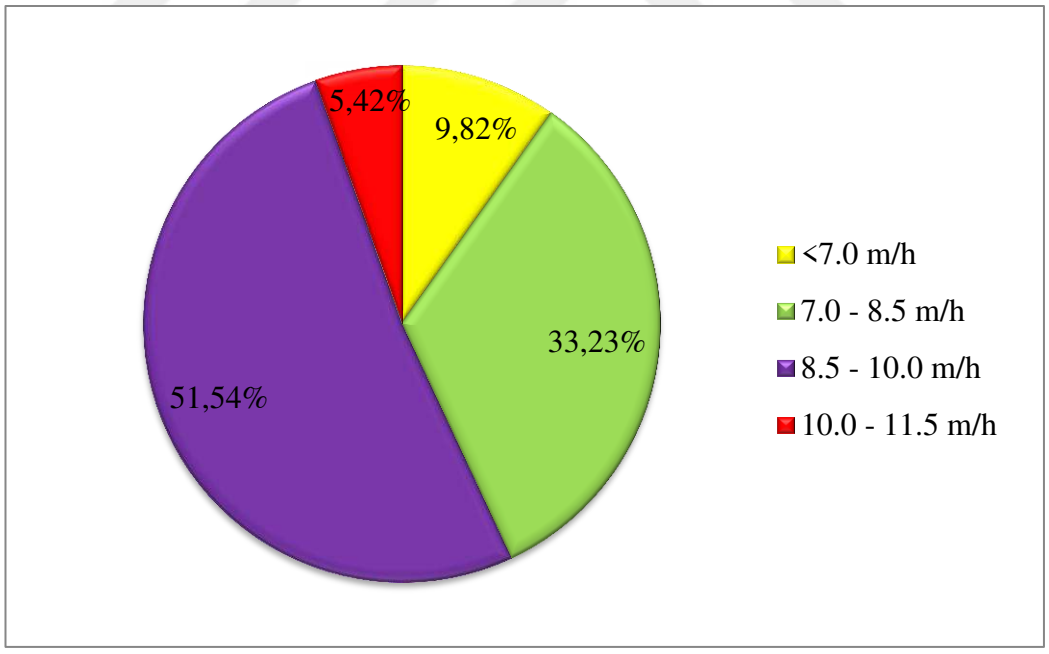

Figure 4. 12 Total wind turbines in wind speed categories areas in 2014

Figure 4.13 shows that cumulative wind turbines in wind speed categories in time and Figure 4.14 includes wind turbines are installed and licensed within the locations with 8.5 – 10.0 m/h wind speed ranges in time.

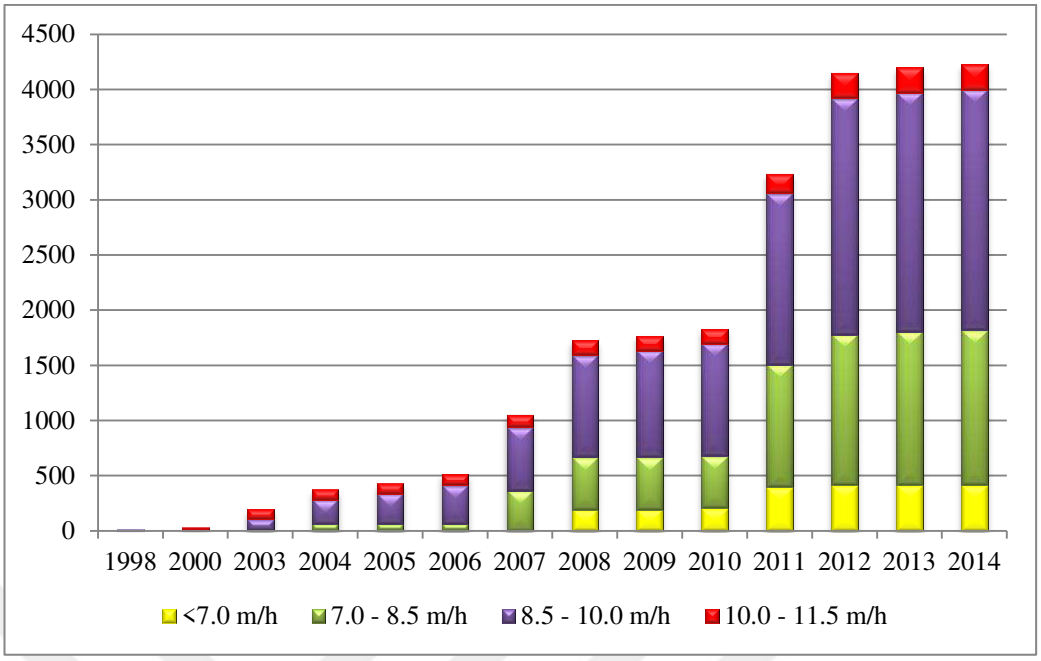

Figure 4. 13 Cumulative wind turbines in wind speed categories areas in time

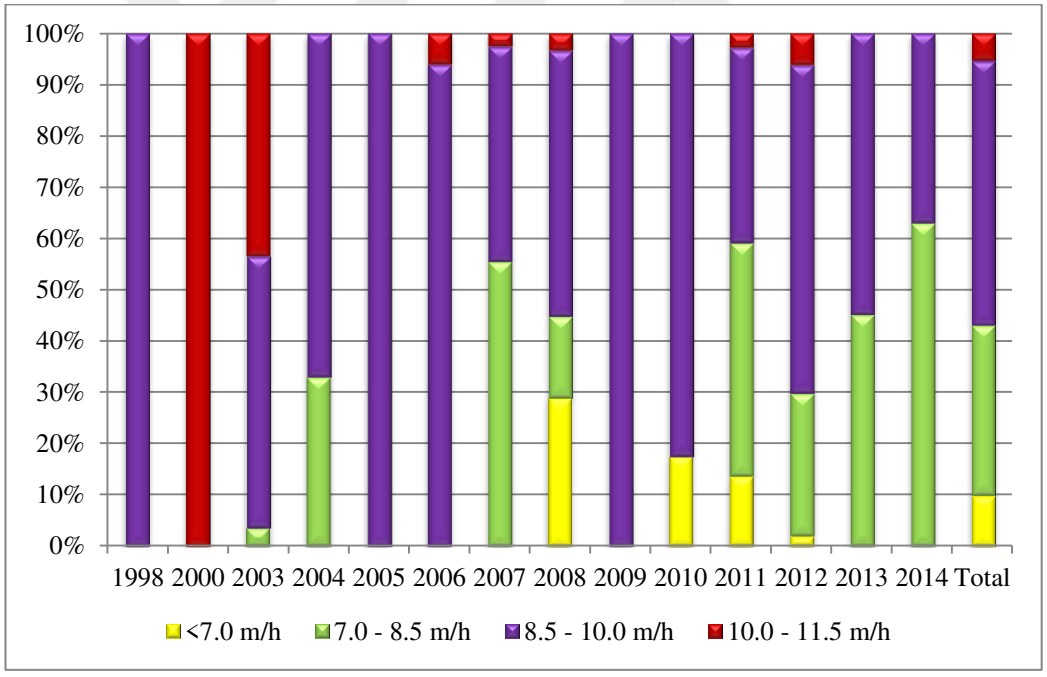

Figure 4. 14 Wind turbines in wind speed categories areas in time (%)

CHAPTER FIVE
CONCLUSION

In developing countries such as Turkey, renewable energy sector grows each day due to increasing demand levels, whether the desired production levels were achieved or not. The process, which was initiated with the establishment of the first plant in 1998, gained momentum over time. However, the growth has shown a decceleration in the recent years. Especially, between the years 2007 and 2012, high amount of production licenses were granted in many cities in Turkey. However, the rate of production licenses granted are deccelerated subsequently. One of the major causes of this situation is the problems which are faced during site selections of the wind turbines. As aforementioned, the locations of wind turbines are mainly affected by the wind speed characteristics of an area. Wind turbines were firstly built around western cities of Turkey. Subsequently, central Anatolia, southern and northern areas of Turkey also become preferable for wind turbines. Nowadays, the main causes of decreasing numbers of production licenses granted by EMRA are the incomplete projects due to the misselection of sites, failures of transformers which are connected to turbines and bureaucratic obstacles.

All of these expressions are closely related to the applicability of planning. Main objective of strategic and development plans in Turkey is to increase the usage of renewable energy, especially wind energy. However, skipping the spatial analysis makes it difficult to manage the project objectives and achieve the desired goals. Moreover, spatial areas are not determined for wind power plants in the 1/100,000 and 1/25,000 scale. Only supporting and implementing terms related to energy are mentioned in the plan notes.

This study is conducted using the data collected from provinces of Turkey. In the framework of planning, findings of the study highlight whether any of the energy policy set out in the development plan, how wind turbines are distributed according to spatial location, whether this locational dispersion changes over time, whether there is a relationship between wind speeds and site selections of wind turbines and whether turbine capacities affect the selection of location and dispersion.

By following a comprehensive approach, it is possible to observe that the spatial site selection of wind power plants in Turkey changed and slightly throughout the years. GIS and spatial statistical methods that are applied in order to observe site selection criterias of wind power plants, indicate that wind power plants are located in specific regions. As a result, despite of being among the developing countries, Turkey has shown a rapid development in adapting wind power in comparison to developed countries. From this perspective, this study has become an available source for planning discipline. These are the main conclusions from this study, which were prepared based on Energy Market Regulatory Authority data.

In the Development Plans that were started to be prepared after 1963, primarily hydrolic energy was mentioned as one of the renewable energy resources and the importance of planning a development policy were highlighted. The Development Plans were put into practice by 5 years intervals and policies regarding to wind power plants were firstly defined in the 8th Development Plan.

Even though the energy policies were not developed in compliance with the targets of the development plans, build-operate-transfer model was put into practice since the Sixth Five Year Development Plan. And the usage rate of renewable energy resources in electricity production increased since the Eighth Five Year Development Plan.

Across the world, not only the wind speed factors but also the effects on bird migration routes, effects on life and health such as aesthetics and noise, effects on natural reserves, effects on the environment and ecosystem are taken into consideration, while selecting the sites for wind power plants. Despite of consulting institutions and organizations when determining locations for wind plants, suggestions are tend to be restrictive and prohibitive. Therefore, while consulting an organization for receiving suggestions, it is expected to ignore the environmental impacts of wind plants and indicate that the scope of project is subjected to public interest.

When the first power station was installed in 1998, wind power industry was not defined legally. However, the process started with the establishment of the Energy Market Regulatory Authority in 2001, and has gained great momentum as private companies have started receiving the production licenses from the Energy Market Regulatory Authority in 2003.

Regardless of evaluating as separate for every year or cumulative throughout the years, site selection of wind power plants have not been changed remarkably and these wind plants are gathered in certain regions. These particular regions are Aegean, Marmara and Eastern Mediterranean, where the wind speed is the most suitable. This study proves that, wind speed is the primary factor that is considered during the decision making process of selecting the best location for wind power plants.

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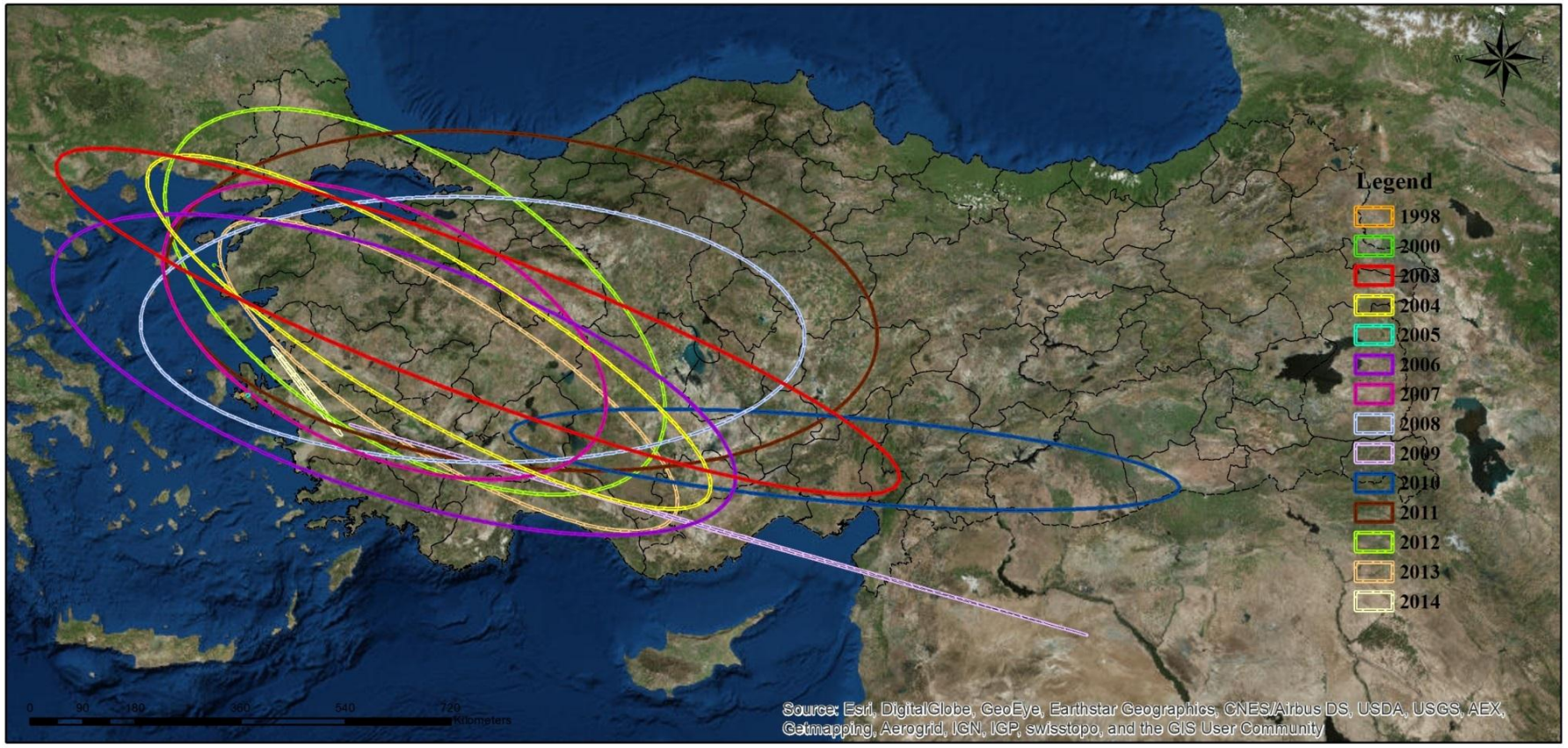
APPENDICES

Appendix- 1: Mean Centers in Time.

Appendix- 2: Weighted Mean Centers in Time.

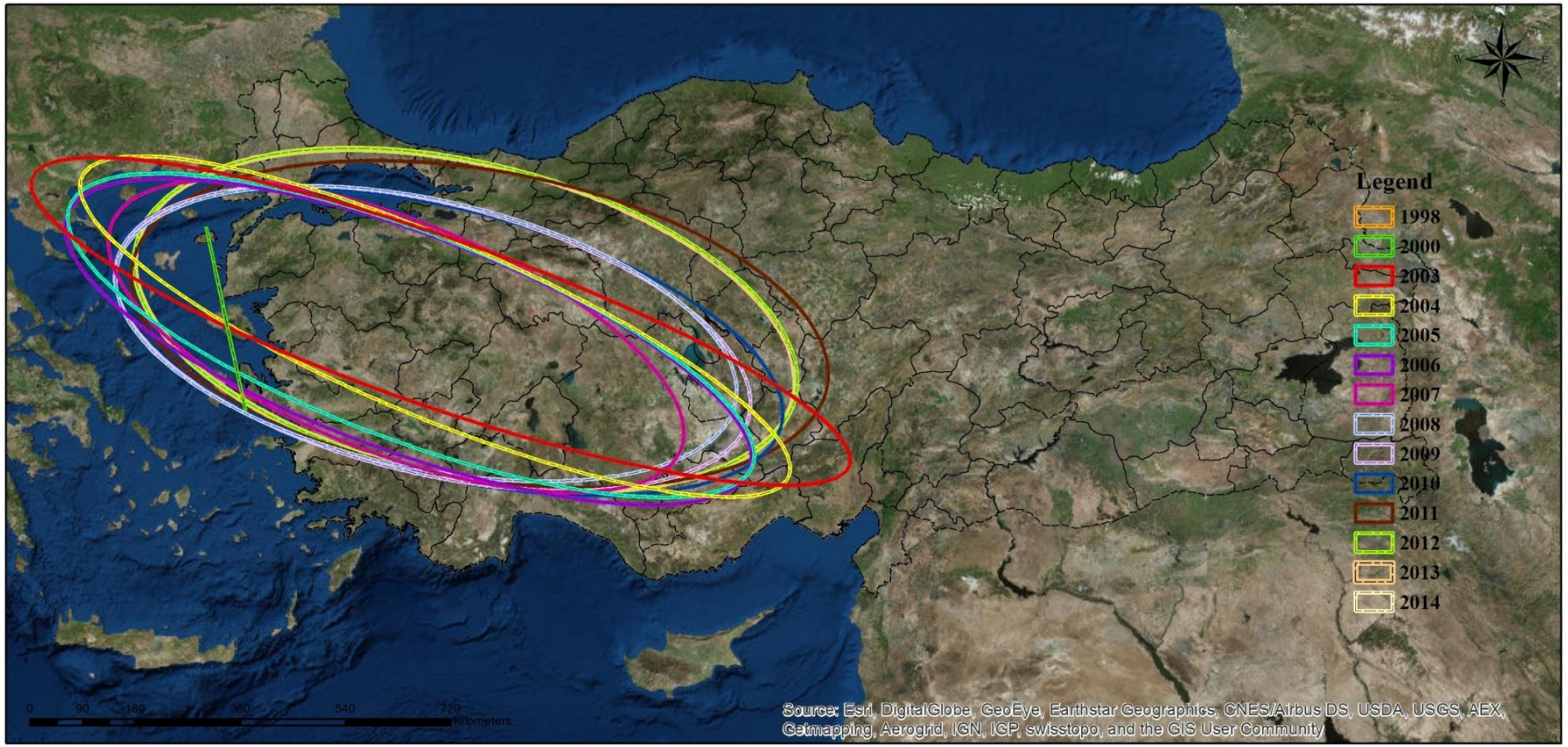
Appendix- 3: Standard Deviational Ellipses in Time.



Appendix- 4: Cumulative Mean Centers in Time.

Appendix- 5: Cumulative Weighted Mean Centers in Time.

Appendix- 6: Cumulative Standard Deviational Ellipses in Time.



Appendix- 7: Wind Power Plants in Turkey in Time. (From page 68 up to page 105)

ID	License No	Start / Effectiand Date	End Date	Name	City	Country	Installed Power (Mwm)	Installed Power (Mwe)	Capacity of Installed (Mwe)	Title
A	EU/4991-9/02971	01.05.2014	01.02.1960	PETKIM	IZMIR	ALIAGA	25	25	0	Petkim Petrochemical Holding Inc.
B	EU/4991-11/02970	01.05.2014	05.06.2018	HADIMKOY-ISTANBUL	ISTANBUL		1.2	1.2	1.2	Sunjut Sun'i Jut Industry and Trade Inc.
D	EU/4817-12/02655	09.01.2014	08.12.1960	TIRE	IZMIR	TIRE	50	50	0	Duzhan Energy Production and Trade Inc.
F	EU/4729-1/02637	26.06.2013	20.09.1961	OVARES	AYDIN	KOSK	15	15	0	Ay RES Electricity Production Inc.
G	EU/4584-1/02629	05.09.2013	12.01.1961	KALFAKOY RES	BALIKESIR	GONEN	10	10	0	Kirca Energy Production and Trade Inc.
H	EU/4325-23/02591	27.03.2013	26.03.1962	MUT	MERSIN	MUT	50	50	0	Guney Wind Energy Production and Trade Inc.

I	EU/4249-3/2534	24.01.2013	15.03.1961	KORUDAGI	TEKIRDAG	MALKARA	3	3	0	Demir RES Power Generatıon Engineering Inc.
J	EU/4270-2/02549	12.02.2013	12.02.1962	ALIAGA	IZMIR	ALIAGA	9.6	9.6	0	Tan Electric Production Inc.
K	EU/4220-20/2527	03.01.2013	03.01.1962	POYRAZ	BALIKESIR		30	30	0	NM Energy Electric Production Inc.
L	EU/4194-6/2496	20.12.2012	20.12.1961	SILE	ISTANBUL	SILE	50	50	0	Cevrım Electric Production Inc.
M	EU/4145-2/2481	06.12.2012	06.12.1961	HARMANLIK	BURSA	KARACABEY	52.8	50	0	Eskoda Energy Productıon Marketıng Import And Export Inc.
N	EU/4129-17/2478	22.11.2012	22.11.1961	GAZI-9	CANAKKALE	GELIBOLU	51	51	0	Gazıres Electricity Production Industry and Trade Inc.
O	EU/4129-2/2474	22.11.2012	22.11.1961	ESENKOY	YALOVA	CINARCIK	18.45	18.45	0	Marmara RES Electricity Production Inc.

P	EU/4074-24/2457	18.06.2012	18.06.1961	GOZTEPE RES	CANAKKALE	AYVACIK	3	3	0	Basak Klima Electricity Production and Service of Wind Energy Plants Ltd.
R	EU/4074-2/2451	18.10.2012	18.10.1961	SAROS	CANAKKALE	GELIBOLU	138	138	0	Boylam Energy Production Inandstment Trade Inc.
S	EU/4052-20/2443	03.10.2012	03.10.1961	KURTINI	MERSIN	GULNAR	14	14	0	Denge Energy Production Industry And Trade Inc.
T	EU/4027-11/2435	20.09.2012	20.09.1961	OVARES	AYDIN	KOSK	15	15	0	Bagci Electrical Energy Production Inc.
U	EU/3961-4/2401	09.08.2012	09.08.1961	YENIKOY	CANAKKALE	GELIBOLU	48	48	0	Mutlu Gelibolu Electricity Production, Inandstment, Construction, Industry and Trade Inc.
V	EU/3925-7/2385	18.07.2012	18.07.1961	YAGCILAR	IZMIR	URLA	10	10	0	Varyap Varlibaslar Constructıon İndustry Tourism Inandstments

										Trade and Electricity Production Inc.
Y	EU/3905-9/2378	05.07.2012	05.07.1961	MERSINLI	IZMIR	BAYINDIR	55	55	0	Yander Electricity Engineering Construction Tourisn and Trade Inc.
Z	EU/3898-4/2362	28.06.2012	28.06.1961	AKKUS	ORDU	AKKUS	10	10	0	Hns Energy Production Ltd.
AA	EU/3898-3/2361	28.06.2012	28.06.1961	BARBAROS	TEKIRDAG	SARKOY	12	12	0	Andrim Energy Inandstment Production Trade Inc.
AB	EU/3887-5/2355	21.06.2012	14.02.1961	TATLIPINAR RES	BALIKESIR	MERKEZ	125	125	0	Tatlipinar Energy Production Inc.
AC	EU/3887-2/2354	21.06.2012	21.02.1960	BAGLAR RES	KONYA	MERKEZ	100	100	0	Baglar Electricity Production Inc.
AD	EU/3860-4/2340	06.06.2012	06.06.1961	ORTAMANDI RA	BALIKESIR	MERKEZ	14.4	10	0	Serin Energy Elektricity Production Distribution Marketing Industry and Trade Inc.

AE	EU/3860-3/2339	06.06.2012	06.06.1961	YENIKOY	CANAKKALE	GELIBOLU	15	15	0	Ayes Electricity Production Inc.
AF	EU/3860-2/2338	06.06.2012	06.06.1961	ORHANLI	HATAY		9	9	0	Elestas Electricity Production Inc.
AG	EU/3860-1/2337	05.07.2011	05.07.1960	DIKILI	KOCAELI	KANDIRA	5	5	0	Ydabay Electricity Production Ltd.
AH	EU/3821-3/2325	09.05.2012	05.09.1961	KOCATEPE	MANISA	KIRKAGAC	25	25	0	Dunya Energy Production Inc.
AI	EU/3821-2/2324	09.05.2012	09.05.1961	GULLUK	MUGLA	BODRUM	33	33	0	Yıldız Energy Electricity Production Inc.
AJ	EU/3760-10/2310	04.04.2012	04.04.1961	KUPTEPE	ISTANBUL	CATALCA	10	10	0	Simay Electricity Production Inc.
AK	EU/3760-9/2309	04.04.2012	04.04.1961	AKYEL-1	KARAMAN	MERKEZ	40	40	0	Akyel RES Electricity Production Industry and Trade Inc.
AL	EU/3749-4/2300	28.03.2012	28.03.1961	KIYIKOY	TEKIRDAG	SARAY	44	44	0	Besiktepe Production and Trade Ltd.

AM	EU/3749-3/2299	28.03.2012	28.03.1961	HILAL-2	KARAMAN	MERKEZ	7	7	0	Hilal RES Electricity Production Industry And Trade Inc.
AN	EU/3749-2/2298	28.03.2012	28.03.1961	AIRRES-4	KIRKLARELI	VIZE	55	55	0	Air RES Electricity Production Industry And Trade Inc.
AO	EU/3741-2/2293	22.03.2012	22.03.1961	KIZILCATERZI	EDIRNE	KESAN	14.4	12	0	Os RES Wind Energy Production Industry And Trade Inc.
AP	EU/3734-17/2288	15.03.2012	03.03.1960	AYDOS	ISTANBUL	USKUDAR	14	14	0	Serbest Energy Industry And Trade Inc.
AR	EU/3734-14/2285	15.03.2012	15.03.1961	MASLAKTEPE	CANAKKALE	GELIBOLU	20	20	0	Eni Energy Construction Commitment Trade And Industry Inc.
AS	EU/3734-2/2279	15.03.2012	15.03.1961	KORUDAGI	TEKIRDAG	MALKARA	3	3	0	Sone Energy Invesment Production And Trade Inc.

AT	EU/3721-9/2273	04.08.2011	04.08.1960	EDINCIK RES	BALIKESIR	BANDIRMA	45	30	0	Edincik Energy Production Inc.
AU	EU/3721-8/2272	08.03.2012	08.03.1961	KINIK	IZMIR	KINIK	50	50	0	Esinti Energy Production Trade And Industry Inc.
AV	EU/3721-1/2269	08.03.2012	08.03.1961	ELMALI	MERSIN		27	27	0	Hanay Electricity Production Inc.
AY	EU/3712-4/2263	01.03.2012	01.03.1961	CERCIKAYA	HATAY	ISKENDERUN	53	53	0	Zt Energy Elektricity Production Industry And Trade Inc.
AZ	EU/3712-3/2262	01.03.2012	01.03.1961	HASANOBA	CANAKKALE	MERKEZ	51	51	0	Kovanci Energy Production Marketing Import And Export Inc.
BA	EU/3712-2/2261	01.03.2012	01.03.1961	GUNDOGDU	BURSA	GEMLIK	9	9	0	Turkay Electricity Production from Alternative Energy Industry And Trade Ltd.
BB	EU/3712-	01.03.2012	01.03.1961	OZBEK	HATAY	SAMANDA	24	24	0	Gyy Electricity

	1/2260					G				Production Inc.
BC	EU/3703-17/2256	23.02.2012	23.02.1961	FUATRES	IZMIR	KEMALPASA	30	30	0	Fuat RES Electricity Production Inc.
BD	EU/3703-16/2255	23.02.2012	23.02.1961	KARABEL	IZMIR	KEMALPASA	3	3	0	Ener Electricity Energy Production Inc.
BE	EU/3703-15/2254	23.02.2012	11.11.1960	MANASTIR	YALOVA	CINARCIK	12	12	0	Manastir Electricity Production Plants Inc.
BG	EU/3696-3/2248	15.02.2012	14.02.1961	SADILLI	EDIRNE	KESAN	38.5	33	0	Can RES Wind Energy Production Industry And Trade Inc.
BH	EU/3683-28/2245	09.02.2012	09.02.1961	SENBUK	HATAY	BELEN	27	27	27	New Belen Energy Electricity Production Industry And Trade Inc.
BI	EU/3683-27/2244	09.02.2012	09.02.1961	SAPDAGI	BALIKESIR	HAVRAN	55	55	0	Barkan Energy Investment Production Trade Inc.
BJ	EU/3683-	09.02.2012	09.02.1961	BERGAMA	IZMIR	BERGAMA	25	25	0	Andnto Electricity

	26/2243									Production Inc.
BK	EU/3683-25/2242	09.02.2012	09.02.1961	AKYAR	MUGLA	BODRUM	15	15	0	Wind Electricity Production Ltd.
BL	EU/3683-7/2239	09.02.2012	09.02.1961	BERGRES	IZMIR	BERGAMA	70	70	0	Berg RES Electricity Production Inc.
BM	EU/3683-6/2238	09.02.2012	09.02.1961	GERES	MANISA	KIRKAGAC	30	30	0	Ge RES Electricity Production Inc.
BN	EU/3683-5/2237	09.02.2012	09.02.1961	KAVAKLI	BALIKESIR	MERKEZ	50	50	0	Briza Wind Electricity Production Industry And Trade Inc.
BO	EU/3683-4/2236	09.02.2012	09.02.1961	G RES	CANAKKALE	GELIBOLU	5	5	0	Bahar Energy Electricity Production Industry And Trade Ltd.
BP	EU/3683-3/2235	09.02.2012	09.02.1961	GOKRES-2	MANISA	AKHISAR	35.75	35	0	Garet Energy Production And Trade Inc.

BR	EU/3683-2/2234	09.02.2012	09.02.1961	EVRENCIK	KIRKLARELI	VIZE	120	120	0	Evrencik Electricity Production from Wind Energy Ltd.
BS	EU/3680-3/2232	01.02.2012	01.02.1961	GERIS	MUGLA	BODRUM	11.2	11.2	0	Wind Electricity Production Ltd.
BT	EU/3663-4/2224	26.01.2012	26.01.1961	PITANE	IZMIR	DIKILI	5	5	0	Bicakcilar Candarli Electricity Production Ltd.
BU	EU/3648-21/2220	18.01.2012	18.01.1961	OMERLI	ISTANBUL	SILE	100	100	0	Betim Energy Investment Production And Trade Inc.
BV	EU/3648-20/2219	18.01.2012	18.01.1961	GAZIOSMAN PASA RES	ISTANBUL	GAZIOSMA NPASA	50	50	0	Oz-Yel Electricity Production Ltd.
BZ	EU/3648-5/2213	18.01.2012	18.01.1961	CAKIL	ISTANBUL	CATALCA	52.5	52.5	0	Bali Wind Electricity Production Industry And Trade Inc.
CA	EU/3640-1/2207	12.01.2012	12.01.1961	AKBUK	MUGLA	MILAS	20	20	0	Ayen Energy Inc.

CB	EU/3634-25/2206	10.01.2012	10.01.1961	AKDAG	KONYA	BEYSEHIR	23	23	0	Ahsen Energy Production Trade And Industry Inc.
CD	EU/3628-3/2203	05.01.2012	05.01.1961	KIRKAGAC	MANISA	KIRKAGAC	45	45	0	Babadag Electricity Production Industry And Trade Inc.
CE	EU/3619-2/2202	04.01.2012	04.01.1961	SOKE RES	AYDIN	SOKE	45	45	0	Soke Electricity Production Plants from Wind Energy Ltd.
CF	EU/3619-1/2201	04.01.2012	04.01.1961	CATALTEPE	ISTANBUL	CATALCA	10	10	0	Super Electricity Production Inc.
CG	EU/3597-5/2200	28.12.2011	28.12.1960	CATALTEPE	ISTANBUL	KARTAL	4	2	0	Grc Renewable Energy Production Industry And Trade Ltd.
CH	EU/3597-4/2199	28.12.2011	28.12.1936	YAPRAK	KIRKLARELI	MERKEZ	15	15	0	Iberdrola Energy Production from Renewable Energy Sources Trade And Industry Ltd.

CJ	EU/3584-23/2194	27.12.2011	27.12.1960	AKYURT	TOKAT	MERKEZ	12.8	12.8	0	Ado Energy Production Industry And Trade Inc.
CK	EU/3584-21/2192	27.12.2011	27.12.1960	KUYULUKOYAK	KONYA	DEREBUCAK	16	16	0	Aladag Wind Energy Production Industry And Trade Inc.
CL	EU/3570-7/2181	22.12.2011	22.12.1960	YUVACIK	KOCAELI	GOLCUK	120	120	0	Yuva Energy Investment Production And Trade Inc.
CM	EU/3570-5/2180	22.12.2011	22.12.1960	KOCALAR	CANAKKALE	MERKEZ	26	26	0	Isider Energy Production Marketing Import And Export Inc.
CN	EU/3570-2/2179	22.12.2011	22.12.1960	KORU	CANAKKALE	LAPSEKI	52.8	50	0	Eskoda Energy Production Marketing Import And Export Inc.
CO	EU/3553-12/2178	20.12.2011	20.12.1960	EGE	IZMIR	KEMALPASA	8	7	0	Meltem Energy Production Ltd.
CP	EU/3553-9/2177	20.12.2011	20.12.1960	PAMUKOVA	SAKARYA	PAMUKOVA	20	20	0	Pamukova Wind Energy Invesment Production And Trade

										Inc.
CR	EU/3519-37/2164	01.12.2011	01.12.1960	ALAPINAR	MUGLA	BODRUM	3.4	0.8	0	Gokova Electricity Production And Trade Ltd.
CV	EU/3519-36/2163	01.12.2011	01.12.1960	YAMACTEPE-2	ISTANBUL	CATALCA	30	30	0	Sancak Energy Services Inc.
CY	EU/3519-7/2158	21.04.2011	21.04.1960	ZINCIRLI	KAYSERI	YAHYALI	12	12	0	Rea Electricity Production Trade And Industry Ltd.
CZ	EU/3519-4/2155	01.12.2011	01.12.1960	ERTAN	ISTANBUL	SILIVRI	3	3	0	Ertan Energy Electricity Production Inc.
DA	EU/3519-3/2154	01.12.2011	01.12.1960	CAMINBASI	ANTALYA	IBRADI	27	27	0	Esin Wind Energy Production Industry And Trade Inc.
DC	EU/3498-11/2145	17.11.2011	17.11.1960	YAHYALI	KAYSERI	YAHYALI	52.5	52.5	0	Se Santral Electricity Production Industry And Trade Inc.

DD	EU/3498-2/2144	17.11.2011	17.11.1960	MAHYADAG	KIRKLARELI	PINARHISAR	30	30	0	Mb Electricity Production Ltd.
DE	EU/3498-1/2143	17.11.2011	17.11.1960	POLAT 2	SAMSUN	HAVZA	9	9	0	Polat Electricity Production Construction Import Export Inc.
DF	EU/3490-17/2141	11.11.2011	11.11.1960	GUNAYDIN	BALIKESIR	MANYAS	12.5	10	10	Man RES Wind Energy Production Industry And Trade Inc.
DG	EU/3490-16/2140	11.11.2011	11.11.1960	MARMARA	BALIKESIR	MARMARA	10	10	0	Babadag Electricity Production Industry And Trade Inc.
DH	EU/3490-15/2139	11.11.2011	11.11.1960	CATALBUK	AYDIN	SOKE	25	25	0	Abk Energy Electricity Production Inc.
DI	EU/3490-14/2138	11.11.2011	11.11.1960	PASALIMANI	BALIKESIR	ERDEK	0.8	0.8	0.8	Rk Wind Energy Plants Electricity Production Industry And Trade Ltd.

DJ	EU/3490-13/2137	11.11.2011	11.11.1960	KARADERE	KIRKLARELI	MERKEZ	16	15	0	Aysu Energy Industry And Trade Inc.
DK	EU/3490-12/2136	11.11.2011	11.11.1960	MAHMUT SEVKET PASA-2	KOCAELI	KORFEZ	100	100	0	Denizhan Energy Invesment Production And Trade Inc.
DL	EU/3490-11/2135	11.11.2011	11.11.1960	HAVZA	SAMSUN	HAVZA	48	48	0	Ekim Electricity Engineering Construction Tproduction And Trade Ltd.
DM	EU/3490-10/2134	11.11.2011	11.11.1941	YILMAZ	IZMIR	MENEMEN	12.5	12.5	0	Capar Electricity Production Ltd.
DN	EU/3490-8/2132	11.11.2011	11.11.1960	HASANBEYLI	OSMANIYE	HASANBEYLI	50	50	17.5	Hasanbeyli Energy Inc.
DO	01.11.2011	01.11.1960		ADA 2	BALIKESIR	MARMARA	4.6	3.2	-	Esit Energy Inc.
DP	EU/3474-38/2118	26.10.2011	26.10.1960	KARTAL	ESKISEHIR	TEPEBASI	39	39	0	Bay Clean Energy Electricity Production Construction Industry And Trade Inc.

DR	EU/3474-7/2115	26.10.2011	26.10.1960	GERMIYAN RES	IZMIR	URLA	9.6	9.6	0	Gural Porcelain Production And Sanitaryware Industry Inc.
DS	EU/3474-6/2114	26.10.2011	26.10.1960	YALOVA	BURSA	GEMLIK	50	50	0	Yares Electricity Production Inc.
EA	EU/3465-1/2094	20.10.2011	20.10.1960	FENER	SINOP	MERKEZ	6	5	0	Orsa Energy Electricity Production And Trade Inc.
EB	EU/3474-5/2113	26.10.2011	26.10.1960	ILBIR	MUGLA		50	50	0	Alanoba Electricity Production Distribution Industry And Trade Inc.
EC	EU/3465-6/2098	20.10.2011	20.10.1960	DATCA	MUGLA	DATCA	12	12	0	Koni Construction Industry Inc.
ED	EU/3465-5/2097	20.10.2011	20.10.1960	DEMIROZU	SIVAS	YILDIZELI	37	37	0	Gundogdu Wind Energy Production Industry And Trade Inc.

EE	EU/3465-3/2096	20.10.2011	20.10.1960	GEYAND	SAKARYA	GEYAND	50	50	0	Hacim Energy Investment Production And Trade Inc.
DT	EU/3465-1/2094	20.10.2011	20.10.1960	FENER	KARABUK	SAFRANBOLU	6	5	0	Or Sa Energy Electricity Production And Trade A.S.
DU	EU/3446-5/2091	06.10.2011	06.10.1960	SALMAN	IZMIR	KARABURUN	27.5	20	20	Ores Electricity Production Inc.
DV	EU/3446-4/2090	06.10.2011	06.10.1960	ICDAS BIGA RES	CANAKKALE	BIGA	60	60	0	Icdas Steel Energy Shipyard And Transportation Industry Inc.
DZ	EU/3433-11/2086	29.09.2011	29.09.1960	SILIVRI RES	ISTANBUL	SILIVRI	57.5	45	0	Silivri Energy Inc.
DZZ	EU/3433-10/2085	29.09.2011	29.09.1960	UCPINAR	CANAKKALE	LAPSEKI	99	99	0	Derbent Energy Production Marketing Import And Export Inc.
EG	EU/3433-9/2084	29.09.2011	29.09.1960	MUGLA	MUGLA	MERKEZ	77.4	77.4	0	Derne Clean Energy Production Inc.

EH	EU/3424-5/2071	19.09.2011	19.09.1960	KONAKPINAR	SIVAS	GURUN	12	12	0	Ado Energy Production Industry And Trade Inc.
EI	EU/3417-3/2066	15.09.2011	15.09.1960	KURTKAYA	KAYSERI		45	45	0	Are Electricity Production Trade And Industry Ltd.
EJ	EU/3409-2/2061	07.09.2011	07.09.1960	YAHYALI	KAYSERI		82.5	82.5	0	Bak Energy Production Inc.
EK	EU/3382-14/2059	18.08.2011	18.08.1960	KARABURUN	IZMIR	KARABURUN	223	120	120	Lodos Karaburun Electricity Production Inc.
EM	EU/3382-13/2053	18.08.2011	18.08.1960	BAGARASI	AYDIN	KOCARLI	48	46	0	Kutle Energy Investment Production And Trade Inc.
EN	EU/3382-12/2052	18.08.2011	18.08.1960	POYRAZGOLU	BALIKESIR	KEPSUT	30	30	0	Ufuk Energy Electricity Production Inc.
EO	EU/3382-11/2051	18.08.2011	18.08.1960	CANTA	ISTANBUL	SILIVRI	47.5	45	0	Bora Wind Electricity Production Industry

										And Trade Inc.
EP	EU/3382-10/2050	18.08.2011	18.08.1960	DENIZLI	DENIZLI	BABADAG	66	66	0	Korda Energy Production Marketing Import And Export Inc.
ER	EU/3382-9/2049	18.08.2011	18.08.1960	KAROVA	MUGLA	BODRUM	30	30	0	Bora RES Energy Production Distribution Marketing Industry And Trade Ltd.
ES	EU/3382-8/2048	18.08.2011	18.08.1960	YENIHISAR	AYDIN	DIDIM	20	20	0	New Energy Investment Production And Trade Inc.
ET	EU/3382-7/2047	18.08.2011	18.08.1960	GOKDAG	KOCAELI	KANDIRA	10	10	0	Conductive Energy Invesment Production And Trade Inc.
EV	EU/3382-6/2046	18.08.2011	18.08.1960	BAFA	AYDIN	SOKE	34	34	0	Kazanim Energy Investment Production And Trade Inc.

EY	EU/3382-5/2045	18.08.2011	18.08.1960	BOZUYUK	BILECIK	BOZUYUK	90	90	0	Cekim Energy Investment Production Trade Inc.
EZ	EU/3330-6/2013	21.07.2011	21.07.1960	KIRAZLI	IZMIR	KIRAZ	50	50	0	Kiraz Energy Investment Production And Trade Inc.
FA	EU/3330-5/2012	21.07.2011	21.07.1960	KARATEPE	TEKIRDAG	CORLU	13	13	0	Tepe Energy Plants Electricity Production Industry And Trade Ltd.
FB	EU/3330-4/2011	21.07.2011	21.07.1960	TAYAKADIN	ISTANBUL	BESIKTAS	50	50	0	Istres Electricity Production Inc.
FC	EU/3330-3/2010	21.07.2011	21.07.1960	SOKE	AYDIN		104	104	0	Akis Energy Invesment Production And Trade Inc.
FF	EU/3323-4/2007	14.07.2011	14.07.1960	ALARES	MANISA	ALASEHIR	10	10	0	Eksel Electricity Production Industry And Trade Ltd.
FG	EU/3308-	06.07.2011	06.07.1960	GUNDALAN	IZMIR	ODEMIS	5	5	0	Karhes Blacksea Hydro Electricity

	8/2001									Production Inc.
FH	EU/3301-12/1992	05.07.2011	05.07.1960	AKBUK	AYDIN	YENIPAZAR	10	10	0	Suay Industry And Trade Inc.
FI	EU/3301-11/1991	08.07.2008	08.07.1957	YALOVA RES	YALOVA		54	54	0	Arova Res Electricity Production Inc.
FJ	EU/3301-10/1990	08.07.2008	08.07.1957	USAK RES	USAK	BANAZ	61.5	54	0	Arnaz RES Electricity Production Inc.
FK	EU/3301-9/1989	05.07.2011	05.07.1960	ARAPKIR	MALATYA	ARAPGIR	10	10	0	Eksi Energy Production Ltd.
FM	EU/3272-1/1978	14.06.2011	14.06.1960	KARACAYIR	SIVAS		10	10	0	Mursal Energy Production Industry And Trade Inc.
FN	EU/3261-18/1977	07.06.2011	06.07.1960	EMRES	IZMIR		2	2	0	Grc Energy Electricity Production Industry And Trade Inc.
FO	EU/3210-13/1950	12.05.2011	12.05.1960	ADARES	IZMIR	SELCUK	10	10	0	Ygt Electricity Production Industry And Trade Ltd.

FR	EU/3201-22/1937	04.05.2011	04.05.1960	KARTALDAGI	GAZIANTEP		63	63	0	Efil Energy Production Trade And Industry Inc.
FS	EU/3191-9/1923	28.04.2011	28.04.1960	KUMRES	ANTALYA		10	10	0	Yıgıt Electricity Productionı from Wind Energy Industry And Trade Ltd.
FT	EU/3191-6/1922	28.04.2011	28.04.1960	ODEMIS	IZMIR	TIRE	20	20	0	Tayf Energy Invesment Production And Trade Inc.
FTT	EU/3175-4/1912	21.04.2011	21.04.1960	UMURLAR	BALIKESIR	DURSUNBEY	10	10	0	Elfa Electricity Production Inc.
FU	EU/3159-3/1906	12.04.2011	12.04.1960	KANGAL	SIVAS		128	128	0	Kangal Electricity Energy Production And Trade Inc.
FV	EU/3144-4/1900	31.03.2011	31.03.1960	BALABANLI	TEKIRDAG		50.6	50	11.5	Balabanli Electricity Production from Wind Energy Inc.
FY	EU/3127-	24.03.2011	24.03.1960	INCESU	AFYONKARA		13.2	10	0	Tamyeli Energy Invesment Production

	5/1889				HISAR					And Trade Inc.
FZ	EU/3118-14/1880	16.03.2011	16.03.1960	SAKARBAYIR	ISTANBUL	SISLI	3	3	0	Ari En Energy Production And Trade Inc.
GA	EU/3118-13/1879	16.03.2011	16.03.1960	KANDIRA	KOCAELI	KANDIRA	49	49	0	Saganak Energy Investment Production Trade Inc.
GC	EU/3118-10/1876	16.03.2011	16.03.1960	AFYON-2	AFYONKARA HISAR	SANDIKLI	88	88	0	Izdem Energy Invesment Production Trade Inc.
GD	EU/3118-9/1875	16.03.2011	16.03.1960	GAZI	ISTANBUL	SISLI	5	5	0	Ari En Energy Production And Trade Inc.
GE	EU/3118-8/1874	16.03.2011	16.03.1960	BEREKETLI	TOKAT	RESADIYE	1	1	0	Bereketli Electricity Energy Production And Trade Inc.
GF	EU/3118-7/1873	16.03.2011	16.03.1960	SULOGLU	EDIRNE		60	60	0	Steag Wind Suloglu Energy Production And Trade Inc.

GH	EU/3118-6/1872	16.03.2011	16.03.1960	DINAR	AFYONKARAHISAR	DINAR	115	50	50	Olgu Energy Investment Production And Trade Inc.
GI	EU/3118-5/1871	16.03.2011	16.03.1931	ALIBEYHUYUGU	KONYA	CUMRA	3	3	0	Abh Electricity Production Agriculture Animal Construction Trade Inc.
JR	EU/5117-7/03139	10.03.2011	10.03.1946	SARAY_RES	TEKIRDAG	CERKEZKOY	4	4	4	Saray Cast And Hardware Parts Industry Tourism Inc.
GJ	EU/3094-10/1844	24.02.2011	24.02.1960	MUTLU RES 5	KONYA		44	44	0	Mutluer Energy Construction Investment Mine Industry And Trade Inc.
GL	EU/3076-12/1836	17.02.2011	17.02.1960	HAMZABEYLI	EDIRNE		3	3	0	Meric Wind Energysı Electricity Production Inc.
GM	EU/3071-35/1826	09.02.2011	09.02.1936	SUBASI	EDIRNE		48	48	0	Iberdrola Renewable Energy Sources Energy

										Production Trade And Industry Ltd.
GP	EU/3061-2/1808	01.02.2011	01.02.1960	DILEK	KAHRAMAN MARAS	ANDIRIN	27.5	27.5	0	Kale Energy Production Trade And Industry Inc.
GR	EU/3053-8/1802	26.01.2011	26.01.1960	AMASYA	AMASYA	MERKEZ	42	42	0	Sehzade Energy Production Trade Industry Ltd.
GS	EU/3034-13/1793	01.05.2008	01.05.1957	BOZYAKA RES	IZMIR	ALIAGA	17.5	12	0	Kardemir Electricity Production Industry Trade Ltd.
GT	EU/3034-11/1792	19.01.2011	19.01.1960	ULUBORLU	ISPARTA	ULUBORLU	60	60	0	Kavram Energy Investment Production And Trade Inc.
GU	EU/3034-10/1791	19.01.2011	19.01.1946	CERIT	KAHRAMAN MARAS	CAGLIYAN CERIT	90	90	0	Pakmem Electricity Production Industry And Trade Inc.
GV	EU/3003-23/1778	06.01.2011	06.01.1960	MERYEM	BILECIK	GOLPAZARI	30	30	0	Safir Energy Investment Production

										And Trade Inc.
GY	EU/3003-22/1777	06.01.2011	06.01.1960	ZONGULDAK	ZONGULDAK		120	120	0	Sonses Energy Invesment Production And Trade Inc.
GZ	EU/2899-50/1747	02.12.2010	02.12.1959	SINCIK	ADIYAMAN	SINCIK	27.5	25	25	Tektug Electricity Production Inc.
HAA	EU/2650-4/1649	15.07.2010	15.07.2035	DEMIRCILER RES	GAZIANTEP		60	60	0	Zorlu Wind Energy Electricity Production Inc.
HA	EU/2650-4/1649	15.07.2010	08.05.1933	DEMIRCILER RES	OSMANIYE	BAHCE	60	60	0	Zorlu Electricity Production from Wind Energy Inc.
HB	EU/2650-3/1648	08.05.2008	08.05.1933	SARITEPE RES	OSMANIYE	BAHCE	50	50	0	Zorlu Electricity Production from Wind Energy Inc.
HC	EU/2520-2/1615	29.05.2008	29.05.1957	ZEYTINELI RES	IZMIR	URLA	49.5	49.5	37.5	Zeytineli RES Electricity Production Inc.

HCC	EU/2466-3/1601	17.03.2010	17.03.2053	MADRANBABA	AYDIN	CINE	20	19,5	19,5	Kiroba Electricity Production Inc.
HD	EU/2461-6/1600	11.03.2010	29.05.1957	CESME	IZMIR	CESME	16	16	0	Abk Cesme RES Energy Electricity Production Inc.
HE	EU/2352-2/1572	24.12.2009	27.01.1953	ZIYARET	HATAY	SAMANDAG	75	75	65	Ziyaret RES Electricity Production Industry And Trade Inc.
HF	EU/2078-5/1467	30.04.2009	30.04.1958	SEFERIHISAR	IZMIR	SEFERIHISAR	18	14	0	Ucgen Seferihisar Electricity Production from Wind Energy Inc.
HG	EU/1904-57/1365	24.07.2008	24.07.1957	KAYADUZU RES	AMASYA	MERZIFON	75	75	0	Merzifon Energy Inc.
HH	EU/1904-55/1363	24.07.2008	24.07.1957	OVACIK	IZMIR	CESME	20	18	0	Cesme Energy Inc.
HI	EU/1904-54/1362	25.12.2008	24.07.1957	SEFERIHISAR	IZMIR		17.5	16	0	Aktepe Energy Inc.
HJ	EU/1770-	30.09.2008	24.09.1957	TEPE RES	ISTANBUL	SILIVRI	6.85	6.85	0.85	Teperes Electricity

	4/1264									Production Inc.
HK	EU/1747-4/1257	10.09.2008	10.09.1957	SENBUK	HATAY	ISKENDERUN	36	28.937	0	Bakras Energy Electricity Production And Trade Inc.
HL	EU/1690-6/1228	24.07.2008	24.07.1957	DAGPAZARI RES	MERSIN	SILIFKE	39	39	39	Enerjisa Energy Production Inc.
HN	EU/1690-4/1226	24.07.2008	24.07.1957	KILLIK RES	TOKAT		85	85	0	Tokat Energy Inc.
HO	EU/1690-2/1224	24.07.2008	24.07.1957	SUSURLUK RES	BALIKESIR	SUSURLUK	72.5	72.5	0	Susurluk Energy Inc.
HP	EU/1690-1/1223	24.07.2008	24.07.1957	ARDICLI RES	KONYA	SELCUKLU	50	50	0	Es-Yel Electricity Production Inc.
HR	EU/1678-4/1218	17.07.2008	17.04.1955	SOMA RES	MANISA		90	90	90	Bilgin Wind Plant Electricity Production Inc.
HS	EU/1678-3/1217	17.07.2008	17.04.1955	ALIAGA	IZMIR	BERGAMA	90	90	90	Bergama RES Energy Production Inc.

HT	EU/1632-6/1194	05.06.2008	05.06.1957	KARADAG RES	IZMIR	ALIAGA	10	10	0	Garet Energy Production And Trade Inc.
HU	EU/1632-5/1193	05.06.2008	05.06.1957	SARES RES	CANAKKALE	EZINE	27.5	27.5	24.75	Garet Energy Production And Trade Inc.
HV	EU/1622-16/1189	29.05.2008	29.05.1957	DEMIRCILI	IZMIR	URLA	40	40	0	Calik Electricity Production from Wind Energy Ltd.
HY	EU/1622-15/1188	29.05.2008	29.05.1957	SARPINCIK	IZMIR	KARABURUN	32	32	0	Calik Electricity Production from Wind Energy Ltd.
HZ	EU/1622-14/1187	29.05.2008	29.05.1957	KORKMAZ	IZMIR		25.2	24	0	Ayen Energy Inc.
IA	EU/1622-13/1186	29.05.2008	29.05.1957	MORDOGAN	IZMIR	KARABURUN	31.5	30.75	30.75	Ayen Energy Inc.
IB	EU/1622-11/1184	29.05.2008	29.05.1957	URLA RES	IZMIR	URLA	15	15	0	Hassas Technical Energy Electricity Production Industry

										And Trade Inc.
IC	EU/1622-10/1183	29.05.2008	29.05.1957	KARADAG	IZMIR	CESME	16.25	16.25	0	Okman Energy Electricity Production And Invesment Inc.
IE	EU/1622-9/1182	29.05.2008	29.05.1957	SENKOY RES	HATAY	MERKEZ	36	26	0	Eolos Wind Energy Production Inc.
IF	EU/1622-8/1181	29.05.2008	29.05.1957	MORDOGAN	IZMIR	KARABURUN	13.8	13.8	0	Egenda Ege Energy Production Inc.
IG	EU/1622-7/1180	29.05.2008	29.05.1957	GERMIYAN	IZMIR	CESME	10.8	10.8	0	Egenda Ege Energy Production Inc.
II	EU/1622-6/1179	29.05.2008	29.05.1957	URLA	IZMIR	URLA	13	13	0	Egenda Ege Energy Production Inc.
IJ	EU/1622-5/1178	29.05.2008	29.05.1957	ALACATI	IZMIR	CESME	16	16	0	Egenda Ege Energy Production Inc.
IK	EU/1622-1/1174	29.05.2008	29.05.1957	YAYLAKOY	IZMIR	KARABURUN	15	15	0	Yaylakoy RES Electricity Production Inc.

IL	EU/1605-1/1167	14.05.2008	14.05.1957	GEYCEK RES	KIRSEHIR		150	150	150	Al-Yel Electricity Production Inc.
IM	EU/1565-7/1139	10.04.2008	10.04.1957	SAH RES	BALIKESIR	BANDIRMA	105	105	93	Galata Wind Energy Inc.
IN	EU/1546-3/1129	25.03.2008	25.03.1957	BANDIRMA III	BALIKESIR	BANDIRMA	25	25	24	Bursa Clean Energy Electricity Production Industry And Trade Inc.
IO	EU/1531-10/1118	13.03.2008	13.03.1957	ATIK	HATAY	ISKENDERUN	30	30	12	Aksa Energy Production Inc.
IP	EU/1501-2/1088	21.02.2008	21.02.1957	CANAKKALE RES	CANAKKALE	EZINE	29.9	29.9	29.9	Enerjisa Energy Production Inc.
IR	EU/1461-1/1055	17.01.2008	17.01.1957	METRISTEPE RES	BILECIK	BOZUYUK	39	39	39	Can Energy Integrated Electricity Production Inc.
IS	EU/1447-8/1049	31.12.2007	31.12.1952	BANDIRMA RES	BALIKESIR		89.7	89.7	60	Bandirma Energy And Electricity Production Inc.

IT	EU/1398-12/1026	07.12.2007	07.12.1956	KOZBEYLI	IZMIR	FOCA	32.2	32.2	32.2	Natural Energy Electricity Production Inc.
IU	EU/1398-11/1025	06.12.2007	12.06.1956	SAMURLU	IZMIR	ALIAGA	30	30	0	Natural Energy Electricity Production Inc.
IV	EU/1398-10/1024	06.12.2007	06.12.1956	SOKE RES	AYDIN	SOKE	30	30	30	Abk Energy Electricity Production Inc.
IY	EU/1391-12/1015	29.11.2007	29.11.1956	AKSU	KAYSERI		72	72	72	Aksu Clean Energy Electricity Production Industry And Trade Inc.
IZ	EU/1332-16/969	05.10.2007	05.10.1952	BANDIRMA	BALIKESIR	BANDIRMA	50	50	35	Yapisan Electricity Production Inc.
JA	EU/1309-3/945	12.09.2007	12.09.1956	KUYUCAK	MANISA	KIRKAGAC	50.1	50.1	0	Alize Energy Electricity Production Inc.
JB	EU/1245-10/901	05.07.2007	07.05.1956	MERSIN	MERSIN		43	34	34	Mediterranean Electricity Production

										Inc.
JC	EU/1217-1/866	08.06.2007	06.08.1956	TURGUTTEPE	AYDIN	CINE	24	24	24	Sabas Electricity Production Inc.
JD	EU/1188-1/853	10.05.2007	10.05.1956	DATCA RES	MUGLA	DATCA	29.6	29.6	0	Dares Datca Wind Energy Plants Industry And Trade Inc.
JE	EU/1179-22/851	03.05.2007	03.05.1956	DUZOVA	IZMIR	BERGAMA	50	50	40	Utopya Electricity Production Industry And Trade Inc.
JF	EU/1179-21/850	03.05.2007	03.05.1956	BOREAS 1 ENEZ RES	EDIRNE	ENEZ	20	20	0	Boreas Energy Production Systems Industry And Trade Inc.
JG	EU/1167-6/839	18.04.2007	18.04.1956	BALIKESIR	BALIKESIR	KEPSUT	143	143	143	Enerjisa Energy Production Inc.
JH	EU/1167-4/837	18.04.2007	18.04.1956	SARIKAYA	TEKIRDAG	SARKOY	33.4	33.4	33.4	Alize Energy Electricity Production Inc.

JI	EU/1167-3/836	18.04.2007	18.04.1952	KELTEPE	BALIKESIR	SUSURLUK	23	23	0	Alize Energy Electricity Production Inc.
JJ	EU/1167-2/835	18.04.2007	18.04.1952	CATALTEPE	BALIKESIR	HAVRAN	16	16	16	Alize Energy Electricity Production Inc.
JK	EU/1167-1/834	18.04.2007	18.04.1956	CAMSEKI	CANAKKALE	EZINE	20.8	20.8	20.8	Alize Energy Electricity Production Inc.
JL	EU/1149-9/829	04.04.2007	04.04.1956	SEYITALI	IZMIR	ALIAGA	37	37	30	Doruk Energy Production Industry And Trade Inc.
JM	EU/1149-8/828	04.04.2007	04.04.1956	POYRAZ RES	BALIKESIR	KEPSUT	66.9	66.9	54.9	Poyraz Energy Production Industry And Trade Inc.
JN	EU/1149-7/827	04.04.2007	04.04.1956	SOMA RES	MANISA	SOMA	240.1	240.1	140.1	Soma Energy Electricity Production Inc.
JS	EU/1149-	04.04.2007	04.04.2027	KIYIKOY	KIRKLARELI		27	27	0	Alenka Energy Production And

	3/823									Invesment Ltd.
JT	EU/1062-6/786	18.01.2007	18.01.1956	AKBUK	AYDIN		31.5	31.5	31.5	Ayen Energy Inc.
JU	EU/1054-11/780	11.01.2007	11.01.1932	AYRES	CANAKKALE		5.4	4.998	0	Ay RES Ayvacik Electricity Production from Wind Energy Plant Ltd.
JV	EU/1003-1/753	12.12.2006	12.12.1955	KAPIDAG RES	BALIKESIR	ERDEK	34.85	34.85	24	Kapidag Electricity Production from Wind Energy Plant Industry And Trade Inc.
JY	EU/973-2/739	09.11.2006	09.11.1955	AYYILDIZ	BALIKESIR		15	15	15	Akenerji Electricity Production Inc.
JZ	EU/973-1/738	09.11.2006	09.11.1955	BELEN	HATAY	BELEN	48	48	0	Belen Electricity Production Inc.
KA	EU/786-2/648	15.06.2006	15.06.1955	MAZI 3 RES	IZMIR	CESME	55	55	30	Yapisan Electricity Production Inc.
KB	EU/786-	15.06.2006	15.06.1955	KOCADAG-2	IZMIR		25	22.5	17.5	Kores Kocadag Wind Energy Plant

	1/647			RES						Production Inc.
KC	EU/757-4/638	16.05.2006	16.05.1955	GERMIYAN	IZMIR	CESME	4.5	4.5	4.5	Alize Energy Electricity Production Inc.
KD	EU/565-5/580	20.10.2005	20.10.1954	MAZI I	IZMIR	CESME	56.2	56.2	0	Mare Manastir Wind Energy Plant Industry And Trade Inc.
KE	EU/332-4/463	22.06.2004	22.06.1953	AKHISAR	MANISA		43.75	43.75	43.75	Akhisar Energy Inc.
KF	EU/325-3/458	04.06.2004	04.06.1953	SEBENOBA	HATAY	SAMANDAG	60	60	0	Sea Electricity Production Ltd.
KG	EU/325-2/457	04.06.2004	06.04.1953	YUNTDAG	IZMIR		60	57.5	52.5	Inno RES Electricity Production Inc.
KH	EU/312-1/434	13.04.2004	13.04.1953	SAYALAR	MANISA		54.2	54.2	20	Natural Energy Electricity Production Inc.
KI	EU/311-4/433	06.04.2004	06.04.1953	SAMLI	BALIKESIR		114	114	0	Baki Electricity Production Ltd.

KJ	EU/284-7/398	08.01.2004	01.08.1953	CATALCA	ISTANBUL		60	60	60	Sanko Wind Energy Industry And Trade Inc.
KK	EU/255-6/391	19.12.2003	19.12.1933	OSMANIYE	OSMANIYE	BAHCE	135	135	135	Rotor Electricity Production Inc.
KL	EU/250-4/389	05.12.2003	05.12.1952	KARAKURT	MANISA		10.8	10.8	10.8	Sea Electricity Production Ltd.
KM	EU/249-3/385	24.11.2003	24.11.1933	INTEPE	CANAKKALE		30.4	30.4	30.4	Anemon Energy Electricity Production Inc.
KN	EU/225-4/372	30.10.2003	30.10.1952	KEMERBURGAZ	ISTANBUL		34	34	24	Lodos Electricity Production Inc.
KO	EU/207-4/353	11.09.2003	11.09.1952	BURGAZ	CANAKKALE	GELIBOLU	31	31	14.9	Natural Energy Electricity Production Inc.
KP	EU/207-3/352	11.09.2003	11.09.2023	ALIBEY ADASI	BALIKESIR		30	30	0	Balikesir Electricity Production from Wind Energy Plant Ltd.

KY	NONE	01.01.2000		BORES-YID	CANAKKALE	BOZCAADA	10.2	10.2		Bores Bozcaada Wind Energy Plant Industry And Trade Inc.
KZ	NONE	28.11.1998	28.11.2018	ARES-YID	IZMIR	ALACATI	7.2	10.2		Ares Alacati Wind Energy Plant Industry And Trade Inc.