MARKET DEVELOPMENT OF RENEWABLE ENERGY IN TURKEY

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ABSTRACT

MARKET DEVELOPMENTS OF RENEWABLE ENERGY IN TURKEY

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Renewable energy is a current issue in the world as well as in Turkey. Turkey has developing policies in the renewable energy field. Although it is a beneficial mean of obtaining energy, there are barriers on renewable energy production. In order to develop renewable energies, those barriers have to be analyzed and suitable implementations should be developed to overcome them. In this thesis policy and implementation on the renewables are evaluated in general and specially for Turkey. The electricity market is one of the crucial factors of development of the renewable energy. The day-ahead market and renewable energy support mechanism in Turkey are investigated. Finally benefit calculations is carried out in order to compare benefits of renewable energy in market and support mechanisms by using real time price and production values of two renewable energy plants; a hydropower and a wind power plants. Further, outcomes of newly developed prediction project for wind power plants are evaluated in terms of market benefit.

Keywords: Renewable energy policies, Renewable energy in Turkey, Legal aspects of energy, Electricity market, RES support mechanism

ÖZ

YENİLENEBİLİR ENERJİNİN TÜRKİYE’DE PİYASA GELİŞİMİ

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Yenilenebilir enerji Dünyada olduğu gibi Türkiyede’de güncel bir konudur. Türkiye yenilenebilir enerji alanında politika geliştirmektedir. Elverişli bir enerji üretimi yolu olmasına rağmen, yenilenebilir enerji üretiminin önünde engeller de vardır. Yenilenebilir enerjinin geliştirilmesi için bu engeller analiz edilmeli ve aşılması için uygun politika ve uygulamalar geliştirilmelidir. Tez kapsamında yenilenebilir enerji politikaları ve uygulamalar genel olarak ve Türkiye özelinde incelenmiştir. Elektrik piyasası, yenilenebilir enerji gelişiminde canalıcı faktördür. Türkiye deki Gün Öncesi Piyasası ve Yenilenebilir Enerji Destek mekanizması incelenmiş, iki yenilenebilir enerji santrali için gerçek zamanlı üretim ve fiyat rakamları kullanılarak gelir hesaplamaları yapılmış ve bu hesaplar üzerinden piyasalar karşılaştırılmıştır. Ayrıca, rüzgar santralleri için yeni geliştirilmiş, gerçek zamanlı üretim tahminini amaçlayan proje sonuçları piyasa getirisi açısından değerlendirilmiştir.

Anahtar Kelimeler: Yenilenebilir enerji politikaları, Türkiye'de yenilenebilir enerji, Yasal açıdan energy, Elektrik piyasası, YEK destekleme mekanizması

To My Family,

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LIST OF ABBREVIATIONS

AD	: Anno Domini
BCE	: Before Common Era
BMU	: German Federal Ministry of Environment
EC	: European Commission
EU	: European Union
EMRA	: Energy Market Regulatory Authority
IEA	: International Energy Agencey
FIT	: Feed-in Tariff
GDP	: Gross Domestic Products
GWh	: Gigawatt-hour
MW	: Megawatt
MWh	: Megawatt-hour
NLPD	: National Load Dispatch Centre
MENR	: Ministry of Energy and Natural Resources
RITM	: Wind Power Monitoring and Forecasting Centre
RES-E	: Renewable Energy Sources based Electricity Production
RES-H	: Renewable Energy Sources based Heating and Cooling
RES-T	: Renewable Energy Sources based Transportation
RESSM	: Renewable Energy Sources Support Mechanism
UNFCCC	: United Nations Framework Convention on Climate Change
UN	: United Nations

CHAPTER 1

INTRODUCTION

1.1 General

Energy is a fundamental requirement of life. Especially in the modern world it is the foundation of all economical and social activities. The global energy need is increasing day by day. The energy had been mostly understood as fossil fuels since Industrial Revolution. However, the limited nature and the complexity make fossil fuels based energy consumption unsustainable. As a result of this, humanity rediscovered nature based renewable energy.

Renewable energy is a key issue in today's world and may continue to play a globally essential role in the future. The trend that started in the last quarter of 20^{th} century seems to continue in a more intense fashion. International organizations are also working on this field to create a common policy for taking advantage of renewable energy in multinational level. Also, currently almost all of the countries are developing policy and trying to determine attainable targets in this field.

Turkey, in terms of fossil fuel sources, can be considered as a poor country; this situation creates economical and political obstacles on the development of Turkey. Besides these problems, Turkey has a large renewable energy potential but lacks implementation policy and essential instruments, so the resources remain unutilized. The legal reforms on the electricity market and liberalization efforts that take European countries as an example changed the situation. The participation of private sector in the energy field started a new era on the production of energy from renewable sources in Turkey.

The capacity usage of renewable energy resources is increasing day by day. Since the early periods of this new era, there has been a consequent effort for reaching the targets of implementation policies. However the process in the renewable field is still in an early stage. It is still far beyond the exploitation of all renewable resources. Since, a considerable amount of time passed after the starting point of this new era, the past effort and experiences need to be carefully analyzed.

In this thesis, it is aimed to investigate the developments in renewable energy field, electricity market and supporting instruments of renewable energy together with legal framework. It is also intended to examine the effectiveness of renewable energy support instruments and to propose some action plans for future works by comparing successful examples in the world.

Throughout the thesis, the renewable will refer wind, solar, biomass, biogas, waves, tidal, hydropower with a concern. Since there are still ongoing discussions about hydropower is renewable or not. But run of river and canal types are accepted as renewable. On the other hand hydropower with storage accepted as renewable according to different measurements and limitations by different countries. Thus it will be underline whenever it is necessary.

1.2 Scope of the Thesis

In Chapter II of the thesis, general overview of global renewable energy policies and implementations investigated. Especially the policies of international entities such as United Nations and European Union are investigated in terms of their objectives and instruments. In this respect, the incentive price instrument in European Union is particularly analyzed. Its costs and effects on development of renewable energy sector are also inquired. The different types of price incentives (also called as feed-in tariff) are introduced and as an example, the policy implementation of Germany in renewable electricity support mechanism presented in detail.

In Chapter III, renewable energy in Turkey is handled in three parts. In the first part, the previous condition of renewable energy field before the legal reforms and regulations have been unfolded. In the second part of the chapter the reforms starting from 2001 in electricity market structure of country, the effects of liberalized market structure on renewable energy, regulations on renewable energy field and also support to renewable sourced energy production are explained. This evolution tried to be analyzed in the framework of European Union accession process. In the last and the third part of the chapter, the developments and the increase in capacity utilization after the reforms in renewable energy field are revealed.

In Chapter IV, electricity market, institutions and regulations, and the operation of the system are examined. The renewable energy sources support mechanism designed to encourage development in this field and the actual levels of participation to the mechanism has been put forward.

In Chapter V, the benefit calculations were done by the usage of yearly production values and real time prices for two renewable energy plants; namely the hydropower and the wind power plants. As a result of these calculations, market and production of plants analyzed and comparison of market and renewable energy support mechanism benefits are compared. Also the benefit analysis of wind power plants was done in accordance with the estimations of recently founded prediction centre. .

In Chapter VI, conclusions of the complete study and recommendations for the future policy and implementation in renewable energy field in Turkey presented.

CHAPTER 2

RENEWABLE ENERGY IN THE WORLD: POLICY AND IMPLEMENTATATION

2.1 General

History of renewable energy started with controlled use of fire by human. Before modern renewable energy technologies developed at late19th century, it was mostly used in agricultural production and for basic daily needs. Industrial revolution changed both the modes of production and daily life needs. Before industrial revolution use of energy mostly based on mechanical power. In early stages of industrial revolution, fossil fuels were the typical source of energy. However this domination created economical, social and environmental problems.

In latter half of 20th century, the preoccupation with the security and sustainability of supplies shaped dramatically the policy trends in the world. Before the oil crisis of 1973, energy policy mostly affected with the developments in the field of engineering and this period named as "The Age of Engineering". After this period oil embargo against Western world, created a new paradigm in the field of energy policies and this period named as "The Age of Security". Especially developed countries preferred to get use of the domestic resources such as hydro and nuclear energies, (Griffin, 2009a).

The last period, "The Neutral or Environmental Age" is highly influenced by the Chernobyl disaster and the findings of scientific studies about climate change. Results of the studies about global warming created social awareness about carbon emission, greenhouse gases, fossil fuels and protection of environment. Pro-environmentalist green movements came into the picture and obtained popular support. In Europe these movements also politicized and showed up as political parties which occasionally manage to be coalition partners in governments. In this period renewable energy technologies were encouraged economically and thus developed rapidly (Griffin, 2009b).

The evaluation of Renewable energy technology can be summarized as follows (History of Alternative Energy and Fossil Fuels, 2012):

4,500,000,000 BCE – The moment the sun first started producing solar energy, creating the potential for life. [solar energy]
3,200 BCE – The Egyptians use the sail, which is the first recorded use of wind energy [wind power].
400 BCE – Passive solar design is advocated by Socrates in an ancient Grecian publication. [solar energy].
200-300 BCE – Parabola-shaped reflective surfaces are demonstrated to be able to focus sunlight (solar energy) into a single high-intensity point. [solar energy].
200 BCE – The Chinese invent the windmill. [wind power].
213 BCE – According to ancient accounts, Archimedes saved Syracuse (Sicily) by setting fire to Roman ships using mirrors to concentrate rays into a primitive laser [solar energy].
BCE – Water wheels are turned by hydropower to grind wheat into flour by the Greeks [hydropower].
100-200 AD – The Oculus is built at the top of the Roman Pantheon [solar energy].
700s – Wind is used in the smelting process in Sri Lanka [wind power].
950s – Persia used vertical axis windmills to grind corn into corn meal [wind power].

1000 AD – By this point in time windmills are used frequently and widely throughout the Middle East [wind power].
1200 AD – Europe developed the horizontal axis post mill [wind power].
1200 AD – Mongolian invaders, under the leadership of Genghis Khan, built windmills in China to facilitate irrigation. Persian's were brought in for their expertise [wind power].
1300 AD – Advancement in English mill-building called the mock mill, where only the top half of the building needs to be moved in order to change its direction [wind power].
1500 AD – Triangle-shaped sails were used to make tower mills more effective in Spain [wind power].
1500's AD – Leonardo da Vinci proposes the first large-scale applications of techniques used to concentrate sunlight [solar energy].
1600 – Windmills are used in the Netherlands (one of the leading industrial nations at the time) to drain water from the lowlands into dike systems. By draining these marshes they were able to increase the amount of land available for cultivation, increasing the amount of food they could annually produce. The Netherlands was a great banking nation, and many scholars suggest they were held back from industrializing before Great Britain because they could not produce enough food domestically to feed their people, and thus depended largely on imports [wind power].
1693 – The Dutch pass a law that requires windmills to have an individual name [wind power].
1700 – Together England and the Netherlands have about 20,000 windmills [wind power].
1759 – English windmill blades are redesigned to turn 20 degrees to get more energy from the wind [wind power].
1767 – Horace de Saussure, a Swiss scientist, invents the first solar collector. He called it a "solar hot box" [solar energy].
1774 French engineer Bernard Forest de Blidor publishes a treatise on water energy called Architecture Hydraulique [hydropower].
1839 The discovery of solar photovoltaics. Edmond Becquerel discovers that sunlight absorbed in certain materials produces electricity [solar energy].
1850s – Daniel Halladay and John Burnham work together to create and commercialize the Halladay Windmill. It was specifically designed for the American Midwest, with thin wooden blades and an open tower design. They went on the start the U.S. Wind Engine Company [wind power].
1861 – Augustin Mouchot, a French scientist, patents a solar engine [solar energy].
1867 – Leonard Wheeler creates the Eclipse windmill for use in the American Midwest, and went on the found the Eclipse Wind Engine Company [wind power].
1880s – John Ericsson, an American engineer, begins the American solar industry. He develops solar-driven engines to power steam generators on ships [solar energy].
1880s – Windmills are used by many homesteaders in the western states of the United States, and were purchased from catalogs, traveling salesmen, or built from scratch. They were used for any activity that required power – like pumping water, shelling corn, sawing wood, and milling grain [wind power].
1880s Thomas Perry invents the mathematical windmill and founds the Aermotor company with LaVerne Noyes [wind power].
1881 A brush dynamo generator is connected to a turbine in a flour mill to provide street lighting at Niagara Falls, New York, using direct-current technology [wind power].
1882 Vulcan Street Power Plant, the world's first hydroelectric power station, is constructed in Appleton, Wisconsin [hydropower].
1889 – 77 windmill companies are in business in America [wind power].
1891 Clarence Kemp of Maryland invents the Climax, a solar water heater. A 32 gallon unit sells for $25. Mr. Kemp has since been attributed with being the father of solar energy in the United States [solar energy].
1890's – First roof-mounted solar water heaters are commercially available in Southern California [solar energy].
1892 – Poul LaCour uses a windmill to generate electricity in Denmark [wind power].
1894 – An explorer named Fridtjof Nansen uses windmills to power lights in his ship's cabin while searching for the North Pole [wind power].
1900's (Early) – California gold miners use wind mills to pump saltwater out of ponds to produce salt [wind power].

1908 – William J. Bailey of the Carnegie Steel Company invents solar collectors that became the predecessors of today’s solar collectors [solar energy].
1920 Hydroelectric power provides 25 percent of all U.S. electrical generation [hydropower].
1920-50s – A solar water heater market of about 50,000 homes exists in South Florida, which is almost entirely wiped out in the 1950s when natural gas and electric service arrives as a much cheaper alternative [solar energy].
1930s – Rear Admiral Richard Byrd brought a Jacobs wind generator to the Antarctic where it ran for 22 years without repairs [wind power].
1933– Tennessee Valley Authority established during the New Deal program [hydropower].
1937 – Jacobs Wind Electric Company is opened by Marcellus Jacobs, and begins selling windmills and generators [wind power].
1940s – ‘Solar Homes’ become popular, and more builders being to consider active and passive solar home design [solar energy].
1941 Palmer Putnam builds a wind turbine (the Smith-Putnam wind turbine) that generates 1.25 MW for New England and had 53-meter blades. When the war comes to America, interest in the project is suspended [wind power].
1941 – Over 60,000 solar water heaters in place in America [solar energy].
1950s – Most windmill companies have gone out of business in America due to fierce price competition with other forms of energy [wind power].
1950s – Photovoltaic solar energy cells are used to power U.S. space satellites [solar energy].
1954 – Bell Telephone researches the sensitivity of a properly prepared silicon wafer to sunlight. The ‘solar cell’ is developed [solar energy].
1960 – First solar powered 2-way radio created. Conversation takes place from coast-to-coast between the U.S. Army Signal Corps in New Jersey and California [solar energy].
1970's The US experiences its first energy crisis. Interest in renewable energy escalates. Gasohol emerges, which is fought by oil producers. Today we use gasohol – 10% or more ethanol. Interest in wind energy also increases at this time [biofuels].
1974 – More than 20 companies start production of flat plate solar collectors in the U.S., largely spurred by the first oil embargo [solar energy].
1974 – Second oil embargo occurs, further strengthening support for alternative energy sources [renewable energy].
1980s – Wind farms are constructed for large scale production in America and Europe [wind power].
1980 – First solar cell power plant dedicated at Natural Bridges National Monument, Utah [solar energy].

As a result of the developments in technology, popular support and incentives, the share in renewable energies of power production and usage of biofuels in transportation increased from year to year.

The year 2011 was also a milestone for the energy policies of many countries because of the consequences of the Fukushima nuclear accident in Japan. The Federal German Government (Bundesrepublik) for instance decided to close all nuclear plants in their territory by the year 2022 and to take all necessary measures for the reform of energy policies (Glaser, 2011).

According to reports of World Energy Council, the share of renewable energy will continue to increase in all areas; including power, heating, cooling and transportation. As of 2011 renewable energy sources supplied 17% global energy supply.

In 2011 about half of newly installed capacities were renewable based. Especially in European zone the share of renewable energy was as high as almost 71%. The renewable energy sector currently employs five million people globally, providing access to energy especially for rural areas in developing countries. 92 countries have implemented incentive policies for the generation of renewable energy production and 72 have encouraged biofuels in a way (Renewable 2012 Global Status Report, 2012).

2.2 Social, Economic, Environmental Aspects of Renewable Energy Policies

Economic growth, economic development, and sustainable development are three different concepts that must be well-understood before any analysis in the field of sustainability of energy. Main parameter of economic growth is measured by only Gross Domestic Product (GDP) figures. GDP is the value of produced service and goods in a given period. In some examples GDP growth achieved at the cost of greater inequality, higher unemployment, weakened democracy and loss of cultural identity and overconsumption of natural sources for the sake of future generation needs. The sustainability of such a growth with these negative effects obviously is not possible for too long. Economic development is the increase in the standard of living of the citizens as a result of sustained growth from a simple, low-income economy to a modern, high-income economy. Economic development includes social and environmental issues and can touch the aspects ignored by the concept of economic growth. In terms of intra-generational equality it can be considered as practical. However, for inter-generational equality the concept of Sustainable Development should be incorporated (World Bank, 2012).

United Nations World Commission on Environment and Development (WCED, 1987) regards any development as sustainable if it "meets the need of present without comprising the ability of future generation to meet their needs". Also sustainability requires the achievement of inter-generational equality and balance between today and future generations.

The goal of a sustainable energy policy is to begin a process that effectively pay attention to environmental and the energy needs of future generations. It also pays attention to the achievement of policy goals while trying to find optimal tools for preventing social and economic disruption, protecting those with the lowest income against economic losses and decreasing resource waste.

In the long term renewable energy will inevitably dominate global energy policy. It is obviously impossible to continue with limited sources based consumption in energy. Despite the developments in the first decade of 21th century, energy consumption still based on fossil fuels and nuclear although the fact that renewable energy sources are the most crucial instrument for sustainable energy policy is well understood.

Widely acknowledged objectives of sustainable energy policies are; competitiveness, sustainability, and security of supply as in case in Europe which is shown in Figure 2-1. Reducing dependence to fossil fuels and diversifying supply sources have turned renewable energy in to a major actor in the field security supplies. As a result of renewable energy usage the emission of greenhouse gases decrease and renewable energy can be considered as the most environmental friendly energy technology. By fostering industrial innovative capacity, it also improves competitiveness and job support sustainability by creating new job (Lipp, 2007).

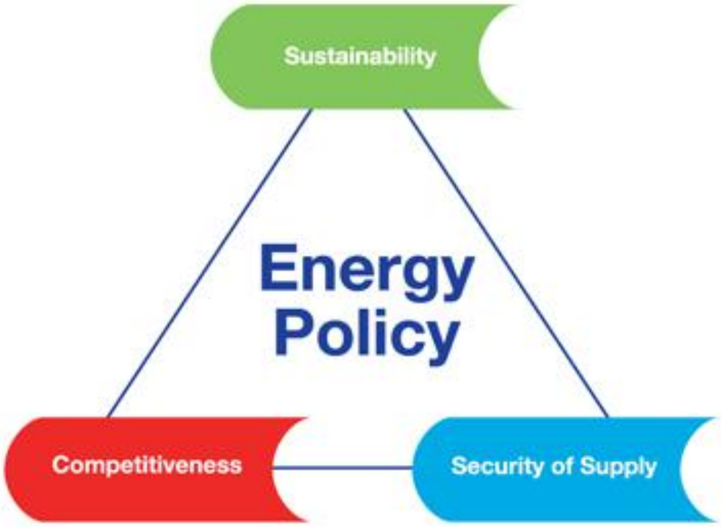

Figure 2-1 "European Strategy for Sustainable, Competitive and Secure Energy"- (Green Paper, 2006)

There are two aspects of supply security; physical availability and economic affordability. Renewable energy is available in all over the world. When compared to other sources of energy supplies it has highest physical availability. This characteristic creates equality in social aspects. Despite the high costs of installation, which is also decreasing with developing technology by the years, it is the cheapest way on producing stage (Konstantinos et al., 2008).

Environmental pollution and climate change affects quality of life on earth. A large contribution of pollution originates from usage of fossil fuels, not limited to as greenhouse gas emission but water and soil pollution as well. Renewable energy usage put away this effects by starting from production phase. Furthermore it reduces the negative consequences related with the transportation of energy sources (Akella et al., 2008).

Renewable energy also contributes to sustainable development by creating new jobs. The production of electro-mechanical parts for renewable energy needs skilled part of labor force but locally produced materials, installation works and additional services create many jobs as well (see Table2-1).

Table 2-1 Estimated Jobs in Renewable Energy Worldwide, By Industry
(Renewable 2012 Global Status Report, 2012)

	Global	China	India	Brazil	USA	EU	Germany	Spain	Other Countries
Technologies	Thousands jobs								
Biomass	750	266	58	-	152	273	51	14	2
Biofuels	1500	-	-	889	56	151	53	2	194
Biogas	230	90	85	-	-	53	51	1.4	-
Geothermal	90	-	-	-	10	53	14	0.6	-
Hydropower (Small)	40	-	12	-	8	16	7	1.6	1
Solar PV	820	300	112	-	82	268	111	28	60
Concentrated SP	40	-	-	-	9	-	2	24	-
Solar Heating/Cooling	900	800	41	-	9	50	12	10	1
Wind Power	670	150	42	14	75	253	101	55	33
Total	5000	1606	350	903	401	1117	372	137	291

2.3 Barriers in Front of Renewable Energy

Implementations on renewable energy face barriers which are mostly cost based but there are also non-cost based barriers. Cost based barriers can be classified as: expenses of technologies, economic difficulties and financing issues.

Although decrease in costs of renewable energy technologies, renewable energy still expensive than market prices of other energy sources. Without incentive mechanisms, it is not possible to compete against traditional fossil fuel and nuclear technologies. Renewable energy investments face difficulties related with finding financial instruments when they are compared to conventional energy systems. In addition to higher expenditure for financing, most institutions are generally unfamiliar with the new technologies and biased to regard them as risky. This situation may lead problems even in the loan contract stage. High financing costs creates suspicion on competitive position of renewable energy, since renewable technologies generally require higher capital costs than others, despite the fact that they have lower operating costs and zero fuel costs (Çiçek, et al., 2009).

Transmission of produced renewable energy can also be classified under both cost related and non-cost barriers. As characteristics of renewables, grid connection can be economically and technically problematic in some regions. Many facilities are small scaled and grid connection costs more than investment and even the transportation of small quantities by grid decreases productivity in some cases. Renewable electricity (RES-E) has unbalanced characteristics because of the unpredictable nature of resources. This balance problem in the production has its reflections in network system as well. For overcoming instability problems on network, a comprehensive effort is needed (BV, 2008).

Renewable energy support policies are the main driving force to overcome cost based problems. Long term price guarantees help investors to overcome fiscal problems. Besides economical efforts, non-economic factors like removal of legal and administrative barriers are needed for the success of policies. By upgrading the power grid infrastructure and simplifying bureaucratic processes, these barriers can be successfully dismantled (Klessman,et al., 2011).

2.4 Recent Developments in the Field of Renewable Energy at the Level of International Organizations

The Kyoto Protocol of the United Nations Framework Convention on Climate Change (UNFCCC) was the first step for obligatory supranational policy development on environmental field. The Kyoto Protocol sets binding obligations for industrialized countries to reduce the emissions of greenhouse gases. The Protocol was adopted on 11 December 1997 in Kyoto, Japan, and entered into force on 16 February 2005. As of September 2011, 191 states have signed and ratified the protocol. The Protocol reviewed and extended in 2020 in Doha.

Kyoto Protocol triggered developments in renewable energy policy field. For instance UN brought the issues of renewable energy and energy efficiency in to the agenda. According to international compromise, countries adapt their national legislation. European Union (UN), both at union and national level reacted rapidly to this new trend. Renewable energy is evaluated under three headlines: electricity, transportation and heat. Renewable electricity (RES-E) is prominent among others. Every single country competes for the success in renewable electricity generation by using their sources in the most productive sense.

2.4.1 UN Policy

The United Nations General Assembly declared 2012 as the “International Year of Sustainable Energy for All”. UN Secretary-General Ban Ki-Moon has launched a global initiative named “Sustainable Energy for All” by 2030. The initiative has three goals and eleven action areas which are grouped into two categories. Providing modern energy services around the globe; doubling the advancement in energy efficiency and rising the share of renewable energy in energy mix by 2030 are the three goals of action plan and can be shown in Figure 2.2. Action areas separated as sectorial and enabling. The seven sectorial areas address power generation and three main sectors of energy consumption; production (industry and agriculture), transport and buildings. The three enabling areas include cross-cutting mechanism for sector designed to become efficient, identify present obstacles and catalyze abrupt increment (Figure 2-3). These eleven Action Areas are useful pathway for the achievement of three goals (The Secretary-General’s High-Level Group on Sustainable Energy for All, April: 2011).

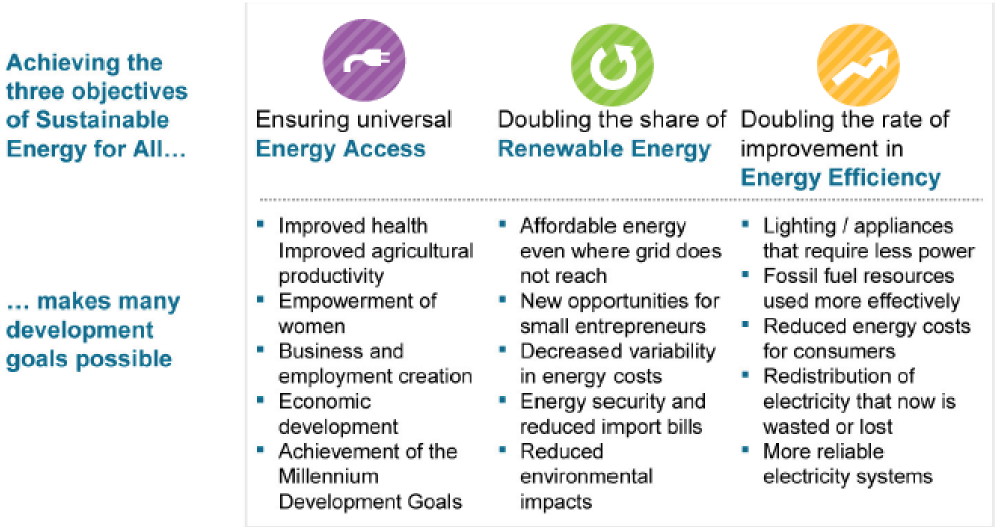

Figure 2-2 Sustainable Energy for all (The Secretary-General’s High-Level Group on Sustainable Energy for All, April: 2011)

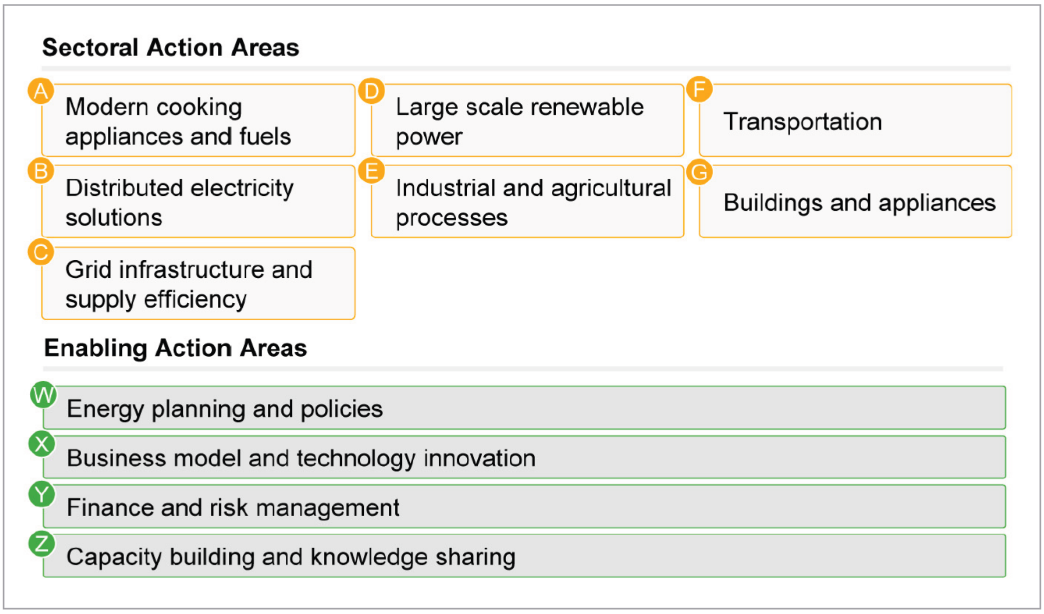

Figure 2-3 Eleven Action Areas support sectorial areas and create convenient environment for goals (The Secretary-General's High-Level Group on Sustainable Energy for All, April: 2011)

2.4.2 EU Renewable Energy Policy

European Union is the leading policy maker and implementer in the field of renewable energy. Renewable energy resources are land based resources. With the new members, territories EU occupies only 2.9% of the World and it only has 3.08 % of global running water. However, European Union as state World's second biggest renewable based electricity producer after China. When hydropower is excluded EU is leader by far as seen in Figure 2-4 (Renewable 2012 Global Status Report, 2012).

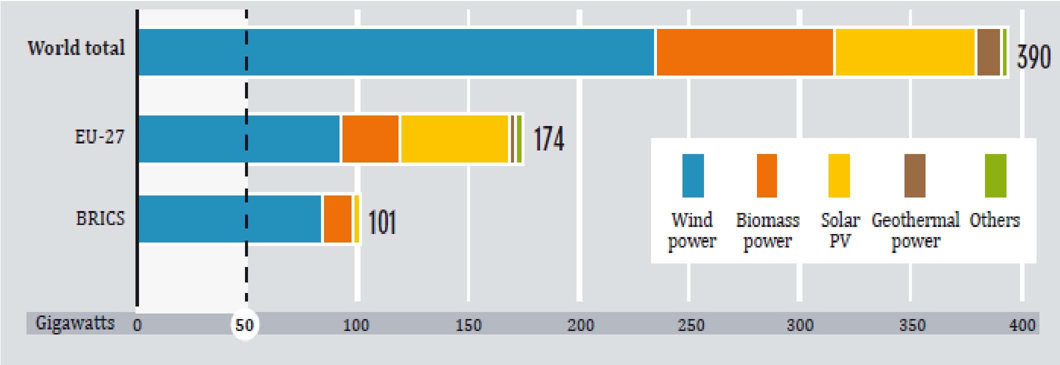

Figure 2-4 Renewable Power Capacities Excluding Hydropower, (Renewable 2012 Global Status Report, 2012).

The experiences gained from EU achievements in the field of renewable energy are quite important for newcomers. Energy was one of the main concerns of the founder members of EU, but in early stages EU history the European Council had not specify mandatory majors in the area due to priorities and resource constraints of member states. But concerns related with environmental and supply security changed the attitudes of the policy makers.

The oil crisis and environmental concerns affected European continent in 1970s and especially Scandinavian countries and Germany revised their energy policy towards renewables. Despite policy changes in some countries, implementation of EU on this area did not support research and development (R&D) activities sufficiently until 1990s. White Paper of 1997 which was published by European Commission specified 12% as the target for 2010 for the renewable energy in total energy consumption. The following directives (Directive 2001/77/EC and Directive 2003/ 30/EC) set indicative targets for the usage of renewable energy sources share in the electricity and transportation sectors. The RES (Renewable Energy Sources) Directive (2009/28/EC) imposed by EU set 20% target renewable energy in final energy consumption and 10% target for biofuels in transportation (Kornelis, 2006).

Energy policy of the EU is based on three major principles: supporting technology and research and development (R&D), goal setting for medium and long term targets and providing support mechanisms. Support on technology and R&D aims to decrease the costs of renewable energy technology, to contribute to employment and also to strengthen firms against increasing competitive capacity of economy.

The European Commission's Energy and Climate Change Policy proposal in 2007 included ambitious targets agreed by the European Council as 20-20-20 (20% reduction of greenhouse gas [GHG] emissions, 20% renewable share in the energy mix and 20% energy efficiency improvement) by 2020. According to Directive 2009/28/EC the 2020 targets are obligatory for all members. Members that could not reach targets by 2020 will have to take some financial actions like buying green certificate of renewable electricity.

Support mechanism is the main instrument for achieving these targets. As a requirement by the Directive (2009/28/EC), each member state has developed their own support mechanisms for achieving the targets. Supports for the electricity production from the renewables come to forefront with variety of support mechanisms due to its historical domination in renewable energy field when compared to heating and transportation (Kitzing et al., 2012). Table 2-2 shows number of member countries by types of support.

Table 2-2 Number of Members by Types of Support, (Kitzing et al., 2012)

	RES-E electricity	RES-H heat/cool.	RES-T transport
Feed-in tariffs; Guaranteed prices	21	-	-
Feed-in premiums; Production premiums	7	3	-
Tender schemes	5	2	-
Quota obligations, Building obligations	6	8	18
Investment grants	20	25	11
Fiscal measures(tax incentives, etc.)	13	12	22
Financing support (loans, etc.)	9	4	-

Feed in tariffs (FIT) is most common policy mechanism to promote renewable energy. Since it provides uninterrupted grid access, guaranteed period and fixed price for purchase. Guaranteed period can be identified by the years (e.g. Germany) or determined amount of first produced. (e.g. 10 TW of production in some projects in Denmark). In most implementations of FIT, producer sells its electricity to the system with constant price and free from market participation.

There are five different types of Feed in Tariff Mechanism (Renewable Energy Policy Country Profiles, 2011)

1. Fixed feed-in tariff: The determination of fixed prices for each type of renewable according to amended regulations (e.g. Germany, Portugal, Lithuania),
2. Time-dependent feed-in tariff: The determination of two or three different (day/night, peak/off-peak) prices for each type of renewable according to amended regulations (e.g. Spain for biomass and hydro for Hungary),
3. Indexed feed-in tariff: Prices are not known in the time of investment, indexed to another parameter like; natural gas price (e.g. Latvia),
4. Adjusting Feed-in tariff: Tariffs are not linked to time of installation, also applicable for existing projects (e.g. Bulgaria and Czech Republic),
5. Target-price Feed-in tariff: The tariff guarantees fixed price according to amended regulations, producer sell its electricity in market, the difference between market and fixed prices are paid after (Denmark).

Feed in premium, on the other hand, determines fixed prices according to regulatory types of projects and this price is paid to producer additionally. It is also categorized into two as fixed and adjusting according to whether implemented on existing projects or not.

In the Member states of EU applying complex Feed in Tariff Policy in line with their special conditions; prices are dependent on type of resource, size. In some of the member countries there is also timeline (e.g. max 2250 hours). Period of incentives changes according to type of resources.

By any means, EU member countries are developing policy and implementation mechanisms to reach 2020 targets. Some of them already beyond their original targets however the revision of these targets are on the agenda. The costs related with renewable energy policies are covered from general budgets of member countries. Total financial support to renewable energy showed an increasing trend in both total and per capita terms in all 27 members. Table-2-3 which is prepared according to data given in Financing Renewable Energy in the European Energy Market (2012) and population and renewable energy statistics of Eurostat shows support per capita and renewables share in gross final consumption (Eurostat,2012).

Table 2-3 Estimation of net Support Costs to Renewable Electricity in EU-27

	2007	2008	2009	2007	2008	2009	2007	2008	2009	2007	2008	2009
	Estimated Support to Renewable Electricity (Million €)			Population			Support Per capita €			Renewable share in gross final electricity consumption %		
Austria	361	384	454	8,282,984	8,318,592	8,355,260	43.58	46.16	54.34	60.72	62.3	67.69
Belgium	250	309	413	10,584,534	10,666,866	10,753,080	23.62	28.97	38.41	3.65	4.62	6.08
Bulgaria	3	4	18	7,679,290	7,640,238	7,606,551	0.39	0.52	2.37	7.52	7.42	9.81
Cyprus	1	2	2	778,684	789,269	796,875	1.28	2.53	2.51	0.06	0.27	0.07
Czech Republic	96	120	207	10,287,189	10,381,130	10,467,542	9.33	11.56	19.78	4.73	5.18	6.78
Denmark	152	150	142	5,447,084	5,475,791	5,511,451	27.90	27.39	25.76	27.04	26.7	27.49
Estonia	6	7	8	1,342,409	1,340,935	1,340,415	4.47	5.22	5.97	1.48	2.04	6.11
Finland	6	8	8	5,276,955	5,300,484	5,326,314	1.14	1.51	1.50	25.92	30.78	25.77
France	121	338	496	63,645,065	64,007,193	64,350,226	1.90	5.28	7.71	12.96	14.07	13.62
Germany	3564	4058	6148	82,314,906	82,217,837	82,002,356	43.30	49.36	74.97	14.11	14.63	16.2
Greece	33	40	49	11,171,740	11,213,785	11,260,402	2.95	3.57	4.35	6.77	8.29	12.45
Hungary	52	60	82	10,066,158	10,045,401	10,030,975	5.17	5.97	8.17	4.29	5.36	6.99
Ireland	13	14	32	4,312,526	4,401,335	4,450,030	3.01	3.18	7.19	9.46	11.69	14.13
Italy	1752	2191	2473	59,131,287	59,619,290	60,045,068	29.63	36.75	41.19	13.25	16.19	20.54
Latvia	1	1	1	2,281,305	2,270,894	2,261,294	0.44	0.44	0.44	36.39	41.21	49.23
Lithuania	1	1	2	3,384,879	3,366,357	3,349,872	0.30	0.30	0.60	4.6	4.65	5.5
Luxemburg	13	15	17	476,187	483,799	493,500	27.30	31.00	34.45	3.33	3.58	3.66
Malta	0	0	0	407,810	410,290	413,609	0.00	0.00	0.00	0	0	0
Netherlands	203	250	391	16,357,992	16,405,399	16,485,787	12.41	15.24	23.72	6.18	7.72	9.15
Poland	159	200	320	38,125,479	38,115,641	38,135,876	4.17	5.25	8.39	3.53	4.27	5.8
Portugal	104	130	195	10,599,095	10,617,575	10,627,250	9.81	12.24	18.35	29.63	26.42	33.27
Romania	10	10	11	21,565,119	21,528,627	21,498,616	0.46	0.46	0.51	26.86	28.37	27.91
Slovakia	7	20	8	5,393,637	5,400,998	5,412,254	1.30	3.70	1.48	16.57	15.48	17.88
Slovenia	8	10	8	2,010,377	2,010,269	2,032,362	3.98	4.97	3.94	22.13	29.11	36.76
Spain	81	94	143	44,474,631	45,283,259	45,828,172	1.82	2.08	3.12	19.45	20.58	25.83
Sweden	942	1832	3804	9,113,257	9,182,927	9,256,347	103.37	199.50	410.96	51.54	54.98	56.44
United Kingdom	1061	1159	1453	60,781,346	61,191,951	61,595,091	17.46	18.94	23.59	4.88	5.4	6.63
EU-27	9001	11408	16867	495,291,925	497,686,132	499,686,575	18.17	22.92	33.76	15.14	16.36	18.25

2.4.5 German Experience

Thanks to effective and costly incentive mechanisms Germany has increased its renewable electricity production successfully starting from 2000. Achievements in the first decade of 21st century made Germany the world's leading and model country. The first examples of support policy for renewable electricity (RES-E) production in Germany started in 1989. In 1989 "100 MW wind" project was introduced with the 3 €ct/kWh incentive. In 1991 programme upgraded to 250 MW. "100,000 Roof-Programme" (1999–2003) provided attractive credits for solar energy and aim to make possible PV (Photovoltaics) usage for the first time (Wustenhagen & Bilharz, 2006).

In 2000 "Renewable Energy Source Act" (German acronym, EGG) was introduced, with its 20 years feed in tariff guarantee, generous incentive prices and advantageous investment conditions. Germany easily has reached the figure of 15% for the share of electricity production from renewable sources in 2008. This figure was even ahead the target for 2010 namely 12.5%. The success in the increase of share of renewable electricity widely considered as an important achievement and policies of Germany had been adopted by other members like France, Italy and Spain (Frondel et al., 2010). Economic concerns and politics of international priorities of the Germany was been quite influential in the EGG Amendment of 2004.

Main objective of legislation can be counted as reducing energy consumption; promoting renewable energy technologies; increasing renewable based electricity production to 12.5% in 2010, 20% in 2020 occasionally; and preventing geopolitical conflicts related with fossil energy resources.

Feed in tariff price scheme of Germany is quite complicated, for instance prices are dependent on the capacity and usage area. Incentive prices started before EGG up to 2004 can be seen in the Table 2-4 and also simplified version incentives prices is available in Table 2-5.

Table 2-4 Feed-in tariffs for renewable electricity generation in Germany 1991–2004 (Wustenhagen & Bilharz, 2006)

		Before EGG	EGG			EGG (Revised)	Annual Reduction	
		Pre-1999 [a]	2000-01	2002	2003	2004	2002	2005
		€ cents/kWh					%	
Hydropower	< 500 kW	6.50		7.67		7.67	0	1
	500 kW-5 MW			6.65		6.65		
	5-150 MW	0.00		0		3.7-7.67[b]	N/A	
Landfill gas, sewage gas, coal mine methane	<500 kW	6.50		7.67		7.67-8.67	0	2
	500 kW-5MW			6.65		6.65-7.65		
	>5MW [g]	0.00		0		6.65-7.65	N/A	
Biomass	< 150 kW	7.10	10.23	10.10	10.00	11.5-15.0	1	2
	< 150 kW					9.90-13.40		
	< 500 kW			9.10	9.01	8.90-12.40		
	< 5 MW [h]	0.00		8	8.51	8.40-11.90		
Geothermal	> 5 MW	N/A	8.70			15.00	0	1[c]
	< 10 MW			8.95		14.00		
	< 20 MW					8.95		
	> 20 MW			7.16		7.16		
Onshore wind	< 5 years	8.20	9.10	9.00	8.87	8.70	1.5	2
	> 5 years		6.19	6.10	6.01	5.50		
Offshore wind	< 9 years	N/A	9.10	9.00	8.87	9.10 [d]	1.5	2 [f]
	> 9 years		6.19	6.10	6.01	6.19 [e]		
PV	Stand-alone	8.20	50.62	48.10	45.57	45.70	5	5
	Building integrated					54.00-62.40		

[a] Indicative numbers based on 1998 actual values
[b] Applies to refurbishment of existing hydropower plants, depending on size
[c] Decrease starting 2010
[d] Applies for 12 years to offshore projects commissioned prior to 2010
[e] Applies to all other offshore projects.
[f] Decrease starting 2008
[g] Coal-bed methane only
[h] Upper limit of 20 MW foreseen in draft EEG amendment 2004
[I] The tariff apply to power generation facilities that have become operational in given year

Table 2-5 Technology-specific feed-in tariffs in € Cents/kWh. BDEW (2001–2009)

	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
Wind on-shore	9.10	9.10	9.00	8.90	8.70	8.53	8.36	8.19	8.03	9.20
Wind off-shore	9.10	9.10	9.00	8.90	9.10	9.10	9.10	9.10	8.92	15.00
Photovoltaics	50.62	50.62	48.09	45.69	50.58	54.53	51.80	49.21	46.75	43.01
Biomass	10.23	10.23	10.13	10.13	14.00	13.77	13.54	13.32	13.10	14.70
Mean Tariff	8.50	8.69	8.91	9.16	9.29	10.00	10.88	11.36	12.25	13.60

In determination stages of tariff**;** Federal Ministry of Environment (BMU) , Federal Grid Agency, Federal Ministry of Food, Agriculture and Consumer Protection and Federal Ministry of Economics and Technology are responsible agencies. After modification on EGG, Germany's target for renewable based electricity is revised as 35% for 2020 and 80% for 2050. With this revision of the act it is possible for producers to choose between fixed feed in tariff or feed in premium options (Renewable Energy Policy Country Profiles, 2011). Last version of tariff prices and developments in renewable electricity production are available in Table 2-6 and Table 2-7.

Table 2-6 Overview of feed in tariffs scheme by technology (Renewable Energy Policy Country Profiles, 2011)

Tariffs incl. bonuses	Support level 2011 (€/ MWh)	Support level 2012 (€/ MWh)	Annual Degression
Hydro	34.3 (>50MW)- 126.7 (<500kW)	34.0 (>50MW)- 127.0 (<500kW)	1 % (from 2013 onwards)
Wind onshore	90.2 (in the first 5-20 years, depending on yield; after that 49.2 base tariff; available bonus: 4.9-9.8)	80.93 (in the first 5-20 years, depending on yield; after that 48.7 base tariff; available bonus: 4.8-9.8)	1.5 % (from 2013 onwards)
Wind offshore	150.0 (in the first 12 years; after that 35.0 base tariff)	150.0 (in the first 12 years; after that 35.0 base tariff)	7 % (from 2018 onwards)
Biomass (incl. biogas)	76.3-114.4 (available bonus:19.6-107.8; higher bonuses for biogas)	60.0-143.0 (available bonus: 25.0-80.0; higher bonuses for biogas)	2 % (from 2013 onwards)
Sewage and landfill gas	59.8-87.3 (available bonus: 19.4)	58.9-86.0 (available bonuses: 10.0; 20.0; 30.0)	1.5 % (from 2013 onwards)
Solar PV	Tariff (direct use)	Tariff (direct use)	1.5 % - 24 % (from 2013 onwards; depending on capacity additions during a 12-months period starting in September of the previous year; “Breathing Cap”)
<30kW	287.4 (123.6-167.4)	244.3 (805.0-124.3)	
30kW -100kW	273.3 (109.5-153.3)	232.3 (685.0-112.3)	
>100kW	258.6 (94.8-138.6)	219.8 (560.0-998.0)	
>1000kW	215.6	183.3	
Ground-mounted installations	211.1-220.7	179.4-187.6	
Geothermal	142.1-196.0 (available bonus for >10MW: 29.4-68.6)	250.0 (available bonus: 50.0)	5 % (from 2018

Table 2-7 Development in Renewable Electricity
(The Federal Ministry for the Environment, Nature Conservation and Nuclear Safety, BMU: Bundesministerium für Umwelt, Naturschutz und Reaktorsicherheit)

Year	Total Installed Capacity MW	Hydro power GWh	Wind energy GWh	Bio_ mass GWh	Bio_ genic Share of Waste GWh	Photo_ voltaics GWh	Geo thermal Energy GWh	Total Electricity Generation GWh	Share in Gross Electricity Consumption %
1990	4,069	15,580	71	221	1,213	0.6	0	17,085.60	3.1
1991	4,097	15,402	100	260	1,211	1.6	0	16,974.60	3.1
1992	4,331	18,091	275	296	1,262	3.2	0	19,927.20	3.7
1993	4,483	18,526	600	433	1,203	5.8	0	20,767.80	3.9
1994	4,865	19,501	909	569	1,306	8	0	22,293.00	4.2
1995	5,464	20,747	1,500	665	1,348	11	0	24,271.00	4.5
1996	5,874	18,340	2,032	759	1,343	16	0	22,490.00	4.1
1997	6,476	18,453	2,966	880	1,397	26	0	23,722.00	4.3
1998	7,473	18,452	4,489	1,642	1,618	32	0	26,233.00	4.7
1999	9,012	20,686	5,528	1,849	1,740	42	0	29,845.00	5.4
2000	10,875	24,867	7,550	2,893	1,844	64	0	37,218.00	6.4
2001	13,755	23,241	10,509	3,348	1,859	76	0	39,033.00	6.7
2002	17,498	23,662	15,786	4,089	1,949	162	0	45,648.00	7.8
2003	20,911	17,722	18,713	6,086	2,161	313	0	44,995.00	7.5
2004	24,007	19,910	25,509	7,960	2,117	556	0.2	56,052.20	9.2
2005	27,735	19,576	27,229	10,978	3,047	1,282	0.2	62,112.20	10.1
2006	31,431	20,042	30,710	14,841	3,844	2,220	0.4	71,657.40	11.6
2007	35,300	21,169	39,713	19,760	4,521	3,075	0.4	88,238.40	14.3
2008	39,497	20,446	40,574	22,872	4,659	4,420	17.6	92,988.60	15.1
2009	45,845	19,036	38,639	25,989	4,352	6,583	18.8	94,617.80	16.4
2010	55,578	20,956	37,793	29,085	4,781	11,683	27.7	104,325.70	17.1
2011	65,483	19,500	46,500	31,920	5,000	19,000	18.8	121,938.80	20.1

CHAPTER 3

RENEWABLE ENERGY IN TURKEY

3.1 General

Turkey has a developing economy and 25.3 % of its 74.7 million population is under 14 years old. (TUIK, 2012). The annual average economic growth rate is 6.5 % for the last ten years and 4.7% for the last thirty years (İmamoğlu, 2012). All of the surveys in the field show a positive relationship between economic growth and energy consumption. Between 1980 and 2011 primary energy consumption of Turkey has increased from 25.2 million tons oil equivalent (Mtoe) to 118.8 (BP-Statistical Review of World Energy, 2012). In this period annual growth rate of primary energy consumption is 5.3% .

This growth trend is also reflected in electricity consumption values. Between 1980 and 2011 electricity consumption values has increased nearly ten times; for the year 1980 it was 23 billion 237 million kWh while for the year 2011 it is 229 billion 344 million kWh (TEIAS,2011). In this period the annual growth rate of electricity consumption is 8%, making it bigger than the annual economic growth rate for the same period and also electricity consumption per capita increased from 494 kWh to 3099 kWh (gross) and the annual growth rate is 6.2%.Yet, it is still nearly 3 times smaller than OECD average although the rising trend seems to be maintained in long term (IEA,2011).

According to reports of Turkish institutions energy consumption will increase in the coming years. The electricity consumption projections of Turkish Electricity Transmission Company (Turkish acronym TEIAS) for the period, between the years 2011-2021 can be seen in the Table 3-1.

Table 3-1 Electricity Consumption 2011-2021 projections (TEIAS, 2011)

	Energy Demand				Capacity Demand			
	High Demand		Low Demand		High Demand		Low Demand	
Yearly	GWh	Increment (%)	GWh	Increment (%)	MW	Increment (%)	MW	Increment (%)
2012	244,026	6.4	244,026	6.4	38,000	5.2	38,000	5.2
2013	262,010	7.4	257,060	5.3	41,000	7.9	40,130	5.6
2014	281,850	7.6	273,900	6.6	43,800	6.8	42,360	5.6
2015	303,140	7.6	291,790	6.5	46,800	6.8	44,955	6.1
2016	325,920	7.5	310,730	6.5	50,210	7.3	47,870	6.5
2017	350,300	7.5	330,800	6.5	53,965	7.5	50,965	6.5
2018	376,350	7.4	352,010	6.4	57,980	7.4	54,230	6.4
2019	404,160	7.4	374,430	6.4	62,265	7.4	57,685	6.4
2020	433,900	7.4	398,160	6.3	66,845	7.4	61,340	6.3
2021	467,260	7.7	424,780	6.7	71,985	7.4	65,440	6.7

Rapidly growing demand for energy in last 30 years brings about economic and structural problems. According to statistical data of Turkish Statistical Institute (Turkish acronym, 2012) approximately 50% of the foreign trade deficit of Turkey resulted from the negative figures related with energy trade. (Table3-2) This situation makes energy issues a key component of Turkish economy.

Table 3-2 Share of Energy Products in Foreign Deficit (TUIK, 2012)

	2010	2011
Total Export (billion $)	113.9	134.9
Total Import (billion $)	185.5	240.8
Energy Products (billion $)	38.5	54.1
Others (billion $)	147	186.7
Foreign Deficit (billion $)	-71.6	-105.9
Share of Energy Prod. / For. Deficit (%)	53.77	51.09

Coal is the main fossil fuel resources of Turkey, however the share of coal in primary energy consumption is only 24% and it is mainly used for electricity generation and in some industrial areas such as cement and steel production (Akdeniz et al., 2001). Since Turkey is not a rich country in terms of fossil fuel resources, increasing primary energy as well as electricity demand of Turkey necessarily makes it to focus on domestic resources which are mostly categorized as renewable.

In this chapter, firstly the situation in terms of renewable energy before the year 2001 (beginning of legal reforms) will be briefly summarized and after that the developments in legal system and its consequences in the field of renewable energy will be dealt.

3.2 Pre-2001 Situation in the Renewable Energy

Until 2001 energy production from renewable energy sources was limited. Other than hydropower projects developed by the government agencies and solar heating systems used by the southern part of the country, the projects in the field of renewables were small sized and had no grid connection. In addition, participation of private sector in the energy business area in general was limited.

3.2.1 Hydropower

History of electricity production by using stream water started in 1902 in Tarsus-Adana with the installation of a small hydropower plant (SHPP) with 88 kW capacities. Building SHPPs for the supplying local demand continued in Turkey in time and capacity of SHPPs reached 38 MW by the year 1955 (Hepbaslı & Ozgener, 2003). The Electrical Power Resources Planning and Survey Administration (EIE) was established in 1935 by Law No 2819 for the purpose of making surveys and investigation about energy sources of the country. After establishment of General Directorate of State Hydraulic Works (DSİ) by Law No. 6200 in 1953 centralized management period of water works and hydropower generation planning, designing, constructing and operating phase started. After 1960s it concluded that SHPPs are not feasible investments. However, after oil crises in 1970s, feasibility studies and building activities were added to agenda (Sen, 2002).

Table 3-4 shows the installed capacity of power plants by the year of 2001. According to DSİ surveys the economically feasible installed capacity and annual average electricity generation are approximately for large and small hydropower totally 35,500 MW and 127,381 GWh /year, respectively. As a result of conducted activities by DSİ and be firms with special concessions (like Build Own Transfer BOT, Build Own BO) ; 129 plants were founded and hydropower installed capacity leads to 11,672 MWh with production of 24,010 GWh/ year by the year 2001. 10108 MWh of installed capacity was state owned and almost all them were generated by big dams (Table 3-4).

3.2.2 Wind Energy

Historically wind energy had been used for only for traditional purposes, i.e. windmills, in Turkey. Technology of electricity production from wind was expensive to use and surveys about wind potential is limited. First Electricity production from wind started in a Hotel in Cesme Izmir, in 1986. Installed capacity of the plant was 55 kW with annual production of 130,000 kWh (Hepbasli, 2001).

At the end of 2001 only three wind energy projects were completed with a total installed capacity of 18.5 MW (Table 3-4).These three plants are 1.1 MW and 7.2 MW plants in Cesme and 10,2 MW in Bozcaada. According to Turkish Wind Atlas which prepared by Turkish Wind Energy Association, there was not a single plant installed between the years 2001 and 2006 (Turkish Wind Energy Association, 2012).

According to early studies, utilizable wind potential of Turkey is estimated 83000 MW technical and 10000 MW economical (Wijk & Coelingh, 1993). The Turkish State Meteorological Service prepared Wind Map of Turkey in 2002 (The Turkish State Meteorological Service,2002). The result of the map presented very similar results. It stated that technical and economical utilizable wind potentials are 88000 MW and 10000 MW accordingly.

3.2.3 Solar Energy

Electricity production by using solar panels was not possible in Turkey before 2005 due to lack of incentives mechanisms. Law No.5346 which was amended by Law 6094 encourages solar electricity production by guaranteed prices and also with contribution for usage of domestic product in plants. Investment studies on this area are on the rise, but material results are still weak.

Despite the weak level of solar systems in electricity production, solar heating and cooling systems are very common in Turkey (Figure 3-1). Especially, in southern Turkey solar heating systems are frequently used and demand is still rising (Figure 3-2). According to Ministry of Energy and Natural Resources (MENR) 287,000 tons oil equivalent (Toe) energy was estimated to be produced by solar heating in the year 2001.

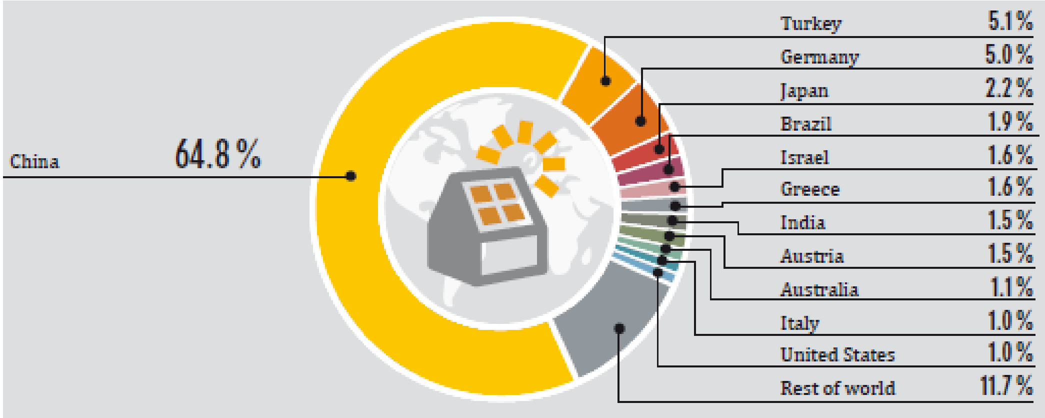

Figure 3-1 Solar Heating Total World Capacity, Top 12 Countries
(Renewable 2012 Global Status Report, 2012)

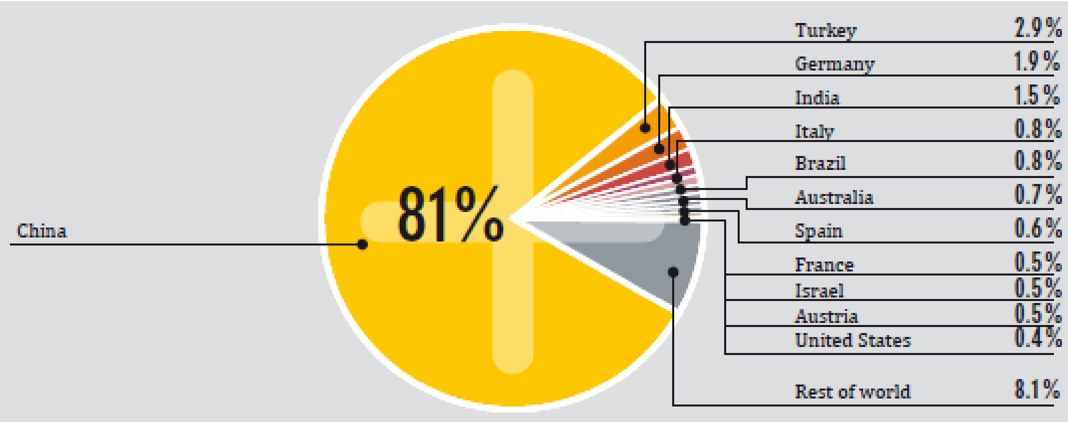

Figure 3-2 Solar Heating Added Capacity, Top 12 Countries
(Renewable 2012 Global Status Report, 2012)

3.2.4 Geothermal Energy

The General Directorate of Mineral Research and Exploitation (MTA) is responsible for development in the field of geothermal energy. Geothermal energy can be considered as useful for heat production and electricity generation. Turkey lies astride deep geological faults and because of that has relatively rich utilizable geothermal resources both for heat and electricity 7th in the world in this area (Mertoglu, 1993).

According to statistics of 2001, Turkey was the fifth country in the world as a direct user of the geothermal resources in electricity production with an 820 MW capacity (Table 3-3). Only 17.5 MW of that capacity was exploited at the end of 2001.

Table 3-3 World's Top Countries-Capacity of Geothermal Energy in Direct Use (Fridleifsson, 2001)

Country	MW
USA	3766
China	2282
Iceland	1469
Japan	1167
Turkey	820
Switzerland	547
Hungary	473
Sweden	377
France	326
Italy	326
New Zealand	308
Russia	308
Georgia	250
Mexico	164
Romania	152

3.2.5 Biomass

Studies of electricity production from biomass started in 1960s, and between the years 1980 and 1986 important researches had been performed by TOPRAKSU Research Institute. Furthermore studies of energy research began in 1980 with the Fourth Five-Year Development Plan of the government. (Hepbaslı & Ozgener, 2003).As a result of accelerated urbanization of society (biomass was a predominantly rural resource for heating), the share of biomass in total energy production decreased 20% to 10% from 1980 to 1998 (Kaygusuz, 2002).

Table 3-4 Installed Capacity in Turkey by 2001 (MW) (Study on long term electricity energy demand for Turkey, 2004)

Institution	Sources	Years					
		1990	1995	1998	1999	2000	2001
Turkish Electricity Production Company	Thermal	8,246.7	6,349.1	6,763.1	8,116.1	7,973.1	7,653.1
	Hydraulic	6,465.1	9,207.6	9,497.9	9,701.7	9,977.3	10,108.7
	Geothermal	17.5	17.5	17.5	17.5	17.5	17.5
	Total	14,729.3	15,574.2	16,278.5	17,835.3	17,967.9	17,779.3
Cukurova Electricity Company	Thermal	106.0	106.0	106.0	-	-	-
	Hydraulic	192.0	482.7	482.7	482.7	482.7	482.7
	Total	298.0	588.7	588.7	482.7	482.7	482.7
Kepez Electricity Company	Hydraulic	80.4	127.6	127.6	127.6	127.6	127.6
Auto production	Thermal	1,183.1	1,334.9	2,291.8	2,362.0	2,955.2	3,319.4
	Hydraulic	10.8	9.7	13.6	21.9	39.2	53.0
	Wind	-	-	1.1	1.1	1.1	1.1
	Total	1,193.9	1,344.6	2,306.5	2,385.0	2,995.5	3,373.5
Production Companies	Thermal	-	-	576.4	1,444.6	1,449.6	1,449.6
	Hydraulic	16.0	35.2	184.7	203.3	518.3	870.8
	Wind	-	-	7.2	7.2	17.4	17.4
	Total	16.0	35.2	768.3	1,655.1	1,985.3	2,337.8
Subsidiaries of Turkish Electricity Company	Thermal	-	3,284.0	3,284.0	3,284.0	3,284.0	3,284.0
Mobile Power Plant	Thermal	-	-	-	79.2	90.6	297.0
Operation Rights Transferred Power Plants (TOOR)	Thermal	-	-	-	-	300.0	620.0
	Hydraulic	-	-	-	-	30.1	30.1
	Total	-	-	-	-	330.1	650.1
General Total	Thermal	9,535.8	11,074.0	13,021.3	15,285.9	16,052.5	16,623.1
	Hydraulic	6,764.3	9,862.8	10,306.5	10,537.2	11,175.2	11,672.9
	Geothermal	17.5	17.5	17.5	17.5	17.5	17.5
	Wind			8.3	8.3	18.5	18.5
	Total	16,317.6	20,954.3	23,353.6	25,848.9	27,263.7	28,332.0

3.3 Electricity Reforms and Regulations in Turkey

The regulations in electricity and energy field started with the establishment of Ministry of Energy and Natural Resources (MENR) in 1963. According to the last version of the Law of Ministry (Law No: 3154) the purpose is “to define targets and policies related to energy and natural resources in a way that serves and guarantees the defense of our country, security, welfare, and strengthening of our national economy; and to ensure that energy and natural resources researches were conducted, developed, generated and consumed in a way that was compatible with said targets and policies” (MENR, 2012).

In 1970 Turkish Electricity Administration (Turkish acronym TEK) was established to supply all levels of electricity, as an official institution. Except from distribution which was carried out by local administrations, the remaining services were carried out by this monopoly. In the 1980’s Turkish model was similar to European countries.

In early 1980’s the role of governments in big infrastructure projects created debate in European public opinion. The difficulties of providing and rehabilitating of large scale infrastructure projects by public resources were well realized. In order to transfer the risks to private sector to decrease the governmental budgetary costs and to increase to social funds Public-Private-Partnerships were preffered.

Under these partnership private sector was responsible for developing projects and providing service in long term period. The private investors gathered operating rights and started to receive fees from users or governments (Engel, Fischer & Galetovic, 2009). The effective implementations of these models necessitate detailed analysis of the benefits of society. Without Public Sector Comparator Test (PSCT), which aims to calculate the public benefits from the projects and competitive bidding model evaluated as surplus value can easily be transferred from public to private sector (Cruz & Marques, 2011).

In 1984 private sector was allowed to build and operate power plants and started to sell electricity to TEK. In terms of regulations, Law No. 3096 was the first step for the participation of the private sector. This law was regulating the Build-Operate-Transfer (BOT) and Build-Own-Operate (BOO) models, which enabled private companies to provide services such as production, transmission and distribution of electricity within the scope of a concession agreement and Transfer of Operating Rights (TOOR) contracts which was allowed company to operate an existing asset and produce its own electricity as an auto-producer.

According to BOT model a private company would build and operate power plant for up to 99 years (right after it was reduced to 49 years) and then transfer it to the State. By using TOOR a government owned plant can be operated by private company through a lease type arrangement. This law also changed status of TEK to state owned enterprise.

In 1993, TEK was included into privatization plan and reformed as two separate companies, Turkish Electricity Generation and Transmission Co. (TEAS) and Turkish Electricity Distribution Co. (TEDAS). In 1994 Law on the Realization of Certain Investments and Services in Build-Operate-Transfer-Model (No: 3996), was amended in accordance with BOT models. Additionally in 1997 Establishing and Operating Electric Power Plants and Sale of Energy through the Build-Operate Law (No: 4283) was amended for participation of private companies to energy generation field.

Laws targeted contribution of private sector created some structural problems in Turkish Electricity Market; i) BOO, BOT, TOOR contracts signed between private companies and TEAS or TEDAS for 15 to 30 years had obliged “take or pay” with fixed quantities and prices, ii) treasury guarantees given by government to these investments is paradoxical with the logic of Public-Private-Partnership (PPP).

The main expectation from private sector participation in this field was to transfer the risk and also to decrease operational costs, to increase quality of services and adapt new technologies in the phases of design and implantation of projects with the help of effectiveness and managerial skills of private companies. Since efficiency-related benefits necessarily associated with competitively tendered projects and there was no significant framework in place on ensures, it is unlikely to enjoy those benefits. In the Turkish case, on the contrary, there was no requirement for prequalification and competitive open tender, neither for a closed tender. The method of tenders was to take offers from three interested companies and the negotiations based on feasibility study of investors. The projects developed, which based on fixed prices and purchase guarantees, the risks were still carried by the Government and the benefits of efficiency were exploited by the investors rather than consumers. The contracts, which were designed and implemented with this sense, turned out to be obstacles in front of new energy investments and competition in sector (Atiyas & Dutz, 2003).

In 2001 Electricity Market Law (No: 4628) and Natural Gas Market Law (No: 4646) were amended for radical changes in Turkish energy market structure. Article 1 of Law (No: 4628) identify the aim as “The purpose of this Law is to ensure the development of a financially sound and transparent electricity market operating in a competitive environment under provisions of civil law and the delivery of sufficient, good quality, low cost and environment- friendly electricity to consumers and to ensure the autonomous regulation and supervision of this market“. In addition to these, the targets of Law (No: 4628) were included liberalizing electricity market and getting rid of purchase and treasury guarantees. TEAS has been reformed as three state owned enterprise; Turkish Electricity Transmission Company (TEIAS), Electricity Trading and Contracting Co. (EUAS) and Turkish Electricity Trading and Contracting Company (TETAS). The licensing process has been rearranged both for generation and distribution. Vertical unbundling process, which is the separation of traditionally provided services by single utility into functionally independent parts, of Turkish electricity field had reached final point. Also Electricity Market Regulatory Authority formed as autonomous body.

In these new structure EUAS has responsibility of existing public power plants operations. TETAS is the state owned whole sale company, holder of all previous BOO, BOT, TOOR contracts. TEIAS is responsible from all transmission services and above all from balancing and settlement procedures. “Market Financial Reconciliation Centre” (in Turkish; Piyasa Mali Uzlaştırma Merkezi-PMUM) has been established under TEIAS in order to establish the market as a system operator (Baskan, 2011).

In 2003 MENR issued a new bylaw. Regulation on the Procedure and Principle of Signing a Water Use Right Agreement to Make Production in the Electricity Market aims to regulate market entrance procedures of private companies. According to this, regulation, a company has to apply to DSİ for an agreement as a first step. At the end of the process DSİ signs Water Use Agreement with the company. After that the company applies for production licenses. The approval date is the official starting date of the project.

As independent body EMRA (Energy Market Regulatory Authority) that was established by the law (No: 4628) turned out to be the most crucial actor in this new structure. Establishing and operating new license system, preparing regulations, controlling new transmission and distribution system, determining new eligible customers level, regulating tariffs; retail sale, whole sale, transmission and distribution, carrying out gas distribution networks tenders, inspect all structure, protect benefits of consumers and charging to rule violator stakeholders are the main functions of EMRA (Erdoğdu, 2006).

Law 4628 has brought about some new concepts such as wholesale company and retail sale company and eligible consumer in order to attain the goal of fully liberalized market. The wholesale company defined as any legal entity engaged in the wholesale, import, export, trade of electricity energy and/or capacity and sale to the eligible consumers. There were limitations on activities in order to avoid monopolies with the rule that envisages the share of a wholesale company together with its affiliates shall not exceed 10% of the total electricity consumed during the preceding year. The retail sale company on the other hand defined as any legal entity engaged in import of electricity and/or capacity and retail sale to consumers, excluding those directly connected to the transmission system, and in providing retail sale services to consumers. The wholesale company can export or import electricity to any country by using interconnection but retail sale company has right to only import via distribution level.

Eligible consumer can be defined as any real person or legal entity that has the right to choose its supplier, on the condition that the consumption of electricity is more than the amount set by the EMRA and/or it has direct connection to the transmission system. Starting from 2002, eligible consumer limits were decreased by EMRA in order cover 100% of consumer in eligibility limits in 2013 (Table 3-5). In 2002 eligible consumer share was 28%, however at the end of 2011 and it was increased 78% and the total number of eligible consumers reached 27.486, the share of eligible consumers in total consumption was 18% in 2012 (EMRA, 2012).

Table 3-5 Eligible Consumer Limits (EMRA, 2012)

Year	Eligible Consumer Limits
2002	9,000,000 kWh/year
2003	9,000,000 kWh/year
2004	9,000,000 kWh/year
2005	7,700,000 kWh/year
2006	6,000,000 kWh/year
2007	3,000,000 kWh/year
2008	1,200,000 kWh/year
2009	480,000 kWh/year
2010	100,000 kWh/year
2011	30,000 kWh/year
2012	25,000 kWh/year

According to Law No: 4628 and revised Law of DSI (No: 6200) transfer of existing, under construction and future hydraulic power plants to generation companies is allowed. (Çakmak & Yıldırım, 2003) The legal reforms and supporting regulations were settled the rules in order to transfer the operational rights of existing HPPs to the private sector and to give water right licenses to newly founded generation companies to develop new projects for producing electricity.

After 2003 market structure started to reshape; EMRA issued 1336 production, 251 auto productions licenses for the projects of private sector between 2003 and 2011. In this period, the public share in installed capacity and production were decreased dramatically. As seen in Table 3-6, Table 3-7, Figure 3-3 and Figure 3-4. The reform process which is explained above is summarized in Figure 3-5.

Table 3-6 Installed Capacity of Turkey by Producers (derived from TEIAS statistics)

	2001		2011	
	MW	%	MW	%
EÜAŞ	17,779.30	62.80	20,280.40	38.30
Subsideries of EÜAŞ	3,284.00	11.60	3,870.00	7.30
Chartered Companies (ÇEAŞ-KEPEZ)	610.30	2.20		
BO+BOT	2,337.80	8.30		
BOT+BO+Generation Companies+TOOR			25742.00	48.70
Autoproducers	3,373.90	11.90	3,018.70	5.70
Mobile	297.00	1.00		
TOOR	650.10	2.30		
Total	2,8332.40	100.00	5,2911.80	100.0

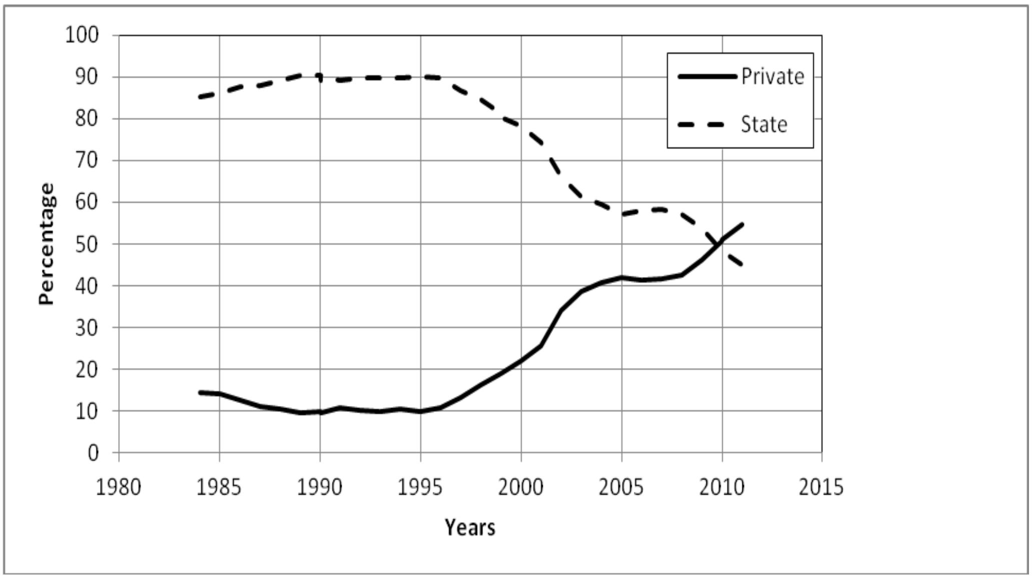

Figure 3-3 Change in Installed Capacity of Turkey by Producer (years versus percent share of public and private sector) (EUAS, 2012)

Table 3-7 Electricity Production in Turkey by Producers (derived from TEIAS statistics)

	2001		2011	
	MWh	%	GWh	%
EÜAŞ	67,468.50	54.98	7,3524.10	32.10
Subsideries of EÜAŞ	18,893.90	15.40	18,826.50	8.20
Chartered Companies (ÇEAŞ-KEPEZ)	1,345.60	1.10		
BOT	13,277.90	10.82		
BO	1.20	0.00		
BOT+BO+Generation Companies+TOOR			12,243.10	54.40
Autoproducers	17,914.00	14.60	12,481.10	5.30
Mobile	1,117.10	0.91		
TOOR	2,706.50	2.21		
Total	12,2724.70	100.00	22,9395.10	100.00

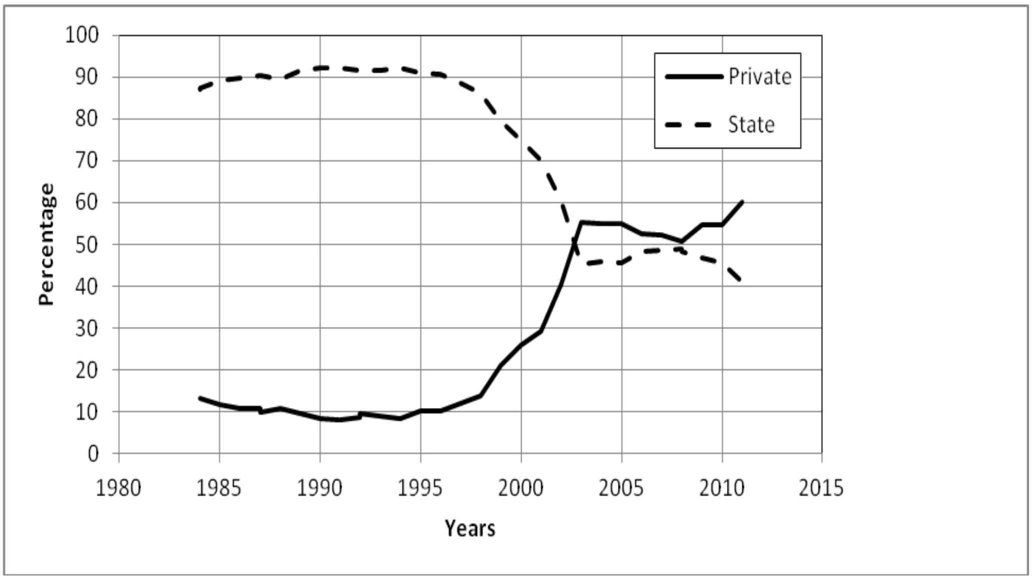

Figure 3-4 Change in Electricity Production in Turkey by Producers Producer (years versus percent share of public and private sector) (EUAS, 2012)

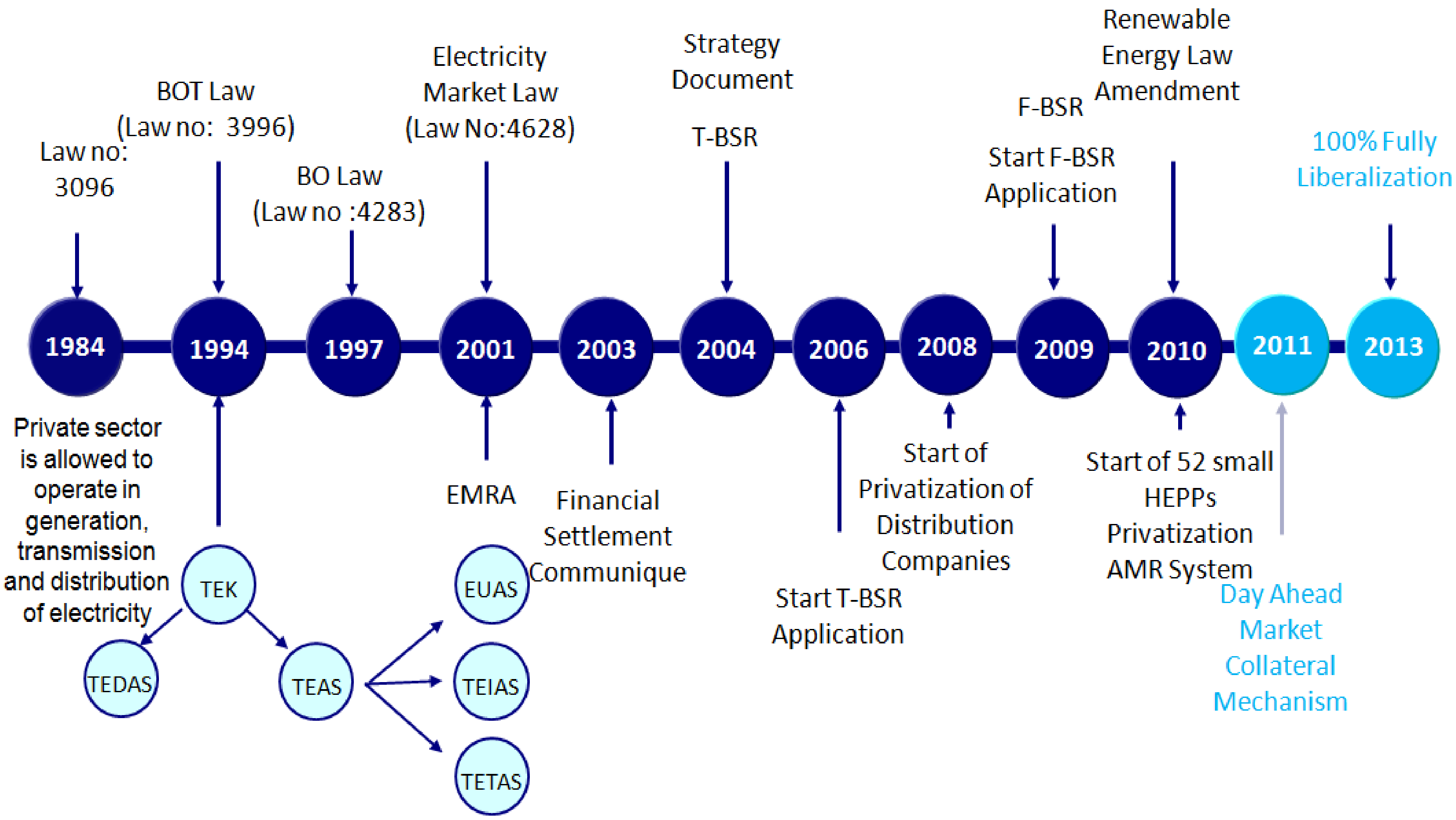

Figure 3-5 Reform Process of Turkish Electricity Market (TEIAS-2011)

3.4 Legal Evaluation of Renewable Energy in Turkey

In 2005 Law on Utilization of Renewable Energy Sources For the Purpose of Generating Electrical Energy (No: 5346) was amended. In the Article-1 purpose was defined as”... to expand the utilization of renewable energy sources for generating electric energy, to benefit from these resources in a secure, economic and qualified manner, to increase the diversification of energy resources, to reduce greenhouse gas emissions, to assess waste products, to protect the environment and to develop the related manufacturing industries for realizing these objectives.”

Law defines renewable energy as non-fossil resources that exemplified as hydraulic, wind, solar, geothermal, biomass, biogas (including landfill gas), wave and current and tidal energy. Hydraulic electricity production plants are restrained to canals, run-off river and reservoir types having a lake area smaller than 15 square kilometers. The law provided; Feed in Tariff between 5-5.5 euro-cent/kWh for all type of resources which designated by The Council of Ministers, grid access priorities and amenities on land acquisition. The law is valid for the projects that realized until the end of 2013. The Council of Ministers is authorized to extend this dead line

Law on renewable energy aimed; to decrease foreign trade deficit by excessively exploiting domestic resources in long term, to attract foreign direct investments in energy sector and to ensure supply security by diversifying electricity production resources. The law also targeted to integrate national energy policy of Turkey to the policies of EU during negotiation phase.

According to European sources the Law basically took German Renewable Energy Law as the modal (Gaupp, 2007). The European Sources in this field claimed that it was valuable starting point for development in this field, but lack of tax advantage can lead difficulty in competition against conventional energy resources and since whole implementation process under the responsibility of EMRA as an independent regulatory authority, a proper division of task is not possible between MENR and EMRA. Furthermore EU criticized the law not to be conformity with the 2010 targets of EU (Turkey Progress Report, 2010).

In 2010 the Law on Renewable Energy was revised by Law 6094. According to this revision, Feed in Tariff values rearranged in dollar-cent terms and these values are specified as resource based (Table 3-8). Electricity produced under renewable energy certification can be sold through Day-Ahead-Market (Market Financial Reconciliation Centre) or RES Support Mechanism. RES Support mechanism is applicable for 10 years after start of production. Validity period was extended to 2015 and The Council of Ministers is authorized to extend period and to regulate prices in accordance with the figures mentioned in the law. The companies producing electricity from renewable resources are obligate to report their preference about uses MFRC, RESSM or bilateral agreements each year. Day-Ahead-Market (Market Financial Reconciliation Centre), RES Support Mechanism and bilateral agreements discussed in Chapter-4.

In addition to incentives for electricity prices, there are also supplementary supports: 85% discount for land rents of renewable energy projects for the first 10 years; paying only 1% of license fee; no annual license fee free for first 8 years and primacy in grid connection.

The law also includes additional incentive mechanism for the domestically manufactured mechanical and/or electro-mechanical equipment used in plants for each component (Table 3-9). Till the end of 2013 there is a limitation for solar electricity plants that total capacity of RES certificated solar electricity plants connected to grid cannot exceed 600MW.The Council of Ministers is authorized to determine the capacity of RES certificated solar electricity plant capacity.

Table 3-8 RES Support Mechanism Prices with respect to Type of Production

Type of Production Facility Based on Renewable Energy Resources	Prices Applicable (US Dollar cent/kWh)
a. Hydroelectric production facility	7.3
b. Wind power based production facility	7.3
c. Geothermal power based production facility	10.5
d. Biomass based production facility (including landfill gas)	13.3
e. Solar power based production facility	13.3

The efforts of Turkey in legal development and realization of renewable energy investments were admired and won recognition in this area. But domestic product incentives remarked as arguable in EU progress reports. EU Progress report of Turkey 2011 stated that the compliance of this incentive mechanism with international trade rules has yet to be confirmed. In “Ability to Take Obligation of Membership“(Part-4; Chapter: 15 Energy) of EU Progress report 2012 also referred to domestic product incentives. According to the report the compliance of the regulation, which was amended in July 2012 in order to specify the minimum domestic content requirements in equipment and their components required for benefiting from the incentives foreseen in the law on renewable energy, with WTO or Custom Union trade rules for incentive mechanism is questionable. (Turkey Progress Report, 2011-2012).

Table 3-9 Domestic Product Incentives

Type of Facility	Domestic Production	Domestic Contribution (US Dollar cent/kWh)
A-Hydroelectric production facility	1- Turbine	1.3
	2- Generator and power electronics	1.0
B- Wind power based production facility	1- Wing	0.8
	2- Generator and power electronics	1.0
	3- Turbine tower	0.6
	4- All of the mechanical equipment in rotor and nacelle groups (excluding payments made for the wing group and the generator and power electronics.)	1.3
C- Photovoltaic solar power based production facility	1- PV panel integration and solar structural mechanics production	0.8
	2- PV modules	1.3
	3- Cells forming the PV module	3.5
	4- Invertor	0.6
	5- Material focusing the solar rays onto the PV module	0.5
D- Intensified solar power based production facility	1- Radiation collection tube	2.4
	2- Reflective surface plate	0.6
	3- Sun chasing system	0.6
	4- Mechanical accessories of the heat energy storage system	1.3
	5- Mechanical accessories of steam production system that collects the sun rays on the tower	2.4
	6- Stirling engine	1.3
	7- Panel integration and solar panel structural mechanics	0.6
E- Biomass power based production facility	1- Fluid bed steam tank	0.8
	2- Liquid or gas fuel steam tank	0.4
	3- Gasification and gas cleaning group	0.6
	4- Steam or gas turbine	2.0
	5- Internal combustion engine or Stirling engine	0.9
	6- Generator and power electronics	0.5
	7- Cogeneration system	0.4
F- Geothermal power based production facility	1- Steam or gas turbine	1.3
	2- Generator and power electronics	0.7
	3- Steam injector or vacuum compressor	0.7

3.5 Developments in Renewable Energy Sector After 2001

After revision of the legal system EMRA has become the responsible institution for issuing the licenses of private sectors projects starting since 2003. The number of the licenses granted by EMRA is available in Table 3-10 for both auto producers and generator companies. When distribution of licenses is analyzed, it is obvious that the majority of licenses are for renewable energy resources based projects. The share of HPP, WPP and total renewable were 55%, 15% and 73% of total number and 30%, 12% and 43% of installed capacity respectively (Table 3-11).

Table 3-10 Numbers of Licenses Granted by EMRA by Types (EMRA, 2011)

	2003	2004	2005	2006	2007	2008	2009	2010	2011	Total
Auto producers	137	14	18	18	10	22	8	16	40	234
Production Companies	105	76	77	146	255	301	199	194	415	1231

Table 3-11 Distribution of Auto producer and Production Licenses by Types of Fuel (EMRA, 2011)

	2011		Total (2003-2011)	
	Number of Licenses	Installed Capacity MW	Number	Installed Capacity MW
HPP (large dams	150	1,841.16	760	19,483.33
Natural Gas	60	6,332.90	278	20,256.21
WPP	120	4,070.20	209	7,479.25
Geothermal	6	139.14	17	401.05
Fuel-Oil	2	60.03	35	1,246.08
Lignite	1	38.10	33	4,379.68
Import Coal	3	20.12	21	9,070.93
Biomass	3	13.63	5	16.43
Biogas	5	8.89	14	22.34
Landfill Gas	1	5.80	9	120.02
Asphaltite	0	0.00	2	688.75
Total	351	12,530.00	1383	62,475.00

*

3.5.1 Hydropower

First implementations of the renewable energy projects were based on hydropower. Although it has low operation and maintenance costs, governments have usually allocated money yearly base due to high capital cost thus the construction periods grew longer and fixed costs of construction created inefficiency in the projects.

After legal improvements in this area, the Government decided to recede projects for hydro resource electricity production, except the projects that are on the construction stage. Consequently some of the HPP plants which were operated by EUAS transferred to the responsibility of Privatization Administration. The 52 SHPP (142MW capacity) in 19 groups which had been transferred Privatization Administration, were privatized by the transfer of operation rights contracts (TOOR) for 30 years starting from 2010 (Figure 3-5).

The hydropower plants which are canal, run-off river and reservoir type having smaller than 15 km^2 lake area, evaluated as renewable in the scope of renewable energy law. The plants having long-term storage capacity are not in the scope of renewable energy law.

Table 3-12 Installed Capacity by Types of Fuel (TEIAS, 2012)

	2011			23.08.2012		
	Installed Capacity MW	%	Number	Installed Capacity MW	%	Number
Fuel Oil-Asphaltite-Naphtha-Diesel	1,362.3	2.6	23	1,362.3	2.4	23
Import Coal-Hard Coal-Lignite	12,355.7	23.4	24	12,390.8	22.2	26
Natural Gas-LNG	16,004.9	30.2	155	17,090.5	30.6	184
Biomass-Biogas-Landfill Gas	115.4	0.2	18	147.6	0.3	28
Multi-fuel (Solid-Liquid)	556.5	1.1	8	675.8	1.2	8
Multi-fuel (Liquid-Gas)	3,536.4	6.7	52	3,150.5	5.6	46
Geothermal	114.2	0.2	7	114.2	0.2	7
HPP-1 (Dams)	13,529.3	25.6	58	14,031.1	25.2	61
HPP-2 (Run of River+Canal)	3,607.7	6.8	251	4,716.1	8.5	302
WPP	1728.7	3.3	47	2,105.9	3.8	58
Total	52,911.1	100.0	643	55,784.8	100.0	743

Private companies took over 760 production licenses of hydropower plants with a total capacity of 19,483.33 MW. Most of these licenses are for run of river and canals type plants. Total number of HPPs with dams and HPPs which are either run of river and canals in operation are 58 and 251, respectively by the end of 2011 and total installed capacity of them is 17137 MW (Table 3.12). According to statistics derived from MENR, 217 of HPPs became operational between the years 2003 and 2011, with total capacity of 4940 MW (Table 3.13).

Table 3-13 HPPs built and put in operation

	Number	Installed Capacity MW
2003	6	360.4
2004	4	66.7
2005	5	260.6
2006	10	157.2
2007	8	332.1
2008	19	432.7
2009	38	725.2
2010	63	1,299.4
2011	64	1,305.6
Total	217	4,940.0

However the utilization of the projects is still less than expected. 553 licensed plant with 13543 MW capacity are still it the phase project or construction phase. The main reasons behind this situation are related with technical, financial, social and environmental issues. Uncertainty of the amount of flow due to ungauging basins and project created problems in terms of project implementation. The problems related with transportation infrastructure are also reported as technical problem in the meetings between DSI by private companies.

In newly liberalized energy market of Turkey, financing is inevitably a difficult issue. In addition to characteristic problems of energy investments such as high capital costs and long return periods, global economic and financial crisis created extra cash flow problems. Especially newly established small sized production companies, whose projects are whether financed by their own resources or by credit agencies, were obliged to slowdown or stop their activities. As a result situation some of the licenses cancelled or revised (World Energy Council Turkish National Committee, 2007).

Projects, there are over the 50 MW limit associated to Environmental Impact Assessment. For the projects below 50 MW limit environmental considerations are only analyzed in accordance introduction part of the Water Usage Rights Act in order to obtain a license. Although some precautionary environmental regulations formed, it did not satisfy academic circles and society. The concerns about the weakness of public participation, environmental problems created by construction and insufficiency of water for residents and nature in operation phase created social obstacle for projects. Some projects were taken in to the courts by individuals and NGOs. In accordance with the decisions of courts, some of the projects were cancelled or stopped. For instance a total of 30 projects with the capacity of 578 MW have legal problems according to figures EMRA (EMRA, 2012).

Despite technical insufficiencies, financial problems, social oppositions and environmentally questionable practices, the number of utilized hydropower plant increasing.

3.5.2 Wind Energy

After legal framework is set, electricity generation from wind resources appeared as new practicable renewable energy resource in Turkey. The high level of non-exploited potential appealed the interest of domestic and foreign investors.

EMRA started to receive production license requests in 2002 and by the time 4,137 MW of 6,122 MW of total applications was wind energy power plants (WPPs). In 2007, with incentive mechanism of Law on Renewable Energy, the investors applied to EMRA for 751 projects which has total capacity of 78,180.2 MW. Although there were more than one application for the same zone, the total capacity of the projects were far beyond the economically developable capacity. These values were the indication of high demand and eager interest to this field.

Up to 2011, EMRA issued license for 209 projects with capacity of 7,479. 25 MW and total installed capacity of 1,728.70 MW. Realization of the projects derived from MENR statistics can be seen in Table 3-14.

Table 3-14 WPPs built and put in operation

	Number	Installed Capacity MW
2006	4	38.9
2007	7	76.4
2008	13	217.1
2009	26	439.1
2010	32	528.6
2011	27	410.9
Total	109	1,711.0

According to reports of TEIAS, capacity factor of WPP plants (percentage of actual production to full capacity production) ranges between 30% and 45% and according to the feasibility studies received by EMRA, the mean capacity factor of licenses 41.9%. When the studies in this field that show the average mean capacity factors of WPP in EU is 21% are considered, with the help of decreasing installation cost and additional incentive mechanisms, the economically eligible potential can increase (Akdağ & Güler, 2010).

Potential in electricity generation by using wind energy in Turkey and incentive mechanism for domestic product usage encourage private sector to produce wind energy equipment. In addition to tower and blade market which are dominated by domestic companies, a Turkish company is designing and manufacturing turbine wind turbines with maximum capacity of 1650 kWh and R&D activities of capacity expansion are still advancing.

As well as private sector, state's institutions and universities; The Scientific and Technological Research Council of Turkey (TUBİTAK), Turkish Aerospace Industries (TUSAŞ-TAI), Istanbul Technical University (ITU), and Istanbul Transportation Co., started to take part in the project of The National Wind Energy System (MILRES) that aims to develop and produce domestic wind turbine.

Turkey's efforts for the development in the field of wind energy are appreciated in international area and Turkey is being considered as one of developing market leaders along with South Africa, India, Brazil and Mexico. 20 GW target for 2023 is seems as an achievable target and even more than 20% of electricity consumption can be supplied by wind resources with development in grid connection and simplified bureaucracy (De Lema, 2012).

3.5.3 Geothermal Energy

Although it has small share in renewable energy resources and electricity production, it is a non-expendable resources with its stable character. Geothermal power plants can operate with high capacity factor rates and without being effected by the natural changes.

As a world's fourth country in usage of geothermal energy after China, U.S.A and Sweden, Turkey is not one of ten in electricity production capacity from geothermal resources (Renewable 2012 Global Status Report, 2012). After the amendments in Law on Renewable Energy which increased Feed in Tariff prices in geothermal field from 5.5 euro-cent to 10.5 euro-cent, the use of Geothermal resources in electricity is continuing to rise.

Before increase in incentive prices in the 2010 EMRA issued licenses for four projects which has capacity of 63 MW, and total number of projects and capacity rose to eleven and 227 MW respectively. In 2011 six projects received license with capacity of 139.14 MW (Table 3-15).

Table 3-15 Geothermal Power Plants built and put in operation

	Number	Installed Capacity MW
2006	1	8.0
2007	0	0.0
2008	1	6.9
2009	1	47.4
2010	2	17.0
2011	1	20.0
Total	6	99.3

Turkey also amended regulations about geothermal in 2008. The field activities like drilling and testing for exploring new areas have increased recently due to involvement of private companies. It is important to explore new fields suitable for electricity generation to reach 2000 MW installed capacity target.

3.5.4 Biomass

Electricity generation from biomass can be examined in three categories; biomass, biogas and landfill gas. Landfill gas is the most common and developed type of usage in Turkey. Uncontrolled urbanization and municipalities’ unplanned response to problems brought about irregular landfill areas. Landfill areas created many problems for public health. As a solution to this problem transfer of operation rights to private sector became a current issue in order to rehabilitate these areas. After liberalization of electricity market and creation of incentive mechanism, utilization electricity production by using landfill gas started especially for bigger cities. EMRA issued licenses for nine projects with 120 MW until 2011. 22 units (additional units of same license) with 73.2 MW capacity started to produce electricity in this period (Table 3.16).

Table 3-16 Landfill Gas Power Plants entered in to Market

	Number	Installed Capacity MW
2006	2	5.2
2007	1	1.4
2008	4	17.0
2009	4	15.6
2010	3	15.6
2011	8	18.5
Total	22	73.2

Biogas plats with small capacities to produce electricity by using industrial waste started to produce electricity in this period (Table-3.17).

Table 3-17 Biogas Power Plants entered in to Market

	Number	Installed Capacity MW
2006	1	0.8
2007	0	0.0
2008	0	0.0
2009	3	6.1
2010	3	1.5
2011	0	0.0
Total	7	8.4

There are also some other plants are operating with waste of factories and gases formed from treatment processes in Waste Water Treatment Plants. These plants are operating without grid connection and aiming to meet demand of their own facility. It can be feasible to sell electricity as renewable source and buy from network after higher incentives rather than own usage. Nevertheless, a mechanism can be designed for those factories and plants to take advantages of being renewable energy producer.

3.5.5 Solar Energy

As world's second user of solar energy in water heating, electricity production by using solar is an undeveloped area in Turkey. Long return period and high unit cost of electricity makes it impossible to produce electricity commercially without incentive mechanisms. Feed in Tariff price envisaged in the first version of Law on Renewable Energy, which was 7.3 dollar-cent, a price which was not considered plausible by the investor to install solar power plants. In 2010 version of the Law, Feed in Tariff prices increased to 13.3 dollar-cent and some new incentive mechanisms were included for a promoting domestic production for solar energy.

Feed in tariff prices of Turkey is still low when compared to incentive prices in EU. The license limitation of 600 MW till the end of 2013 also shows Government has a slow approach on this area. The reasons of this policy can be analyzed in many ways. There is a rapid advance in solar power technology, the installation costs are expected to decrease. Uncontrolled development in solar electricity production by using import panels can increase balance of trade deficit which is considered as crucial issue in recent years. The effects of higher Feed in Tariff prices on RES Support Mechanism which is financed by all supply companies can increase electricity prices.

3.5.6 Energy Efficiency

Energy efficiency is considered as a type of renewable energy resources. According to reports, Turkey ranks as one of worst among OECD countries in energy efficiency (Flipini & Hunt, 2009). In 2007 Law on Energy Efficiency (No:5627) amended and an energy efficiency strategy was published in February 2012, identified a set of policies and action plans to reduce energy intensity of Turkey by at least 20% until the 2023. In terms of electricity, efficiency of machinery in industry and reduction of losses in transmission and distribution lines are two major factors in efficiency concerns.

3.5.7 Unlicensed Electricity Production

In 2011, the regulation on unlicensed electricity production was issued. According to this regulation, any natural or legal entity can produce electricity by installing plant up to 500 kW without obligation of establishing company for their own consumption. It is valid for renewable energy resources and micro generation systems (cogeneration units; producing two or three of; heating, ventilation and air conditioning, mechanical energy and electric power). It also allows to sell redundant part by using grid. After improvements in grid system, unlicensed electricity generation by using renewable sources like integrated solar home systems or micro wind and hydro turbines in rural areas; turns out to be a promising way of for reaching potential of Turkey . At the time being, grid system does not allow two ways conveyance at the level of residential consumers.

CHAPTER 4

ELECTRICITY MARKET AND RES SUPPORT MECHANSIM

4.1 General

A comprehensive analysis of market development of renewable energy in Turkey required detailed understanding of electricity market and pricing mechanisms applied for electricity produced by renewable resources.

Law No. 5346 (Law on Utilization of Renewable Energy sources for the purpose of generating electricity) entered into force in 2005. In 2010 Law 5346 was amended and Law No: 6094 appeared as the final version of legal regulation in the field of electricity generation by using renewable resources. For the purpose of promoting renewable energy development, Renewable Energy Sources (RES) Support Mechanism is defined in the law. After complete definition of mechanism, it is also indicated that producers are free to participate in the RES Support mechanism. Any producer can sell its electricity by using bilateral contracts or directly to the other companies and to the market. Renewable energy producers can benefit from RES Support mechanism by using their RES license for a ten year period. After this period they have to sell electricity by using regular market instruments.

TEIAS has the responsibility of operating the system together with as well as its transmission business as a state enterprise. In the TEIASs Articles of Association in the items 23 and 24 of Article-4 (titled Purpose and Activity Field of the Establishment), its role in Balancing and Settlement procedure is identified as; “23. To ensure infrastructure of all sorts of communication, information and control in relation with the system control and operational activities, to set up infrastructure required by the Balancing and Settlement Regulation and to execute implementation pursuant to the said Regulation and in this context, to ensure operation of the financial reconciliation system”, “24. To improve and implement the infrastructure oriented towards implementation of new trade methods and sales channels, in line with the decision of the Board, depending on the development of the Market”.

As it was mentioned above two institutions of TEIAS are assigned balancing and settlement tasks under the organizational framework. National Load Dispatch Centre, which is called as system operator also, is responsible for technical tasks of balancing on the other hand Market Financial Reconciliation Centre, is responsible for financial settlement.

Market Financial Reconciliation Centre (MFRC) of TEIAS which has evolved since the day it was founded seems appearing as the main body of financial market. The fundamental function of MFRC is to settle power market financially with the help of day-ahead market in addition to bilateral agreements. Producer companies which prefer to sale electricity in day-ahead market, have to be registered by MFRC and have to report their expected production plans and their price offers.

The present chapter includes an overview of electricity market, balancing and settlement procedure, bilateral agreements, day-ahead planning and day-ahead market concepts, an evaluation of the structure of pricing mechanism, operation of MFRC and also RES Support Mechanism.

4.2 An Overview of Electricity Market in Turkey

The first element of smoothly functioning energy market is an uninterrupted, regular and controlled flow system. The energy flow system of Turkey schematically can be seen in Figure 4-1. In general energy produced by private companies or EUAS transmitted by TEIAS to distribution companies and finally to consumers. Apart from this private producers can convey electricity to their customer by using distribution lines. Transmission lines are under ownership of TEIAS and distribution companies have operating rights of distribution lines. Any market participant which has taken required licenses from EMRA can use transmission and distribution lines for its activities by paying charge. The charge of line usage determined regularly by EMRA.

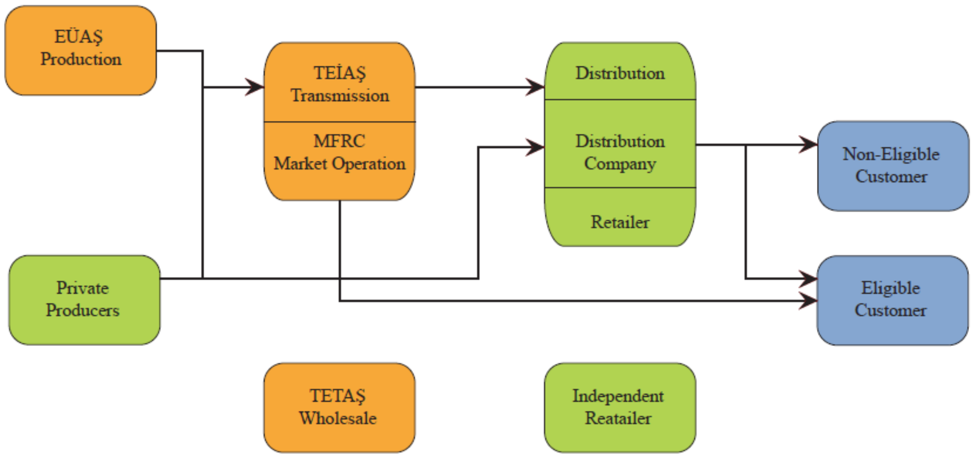

Figure 4-1 Energy Flow Diagram and Connections in Turkey

Balancing is the ability to actually create a balance between supply and demand in a specific time and balancing market is the mechanism in which this balance is acquired. Primary component of balancing market is bilateral agreements. Bilateral agreements are deals between energy producers and eligible consumers. Bilateral agreements are constitutive bases of the market and expect from these agreements there are also independent producers in the supply side and non-eligible consumers in the demand side. Functional need for balancing is appears in this level. There must be a market mechanism which balances suppliers' production and consumers' demand.

The element of balancing and settlement can be seen in Figure 4-2. MFRC which is operated by TEIAS is the financial centre of balancing system. All bilateral agreements, production and consumption data collected in the centre and the system is balanced accordingly. Detailed analysis of MFRC will be further discussed in section 4-2-3.

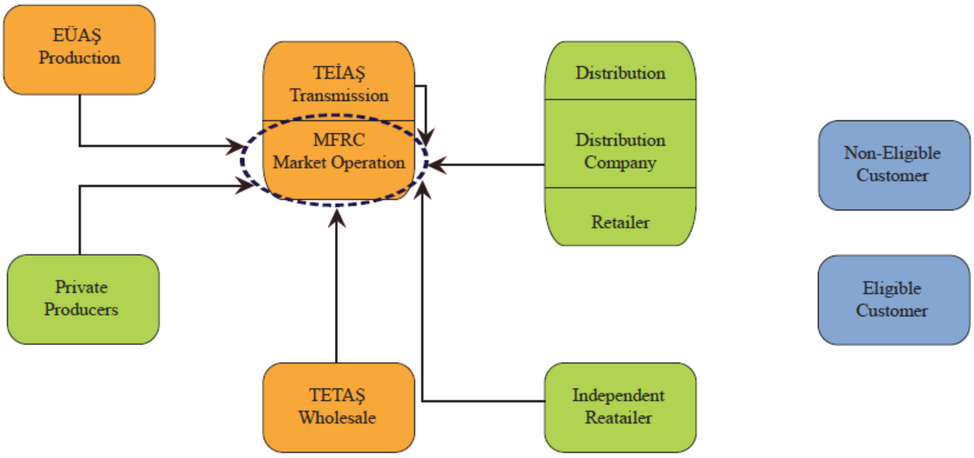

Figure 4-2 Balancing and Settlement Diagram

Energy trade between market participants is designed according to new legal framework. According to current mechanism energy trade can be done many ways. Figure 4-3 illustrates energy trade, EUAS and TETAS are state owned components of market and others are private. EUAS and TETAS will remain like TEIAS as state owned enterprises. EUAS is still biggest producer and sells its generation directly to TETAS, to distribution companies via bilateral agreements and to the directly market by using MFRC instruments. TETAS as a state-owned wholesale company can also supply to independent retail companies or to distribution companies and to eligible consumers. Distribution companies also conduct retail works with their distribution activities. According to legal regulations, private sector may also establish wholesale companies by taking wholesaler license from EMRA

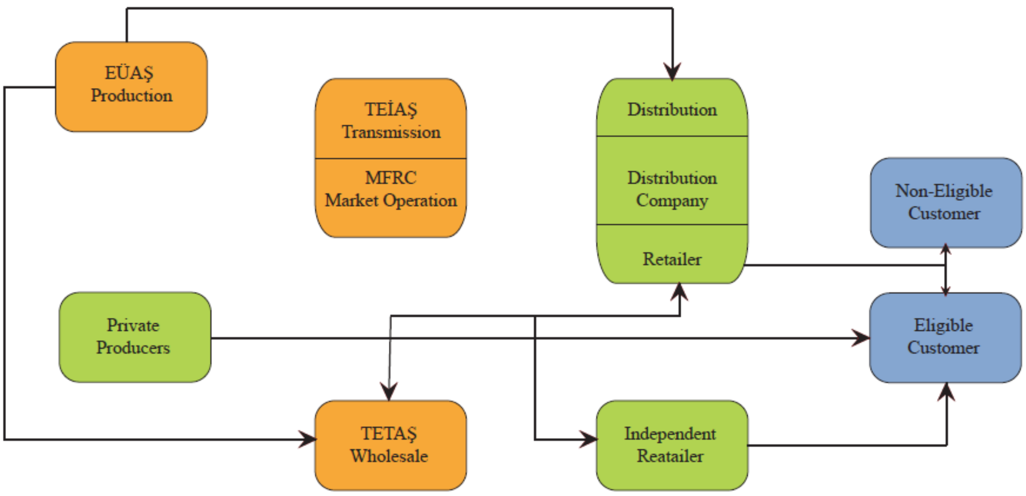

Figure 4-3 Energy Trade Diagram

Private companies can sell its production to wholesale companies, to distribution companies, to independent retailers and eligible consumers by bilateral agreements and to the market via MFRC. Distribution companies as retailer sell its electricity to eligible and non-eligible consumers. Independent retailers sell electricity to eligible consumers. There are also auto-producers which generate electricity for their own usage under license of EMRA. Auto producers also can sell up to 50% of their production. According to Regulation an auto-producer which sells its production can act as a production company.

4.2.1 Balancing and Settlement

A functioning electricity market is the keystone for liberalization reforms and unbundling process of electricity structure of the country. The reconstruction of energy industry according to competitiveness and open market rules is a vital need. After legal reforms in 2001, EMRA started to work on to create competition based balancing and settlement market as responsible authority in Turkey. These two concepts can be identified as; balancing is the task of maintaining the supply and demand in real time and settlement is the task of calculating debts and owing among the market participants due to power exchange made through the Balancing Market.

In March 2004, Turkish High Planning Council adopted Electricity Sector Strategy Paper with a road map aiming at sectorial reform. According to the strategy paper, "The liberal market structure to be implemented in Turkey is based on bilateral contracting between buyers and sellers, complemented by a balancing and settlement mechanism. To achieve the objectives and principles of this strategy it is essential that the balancing and settlement regime acts as a market where un-contracted generation can be bought and sold and the application enhances security of supply by facilitating participation of independent and small generator. Balancing and settlement mechanism will involve the target for establishment of a spot market and will include signals to attract new investments".

In November 2004, Electricity Market Balancing and Settlement Regulation was published in Official Gazette by EMRA. First three articles of Section 1 of the Regulation are important in terms of clarifying objective, scope and legal basis:

-Article 1- The objective of this Regulation is to set forth the principles and procedures regarding the activities related with real-time balancing and settlement of the active electricity demand and supply.

-Article 2- The scope of this Regulation covers parties involved in balancing and settlement system, duties, authorities and responsibilities of the related parties and the principles and procedures regarding; activities related with real-time balancing the active electricity demand and supply, and financial settlement of payables and receivables arising from participation of the licensees in balancing and settlement mechanism.

-Article 3- This Regulation has been issued in compliance with the provisions of Electricity Market Law no. 4628

Within the scope of the regulation two institutions were designed for Balancing and Settlement Market activities; National Load Dispatch Centre for the balancing, Market Financing System for the settlement.

4.2.2 National Load Dispatch Centre

In Balancing and Settlement regulation, The National Load Dispatch Centre (NLDP) which is under the organizational framework of TEIAS, is responsible real-time balancing of electricity demand and supply and named as system operator.

Its responsibilities in Regulation stated in Article 14 as (EMRA, 2009);

Article 14- The National Load Dispatch Centre shall be authorized as the system operator. The system operator shall be executing the following balancing and settlement activities:

a) Notification of the demand estimates to balancing mechanism participants,

b) Receipt of physical notifications, associated data and bids and offers from balancing mechanism participants for each balancing mechanism entity,

c) Evaluation of bids and offers with due regard to bid and offer prices, the balancing mechanism entity's technical constraints, transmission and distribution system constraints and associated data of the balancing mechanism entity; identification of the bids and offers to be accepted as a result of the evaluations with the aim to equalize the planned generation with the forecasted consumption and the real-time generation with consumption and tagging the instructions regarding the accepted bids and offers,

d) Notification of the instructions regarding accepted bids and offers to the related balancing mechanism participants and keeping required records of such transactions,

e) Notification of the information required for settlement actions to the MFSC in a timely manner, and

f) Performance of other related activities indicated in this Regulation.

As the system operator NLDP has to perform technical efforts for the stable gird as stated in regulation. It makes day ahead planning by using daily supply and demand quantities and by bilateral agreements which are reported by market components, both from supply and demand side. There can be, mismatches in bilateral agreements and day-ahead market imbalance either from supply or demand side. The failures in plants, distribution and transmission lines, constraints in grid and other problems in ancillary services, lead imbalances in load frequency. NLPD has to investigate grid all they long and establish load frequency by using Up-regulation and Down-regulation instructions to up regulator or down regulator generators determined by Day Ahead Market before the day according to price and capacity calculations and have been reported to system regulator (NLDP). Day Ahead Market activity as settlement part of is Balancing and Settlement process carried out also by other partner which is Market Financial Reconciliation Centre.

In Balancing and Settlement regulation defines Up regulation and Down regulations and instructions are defined as (EMRA, 2009);

- Up-regulation: The situation where a balancing entity sells energy to the system by increasing its generation or decreasing its consumption, in line with the instructions issued by System Operator.
- Up-regulation Instruction: The notifications issued by the System Operator or Market Operator to the related market participants, for up-regulation of the market participants participating in day ahead planning or balancing power market.
- Down-regulation: The situation where a balancing entity buys energy from the system by decreasing its generation or increasing its consumption, in line with the instructions issued by System Operator.
- Down-regulation Instruction: The notifications issued by the System Operator or Market Operator to the related market participants, for down-regulation of the market participants participating in day ahead planning or balancing power market.

4.2.3 Market Financial Reconciliation Centre

Market Financial Reconciliation Centre is designated for financial settlement of market and named as the market operator. Its function is simply be defined as to reconciliation supply and demand side of energy market in terms prices. After early phases, final market consist of five components as : the market of bilateral contracts among the market participants, an organized day-ahead market, a real-time system balancing and operational mechanism, an organized market for financially settled electricity contracts, and one or more organized markets for procurement of ancillary services (Camadan & Erten, 2011).

Before its final structure market had two phases as shown in Figure 4-4. In final stage it has contract based sub-markets. Day-Ahead Market, which includes also bilateral agreements, is the organized wholesale electricity market established for purchase and sale transactions of electricity to be delivered in the day ahead on the basis of settlement period. Bilateral agreements are the commercial contracts between license holder legal entities and real persons; or legal entities; or license holder legal entities for the activity purchase and/or sale of electricity under the provisions of civil law. Other than bilateral agreements, parties from supply and demand side reported their hourly plans in a daily basis. According to production and consumption predictions of each side and their price offers, the system is balanced and the prices are settled.

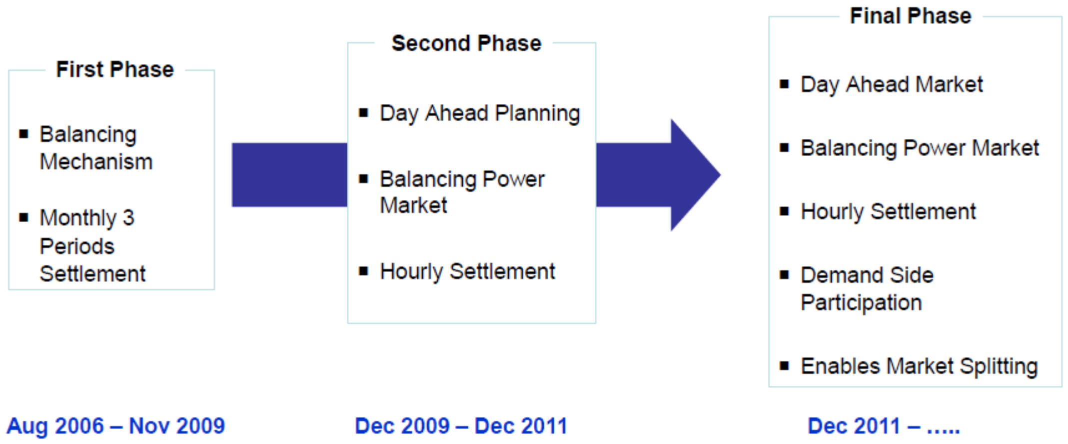

Figure 4-4 Evaluation of Balancing and Settlement (EMRA, 2012)

Another sub market under Balancing and Settlement Market is Balancing Power Market for hourly power balancing. As stated in National Load Dispatch Centre's assignment; during the day in the case of mismatches supply and demand, bilateral agreements and technical problems balance is ensured by up-regulation and down regulation instructions. In Balancing Power Market, participant generators bid for increase and decrease their productions according to this instruction. According to bids, network failure and constraints the plants which decrease or completely stop production and increase or start generation identified. In the case of need, the plants instructed to up or down regulation for hourly settlement and can make profit from this process.

There is no obstacle for Renewable energy producers to participate in Balancing Power Market. In Balancing and Settlement Regulation Article-70 (Structure and content of the offers and bids submitted within the context of balancing power market) identify characteristics of system. In this respect, items 1, 4 and 5 of the Article 70 of Regulation are important and given below:

(Item 1) The market participants participating in balancing power market shall submit hourly offers and bids related to the generation/consumption increases or decreases they can realize in 15 minutes to System Operator via MMS, as effective for the following day considering the maximum up-regulation and down-regulation rates and on the basis of balancing entities within the context of the balancing power market, as inclusive of offer and bid prices and volumes, separately for each trade zone and for each hour of the related day

(Item 4) Market participants within the context of balancing power market may submit offers and bids at 15 levels of volumes, separately for up-regulation and down-regulation directions. Except the hydroelectric power plants, prices regarding hourly offer and bid volumes are submitted separately for up-regulation and down-regulation directions as single price for all levels of volume by the market participants. Hydroelectric power plants may submit separate offer and bid price for each level of volume.

(Item 5) The sum of offer and bid volumes regarding an hour and a balancing entity within the context of balancing power market shall be determined by taking into consideration the change achievable in output power or consumption within 15 minutes after the instruction reaches the related balancing entity. For any given hour, all offers submitted regarding a balancing entity within the context of the balancing power market must be achievable by the related balancing entity within maximum 15 minutes. Likewise, for any given hour, all bids submitted regarding a balancing entity within the context of the balancing power market must be achievable by the related balancing entity within maximum 15 minutes. For an offer or bid submission to be valid, the owner of offer or bid must keep needed capacity available so that the offer or bid he has submitted can be achievable within maximum 15 minutes. The minimum offer and bid volume shall be 10 MW. If deemed necessary, the System Operator may set a different minimum limit for offers and bids providing that market participants are notified at least one month before. All submitted offer and bid volumes shall be expressed in 1 MW term and its folds.

Majority of Renewable Energy plants has small capacities, 10 MW limitations for bids restrain their activities in Balancing Power Market. Renewable energy systems are variable systems, which based on resources that fluctuate during the course of any given day or season and because of this they evaluated as need to be balanced power (IEA, 2012). In addition to this, the renewable sources aren’t storable, except for hybrid systems (i.e. pump storages), and because of this their usage for balancing leads waste of the sources and paradoxical to logic of renewable. Therefore participation to Day Ahead Market is much more convenient for renewable energy plants when compared to Balancing Power Market.

4.2.4 Day Ahead Market

Day Ahead Market operates under the organizational framework of Market Financial Reconciliation Centre. Within the framework of Balancing and Settlement Regulation, day-ahead market daily transactions are performed on an hourly basis. Each day divided to hourly time intervals, starting at 00:00, ending the next day at 00:00. Day Ahead market transactions during the relevant time period correspond to a fixed level of supply or demand. All proposals submitted to Day Ahead market are valid for certain day and certain period of time in that day. The participants of Day Ahead Market, can tender, hourly buying and selling offers, block sales and purchase bids within the scope of market which is active electricity energy purchase or sales bids that are valid for more than one consecutive hour for the next day. It includes average price and average quantity information for the time interval it spans and submitted by market participants that participate to the day-ahead market (EMRA).

Day-ahead market participants submit purchase and sales bids with price and quantity information. In addition, each participant reports that the amount of the purchase and sale of energy within the scope of bilateral agreements. The period of bid for a day has starts five days before of relevant day and lasts the at 11:30 p.m. at previous day. Each submitted proposal in a day-ahead market is evaluated by the Market Operator in accordance with the provisions of Balancing and Settlement Regulation Article 57 (Submission and validation of day-ahead market bids). Every day between 11:30 a.m. and 1:00 p.m., the Market Operator calculates the price for the day-ahead market for each hour of the next day, and for each trade zone and reports the approval of commercial transactions, including purchase and sales quantities for each participant to all of the market participants. Every day between 13:00 and 13:30, market participants participating in day-ahead market check transaction approvals reported by the Market Operator and when it is necessary participants notify objections about transaction approvals. Every day between 13:30 and 14:00, the Market Operator shall evaluate the objections; reports the results of objections to market participants.

There are also other factors than price bids and offers submitted to balancing mechanism entities. These are transmission, distribution constraints and technical constraints of balancing mechanism entities. The market operator establishes final market clearing price by using bids with consideration other factors. Symbolic price formation can be seen in Figure 4-5.

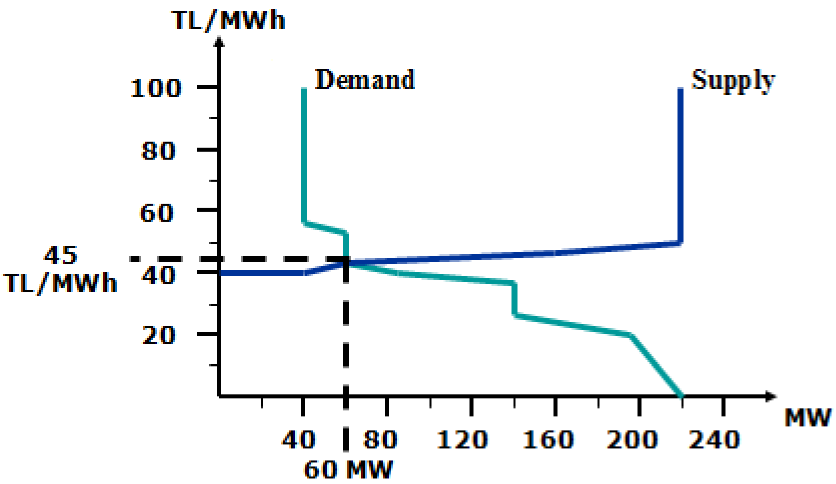

Figure 4-5 Price formation in Day Ahead Market

At the end of the day amount to be paid to producers calculated by taking into consideration the amount of production. If producer can produce the amount reported on time, it entitled to receive the payment on the basis of Market Clearing Price. If the producer produces over or under the reported amount, it is in condition of imbalance. In imbalance situations, the payment is calculated in different ways and System Marginal Prices in Balancing Power Market becomes a part of this process.

It is stated in Balancing and Settlement Regulation Article (9) part c as: The imbalances of balance responsible parties arising from their balance responsibilities shall be settled over the system imbalance price to be determined on a settlement period basis. The system imbalance price applicable for each settlement period is a single price to be determined equal to the hourly system marginal price established in the balancing power market for the aforementioned settlement period.

System Marginal Price can be identified as the maximum accepted hourly offer price applied to up-regulated balancing entities to correct the energy deficit in the system or the minimum accepted bid price applied to down-regulated balancing entities to correct the energy surplus in the system, for the purposes of balancing and irrespective of transmission system congestion, within the context of day ahead planning or balancing power market.

At the end of the day MFRC announce summary of the daily day in the Daily Report Screen which can be seen Figure 4-6 for a regular day. In Figure all parameters symbolized by numbers. The predicted value of load by system operator for given period indicated as (1). The decelerated bilateral agreements indicated as (2). Market Clearing Price indicates as (3). SPV (4) is the actual System Purchase Volume (MWh) of market participant under its bid for the settlement period. SSV (5) is the actual System Sales Volume (MWh) of market participants under their bid for the settlement period, determined as a result of day ahead balancing. FDGS (Final Day Ahead Generation/Consumption Schedule) (6) is production or consumption values which a settlement aggregation entity anticipates to realize in the following day and notifies the System Operator at the opening of the balancing power market according to the obligations of the balance responsible party to whom it is attached and the result of day ahead balancing. System Marginal Price indicated as (7).Upgrading and downgrading amounts are indicated as (8&9). There 3 types of upgrading and downgrading. Code 0 is representing up or down grading for balancing originated from generation. Code 1 is representing up or down grading for balancing originated from Transmission. Code 2 is representing up or down grading for balancing originated from ancillary services.

The basis of payment calculated as follows; all day ahead market participants receive payments according to amount in their bid and Market Clearing Price. After then, if any, their imbalance is calculated. The imbalances of balance responsible parties arising from their balance responsibilities shall be settled over the system marginal price. If the producer loads more than the volume offered, it receives extra payment. If producers load less than the volume offered, it has to pay-back according to deficit.

If there is positive imbalance, entitled payment to the producers is calculated in accordance with minimum of Market Clearing Price and System Marginal Price. If there is negative imbalance, entitled payment to the producers is calculated according to maximum of Market Clearing Price and System Marginal Price. System Marginal price is higher than Market Clearing Price in negative imbalance of all system and lower than Market Clearing Price in positive imbalance of all system. The same procedure also applied to bilateral agreements (Kaya, 2012).

A numerical example can be illustrated as; if a producer offers for 100 MW for determined hour and system has positive imbalance. According to market offers from supply and demand side Market Clearing Price comprise of 100 TL/MWh as an assumption. Because of positive imbalance, System Marginal Price will be less and can assume to be 90 TL/MWh. 10 MW positive and negative imbalance have created effect on the accounts of that specific hour is calculated and given in Table 4-1

Table 4-1 Day Ahead Market Tariffing in Positive Imbalance of System

Offer (MWh)	Loading (MWh)	Day After Payment (TL)	Additional Payment (TL)	Pay-back (MW)	Value of Generation (TL)	Worth of Mismatch (TL)
100	110	10,000	900	0	11,000	100
100	100	10,000	0	0	10,000	0
100	90	10,000	0	1,000	9,000	0

As second example: a producer offer for 100 MW for determined hour and system has negative imbalance and Market Clearing Price is 100 TL/MWh. Because of negative imbalance, System Marginal Price will be less and can be assumed 110 TL/MWh. 10 MW positive and negative imbalances have created effect on the accounts of that specific hour as in Table 4-2.

Table 4-2 Day Ahead Market Tariffing in Negative Imbalance of System

Offer (MWh)	Loading (MWh)	Day After Payment (TL)	Additional Payment (TL)	Pay-back (MW)	Value of Generation (TL)	Worth of Mismatch (TL)
100	110	10,000	1000	0	11,000	0
100	100	10,000	0	0	10,000	0
100	90	10,000	0	1100	9,000	100

Günlük Parametre Raporu Listesi															
Saat	Yük Tahmin Planı (MWh) 1	İkili Anlaşma (MWh) 2	PTF (TL) 3	SAM (MWh) 4	SSM (MWh) 5	KGÜP (MWh) 6	SMF (TL) 7	YALM (MWh) 8				YATM (MWh) 9			
								(0) Kodlu	(1) Kodlu	(2) Kodlu	Teslim Edilemeyen	(0) Kodlu	(1) Kodlu	(2) Kodlu	Teslim Edilemeyen
00:00-01:00	23,800	18,923	142.99	4,316	4,316	20,931	142.99	78	348	558	19.93	713	25	336	13.71
01:00-02:00	22,400	18,174	129.99	4,264	4,264	19,837	129.99	0	0	820	0	1,085	0	8	9.07
02:00-03:00	21,700	18,258	67.88	3,800	3,800	19,137	67.88	0	0	828	66	942	0	0	84.45
03:00-04:00	21,200	18,268	64	3,909	3,910	18,772	64	0	0	828	69.4	1,004	0	0	126.39
04:00-05:00	21,100	18,274	64	3,931	3,931	18,759	63.35	0	0	820	60.3	1,289	0	0	147.42
05:00-06:00	21,700	18,285	64	3,824	3,824	19,040	39	0	0	820	0	1,746	0	0	115.42
06:00-07:00	22,400	18,422	100.01	4,043	4,043	19,648	64	0	0	820	0	1,677	0	0	114.22
07:00-08:00	23,300	18,899	145	4,714	4,714	20,870	144.99	66	132	691	0.2	803	0	291	11.51
08:00-09:00	27,500	20,662	184.79	5,838	5,837	24,114	190	1,184	158	440	228.26	243	0	606	72.99
09:00-10:00	30,000	22,958	180.01	5,977	5,977	26,495	199	1,845	175	38	179.16	0	0	837	89.86
10:00-11:00	30,900	23,553	180.01	6,184	6,184	27,139	200	1,970	192	0	112.17	69	0	799	46.05
11:00-12:00	31,200	23,671	181	6,179	6,179	27,327	200.01	2,200	70	0	140.34	0	0	920	35.42
12:00-13:00	29,900	22,362	180.01	6,226	6,226	26,240	199.99	1,585	70	76	93.58	0	0	795	5.9

Figure 4-6 Sample MFRC Daily Parameter Report List

4.3 RES Support Mechanism

Turkey's Renewable Energy Support (RES) Mechanism is finally in place with the enactment of amendments to Law No. 5346. Accordingly, power plants that have started into operation since 18 May 2005 or will start to operation before 31 December 2015 will be entitled to receive the feed-in tariffs for the first ten years of their operation. The Cabinet will decide on the incentives that will be given to power plants that come into operation after 31 December 2015.

The figures applicable to electricity production facilities based on Renewable Energy Sources according to type and the use of mechanical and/or electromechanical components manufactured in Turkey discussed in Chapter III (under the head of Legal Evaluation of Renewable Energy in Turkey shown in Table3-7 and Table 3-8).

The Energy Market Regulatory Authority has released the Regulation on Documentation and Support for Renewable Energy Resources, detailing how the Renewable Energy Mechanism will be integrated into the Balancing and Settlement Market. Accordingly, market participants will not be required to obtain Renewable Energy certificates to participate in the Mechanism. Instead, their licenses will be valid as Renewable Energy certificates. In order to participate in the Renewable Energy Support Mechanism in the following calendar year, power plants are required to apply to the EMRA by 31 October. Market Financial Reconciliation Centre established a RES portfolio registered within the Balancing and Settlement Market for the Settlement of the energy within the Renewable Energy Sources Support Mechanism, and it will be able to use the collaterals that are collected according to the Balancing and Settlement Market regulation.

According to Regulation; Market Financial Reconciliation Centre manages all participants gathered to portfolio as a pool and buys electricity from the participants of the mechanism and sells it on the Day Ahead Market on behalf of power suppliers. The prices to be paid are calculated according to incentive prices which are multiplied with their production. Prices to be paid to mechanism participants shall be calculated in the Turkish Lira currency. The conversion of the guaranteed price from US Dollars to Turkish Lira shall be made using the Central Bank's buying rate of exchange for each transaction date.

According to legislation, all electricity suppliers are obligated to finance Renewable Energy Support Mechanism. By considering the difference between acquired earnings as a result of Day Ahead Market sales and payments to Renewable Energy Support Mechanism participants, the purchase obligation amount is calculated. The purchase obligation ratio of each supplier shall be determined by Market Financial Reconciliation Centre by identifying the ratio of the amount of energy supplied to consumers by each of the suppliers for the same invoicing period to the total amount of energy supplied to all of the final consumers in Turkey. The amount corresponding to the share of each supplier shall then be calculated by multiplying the purchase obligation ratio of each supplier with the total price to be paid to the mechanism. The parties shall then be notified and the relevant supplier will be invoiced by Market Financial Reconciliation Centre.

Energy Market Regularity Authority publishes list of Renewable Energy Support Mechanism participants for a year after the end of application period. In 2011 the number of support mechanism participants was 20. It increased to 78 power plants in 2012 but it is 30 for 2013. While almost all of biomass plants and most of geothermal plants have chosen to participate in the mechanism, this mechanism is far less popular for hydropower and wind power plants. Figure 4.7 which is prepared according to statistics of MENR and EMRA, shows the share of RES Support mechanism participants to total capacity of plants have right to participate mechanism. Also full list of the participants of mechanism in 2011, 2012 and 2013 mechanism are introduced in Appendix-A.

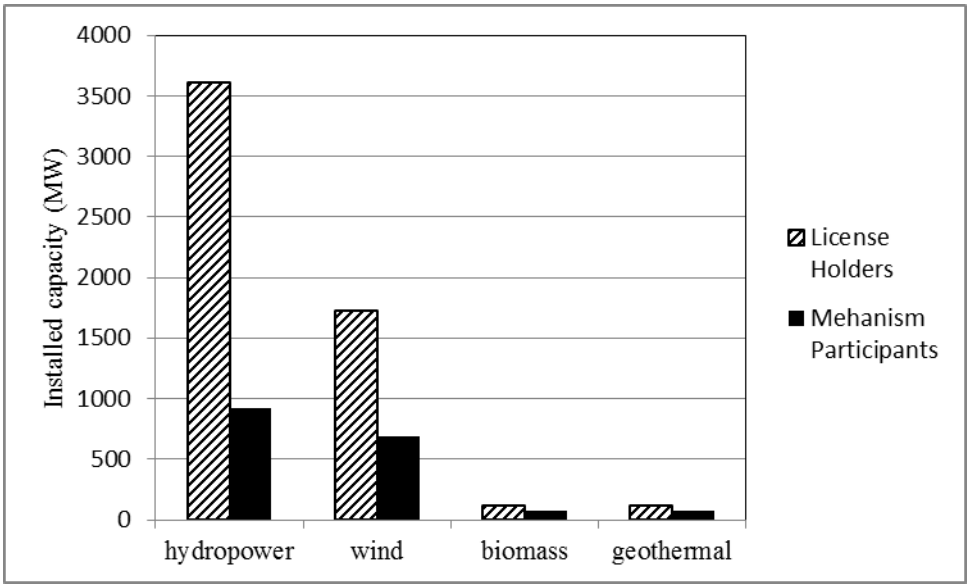

Figure 4-7 Share of RES Support mechanism participants to total license holder

CHAPTER 5

BENEFIT COMPARISON OF MARKET AND RES SUPPORT MECHANISM FOR WPP AND SHPP

5.1 General

The main concern for electricity production from renewable sources is commercializing it after the operation stage. The feed in tariff mechanisms is constituted for this purpose. However mechanisms have a time limitation of ten years in the case of Turkey. After ten years of guarantee period, the firms obliged to sell their productions in the market. It is also important to analyze market structure and prices for acquiring further profit from produced electricity even in the validity period of incentives.

The characteristics of renewable energy plants using solar, wind and hydropower are different than renewable energy plants using geothermal and biomass. In power plants based on geothermal and biomass resources, production regimes are much more stable and predictable. However renewable energy plants using solar, wind or hydropower have more variable regimes and making predictions about production for short-term is a more difficult and complicated process.

Other than the bilateral agreements, day-ahead market is the only instrument for selling electricity. According to day-ahead market procedures, the production companies have to notify their production predictions the day before the purchase day. The profit obtained from produced electricity depends on the success of forecasting.

In Chapter 5, the prices on electricity market for a specific period are analyzed. By using real prices and production values, the profits are calculated for a hydropower and a wind energy plant. The results of the calculations obtained by using day-ahead market prices with varying predictions are also compared with renewable energy support mechanism profits.

There is a recently started project for wind power monitoring and forecasting for plants in Turkey named RITM. Although project is in its developing stage, the prediction results are very inspiring and promising. By using the predictions derived from project data and real prices of market, the day-ahead market profits are calculated for plants within the project. It is also compared with renewable energy support mechanism incomes.

The problems created by imbalance of production on electricity network can be considered as the barriers against the development of renewable based electricity production from the side of system operator. Besides that, maximizing the profits is also important for the development of electricity based renewable sources from the side of investor. For this purpose analysis of market and high tech forecasting are important for the development of renewable sources based electricity production.

5.2 Analysis of Sample Plants and Electricity Market prices on the determined period

In this part of the study, two renewable energy plants, namely a run-off river hydropower plant and a wind energy plant, are analyzed. The hydropower plant (Çamlıkaya HPP) is located in the Black Sea Region with a 8.5 MW of installed capacity. The wind power plant (Turguttepe WPP) is located in Aegean Region in Aydin with a 24 MW of installed capacity. In the analysis, the real production values of two plants for a year (between 1st September 2011 00-01- 31 August 2012 23-24) are used. The total production values and capacity factor which is the ratio of the actual output of a power plant over a period of time and its potential output if it had operated at full capacity can be seen in Table 5-1. Note that 2012 is leap year so the period is 366 days and 8784 hours. Capacity factor is not a direct measure of efficiency. According to studies, the capacity factors of wind power plants range between 20% and 40% (Community Wind Power-Fact Sheet, 2010). The capacity factor both WPP and HPP depend on the availability of sources as well as design criteria.

Table 5-1 Capacity factors of Plants

Plants	Installed Capacity (MW)	Total Production (MWh)	Capacity Factor %
WPP	24.5	70,621.48	32.82
HPP	8.5	24,538.09	32.86

The average hourly and total production values for a month and the average hourly and total production for hourly intervals for the two plants are shown in Table 5-2, Table 5-3 and graphically in Figure 5-1, Figure 5-2, Figure 5-3, and Figure 5-4.

Table 5-2 The average hourly and total production values for each month

Plants	WPP (24 MW Installed power)		HPP (8,5 MW Installed power)	
Months	Average hourly (MWh)	Total Production (MWh)	Average hourly (MWh)	Total Production (MWh)
September	6.12	4,407.65	1.24	894.90
October	6.81	5,069.41	2.23	1,656.43
November	7.97	5,735.90	2.06	1,484.21
December	9.40	6,991.73	1.10	814.73
January	10.65	7,923.53	0.71	530.37
February	9.02	6,264.14	0.70	483.85
March	10.42	7,751.04	1.20	891.40
April	7.37	5,306.57	7.47	5,376.98
May	5.05	3,756.73	8.39	6,243.75
June	5.32	3,831.35	5.62	4,045.28
July	7.09	5,271.64	1.61	1,194.39
August	11.17	8,311.80	1.24	921.81

Table 5-3 The average hourly and total production values for hourly intervals

Plants	WPP (24 MW Installed power)		HPP (8.5 MW Installed power)	
Hourly Intervals	Average hourly (MWh)	Total Production (MWh)	Average hourly (MWh)	Total Production (MWh)
00-01	7.55	2,763.24	0.86	130.96
01-02	7.68	2,809.95	1.26	192.63
02-03	7.75	2,837.68	1.74	266.21
03-04	8.08	2,953.53	1.99	304.48
04-05	8.34	3,051.40	1.12	170.75
05-06	8.61	3,149.68	1.15	175.54
06-07	8.84	3,236.35	1.35	207.31
07-08	8.83	3,231.82	1.99	304.14
08-09	8.51	3,115.00	1.21	185.30
09-10	8.23	3,011.41	1.12	170.77
10-11	7.94	2,906.42	1.60	245.03
11-12	7.70	2,818.16	2.66	406.25
12-13	7.67	2,807.53	1.08	165.49
13-14	7.66	2,801.97	1.31	200.81
14-15	7.81	2,857.45	2.16	329.91
15-16	7.86	2,875.47	1.75	268.35
16-17	8.13	2,975.30	1.45	222.26
17-18	8.33	3,048.88	2.08	318.60
18-19	8.35	3,054.49	1.60	244.41
19-20	8.11	2,969.52	1.63	248.67
20-21	8.07	2,954.73	1.73	262.32
21-22	7.87	2,882.00	1.17	177.94
22-23	7.59	2,778.50	1.65	250.46
23-24	7.46	2,731.02	2.12	322.44

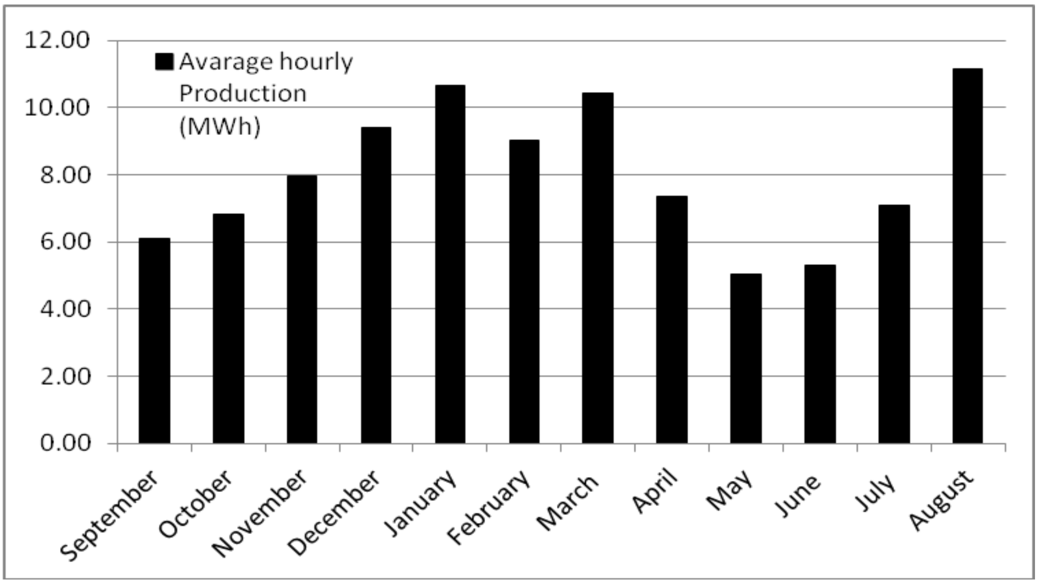

Figure 5-1 Distribution of average hourly production of WPP by months

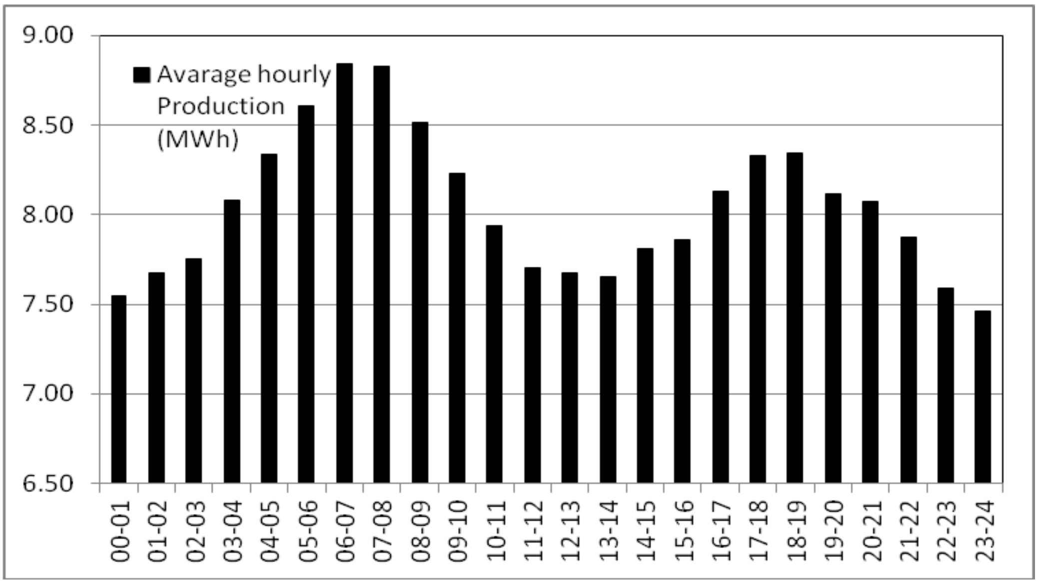

Figure 5-2 Distribution of Average hourly production of WPP by hourly intervals

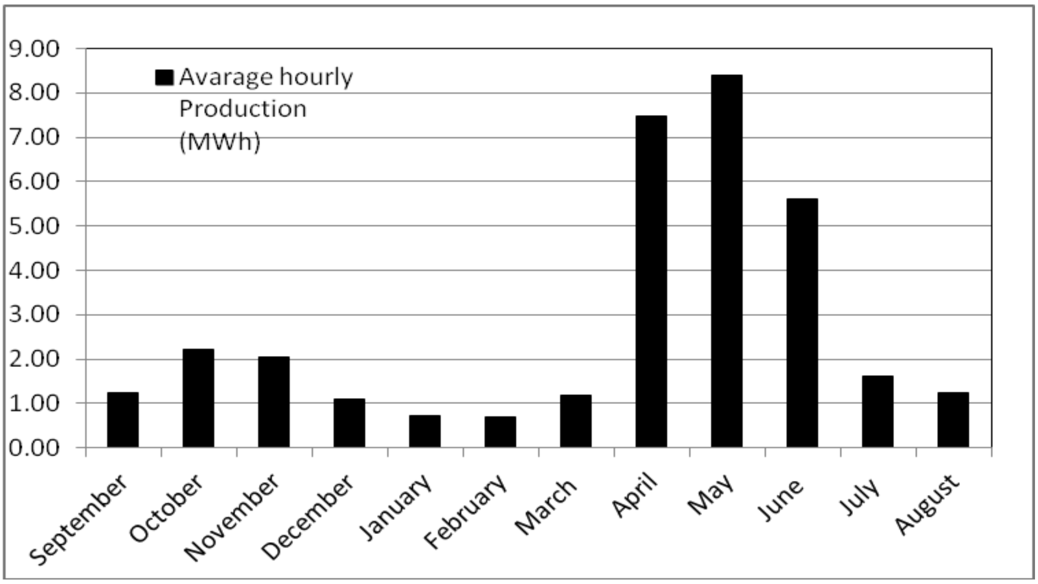

Figure 5-3 Distribution of average hourly production of HPP by months

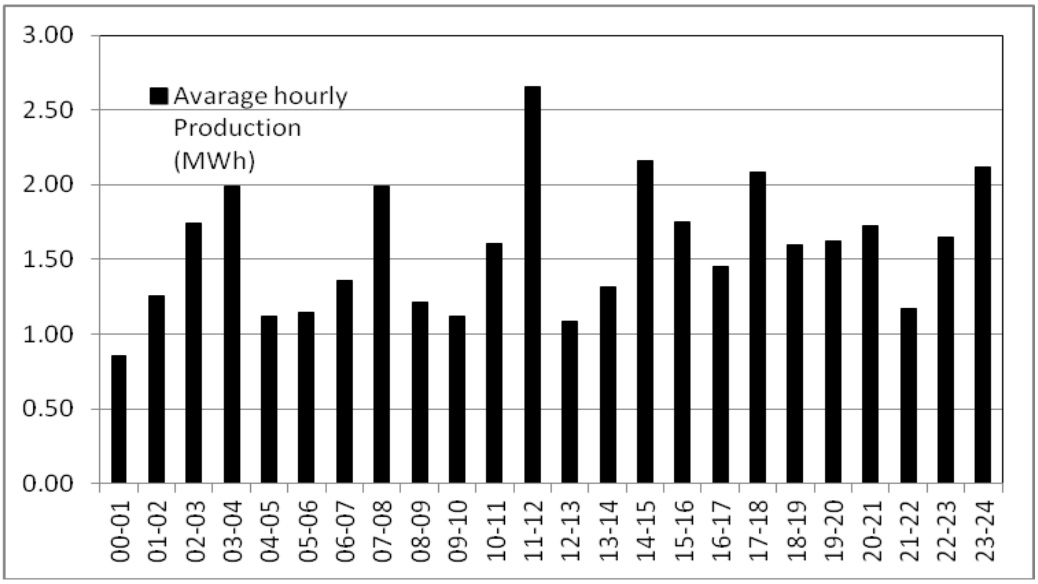

Figure 5-4 Distribution of average hourly production of HPP by hourly intervals

The graphs in Figure 5.5, Figure 5.6, also show the sorted production of WPP and HPP in a determined period for 8874 hourly intervals.

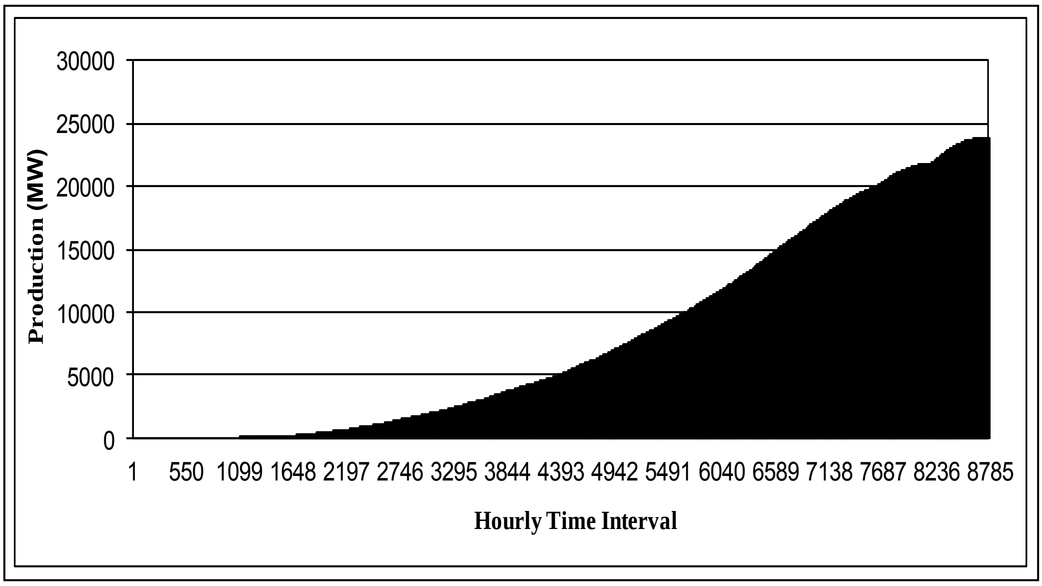

Figure 5-5 The sorted production of WPP in a given time period

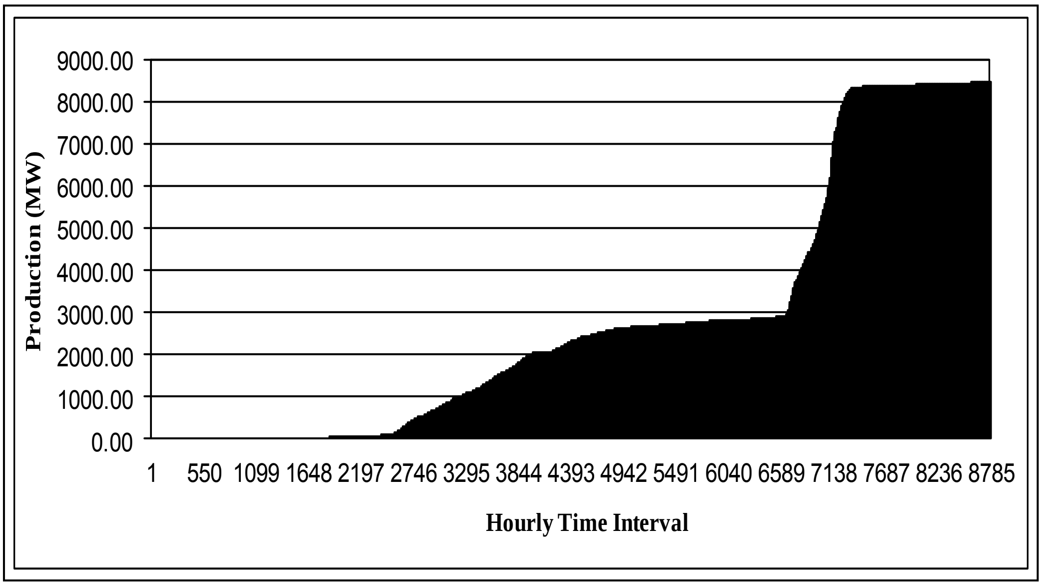

Figure 5-6 The sorted production of HPP in a given time period

The average Market Clearing Prices and System Marginal prices for months are shown in Table 5-4 and hourly intervals are in Table 5-5.

Table 5-4 Average Market Clearing Prices and System Marginal Prices for months

Months	Avarage hourly MCP (TL/ MWh)	Avarage hourly SMP (TL/ MWh)
September	149.16	147.86
October	137.87	133.60
November	150.84	157.52
December	149.77	143.61
January	148.23	150.45
February	195.81	198.01
March	121.91	121.64
April	112.55	82.35
May	141.13	130.62
June	144.17	141.72
July	168.42	170.36
August	160.55	143.57

Table 5-5 Average Market Clearing Prices and System Marginal Prices for hourly intervals

Hours	Avarage hourly MCP (TL/ MWh)	Avarage hourly SMP (TL/ MWh)	Hours	Avarage hourly MCP (TL/ MWh)	Avarage hourly SMP (TL/ MWh)
00-01	145.22	140.41	12-13	166.12	157.34
01-02	135.02	134.29	13-14	168.19	159.60
02-03	124.65	121.35	14-15	172.23	169.03
03-04	113.02	105.41	15-16	165.69	154.40
04-05	108.92	100.77	16-17	165.28	159.89
05-06	103.26	100.12	17-18	167.06	164.23
06-07	99.59	94.05	18-19	163.10	160.26
07-08	120.01	111.69	19-20	159.46	155.94
08-09	146.18	138.51	20-21	156.48	152.80
09-10	159.34	158.94	21-22	152.41	150.69
10-11	172.63	170.12	22-23	160.13	152.67
11-12	180.73	179.51	23-24	151.45	150.33

The sorted distribution of Market Clearing Price and System Marginal prices of 8784 hourly intervals are shown in Figure 5-7 and Figure 5-8 and for a better illustration the prices divided into two parts (smaller than 200 TL/MWh, bigger than 200 TL/MWh). The latter parts Figure 5-7 b and Figure 5-8 b is particularly a result of natural gas supply crisis in Turkey (Energy Institute,2012).In this period, for 4856 hourly intervals System Marginal Price is bigger than Market Clearing Price, which shows negative imbalance, system needs loading (upgrading instruction is bigger), for 2053 hourly intervals System Marginal Price is smaller than Market Clearing Price, which shows positive imbalance, system need de-loading (downgrading instruction is bigger) and 1865 cases System Marginal Price is equal to Market Clearing Price, which shows that system is in balance.

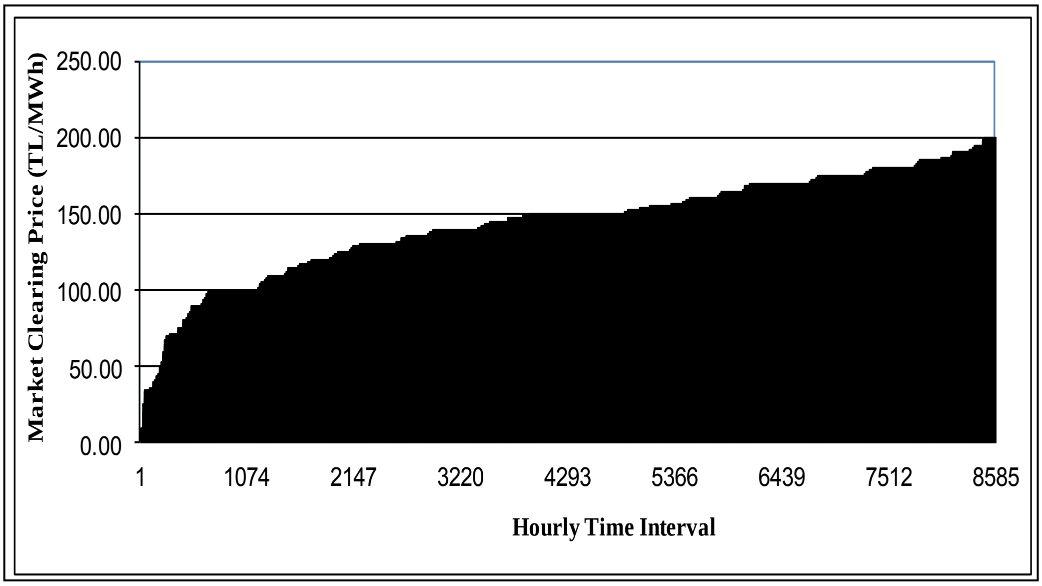

Figure 5-7 (a) The sorted distribution of Market Clearing Prices between 1-8585 hourly interval

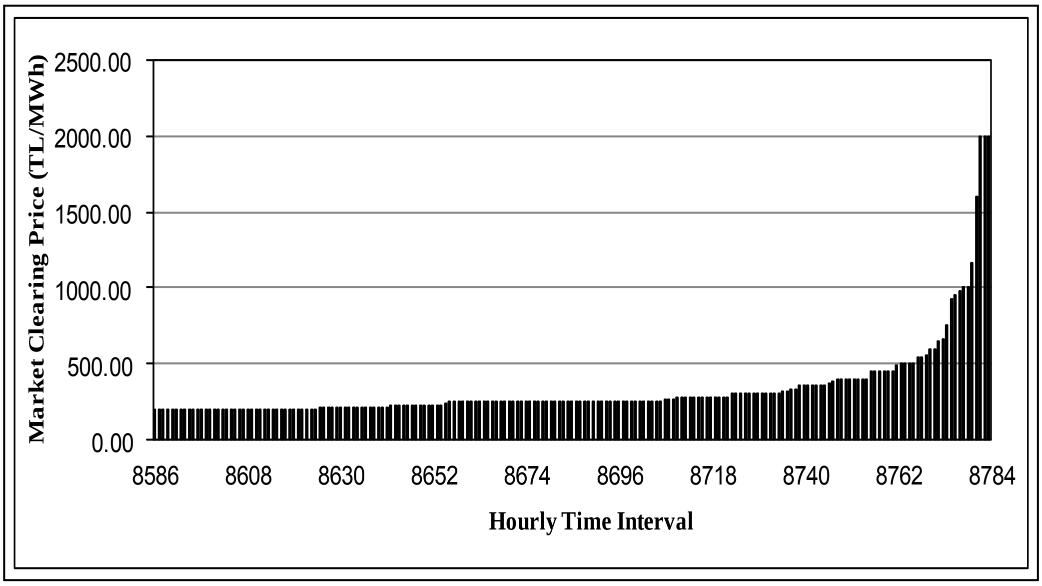

Figure 5-7 (b) The sorted distribution of Market Clearing Prices between 8556-8784 hourly interval

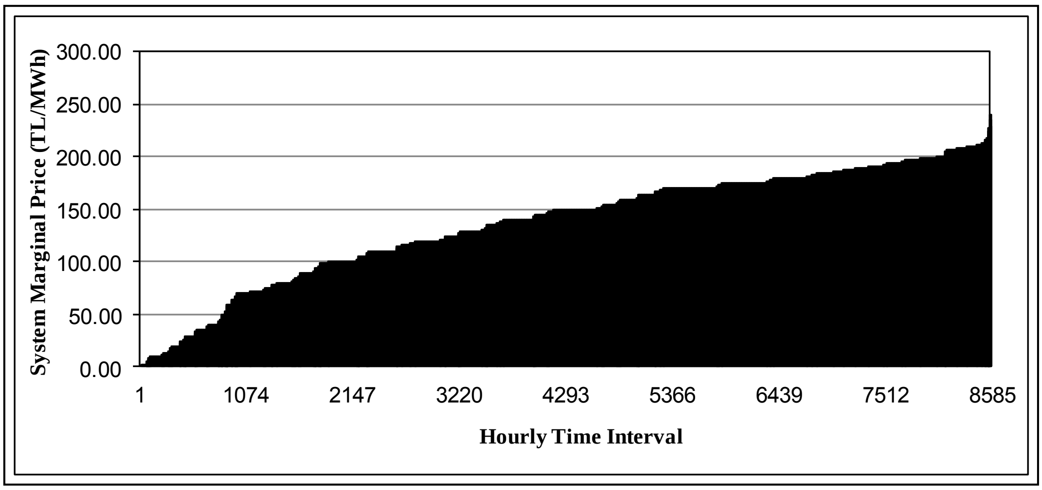

Figure 5-8 (a) The sorted distribution of System Marginal Prices between 1-8585 hourly interval

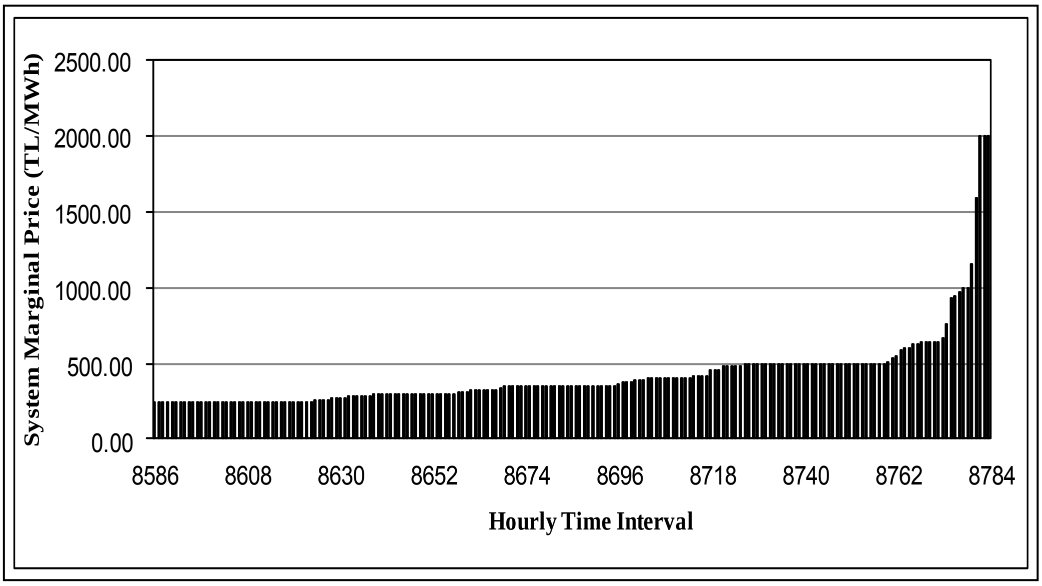

Figure 5-8 (b) The sorted distribution of System Marginal Prices between 8556-8784 hourly interval

5.3 Comparison of Market and RES Support Mechanism

The comparison of market incomes and renewable energy support mechanisms is carried out in accordance with the assumed predictions. The sales of plants in day-ahead market are projected according to 1%, 5%, 25%, 50%, 100% and 200% over and under estimation of production offers for the comparison with support mechanism. The results of over and under estimation for plants has been compared with RES support mechanism prices. The misestimation results corresponding to RES support mechanism prices determined.

The WPP's over and under estimate cases and comparison with RES support benefit shown in Table 5-5 and Table 5-6. The change in percentage loss over / under estimation cases and comparison with support mechanism for WPP are shown in Figure 5-9, Figure 5-11. The benefit change in over / under estimation cases for WPP and comparison with support mechanism for WPP are shown in Figure 5-10, Figure 5-12.

Table 5-6 Benefits and losses in over estimation cases for WPP

Cases	Benefit (TL)	Loss (TL)	Percentage of Loss
100% Estimation	10,339,422.77 TL	0,00 TL	0
1% over Estimation	10,328,966.27 TL	10,456.51 TL	0.10
5% over Estimation	10,287,663.07 TL	51,759.70 TL	0.50
10% over Estimation	10,235,903.36 TL	103,519.41 TL	1.00
25% over Estimation	10,080,624.25 TL	258,798.52 TL	2.50
50% over Estimation	9,821,825.73 TL	517,597.05 TL	5.01
100% over Estimation	9,304,228.68 TL	1,035,194.09 TL	10.01
RES Support Mechanism	9,280,185.27 TL	1,059,237.50 TL	10.24
200% over Estimation	8,269,034.59 TL	2,070,388.18 TL	20.02

Table 5-7 Benefits and losses in under estimation cases for WPP

Cases	Benefit (TL)	Loss (TL)	Percentage of Loss
100% Estimation	10,339,422.77 TL	0,00 TL	0
1% under Estimation	10,326,609.80 TL	12,812.97 TL	0.12
5% under Estimation	10,275,357.92 TL	64,064.85 TL	0.62
10% under Estimation	10,211,293.07 TL	128,129.70 TL	1.24
25% under Estimation	10,019,098.52 TL	320,324.25 TL	3.10
50% under Estimation	9,698,774.27 TL	640,648.50 TL	6.20
75% under Estimation	9,378,450.02 TL	960,972.75 TL	9.29
RES Support Mechanism	9,280,185.27 TL	1,059,237.50 TL	10.24
100% under Estimation	9,058,125.77 TL	1,281,297.01 TL	12.39

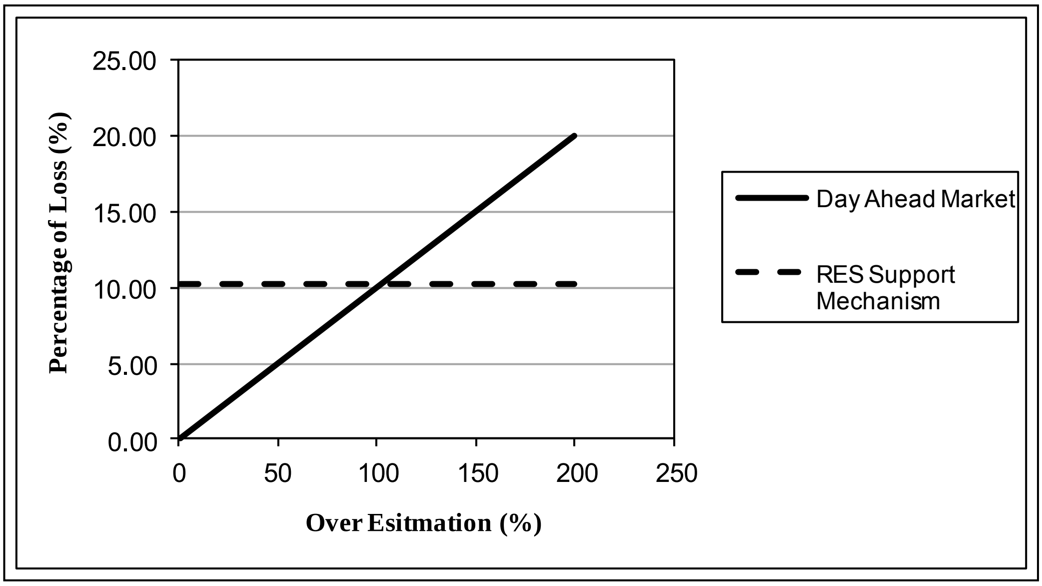

Figure 5-9 The change in percentage loss over estimation cases for WPP

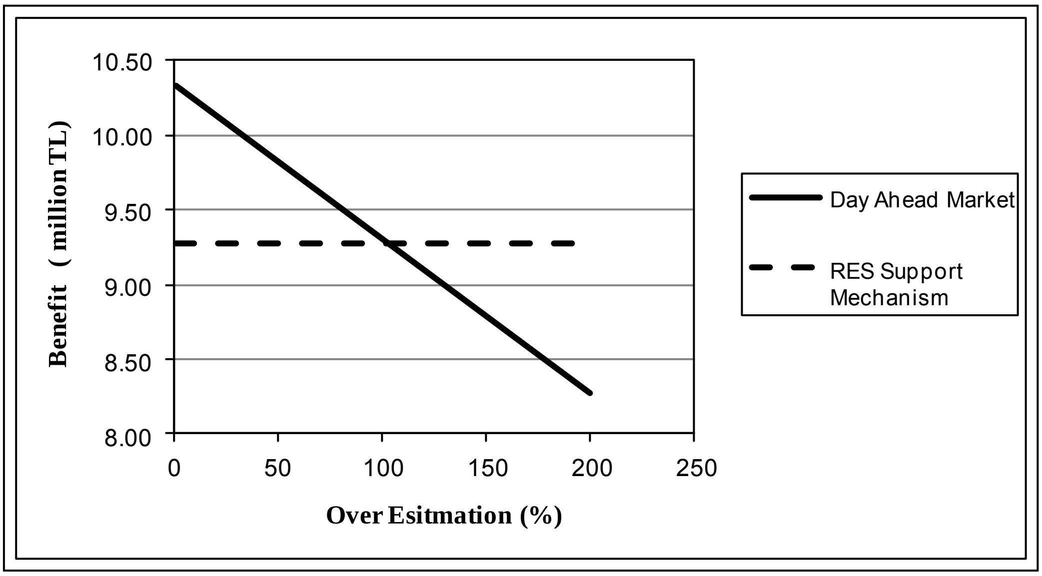

Figure 5-10 The benefit change in over estimation cases for WPP

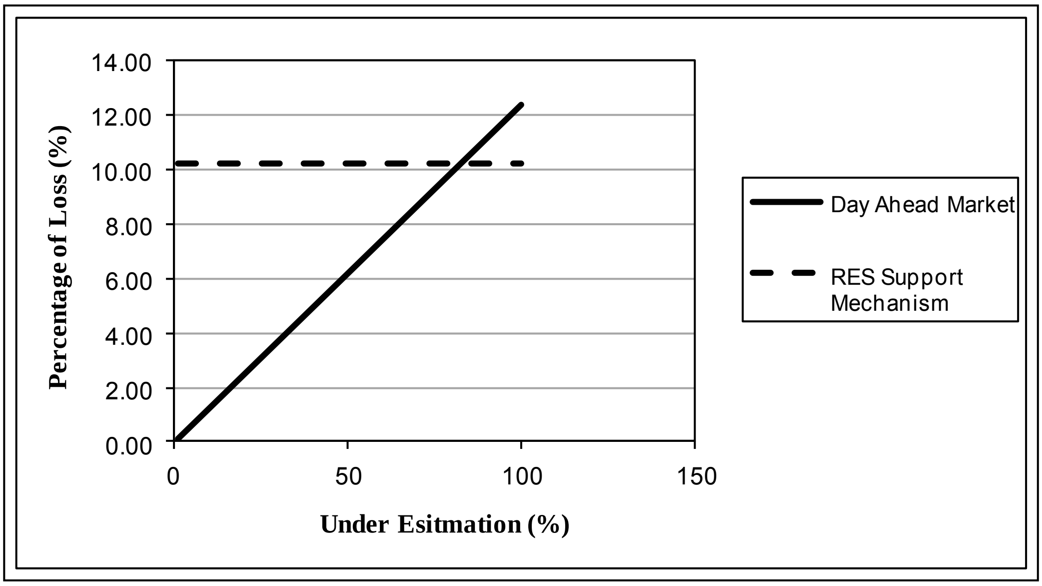

Figure 5-11 The change in percentage loss under estimation cases for WPP

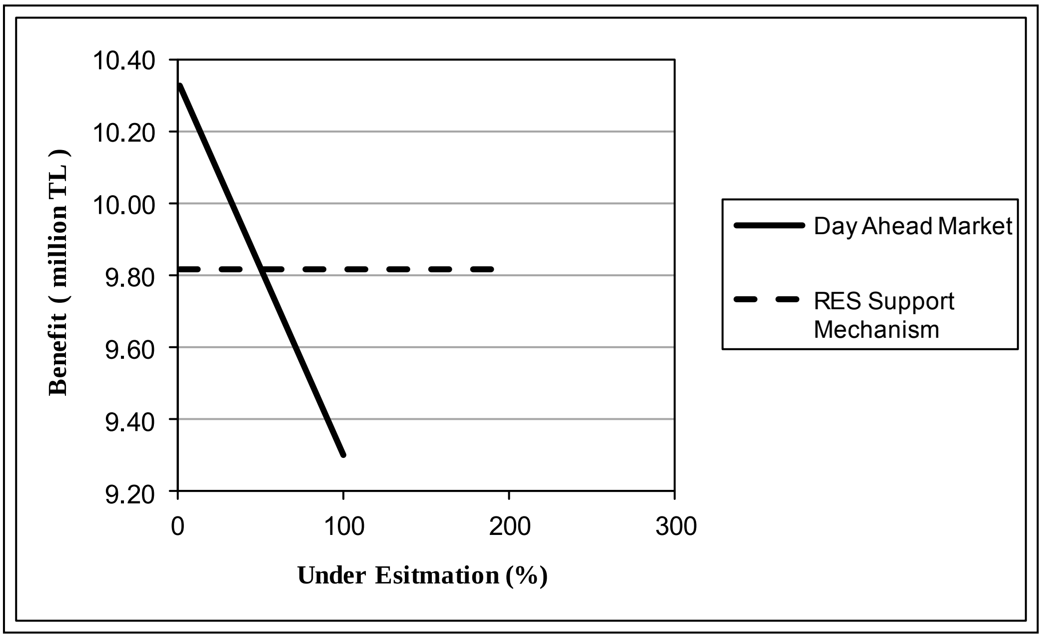

Figure 5-12 The benefit change in under estimation cases for WPP

The HPPs over and under estimate cases and comparison with RES support benefit are shown in Table 5-8 and Table 5-9. The change in percentage loss over / under estimation cases and comparison with support mechanism for WPP are shown in Figure 5-13, Figure 5-15. The benefit change in over / under estimation cases for WPP and comparison with support mechanism for WPP are shown in Figure 5-14, Figure 5-16.

Table 5-8 Benefits and losses in over estimation cases for HPP

Cases	Benefit (TL)	Loss (TL)	Percentage of Loss
100% Estimation	3,386,577.00 TL	0,00 TL	0
1% Over Estimation	3,384,102.33 TL	2,474.66 TL	0.07
5% Over Estimation	3,374,203.68 TL	12,373.32 TL	0.37
10% Over Estimation	3,361,830.36 TL	24,746.64 TL	0.73
25% Over Estimation	3,324,710.39 TL	61,866.60 TL	1.83
50% Over Estimation	3,262,843.79 TL	123,733.21 TL	3.65
RES Support Mechanism	3,223,220.90 TL	163,356.10 TL	4.82
100% Over Estimation	3,139,110.58 TL	247,466.41 TL	7.31

Table 5-9 Benefits and losses in under estimation cases for HPP

Cases	Benefit (TL)	Loss (TL)	Percentage of Loss
100% Estimation	3,386,577.00 TL	0,00 TL	0
1% under Estimation	3,381,536.95 TL	5,040.04 TL	0.15
5% under Estimation	3,361,376.78 TL	25,200.22 TL	0.74
10% under Estimation	3,336,176.56 TL	50,400.43 TL	1.49
25% under Estimation	3,260,575.92 TL	126,001.08 TL	3.72
RES Support Mechanism	3,223,220.90 TL	163,356.10 TL	4.82
50% under Estimation	3,134,574.84 TL	252,002.16 TL	7.44

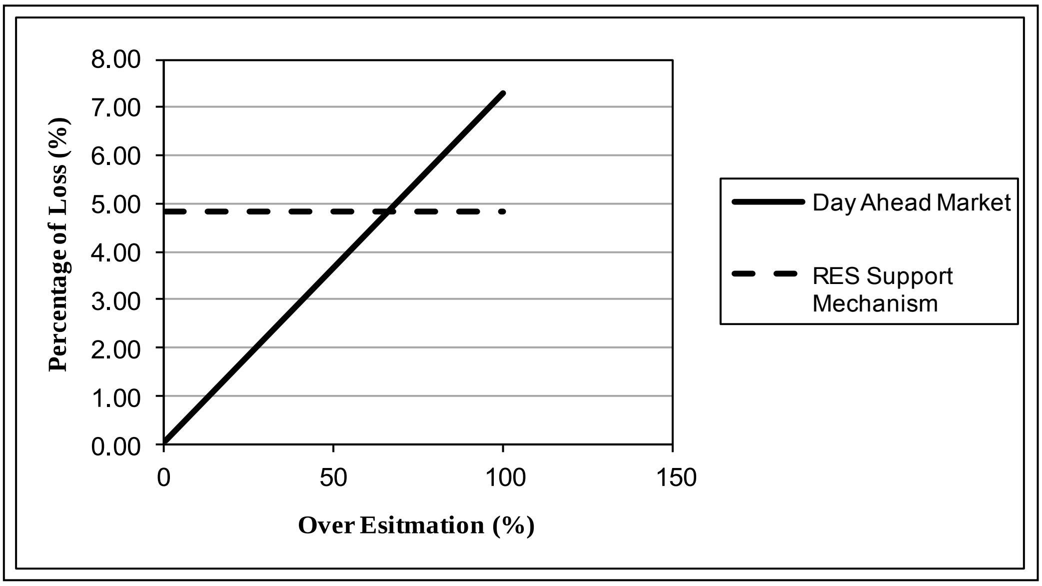

Figure 5-13 The change in percentage loss over estimation cases for HPP

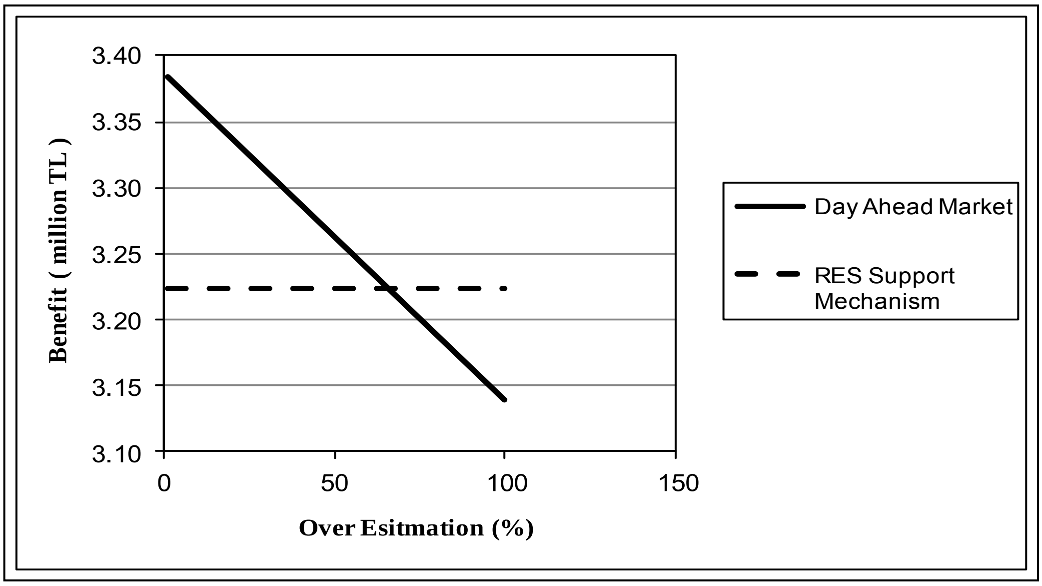

Figure 5-.14 The benefit change in over estimation cases for HPP

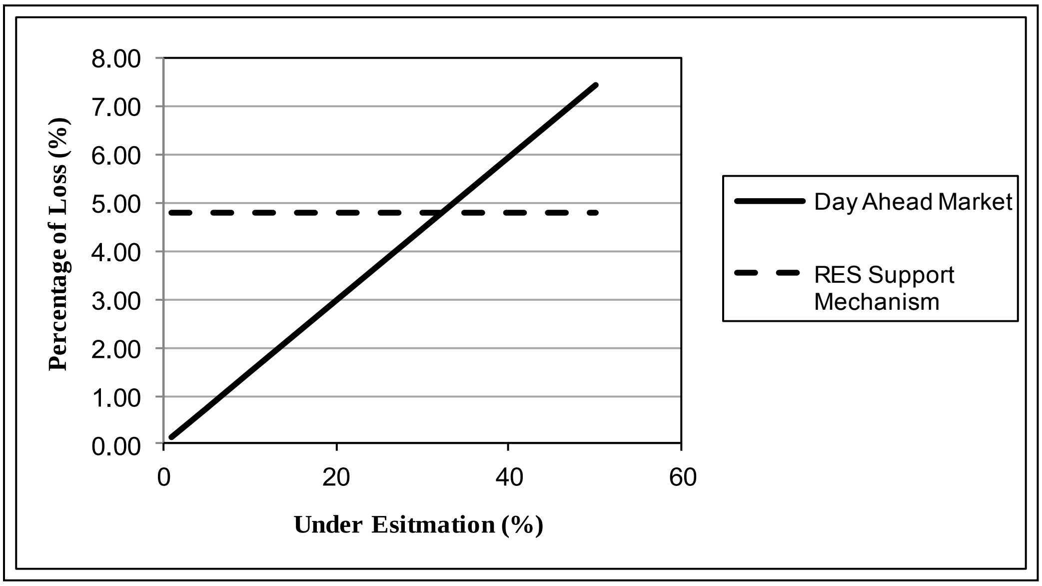

Figure 5-15 The change in percentage loss under estimation cases for HPP

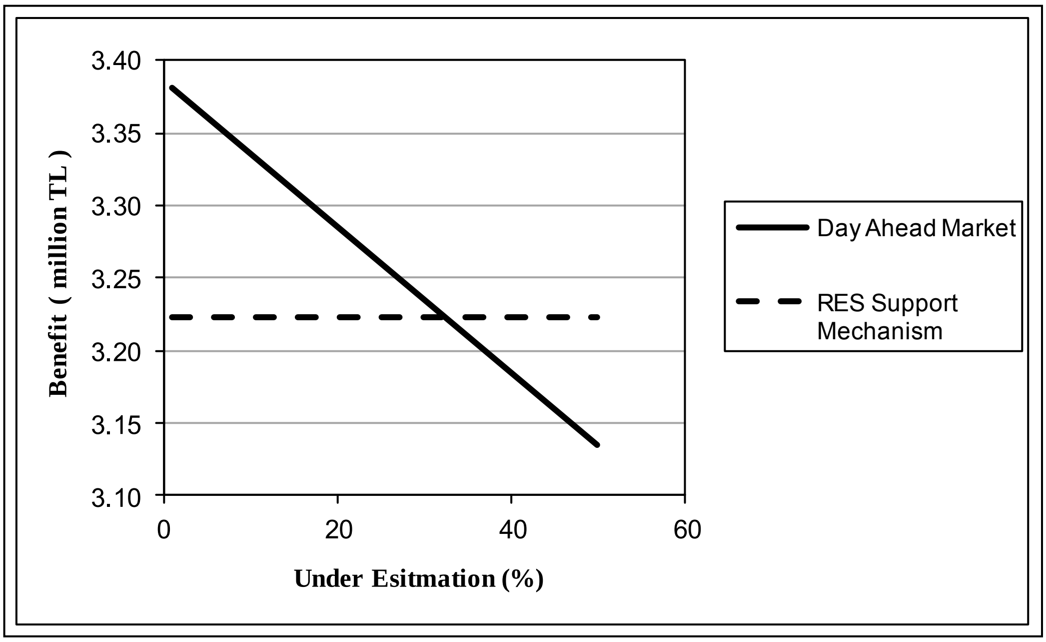

Figure 5-16 The benefit change in under estimation cases for HPP

The calculated benefit of renewable energy support mechanism obtained by using feed-in tariff prices are less than day-ahead market benefit in even at a high ratio of misestimation. The loss of benefit is not only due to misestimation but also the imbalance situation of the system as well. Positive imbalance of the system gives benefits higher than negative imbalance when the production is underestimated. On the other hand positive imbalance of the system gives benefits lower than negative imbalance when the production is overestimated. For the analysis of determined period of this study, the negative imbalance situations more beneficial than over estimation cases because the positive imbalance hourly intervals (production much than offer) is more than the negative imbalance hourly intervals (producing less than estimation).

When the benefits of day-ahead market and rest support mechanism are compared for both plants, it can be concluded that error margin in WPP is higher than HPP. The reason of this can be found by re-analyzing Figures 5-5 and 5-6. The sorted productions of two plants demonstrate different trends. There is a gradual increase in WPP. On the other hand there are sharp step-wise increase in HPP. Thus HPP production regime is more specific. The zero and full capacity productions of HPP domination is higher than WPP. Nevertheless, if the seasonal distribution of productions of two plants are compared in (Figure 5-1 and Figure 5-3), it can be deduced that HPP will advantage in day-ahead market trade because of high capacity factor of specific months, namely April, May, June.

5.4 “RİTM” Project

RİTM project aims to integrate wind power plants to Turkish Electricity System. The project is carried out with the cooperation of Ministry of Energy and Natural Resources, Turkish State Meteorological Service, and the Space Technologies Research Institute. The wind power monitoring and forecasting system has been developed for the sake of this project. The system includes 5 sub systems.

- WPP Measurement Sub-System
- Wind Forecast Sub-System
- Forecast Subsystem of Electrical Power That Will Be Produced From The Wind
- Monitoring and Prediction Center Sub-System
- User Sub-System

The functioning of system can be summarized as follows: Meteorological data (speed, direction, temperature, etc.) from existing WPPs is retrieved via wind measurement stations. Turbine status conditions are taken through the SCADAs. In addition, with the help of "Monitors" established in the transformer centres of stations, data (power, current, voltage and so on.) are transmitted in real-time to Wind Energy Monitoring and Forecast Centre.

By using wind power monitoring and forecasting system, on-line monitoring of Wind Power Plants (WPPs) and short-term prediction from 1 hour to 72 hours is possible. The prediction approaches are similar to that of German transmission system operation centres and The Special Regime Control Centre (CECRE) in Spain and based on numerical wind speed/direction predictions and artificial neural networks (ANN). A prediction algorithm Sipreolico is used for utilizing the collected data to produce hourly forecasts up to 48 hours and aggregated forecasts up to 10 days. (The Architecture of a Large-Scale Wind Power, 2012)

The implementation “RİTM” project covers 14 pilot WPPs in Turkey which has a total installed capacity of 740.9 MW. The total installed capacity of all WPPs on the starting date of project in operation in Turkey is about 2202.4 MW, that is to say it is nearly 32% of the wind electricity production of the country. For the related wind power plants, forecasts produced within the system can be monitored. The forecast outputs of the system are put in to service for WPPs operators for the day-ahead market and other commercial usages. (Monitoring and Forecasting System Development for Wind Generated Electrical Power in Turkey, 2012)

The prediction data between 2 May 00-01 and 25 December 15-16 of 2012 were taken from project administrator for the usage in analysis of this study. The maximum usage of capacity, which is 740.9 MW of installed capacity of 14 WWP in 31 July 17-18 interval with 615.89 MW. 27 October 00-01 interval is minimum capacity usage with 0.25 MW. The comparison results of forecasts with real time data shown in Table 5.3. The distributions of real time and forecast data are shown in Figure 5.17 and 5.18 as sorted and Figure 5.19 and Figure 5.20 time based.

Table 5-10 Comparison of RITM Estimation and Real Time Production Values

Total Number of Hourly Interval	Total Production (MWh)	Estimated Power by RITM (MWh)	Estimation Success for Total Period (%)
5704	1,372,539.67	1,294,928.26	94,35
Number of Interval (Production> Estimation)	Total Amount of (Production>Estimation) Cases (MWh)	Total Misestimation Percentage (Production>Estimation) (%)	Average Misestimation for a Intervals (Production> Estimation) (MWh)
3497	146,980.87	10.71	42.03
Number of Interval (Estimation> Production)	Total Amount of (Estimation>Production) Cases (MWh)	Total Misestimation Percentage (Estimation>Production) (%)	Average Misestimation for a Intervals (Estimation> Production) (MWh)
2207	69,369.46	5.05	31.43

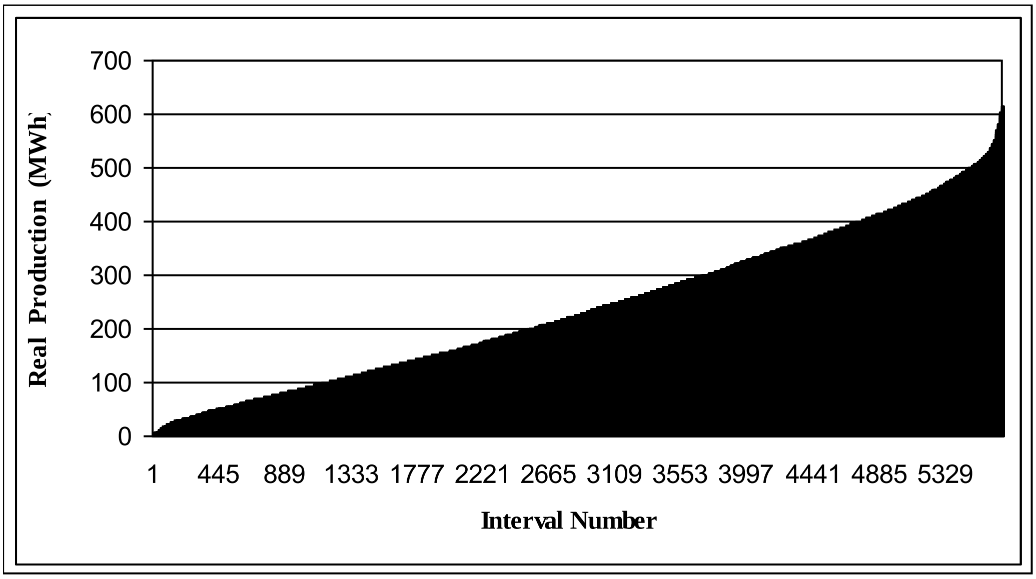

Figure 5-17 Sorted distribution of production

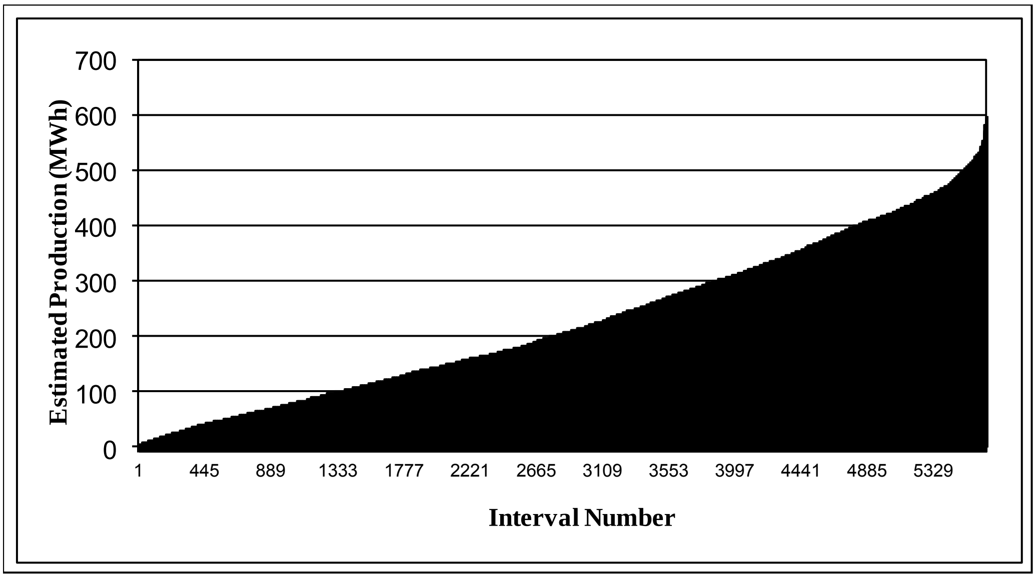

Figure 5-18 Sorted distribution of estimation

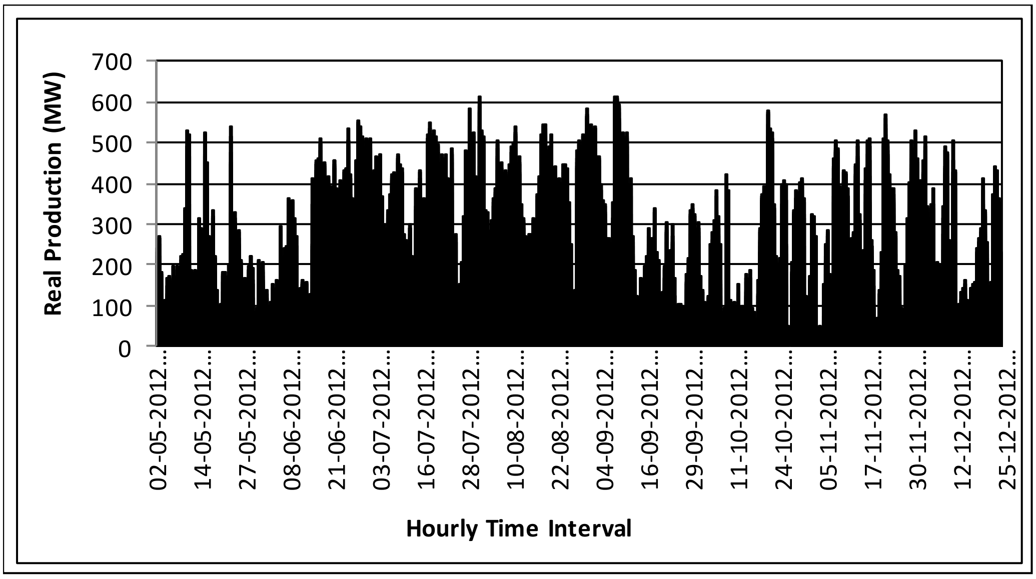

Figure 5-19 Distribution of production time based

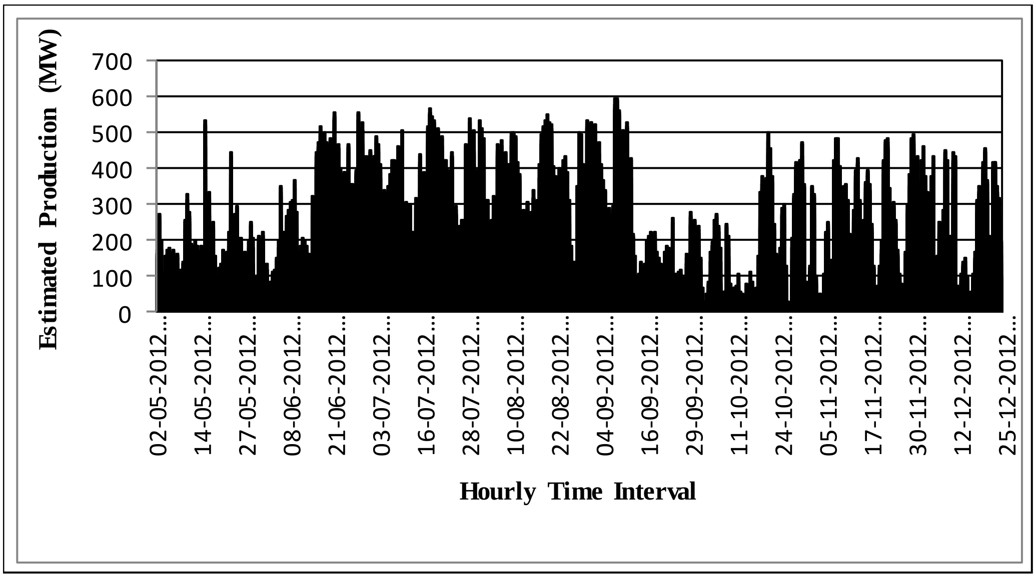

Figure 5-20 Distribution of estimated production time based

The sorted and time based distribution of negative (Estimation>Production) and positive (Production>Estimation) imbalance values can be seen in Figure 5-21 Figure 5-22.

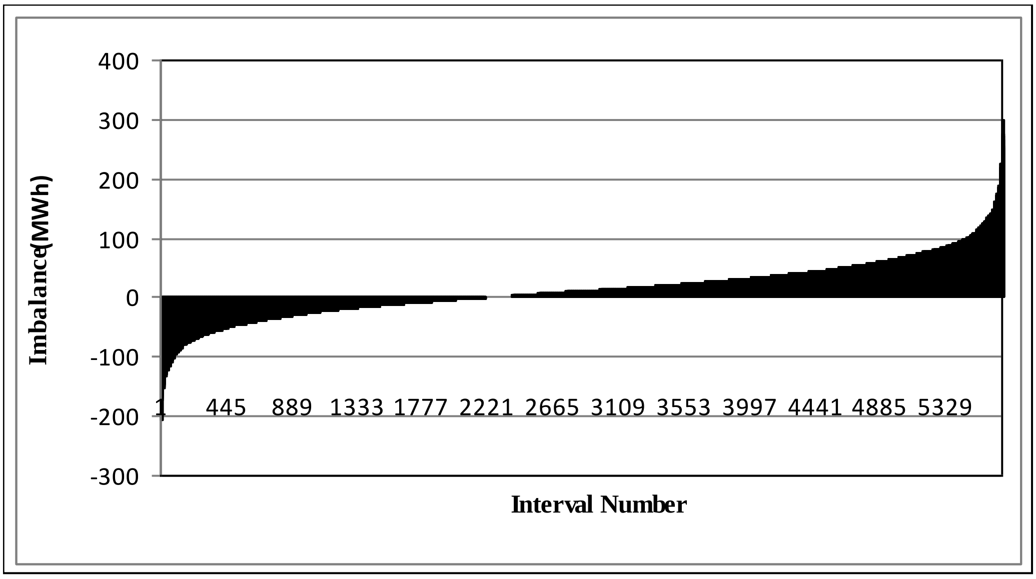

Figure 5-21 Sorted distribution of imbalance

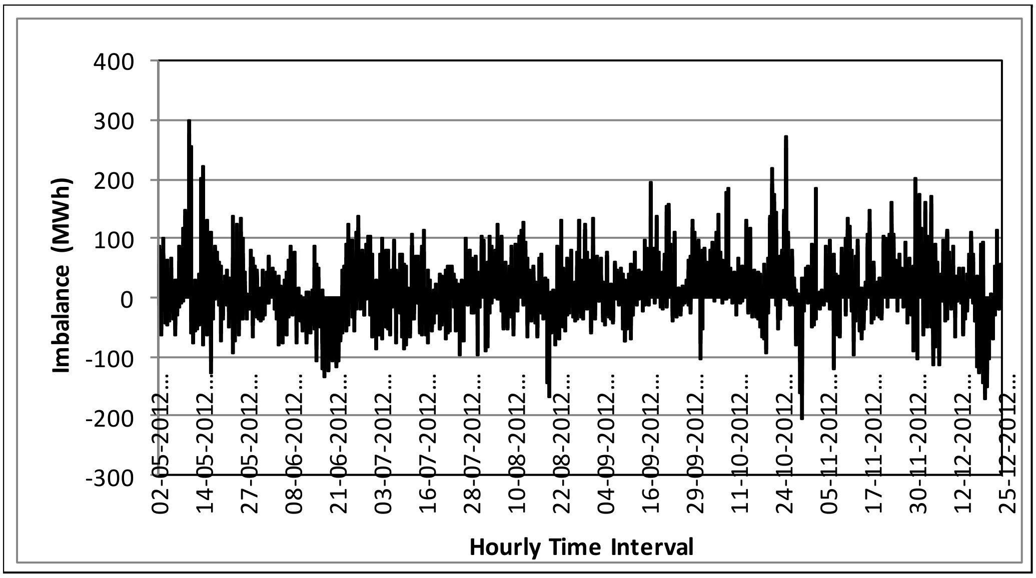

Figure 5-22 Distribution of Estimated imbalance time based

The sorted distribution of Market Clearing Price (MCP) and System Marginal Price (SMP) values can be seen in Figure 5-23, Figure 5-24., Figure 5-25, Figure 5-26

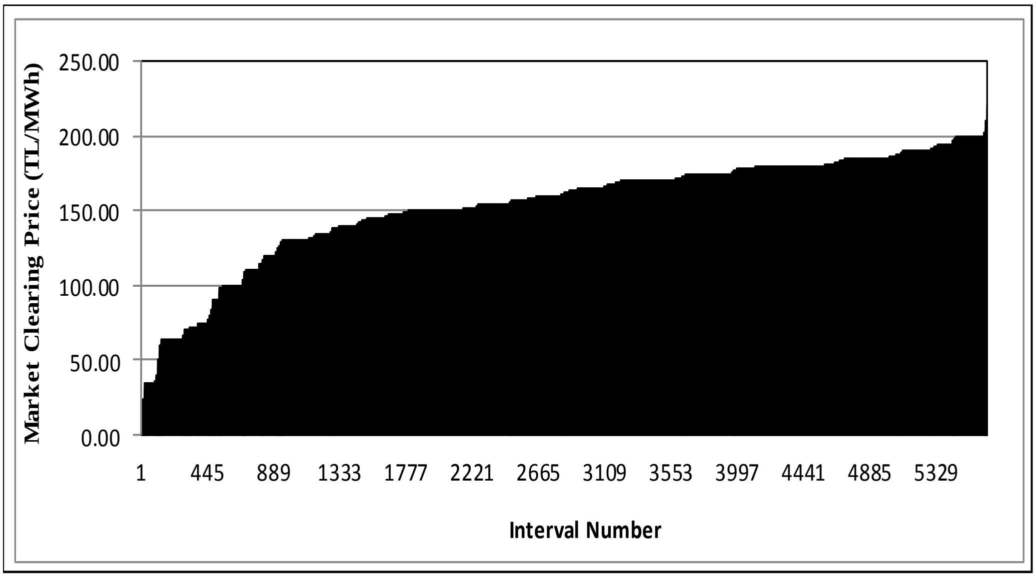

Figure 5-23 Sorted distribution of market clearing price

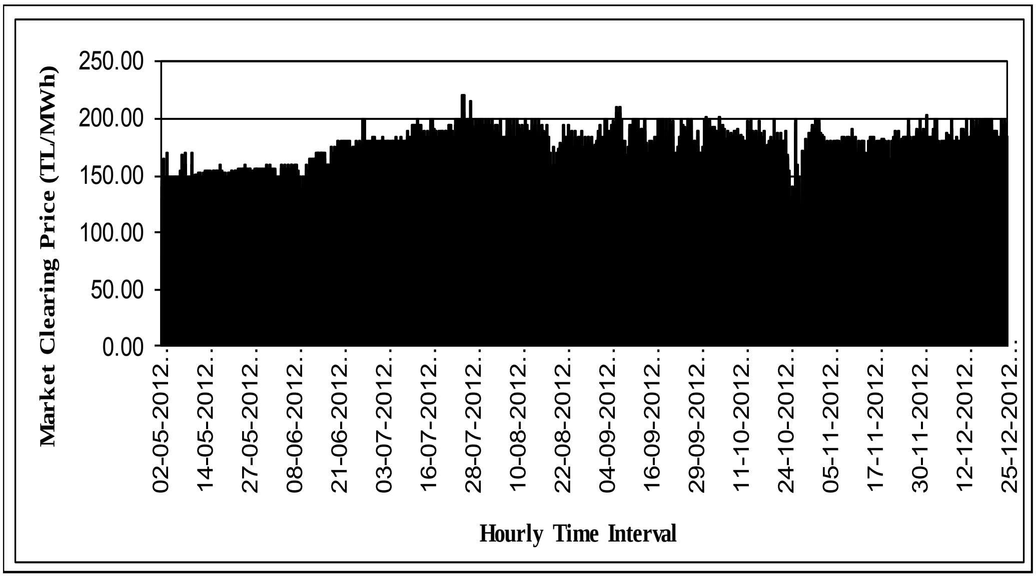

Figure 5-24 Distribution of market clearing price time based

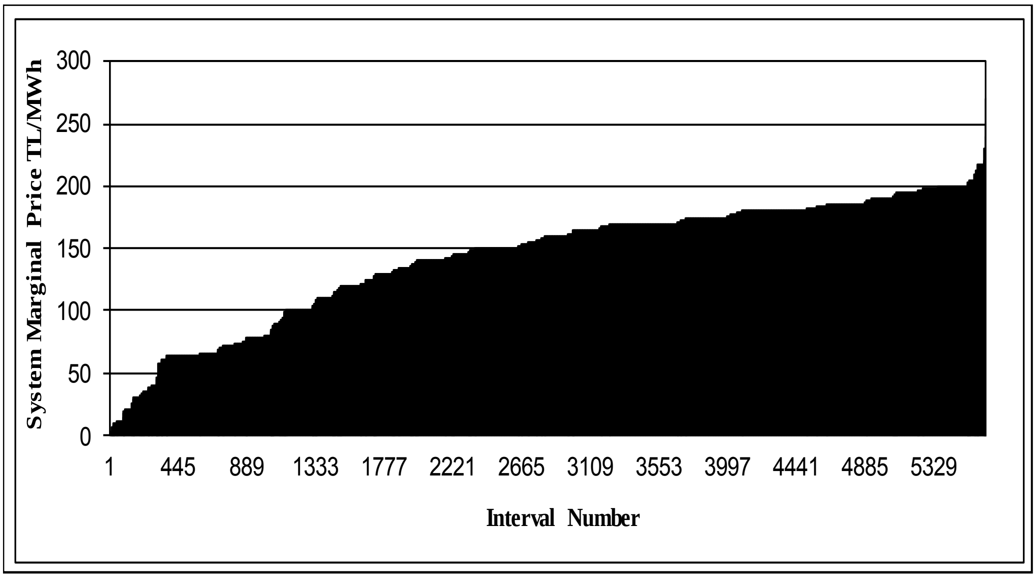

Figure 5-25 Sorted distribution of System Marginal Price

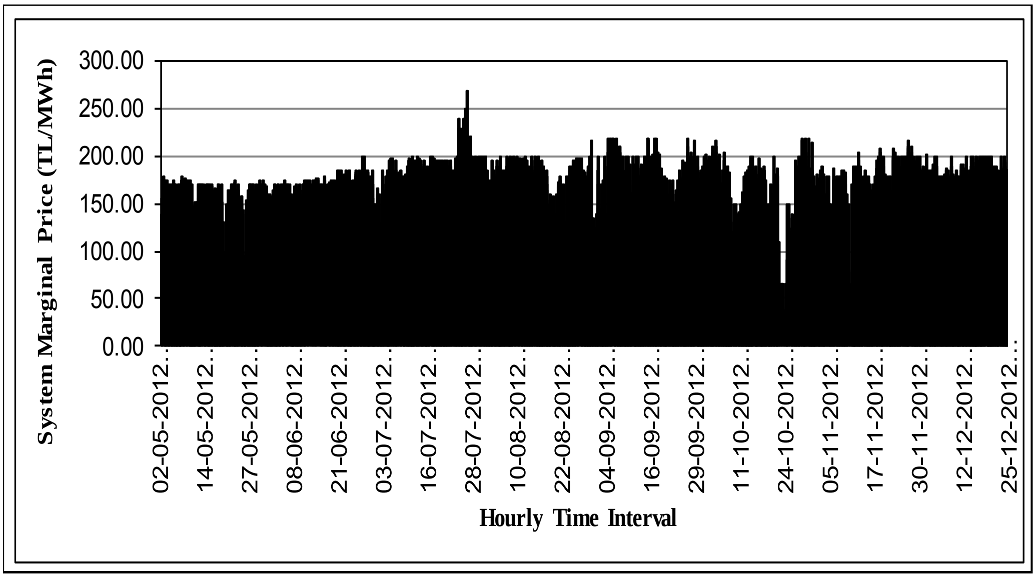

Figure 5-26 Distribution of system marginal price time based

By using real time prices and real time production values and estimation values, the benefits are calculated for the determined period (2 May 00-01 and 25 December 15-16) and also are compared with Renewable Energy Support Mechanism Prices. Results are represented in Table 5-11. According to the results, it can be claimed that predictions did increased income and benefits.

Table 5-11 Benefit calculation results

Offer according to RITM Estimation (MWh)	Day Ahead Market Total day after payment (TL)	Additional Payment of positive Imbalance (TL)	Pay-back of negative Imbalance (TL)
1,294,928.26	199,448,229.24	18,609,444.35	11,333,227.53
Real Production (Taken as 100% estimated) (MWh)	Net Income of real production (TL)	RESSM Income (TL)	Net Income As a result of RITM estimation (TL)
1,372,539.67	210,646,921.7	179,862,542.57	206,724,446.06

CHAPTER 6

CONCLUSIONS AND RECOMMENDATIONS

Renewable energy in Turkey is still on a development process. Although there are the legal reforms and regulations to support the process, the system has not been completely settled. The development rate is still below the expectations and there is also a considerable level of non-utilized potential. In the area of renewable energy, the incentives are main driving force as explained in detail. According to the results of the study on feed-in tariffs, the prices applicable to renewable resources oriented energy production are not functional especially for hydropower and wind power plants. This situation is also apparent when the participation statistics of renewable energy source support mechanism are considered.

The market structure also is not sustainable for renewable energy companies. In the long-term, with increasing share of renewables in total electricity production, imbalance of the system will be increased and this situation will consequently result in marginal price instability. This mostly affects renewable energy companies as declining their incomes. If it is the case, large scale companies producing electricity from conventional resources gain advantage over small-scaled companies specialized on renewable energies. As a result, monopolization will occur on the contrary to the aims of electricity reform in Turkey and to participation paragidm of renewables.

As stated in Chapter III, the main determination criterion for feed-in tariffs is the average price of electricity in market according to the Law on Renewable Energy. This simple approach is unsatisfactory and non-applicable. An optimum support mechanism needs detailed long term economical studies. The prices should be determined in accordance with the requirements of job creation, reduction in foreign dependency, and technology and product export perspective. A price scale should be set by considering the scale of the project as well as the special conditions of them; German practice can be a good example. The target price feed-in tariff and feed-in premium options should also be considered. Furthermore, the incentives have to be applicable to the auto-producer renewable energy plants.

The incentives were designated to include additional premises for domestically manufactured equipment used in renewable energy production. This approach can be classified as an indirect support for the industry of renewable energy equipment production. However, a direct support mechanism for this industry is thought to be a more functional way. This kind of support policy will not only contribute to national industrial enterprises for domestic consumption but also will create an important opportunity in terms of export.

The complete exploitation of renewable energy resources necessitates the participation of small scaled production units into the process. Regulation on Unlicensed Production is an important step towards this direction though it needs to be supported with long-term loan possibilities. Programs like the “100,000 roof–solar programme”, similar to German practices, have to be designed. The complete efficiency also requires improvement of grid and connections in accordance with the needs of these small-scaled units.

The ability of making well-established predictions for short-term production of energy plants will also contribute to the energy balance of the system and the profits of the companies as well. According to the calculations carried out within the scope of this thesis, the net income has a positive relationship with successful estimates. The short-term results of recently initiated RITM project are promising in this direction. Prediction studies have to be increased and improved. The similar prediction projects have to be developed for also HPPs with the cooperation of government intuitions and private companies.

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APPENDIX-A

Renewable Energy Support Mechanism Participants

Table A.1 Renewable Energy Support Mechanism Participants-2011

2011					
License Owner Company	**Source Type**	**Facility Type**	**Installed Capacity (MW)**	**Annual Production Amount (kWh)**	**Commissioning Date**
Katırcıoğlu Elektrik Üretim Ltd.Şti.	Hydropower	Canal	1.4	5,479,400	30.09.2010
Akua Enerji Üretim ve Pazarlama Sanayi ve Ticaret A.Ş.	Hydropower	Canal	1.6	8,322,000	28.08.2010
Tektuğ Elektrik Üretim Anonim Şirketi	Hydropower	Reservoir	13.0	52,288,000	10.11.2009
Tektuğ Elektrik Üretim Anonim Şirketi	Hydropower	Canal	5.0	31,686,000	09.05.2007
Yapısan Elektrik Üretim A.Ş.	Wind	Wind Power	30.0	105,000,000	16.09.2009
Boreas Enerji Üretim Sistemleri Sanayi ve Ticaret A.Ş.	Wind	Wind Power	15.0	62,546,400	09.04.2010
Bergama RES Enerji Üretim A.Ş.	Wind	Wind Power	90.0	354,790,000	16.06.2010
Bilgin Rüzgar Santrali Enerji Üretimi A.Ş.	Wind	Wind Power	90.0	360,120,000	11.11.2010
Doruk Enerji Elektrik Üretim Anonim Şirketi	Wind	Wind Power	30.0	110,000,000	22.07.2011
Doğal Enerji Elektrik Üretim Anonim Şirketi	Wind	Wind Power	14.9	47,660,000	08.05.2008
Yapısan Elektrik Üretim A.Ş.	Wind	Wind Power	30.0	105,000,000	26.05.2006
Doğal Enerji Elektrik Üretim Anonim Şirketi	Wind	Wind Power	34.2	103,047,059	25.06.2008
Rotor Elektrik Üretim A.Ş.	Wind	Wind Power	135.0	510,000,000	15.10.2010
Menderes Geothermal Elektrik Üretim A.Ş.	Geothermal	GEP	9.5	70,000,000	26.03.2010
Menderes Geothermal Elektrik Üretim A.Ş.	Geothermal	GEP	8.0	56,000,000	10.05.2006
Gürmat Elektrik Üretim A.Ş.	Geothermal	GEP	47.4	312,497,280	02.04.2009
Tuzla Jeotermal Enerji A.Ş.	Geothermal	GEP	7.5	63,000,000	13.01.2010
ITC-KA Enerji Üretim Sanayi ve Ticaret A.Ş.	Biomass	Landfill Gas	5.7	49,615,560	08.04.2011
ITC-KA Enerji Üretim Sanayi ve Ticaret A.Ş.	Biomass	Landfill Gas	22.6	198,046,080	23.05.2007
Ortadoğu Enerji Sanayi ve Ticaret Anonim Şirketi	Biomass	Landfill Gas	17.0	132,000,000	24.02.2010

Table A.2 Renewable Energy Support Mechanism Participants-2012

2012						
License Owner Company	**Plant Name**	**Source Type**	**Facility Type**	**Installed Capacity (MW)**	**Annual Production Amount (kWh)**	**Date of Commissioning**
CEYKAR ELEKTRİK ÜRETİM A.Ş.	Bağışlı HES	Hydropower	Canal	29.6	99,440,000	07.05.2009
ÇAMLIKAYA ENERJİ ÜRETİM VE TİCARET A.Ş.	Çamlıkaya HES	Hydropower	Run-off River	8.5	35,100,000	11.08.2011
FIRTINA ELEKTRİK ÜRETİM A.Ş.	Sümer HES	Hydropower	Run-off River	21.6	59,406,000	16.04.2010
Kalen Enerji Elektrik Üretim A.Ş.	Kalen I-II HES	Hydropower	Canal	36.5	112,121,000	19.06.2009
AKUA ENERJİ ÜRETİM ANONİM ŞİRKETİ	Kayalık HES	Hydropower	Canal	5.8	45,100,000	15.07.2009
Birim Hidroelektrik Üretim San. Tic. A.Ş.	Erfelek HES	Hydropower	Canal	6.5	19,030,000	14.05.2010
Fetaş Fethiye Enerji ve Ticaret A.Ş.	Sarmaşık II HES	Hydropower	Run-off River	21.6	104,210,000	28.11.2008
Fetaş Fethiye Enerji ve Ticaret A.Ş.	Sarmaşık I HES	Hydropower	Run-off River	21.0	95,330,000	28.11.2008
GÖK ENERJİ ELEKTRİK SANAYİ VE TİCARET A.Ş.	GÖK HES	Hydropower	Canal	10.0	42,840,000	06.08.2010
GENEL DİNAMİK SİSTEMLER ELEKTRİK ÜRETİM A.Ş.	Sarıtepe HES	Hydropower	Canal	4.9	20,000,000	24.12.2009
Akenerji Elektrik Üretim A.Ş.	Akocak HES	Hydropower	Run-off River	81.0	257,440,000	29.07.2010
BEYTEK Elektrik Üretim Anonim Şirketi	Çataloluk Hes	Hydropower	Run-off River	9.5	31,990,000	07.04.2010
İÇ-EN ELEKTRİK ÜRETİM VE TİC. A.Ş.	Çalkışla Regülatörü ve HES	Hydropower	Canal	7.7	17,263,000	22.05.2008
Kale Enerji Üretim Ticaret ve Sanayi A.Ş.	Kale HES	Hydropower	Canal	34.1	107,280,000	16.06.2010
ETİ BAKIR A.Ş.	Murgul HES	Hydropower	Canal	24.2	67,300,000	11.11.2010
Akım Enerji Üretimi Sanayi ve Ticaret A.Ş.	Cevizlik HES	Hydropower	Canal	91.4	330,000,000	28.05.2010
Akım Enerji Üretimi Sanayi ve Ticaret A.Ş.	Yokuşlu Kalkandere HES	Hydropower	Canal	39.7	180,480,000	28.01.2011
TEMSA ELEKTRİK ÜRETİM LİMİTED ŞİRKETİ	Gözede HES	Hydropower	Run-off River	2.4	8,327,000	29.01.2008
Asa Enerji Elektrik Üretim Sanayi A.Ş.	Kale Reg. ve HES	Hydropower	Canal	9.6	39,550,000	19.02.2010
ANG Enerji Elektrik Üretim Sanayi Ticaret Ltd. Şti.	Sabunsuyu-II HES	Hydropower	Canal	7.4	20,650,000	28.10.2010
Laskar Enerji Üretim Pazarlama A.Ş.	İncirli Regülatörü ve HES	Hydropower	Run-off River	25.2	126,020,000	25.05.2011

Table A.2 (continued)

2012						
License Owner Company	**Plant Name**	**Source Type**	**Facility Type**	**Installed Capacity (MW)**	**Annual Production Amount (kWh)**	**Date of Commissioning**
Çakıt Enerji A.Ş.	Çakıt HES	Hydropower	Run-off River	20.2	95,850,000	01.06.2010
BME Birleşik Müteahhitler Enerji Üretim ve Tic. A.Ş.	Erenler HES	Hydropower	Canal	45.0	125,500,000	04.06.2010
HAMEKA HİDRO ELEKTRİK ENR.ÜRT.A.Ş.	Taşova ve Yenidereköy HES	Hydropower	Canal	2.0	10,080,000	30.01.2009
Çamlıca Elektrik Üretim A.Ş.	Çamlıca III HES	Hydropower	Canal	27.6	104,488,000	01.04.2011
İdeal Enerji Üretimi Sanayi ve Ticaret A.Ş.	Karasu I HES	Hydropower	Canal	3.8	21,560,000	19.05.2011
İdeal Enerji Üretimi Sanayi ve Ticaret A.Ş.	Karasu IV-3 HES	Hydropower	Canal	4.6	21,620,000	05.08.2011
İdeal Enerji Üretimi Sanayi ve Ticaret A.Ş.	Karasu V HES	Hydropower	Canal	4.1	24,270,000	03.08.2011
Beyobası Enerji Üretimi A.Ş.	Otluca HES	Hydropower	Canal	47.7	224,000,000	16.09.2011
Çamlıca Elektrik Üretim A.Ş.	Saraçbendi HES	Hydropower	Canal	25.5	100,470,000	06.05.2011
ELDA ELEKTRİK ÜRETİM LTD. ŞTİ.	Dinar HES	Hydropower	Canal	4.4	15,384,000	03.07.2010
Yıldızlar Enerji Elektrik Üretim A.Ş.	Kulp-I HES	Hydropower	Canal	22.9	78,239,000	04.03.2011
Yıldızlar Enerji Elektrik Üretim A.Ş.	Kulp-IV HES	Hydropower	Canal	12.3	39,318,000	13.01.2010
Nuryol Enerji Üretim Tic. ve San. A.Ş.	Defne HES	Hydropower	Canal	7.2	22,021,000	26.03.2010
Tektuğ Elektrik Üretim Anonim Şirketi	Erkenek HES	Hydropower	Reservoir	13.0	52,288,000	10.11.2009
Arsın Enerji Elektrik Üretim San. A.Ş.	Selimoğlu HES	Hydropower	Canal	8.8	27360000	07.01.2010
Aksu Madencilik Sanayi ve Elektrik Üretim Ticaret A.Ş.	Tefen HES	Hydropower	Canal	33.0	141 200 000	13.10.2011
Yedigöl Hidroelektrik Üretim ve Ticaret A.Ş.	Yedigöl HES	Hydropower	Canal	21.9	60,090,000	13.10.2011
Özcevher Enerji Elektrik Üretim Anonim Şirketi	Cevher I-II HES	Hydropower	Run-off River	16.4	56,000,000	17.01.2011
Değirmenüstü Enerji Üretim Ticaret ve Sanayi A.Ş.	Değirmenüstü HES	Hydropower	Run-off River	40.0	109,000,000	16.04.2009
Seyrantepe HES Elektrik Üretimi A.Ş.	Seyrantepe HES	Hydropower	Run-off River	56.8	163,590,000	25.09.2008
Katırcıoğlu Elektrik Üretim Ltd.Şti	Kahraman Reg. Ve HES	Hydropower	Canal	1.4	5,479,400	30.09.2010
İdeal Enerji Üretimi Sanayi ve Ticaret A.Ş.	Karasu II-III HES	Hydropower	Canal	3.1	18,970,000	03.06.2011
BOREAS Enerji Üretim Sistemleri San. ve Tic. A.Ş.	Hisartepe RES	Wind	Wind Power	15.0	62,546,400	09.04.2010

Table A.2 (continued)

2012						
License Owner Company	**Plant Name**	**Source Type**	**Facility Type**	**Installed Capacity (MW)**	**Annual Production Amount (kWh)**	**Date of Commissioning**
Kores Kocadağ Rüzgar Enerji Santralı Üretim A.Ş.	Kocadağ-2 RES	Wind	Wind Power	15.0	60,000,000	23.12.2009
ASMAKİNSAN TEMİZ ENERJİ ELEKTRİK ÜRETİM SAN. VE TİC. A.Ş.	Bandırma III	Wind	Wind Power	25.0	75,000,000	26.03.2010
Alize Enerji Elektrik Üretim A.Ş.	Çataltepe	Wind	Wind Power	16.0	62,580,000	19.04.2011
Alize Enerji Elektrik Üretim A.Ş.	Keltepe	Wind	Wind Power	20.7	73,200,000	18.04.2010
Alize Enerji Elektrik Üretim A.Ş.	Kuyucak	Wind	Wind Power	25.6	87,460,000	09.12.2010
Alize Enerji Elektrik Üretim A.Ş.	Sarıkaya	Wind	Wind Power	28.8	96,291,000	19.10.2009
Alize Enerji Elektrik Üretim A.Ş.	Çamseki	Wind	Wind Power	20.8	81,800,000	24.06.2009
Anemon Enerji Elektrik Üretim A.Ş.	İntepe	Wind	Wind Power	30.4	92,420,000	22.11.2007
Dares Datça Res Sanayi ve Ticaret A.Ş.	Datça RES	Wind	Wind Power	29.6	83,660,000	16.04.2009
Mare Manastır Res Sanayi ve Ticaret A.Ş.	Mazı I	Wind	Wind Power	39.2	128,700,000	13.04.2007
DENİZ ELEKTRİK ÜRETİM LTD ŞTİ.	Karakurt	Wind	Wind Power	10.8	30,100,000	28.05.2007
Sanko Rüzgar Enerjisi Sanayi ve Ticaret A.Ş.	Çatalca	Wind	Wind Power	60.0	207,400,000	27.12.2008
Doğal Enerji Elektrik Üretim A.Ş.	Burgaz	Wind	Wind Power	14.9	47,660,000	08.05.2008
Doruk Enerji Elektrik Üretim A.Ş.	Seyitali	Wind	Wind Power	30.0	110,000,000	22.07.2011
Doğal Enerji Elektrik Üretim A.Ş.	Sayalar	Wind	Wind Power	34.2	103,047,059	25.06.2008
Bilgin Rüzgar Santrali Enerji Üretimi A.Ş.	Soma RES	Wind	Wind Power	90.0	360,120,000	11.11.2010
Bergama RES Enerji Üretim A.Ş.	Aliağa	Wind	Wind Power	90.0	354,790,000	16.06.2010
Yapısan Elektrik Üretim A.Ş.	Bandırma	Wind	Wind Power	30.0	105,000,000	26.05.2006
Yapısan Elektrik Üretim A.Ş.	Mazı 3 RES	Wind	Wind Power	30.0	105,000,000	16.09.2009
AYRES AYVACIK RÜZGAR ENERJİSİNDEN ELEKTRİK ÜRETİM SANTRALİ LTD. ŞTİ.	Ayres	Wind	Wind Power	5.0	17,000,000	23.10.2011
Kores Kocadağ Rüzgar Enerji Santralı Üretim A.Ş.	Kocadağ-2 RES	Wind	Wind Power	15.0	60,000,000	23.12.2009
SABAŞ ELEKTRİK ÜRETİM ANONİM ŞİRKETİ	Turguttepe	Wind	Wind Power	24.0	74,200,000	04.03.2011

Table A.2 (continued)

2012						
License Owner Company	**Plant Name**	**Source Type**	**Facility Type**	**Installed Capacity (MW)**	**Annual Production Amount (kWh)**	**Date of Commisoning**
MENDERES Geothermal Elektrik Üretim A.Ş.	Salavatlı	Geothermal	GES	8.0	56,000,000	10.05.2006
MENDERES Geothermal Elektrik Üretim A.Ş.	Dora-2 Jeotermal Enerji Santrali	Geothermal	GES	9.5	70,000,000	26.03.2010
GÜRMAT ELEKTRİK ÜRETİM A.Ş.	Germencik	Geothermal	GES	47.4	312,497,280	02.04.2009
TUZLA JEOTERMAL ENERJİ A.Ş.	Tuzla	Geothermal	GES	7.5	63,000,000	13.01.2010
ITC-KA Enerji Üretim Sanayi ve Ticaret A.Ş.	Sincan Çadırtepe Biyokütle Enerji Sanrali	Biomass	Landfill Gas	5.7	49,615,560	08.04.2011
CEV MARMARA ENERJİ ÜRETİM SAN. VE TİC. LTD. ŞTİ.	Bolu Çöp Biyogaz Projesi	Biomass	Landfill Gas	1.1	8,143,200	26.08.2011
CEV ENERJİ ÜRETİM SAN. VE TİC. LTD. ŞTİ.	Gaziantep Büyükşehir Belediyesi Katı atık Depolama Alanı	Biomass	Landfill Gas	5.7	48,859,000	24.08.2011
ORTADOĞU ENERJİ SAN. VE TİC. A.Ş.	Odayeri Çöp Gazı Santralı	Biomass	Landfill Gas	17.0	132000000	24.02.2010
ITC Adana Enerji Üretim Sanayi ve Ticaret A.Ş.	ITC Adana Enerji Üretim Tesisi	Biomass	Landfill Gas	11.3	99,231,120	06.10.2011
ITC-KA Enerji Üretim Sanayi ve Ticaret A.Ş.	Aslım Enerji Üretim Tesisi	Biomass	Landfill Gas	5.7	44,224,000	21.10.2011
ITC-KA Enerji Üretim Sanayi ve Ticaret A.Ş.	Mamak Katı Atık Alanı Enerji Üretim Tesisi	Biomass	Landfill Gas	25.4	218,675,492	23.05.2007

Table A.3 Renewable Energy Support Mechanism Participants-2013

2013						
License Owner Company	**Plant Name**	**Source Type**	**Facility Type**	**Installed Capacity (MW)**	**Annual Production Amount (kWh)**	**Date of Commissioning**
CEYKAR ELEKTRİK ÜRETİM A.Ş.	Bağışlı HES	Hydropower	Canal	29.6	99,440,000	07.05.2009
DU Elektrik Üretim A.Ş	Suluköy HES	Hydropower	Canal	6.9	14,216,000	16.03.2012
Uhud Enerji Üretim Ticaret ve Sanayi A.Ş.	Gökgedik HES	Hydropower	Canal	24.3	58,900,000	30.03.2012
Rinerji Rize Elektrik Üretim Anonim Şirketi	Cuniş Regülatörü ve HES	Hydropower	Canal	8.4	32,410,000	28.09.2012
Kalen Enerji Elektrik Üretim A.Ş.	Kalen I-II HES	Hydropower	Canal	36.5	112,121,000	19.06.2009
Katırcıoğlu elktirik üretim Ltd . şti	Kahraman Reg. Ve HES	Hydropower	Canal	1.4	5,479,400	30.09.2010
AKUA ENERJİ ÜRETİM ANONİM ŞİRKETİ	Kayalık HES	Hydropower	Canal	5.8	45,100,000	15.07.2009
ÇAMLIKAYA ENERJİ ÜRETİM VE TİCARET A.Ş.	Çamlıkaya HES	Hydropower	Canal	8.5	35,100,000	11.08.2011
GÖK ENERJİ ELEKTRİK SANAYİ VE TİCARET A.Ş.	GÖK HES	Hydropower	Canal	10.0	42,840,000	06.08.2010
TEMSA ELEKTRİK ÜRETİM LİMİTED ŞİRKETİ	Gözede HES	Hydropower	Run-off River	2.4	8,327,000	29.01.2008
İÇ-EN ELEKTRİK ÜRETİM VE TİC. A,Ş.	Çalkışla Regülatörü ve HES	Hydropower	Canal	7.7	17,263,000	22.05.2008
Değirmenüstü Enerji Üretim Ticaret ve Sanayi A.Ş.	Değirmenüstü HES	Hydropower	Run-off River	40.0	109,000,000	16.04.2009
Yıldızlar Enerji Elektrik Üretim A.Ş.	Kulp-I HES	Hydropower	Canal	22.9	78,239,000	04.03.2011
Yıldızlar Enerji Elektrik Üretim A.Ş.	Kulp-IV HES	Hydropower	Canal	12.3	39,318,000	13.01.2010
Dares Datça Res Sanayi ve Ticaret A.Ş.	Datça RES	Wind	Wind Power	29.6	83,660,000	16.04.2009
Alize Enerji Elektrik Üretim A.Ş.	Kuyucak	Wind	Wind Power	25.6	87,460,000	09.12.2010
Alize Enerji Elektrik Üretim A.Ş.	Keltepe	Wind	Wind Power	20.7	73,200,000	28.04.2010
TUZLA JEOTERMAL ENERJİ A.Ş.	Tuzla	Geothermal	GEP	7.5	63,000,000	13.01.2010
GÜRMAT ELEKTRİK ÜRETİM A.Ş.	Germencik	Geothermal	GEP	47.4	312,497,280	02.04.2009
MENDERES Geothermal Elektrik Üretim A.Ş.	Dora-2 Jeotermal Enerji Santrali	Geothermal	GEP	9.5	84,367,962	26.03.2010
MENDERES Geothermal Elektrik Üretim A.Ş.	Dora-1 Jeotermal Enerji Santrali	Geothermal	GEP	8.0	56,000,000	10.05.2006
MAREN MARAŞ ELEKTRİK ÜRETİM SANAYİ VE TİCARET A.Ş.	Maren Santrali	Geothermal	Geothermal	44.0	350,000,000	11.11.2011

Table A.3 (continued)

2013						
License Owner Company	**Plant Name**	**Source Type**	**Facility Type**	**Installed Capacity (MW)**	**Annual Production Amount (kWh)**	**Date of Commissioning**
MAREN MARAŞ ELEKTRİK ÜRETİM SANAYİ VE TİCARET ANONİM ŞİRKETİ	Deniz JES	Geothermal	Geothermal	24.0	186,000,000	30.10.2012
Pamukova Yenilenebilir Enerji ve Elektrik Üretim A.Ş.	Pamukova Katı Atık Yönetimi Entegre Tesisi	Biomass	Landfill Gas	1.4	9,670,000	05.05.2012
HER ENERJİ ve ÇEVRE TEKNOLOLOJİLERİ ELEKTRİK ÜRETİM A.Ş.	Her Enerji Kayseri Katı Atık Depo Sahası Biyogaz otoprodüktör Santrali	Biomass	Landfill Gas	2.9	16,500,000	27.07.2012
BEREKET ENERJİ ÜRETİM A.Ş.	Kumkısık Lfg Santrali	Biomass	Landfill Gas	0.6	5,080,000	17.06.2012
ITC-KA Enerji Üretim Sanayi ve Ticaret A.Ş.	Sincan Çadırtepe Biyokütle Enerji Sanrali	Biomass	Landfill Gas	5.7	49,615,560	08.04.2011
ITC Adana Enerji Üretim Sanayi ve Ticaret A.Ş.	ITC Adana Enerji Üretim Tesisi	Biomass	Landfill Gas	11.3	108,955,000	06.10.2011
ITC-KA Enerji Üretim Sanayi ve Ticaret A.Ş.	Aslım Enerji Üretim Tesisi	Biomass	Landfill Gas	5.7	44,224,000	21.10.2011
ITC-KA Enerji Üretim Sanayi ve Ticaret A.Ş.	Mamak Katı Atık Alanı Enerji Üretim Tesisi	Biomass	Landfill Gas	25.4	178,038,000	23.05.2007
ITC Bursa Enerji Üretim Sanayi ve Ticaret A.Ş.	ITC Bursa Hamitler Tesisi	Biomass	Landfill Gas	9.8	85,848,000	07.09.2012
Arel Çevre Yatırımları Enerji ve Elektrik Üretimi Ltd. Şti.	Arel Enerji Biyokütle Tesisi	Biomass	Landfill Gas	2.4	16,800,000	25.05.2012
ORTADOĞU ENERJİ SAN. VE TİC. A.Ş.	Odayeri Çöp Gazı Santralı	Biomass	Landfill Gas	21.1	202,069,000	24.02.2010
ORTADOĞU ENERJİ SAN. VE TİC. A.Ş.	Kömürcüoda Çöp Gazı Santralı	Biomass	Landfill Gas	8.5	60,000,000	16.10.2012
KALEMİRLER ENERJİ ELEKTRİK ÜRETİM LTD.ŞTİ	Sezer Bio Enerji	Biomass	Animal Waste	0.5	3,500,000	17.08.2012
Körfez Enerji Sanayi ve Ticaret A. Ş.	Kocaeli Çöp Biyogaz Projesi	Biomass	Landfill Gas	2.3	9,430,000	15.10.2012
Ekim Grup Elektrik Üretim Madencilik İnşaat Tarım Hayvancılık Sanayi Ticaret Ltd. Şti.	Ekim Grup Biyogaz	Biomass	Animal Waste	1.2	9,936,000	30.10.2012
Samsun Avdan Enerji Üretim ve Ticaret AŞ	Samsun Avdan Biyogaz Tesisi	Biomass	Landfill Gas	2.4	9,600,000	09.03.2012