AN EXAMINATION OF THE LEGISLATIVE FRAMEWORK FOR SUPPORTING THE RENEWABLE TARIFFS

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ABSTRACT

AN EXAMINATION OF THE LEGISLATIVE FRAMEWORK FOR SUPPORTING THE RENEWABLE TARIFFS

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Sustainability and environmental concerns are critical issues in energy sector. Limited availability of fossil resources, environmental pollution caused by the greenhouse gases emitted as a result of fossil fuel usage and safety issues of nuclear power plants cause the seek of new resources in energy industry. Renewable energy sources emerge as the alternative energy resources for the industry. The unlimited availability of most of the renewable resources meets the sustainability needs in the energy sector. Energy generation from renewable resources causes low greenhouse gas emissions, which eliminates the environmental concerns. Moreover, use of renewable resources does not involve risks like radioactive emissions. Despite all these factors, renewable energy resources are not competitive yet. The cost of energy generation from renewable resources is high compared to the cost of using conventional resources like coal for energy generation. This situation acts as a barrier for the development of renewable energy technologies and cost reduction. In order to bring renewable energy to a competitive level in the energy market, some supportive mechanisms have been developed and implemented in various countries. This thesis work examines the mechanisms in the EU, the USA and Turkey. An examination has been performed on the current laws and policies effective on renewable energy sector in Turkey. As a result of the examinations, recommendations have been made to improve the legislative framework for the promotion of renewable energy in Turkey.

Keywords: renewable, law, Turkey

ÖZ

YENİLENEBİLİR TARİFELERİNİN DESTEKLENMESİ İÇİN GEREKLİ YASAL MEVZUAT HAKKINDA İNCELEME

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Sürdürülebilirlik ve çevresel endişeler enerji sektöründeki kritik konulardır. Fosil kaynaklarının sınırlılığı, fosil yakıtlarının kullanımı sonucunda yayılan sera gazlarının neden olduğu çevresel kirlenme ve nükleer santrallerle ilgili güvenlik konuları, enerji endüstrisinde yeni kaynakların arayışına neden olmaktadır. Yenilenebilir enerji kaynakları endüstri için alternatif enerji kaynakları olarak ortaya çıkmaktadırlar. Çoğu yenilenebilir kaynakların sınırsız oluşu, enerji sektöründeki sürdürülebilirlik ihtiyaçlarını karşılamaktadır. Yenilenebilir kaynaklardan enerji üretimi düşük sera gazı yayınımına sebep olmakta, bu da çevresel endişeleri gidermektedir. Ayrıca, yenilenebilir kaynakların kullanımı, radyoaktif yayınım benzeri riskler taşımamaktadır. Bütün bu faktörlere rağmen yenilenebilir enerji kaynakları henüz rekabet edebilir düzeyde değildir. Yenilenebilir kaynaklardan enerji üretiminin maliyeti, enerji üretimi için kömür gibi geleneksel kaynaklar kullanmanın maliyetiyle karşılaştırıldığında yüksektir. Bu durum, yenilenebilir enerji teknolojilerinin gelişmesine ve maliyetlerin azalmasına engel teşkil etmektedir. Yenilenebilir enerjiyi enerji piyasasında rekabet edebilir düzeye getirmek için çeşitli ülkelerde destekleyici mekanizmalar geliştirilmiş ve uygulanmıştır. Bu tez çalışması AB, ABD ve Türkiye'deki mekanizmaları incelemektedir. Türkiye'deki yenilenebilir enerji sektörü üzerindeki mevcut yasa ve politikalarla ilgili inceleme yapılmıştır. İncelemeler sonucunda Türkiye'deki yenilenebilir enerjiyi destekleyici yasal yapıyı geliştirmek için önerilerde bulunulmuştur.

Anahtar Kelimeler: yenilenebilir, kanun, Türkiye

To My Family

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LIST OF ABBREVIATIONS

AB: Avrupa Birliği

ABD: Amerika Birleşik Devletleri

ADB: Asian Development Bank

AfDB: African Development Bank

ARAS: Aras Electricity Distribution Company (Aras Elektrik Dağıtım Anonim Şirketi)

ARS: Acute radiation syndrome

ASTAE: Asia Alternative Energy Program

BEDAŞ: Başkent Electricity Distribution Company (Başkent Elektrik Dağıtım Anonim Şirketi)

BMU: German Federal Ministry for the Environment, Nature Conservation and Nuclear Safety

BOO: Build-operate-own

BOT: Build-operate-transfer

BWE: German Wind Energy Association

CCGT: Combined cycle gas turbine

CDM: Clean Development Mechanism

CER: Certified Emission Reduction

CH_4: Methane

CHP: Combined heat and power

CIF: Climate Investment Funds

CO_2: Carbon dioxide

CPUC: California Public Utilities Commission

CRW: Combustible renewables and waste

CSI: California Solar Initiative
CSP: Concentrated solar power
CTC: Carbon Tax Center
DANIDA: Danish Development Assistance Agency
DC: Direct Current
DG-CHP: Distributed Generation as Combined Heat and Power
DLR: German Aerospace Centre
DoE: U.S. Department of Energy
DPT: Turkish State Planning Organization (Devlet Planlama Teşkilatı)
DSİ: State Hydraulic Works (Devlet Su İşleri)
EBRD: European Bank for Reconstruction and Development
ECU: European currency unit
EIB: European Investment Bank
EİE: Electrical Power Resources Survey and Development Administration (Elektrik İşleri Etüt İdaresi)
EML: Electricity Market Law
EMRA: Energy Market Regulatory Authority (Enerji Piyasası Düzenleme Kurumu)
EPA: Environmental Protection Agency
EPACT: Energy Policy Act
EPAct05: Energy Policy Act of 2005
EPBB: Expected Performance-Based Buydowns
ERU: Emission Reduction Unit
ET: Emissions Trading
ETA: Energy Tax Act
EU ETS: European Union Greenhouse Gas Emission Trading Scheme
EU: European Union
EÜAŞ: Turkish Electricity Generation Company (Elektrik Üretim Anonim Şirketi)

EWEA: European Wind Energy Association

ExternE: Externalities of Energy

FERC: Federal Energy Regulatory Commission

FhG-ISI: Fraunhofer Institute for System and Innovation Research

GEF: Global Environment Facility

GHG: Greenhouse Gas

GJ: Gigajoule

GW: Gigawatt

GW_e: Gigawatt (electrical)

GWEC: Global Wind Energy Council

GWh: Gigawatt hour

GW_{th}: Gigawatt (thermal)

H_2S: Hydrogen Sulfide

HAWT: Horizontal Axis Wind Turbines

HDR: Hot dry rock

HFC: Hydro fluoro carbon

HFR: Hot fracture rock

HPB: High Planning Board

IADB: Inter-American Development Bank

IBRD: International Bank for Reconstruction and Development

ID: Identification

IDB: Inter-American Development Bank

IEA: International Energy Agency

IFC: International Finance Corporation

IGCC: Integrated gasification combined cycle

IPCC: Intergovernmental Panel on Climate Change

IRA: Independent regulation authority

IREDA: Indian Renewable Energy Development Agency

JI: Joint Implementation

KfW: German Credit Institution for Reconstruction (Kreditanstalt für Wiederaufbau)
ktoe: Kilo tonnes of oil equivalent
kW: Kilowatt
kW_e: Kilowatt (electrical)
LIBOR: London Interbank Offered Rate
MBtu: Million British thermal units
MENR: Ministry of Energy and Natural Resources
MERAM: Meram Electricity Distribution Company (Meram Elektrik Dağıtım Anonim Şirketi)
MIGA: Multilateral Investment Guarantee Agency
MSW: Municipal solid waste
MToe: Million tonnes of oil equivalent
MW: Megawatt
MW_e: Megawatt (electrical)
MW_p: Peak power in megawatts
MW_{th}: Megawatt (thermal)
MYTM: National Load Dispatch Centre (Milli Yük Tevzi Merkezi)
N_2O: Nitrous oxide
NEA: National Energy Act
NFFO: Non-Fossil Fuel Obligation
NGO: Non-governmental organization
NO_x: Nitrogen oxide
NPO: National Planning Organization
NREL: National Renewable Energy Laboratory
nTPA: Negotiated Third Party Access
NYSERDA: New York State Energy Research and Development Authority
OECD: Organisation for Economic Co-operation and Development

PBI: Performance Based Incentives

P_{kin}: Kinetic power

PMUM: Market Financial Settlement Centre (Piyasa Mali Uzlaştırma Merkezi)

PREGA: Promotion of Renewable Energy, Energy Efficiency and greenhouse Gas Abatement

PRG: Partial risk guarantee

PROÁLCOOL: Brazilian National Alcohol Program

PTC: Production Tax Credit

PURPA: Public Utility Regulatory Policies Act

PV: Photovoltaic

R&D: Research and development

RE: Renewable Energy

REAP: Rural Energy for America Program

RECS: European Energy Certificate System

REPI: Renewable Energy Production Incentive

RES: Renewable Energy Resource

RPS: Renewables Portfolio Standard

rTPA: Regulated Third Party Access

SEDAŞ: Sakarya Electricity Distribution Company (Sakarya Elektrik Dağıtım Anonim Şirketi)

SO_2: Sulphur dioxide

TCA: Turkish Competition Authority

TEAŞ: Turkish Electricity Generation Transmission Company (Türkiye Elektrik Üretim, İletim Anonim Şirketi)

TEDAŞ: Turkish Electricity Distribution Company (Türkiye Elektrik Dağıtım Anonim Şirketi)

TEİAŞ: Turkish Electricity Transmission Company (Türkiye Elektrik İletim Anonim Şirketi)

TEK: Turkish Electricity Authority (Türkiye elektrik Kurumu)
TETAŞ: Turkish Electricity Trading and Contracting Company (Türkiye elektrik Ticaret ve Taahhüt Anonim Şirketi)
TGC: Tradable Green Certificate
TJ: Terajoule
TOKİ: Turkish Public Housing Administration (Toplu Konut İdaresi)
TOOR: Transfer of operating rights
TPES: World total primary energy supply
TRT: Turkish Radio Television (Türkiye Radyo Televizyon Kurumu)
TWh: Terawatt hour
UK: United Kingdom
UNDP: United Nations Development Programme
UNEP/DTIE: United Nations Environment Programme / Division of Technology, Industry and Economics
UNEP: United Nations Environment Programme
US: United States
USA: United Stated of America
USDA: United States Department of Agriculture
VAT: Value added tax
VAWT: Vertical Axis Wind Turbines
W: Watt

CHAPTER 1

INTRODUCTION

1.1 INTRODUCTION

Together with the developments in technology, the need for energy has increased enormously in the twentieth century, especially due to the growth of the industry. The need for energy increases continuously, but the fact that resources of fossil fuels on earth are limited forces energy sector to seek for new resources. The limited availability of the fossil fuels is not the only reason of seeking new energy resources. The environmental concerns are also effective on searching for new and "clean" energy sources.

The excessive injection of the emission products emerging due to the use of fossil fuels to the nature shifts the ecological balance. Greenhouse gas (GHG) emission is the main reason for the global warming. Gases like CO_2 in the atmosphere causes the heat coming from the sun to be trapped in the atmosphere causing the average temperature of earth to increase. According to the joint report published by Intergovernmental Panel on Climate Change (IPCC), the globally averaged surface temperature is projected to increase by 1.8 to 4˚C over the period 1980-1999 to 2090-2099 [1]. As determined by many researchers, the climate has changed considerably in the last century and if GHG emission cannot be stopped, this change will have effects like acid rains or increase in the sea level.

Unlike the process of extracting energy from fossil based fuels, there is no CO_2 emission in the nuclear processes. However, issues on the safety of the nuclear plants and the disposal of nuclear waste are also effective on the search for new energy resources.

At this point, the concept of renewable energy provides a solution to the environmental pollution caused by fossil fuels and security concerns about nuclear energy. Unlike plants using fossil fuels, renewable energy plants cause extremely small amount of GHG emissions. Renewable energy also provides sustainability in energy, since most of the renewable energy resources are unlimited. Although the share of renewable energy today is small, it is continually increasing. The clean-energy market is expected to expand from $ 55.4 billion in 2006 to $ 226.5 billion in 2016 [2].

Despite the solution provided by the renewable energy resources, they need special financial instruments to be supported by. There are many reasons for this, technical and financial. Risks involved in renewable energy investments increase the investment costs, high costs and low capacity factors, such as 30-40 % of the renewable energy projects reduce their competitiveness. Not including the external costs of conventional energy resources in their costs also acts as a barrier for renewable energy. Another factor hindering the development of renewable energy is the intermittency of the renewable resources. Because of the intermittent structure of these resources, they are not preferred by the transmission system operators as it becomes harder to keep the system stable.

Reducing the risks of renewable projects will increase the investments, which will lead to technology development and eventually cost reduction. However, in a liberalized market large investment shifts towards renewable projects would not occur until the risks are all reduced. Therefore, it would take a long time to become competitive in the energy market. To change this situation and boost the development in renewable energy industry, a number of financial and legislative instruments have been developed in EU and the USA.

Loans with low interest rates and long terms or grants serve as financial instruments to reduce the investment costs of renewable energy projects. Legislative instruments like the purchase and priority connection obligations imposed on the transmission system operators strengthen the status of the renewable energy projects in the energy market and reduce the risks.

Major aim of the present thesis is to examine the legislations and policies supporting renewable energy development in the Turkey and present recommendations to improve them. For this purpose, various supportive mechanisms, specifically the mechanisms used in the EU and the USA are also examined.

1.2 OUTLINE OF THE THESIS

Chapter 1 presents an introduction to the concept of renewable energy resources and support mechanisms. The developments in energy sector and the environmental effects of energy generation using fossil fuels and the security related concerns on nuclear power are presented. Moreover, the factors hindering the renewable energy from being competitive are introduced. Finally, the aim of the thesis is stated as “to examine the legislations and policies supporting the renewable energy development in Turkey and present recommendations to improve these policies”.

In Chapter 2, general information on renewable energy resources is presented. Information is provided for each renewable energy resource (solar, wind, hydroelectric, wave and tide, geothermal and bio resources). The development and future projections of energy generation from these resources in Turkey, the EU and the world is demonstrated in various graphs and tables.

Chapter 3 presents the characteristics of renewable energy resources. The environmental effects and sustainability of renewable energy resources are presented in two subsections. Intermittency, plant locations, low capacity factors, high costs and financial risks issues are also evaluated in this chapter.

Chapter 4 outlines the investment costs of renewable energy plants. A comparison of the investment costs of renewable energy plants and conventional power plants are provided by data obtained from various sources. The development of investment costs and projected costs are also stated.

In Chapter 5, information on financing mechanisms for renewable energy projects are presented. The institutions providing funds for renewable energy projects are introduced. Available funds are mentioned and information on the loans provided for renewable energy investments are presented.

Chapter 6 provides information on the incentive mechanisms. The two main mechanisms, feed-in tariffs and quota system are examined and a comparison of the two systems is presented. Other than these two mechanisms, information on tax incentives, grants, loans, loan guarantees, Kyoto mechanisms, white certificates and net metering are also given in this chapter.

Chapter 7 presents information on environmental pollution and its cost to future. Moreover, the use of environmental issues as an incentive mechanism for renewable energy generation is questioned.

In Chapter 8, the legislative framework regulating the renewable energy related issues and the policies in the EU and the USA are studied. Since in the USA, states can adopt their own policies, the policies in one of the states (California) are also presented. The effects of these policies on the development of renewable energy are demonstrated.

In Chapter 9, information on the legislative framework in Turkey has been presented. Following the presentation of the general information on and a brief history of the energy market in Turkey, the new market structure introduced by the Electricity Market Law (EML) is outlined. Lastly, the main points of the Law No: 5346 (referred to as the Renewable Energy Law) has been stated.

In Chapter 10, an examination of the legislative framework on the energy sector in Turkey is presented. This chapter studies the Electricity Market Law, the EML 4628 and the Renewable Energy Law 5346. As a result of these studies, recommendations have been presented for supporting the development of renewable energy in Turkey.

Chapter 11 summarizes the recommendations.

CHAPTER 2

RENEWABLE ENERGY RESOURCES

The solar energy reaching earth is converted into different energy forms by natural processes. Capturing energy from the energy flow in a natural process is the basic principle of renewable energy. Some examples of the natural processes that energy extraction is possible are solar radiation, flow of fluids such as water or air, geothermal activities and cycles of biological waste. The renewable energy can be used either directly or after converting into other energy products such as electricity.

The US Department of Energy defines “Renewable Energy” as “***Energy derived from resources that are regenerative or for all practical purposes cannot be depleted***” [3]. Sustainability is the main focus of the usage of renewable energy sources. Fossil fuels are formed in millions of years and there are limited sources on earth. Whereas, considering renewable energy; either no raw material is consumed and transformed into another material, or if another material is formed during energy extraction, then the end product can easily be re-transformed into the raw material in a short period. An example for the first case is wind power stations. The energy is extracted from the flow of air. Kinetic energy of the air flow is used for rotating the turbine and producing electricity. Here the raw material is air flow, but during this process the molecules in the air are not consumed or transformed into other materials during energy extraction. Biomass usage is an example for the second case. After burning of plants, they are destroyed and CO_2 is released; but the released CO_2 can easily be used in photosynthesis by other plants and re-transformed into the raw material, so that the natural balance is maintained.

In order to prevent possible accidents like the one in Chernobyl and not to cause severe changes in climate, the energy usage shifts towards renewable sources. Observations have shown that the concentration of greenhouse gases has been increasing since 1750 [4]. Although the concentration of CO_2 and CH_4 was almost constant between 1000 and 1750, their concentration increased by 31±4 % and 151±25 % respectively between 1750 and 2000 [4]. Apart from the environmental causes, economical causes also force us to use renewable energy. Because of the dependency on fossil fuels, the prices of fossil fuels have great effects on world's economy. Since the resources of fossil fuels are limited, their price will continue to increase as they tend to run out. Therefore, it is also advantageous to use renewable energy resources, since there is no possibility of running out of them. The price change of fossil fuels is given in Figure 1. As it is seen in Figure 1, the prices of fossil fuels are increasing.

> ***Types of renewable energy resources include water flow or movement (hydroelectric, tidal and wave power), thermal gradients in ocean water, biomass, geothermal energy, solar energy, and wind energy. Municipal solid waste (MSW) is also considered to be a renewable energy resource*** [3].

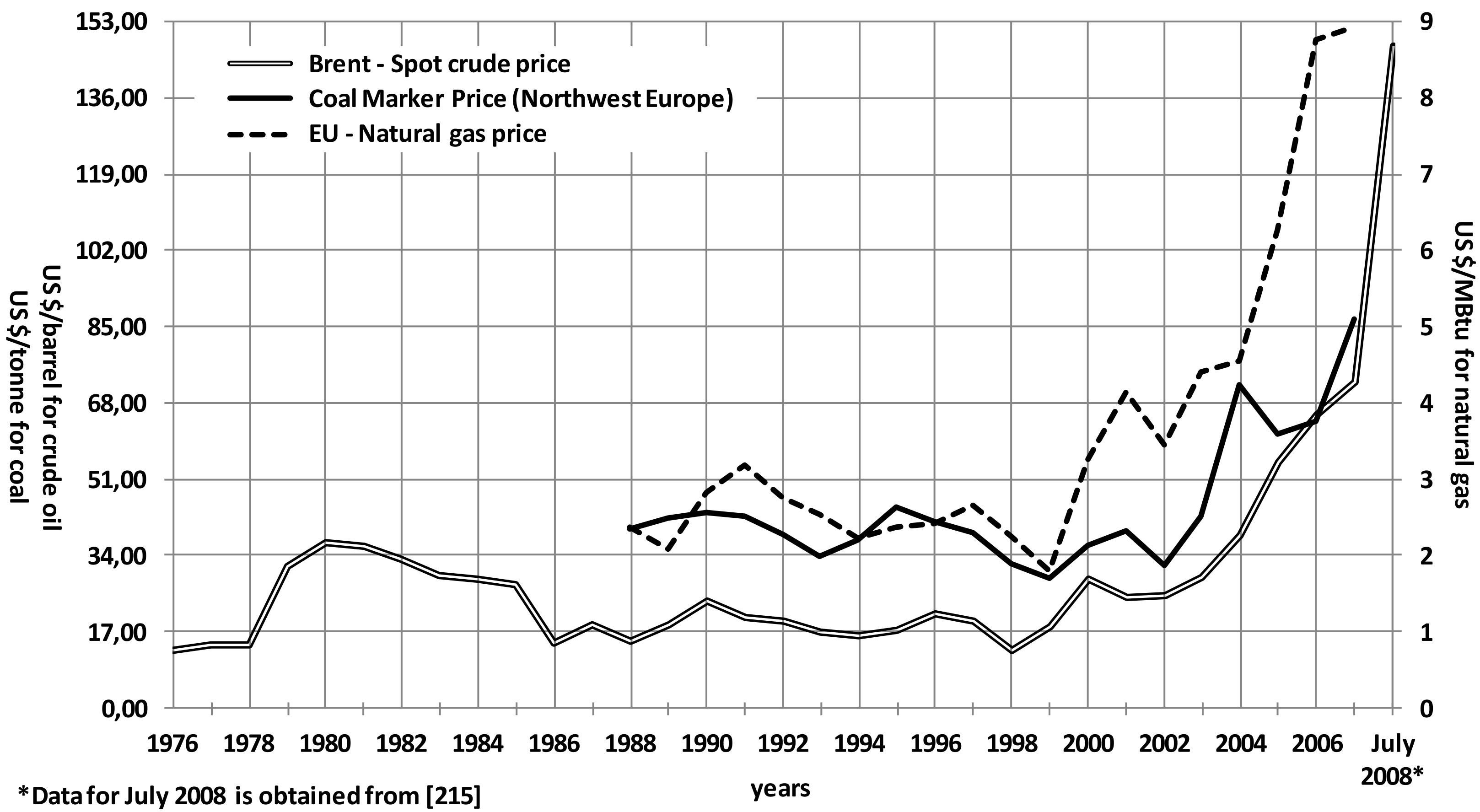


Figure 1 Price change of fossil fuels [6], [215]

Since the sun is the main source of energy for the earth and solar energy is transferred to the atmosphere, oceans and the ground, it can be said that solar energy is the main source for all of the renewable energy forms. The atmospheric activity is mainly due to the heat transferred from the sun. The stream in the oceans is also caused by the solar activity.

In 2004, the contribution of renewable energy to world's total primary energy consumption was only 13.1 %. 79.4 % of this contribution came from combustible renewable and waste, 16.7 % was from hydroelectric. Although the contribution of other renewable like solar, wind or geothermal energy was very small, their annual growth rates were greater than the annual growth rates of combustible renewable and waste and hydroelectric power [5]. The comparison of annual growth rates from 1971 to 2004 are given in Figure 2. As it is seen in Figure 2, the annual growth rates of geothermal, solar and wind energy is greater than the overall renewable energy growth rate. International Energy Agency's (IEA) projection of energy generation from renewable energy resources according to the reference scenario is given in Table 1.

By 2004, renewable contribution in Turkey's total primary energy consumption was 13.2 % including the combustible renewable and waste and 6.4 % excluding combustible renewable and waste [5]. In 2006, total electricity generation from renewable resources was 44,618.7 GWh. This amount of generation accounted for 25.3 % of total electricity generation in Turkey in 2006. 99.1 % of renewable electricity generation is supplied from hydroelectric plants [7]. Large hydroelectric plants are included in these calculations. Note that run-of river type hydroelectric plants with a capacity more than 50 MW and dam type hydroelectric plants with a reservoir area of more than 15 km^2 or with a reservoir volume of 100 million m^3 are not considered as renewable energy plants by the Electricity Market License Regulation[1]. The renewable energy generation projection made by Turkish Energy and Natural Resources Ministry up to 2020 is shown in Table 2.

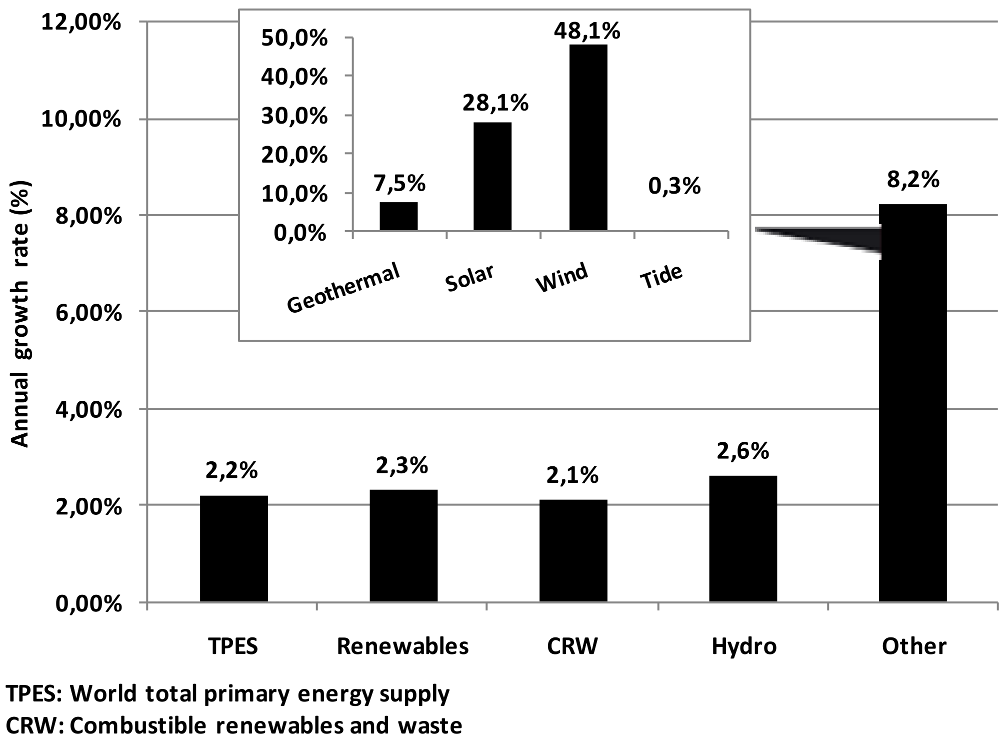


Figure 2 Annual growth rates of renewables in various categories [5]

[1] Elektrik Piyasası Lisans Yönetmeliği

Table 1 Renewable energy generation projections up to 2030 – World [8]

		1990	2004	2015	2030
Electricity Generation (TWh)	**Total**	**2315**	**3179**	**4668**	**7014**
	Hydropower	2148	2809	3682	4749
	Biomass	125	227	422	805
	Wind	4	82	433	1132
	Geothermal	36	56	100	174
	Solar	1	4	30	142
	Tide and Wave	1	1	1	12
Biofuels (Mtoe)		**6**	**15**	**54**	**92**

Table 2 Renewable energy generation projections up to 2020 – Turkey [9]

YEARS	HYDRO POWER (ktoe)	GEOTHERMAL POWER (ktoe)	GEOTHERMAL HEAT (ktoe)	WIND (ktoe)	SOLAR (ktoe)	WOOD (ktoe)	ANIMAL AND PLANT RESIDUES (ktoe)
2007*	4575	330	1308	330	441	3822	1115
2008	4678	330	1442	361	460	3669	1087
2009	4692	330	1588	391	475	3523	1059
2010	**4903**	**330**	**1750**	**421**	**495**	**3383**	**1034**
2011	5177	330	1928	450	515	3319	1009
2012	5646	330	2124	480	536	3256	986
2013	6172	330	2339	511	558	3194	965
2014	6673	330	2575	541	580	3134	945
2015	**7060**	**330**	**2836**	**571**	**605**	**3075**	**926**
2016	7491	330	3122	601	650	3075	909
2017	7948	330	3437	631	697	3075	892
2018	8421	330	3784	661	748	3075	877
2019	8932	330	4165	691	803	3075	863
2020	**9419**	**330**	**4584**	**721**	**862**	**3075**	**850**
*2007 values are estimated							

2.1 SOLAR ENERGY

Considering that “Solar energy has a share of more than 99.9 % of all the energy converted on earth.” [10], we can say that sun is the main and the only source of life on earth and the life on earth depends on the existence of it. Therefore, solar energy may be considered to be the main renewable energy source.

Solar power density constant which is 1367 W/m^2 is the power per unit area on earth’s atmosphere. Because of the losses in atmosphere and the daily and seasonal variations in the amount of energy reaching on a specific location on earth, the power density drops to an average of 170 W/m^2. Calculating the energy over one year, the energy reaching per m^2 on earth’s surface from sun is 5.4 GJ which is equal to the energy that can be obtained from 1 barrel of oil [11]. Calculating the total energy on earth’s surface and using the world’s daily consumption of 83,607.220 [12] barrels of oil, one can conclude that the solar energy is 16,714 times the oil consumption of world.

Solar energy can be used in various ways. The usage can either be directly or indirectly. Examples of direct usage of solar energy are space lighting, heating, cooling and drying. The indirect usage examples are electricity generation using photovoltaic cells or concentrated solar thermal power plants.

Solar water heating have been used widely since the introduction of the first commercial water heaters by Clarence Kemp in 1891 [13]. Water can be heated using solar energy either directly or indirectly. In direct heating method (using open loop heaters), the heated fluid is water itself. However, in indirect heating method (using closed loop heaters) a heat transfer fluid is used to heat the water. Closed loop heaters are used in colder climates and anti-freeze fluids are used as heat transfer fluid in order to prevent the piping from freezing. Depending on the water circulation mechanism, active and passive systems are available. Active systems use electric pumps to circulate the fluid (either water or heat transfer fluid), whereas passive systems does not include any electric components[2]. Heating is achieved by different types of collectors. Flat-panel collectors are the most common one. In this type of collector, the pipes are installed within an absorber material in a glazed rectangular box. Not only water, but also air can be heated using this system. Water can be heated typically up to 82°C by flat-panel collectors. However, using evacuated-tube collectors, it is possible to achieve water temperatures of 176°C. Evacuated-tube collectors consist of parallel glass tubes placed in a glazed rectangular box. The glass tubes contain metal, absorber tubes in which fluid tubes are placed. The third type of collectors (batch collectors) is probably the simplest. Batch collectors include one or more tanks covered with heat absorbing coating placed in a glazed box. All of these collector types are used widely. The total solar thermal capacity installed worldwide at the end of 2006 was 127.8 GW [15]. In Europe, the installed capacity of a few hundred MW_{th} at the beginning of 1980s [16] has reached 15.4 GW_{th} [17] at the end of 2007. Annual and cumulative solar thermal capacity in the European Union (EU) is given in Figure 3. Turkey's solar thermal energy consumption is given in Figure 4 and projected costs and solar thermal capacity are given in Figure 5.

[2] Information about open-closed loop heaters and active-passive systems are gathered from [14]

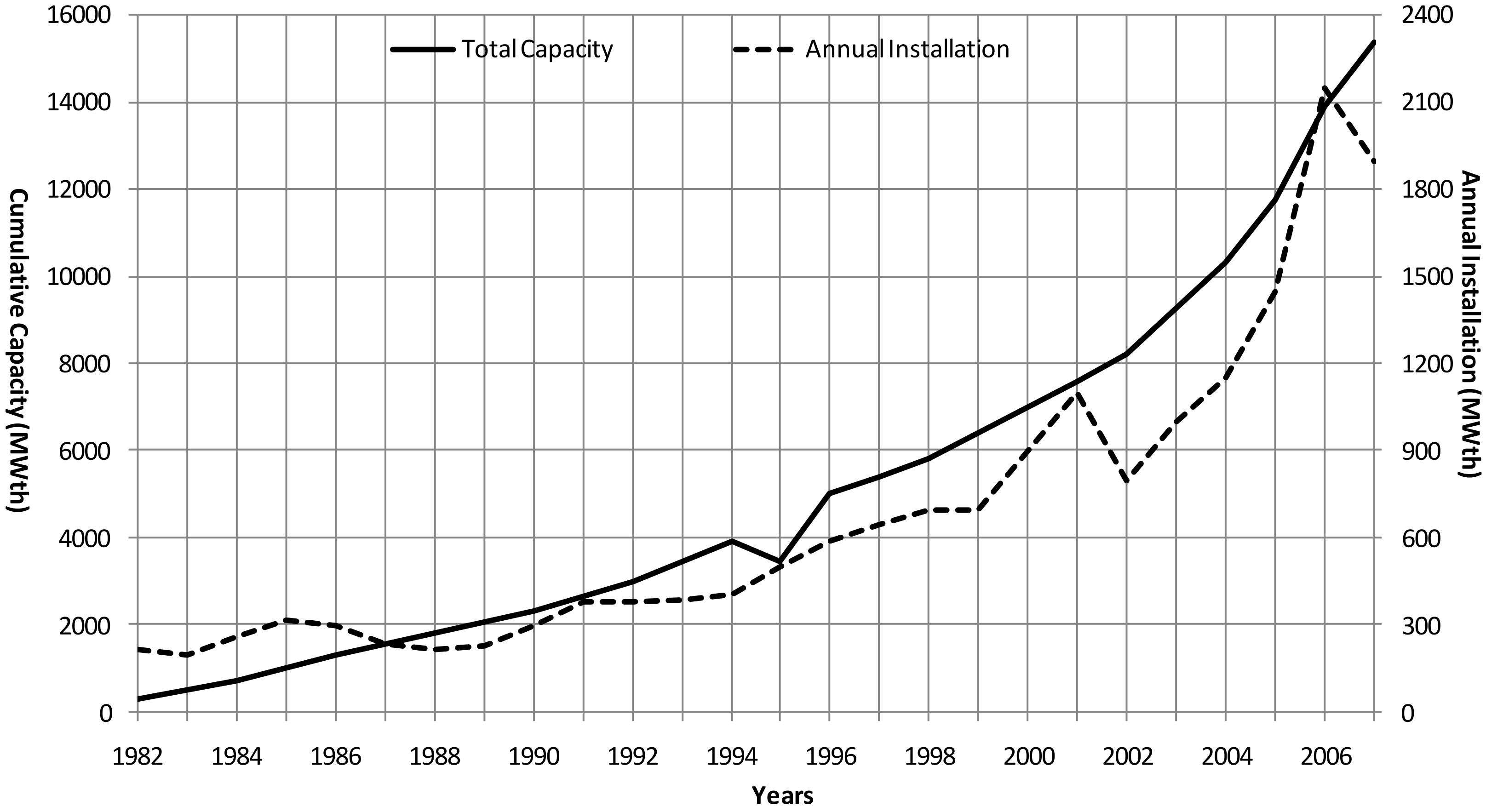


Figure 3 Annual and cumulative solar thermal capacity in the EU [16], [17]

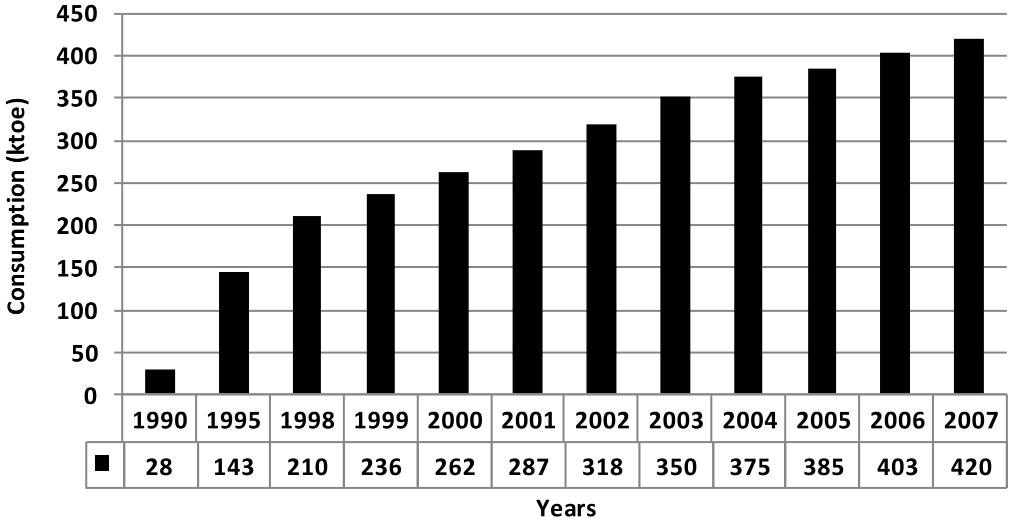


Figure 4 Solar thermal energy consumption in Turkey [18], [19]

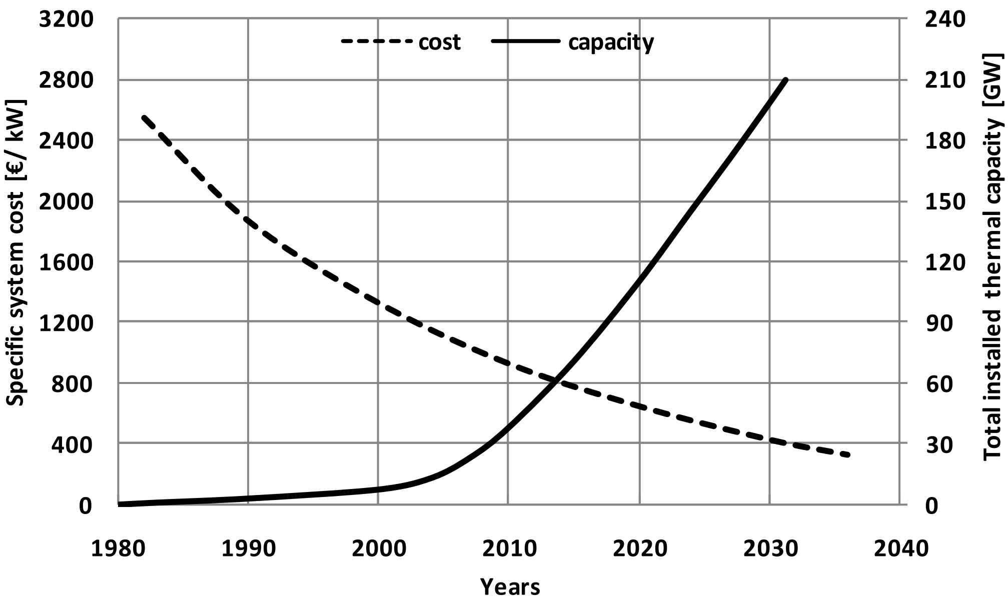


Figure 5 Projected costs and thermal capacity in the EU [20]

Solar building design uses solar radiation directly for lighting, heating and cooling purposes. It is possible to benefit more from daylight by proper positioning of windows. It is also possible by using special construction and insulation techniques to cool or heat a building using solar radiation. In 2004, residential energy consumption accounted for 11 % of the worldwide energy consumption [21]. In order to decrease this percentage, solar energy can be used efficiently.

Similar to water heating systems, space-heating systems are either passive or active. Passive space-heating systems basically depend on special materials used in a building that can absorb heat during daytime and release that heat at night. Apart from special materials used in a building, it is also possible to heat air in a sunroom near a house and use the warm air in order to heat the house. Active solar space-heating systems consist of collectors that collect and absorb solar radiation combined with electric fans or pumps to transfer and distribute that solar heat. Active systems also generally have an energy-storage system to provide heat when the sun is not shining[3].

Space-cooling using solar energy is possible in three ways. In absorption cooling, heat collected from a solar thermal collector is used to evaporate a pre-pressurized refrigerant in a vapor generator. In desiccant cooling, a desiccant is used to remove most of the moisture content from the air. In heat engine cooling, solar collectors are used to heat the working fluid in the heat engine system[4].

[3] Information on space heating systems is gathered from [22]

[4] Information on space cooling systems is gathered from [23]

Electricity generation is also possible using solar energy. This can be done either by concentrated solar thermal power systems or photovoltaic systems. In concentrated solar thermal power systems, solar energy is used for supplying heat for an engine or a heat transfer fluid which will be used for production of steam needed to run steam turbine generators. Whereas, in photovoltaic systems; electricity is directly produced by photovoltaic semiconductor cells that are exposed to solar radiation.

There are mainly 3 types of concentrated solar power (CSP) systems. The first type of CSP technology is "Parabolic-Trough". Parabolic-Trough systems consist of tubes containing heat-transfer fluid placed on the center of parabolic mirrors and lying parallel to them. The tube is coated with a special absorbing material and lies in a vacuumed glass tube. The temperature of the fluid in the tube reaches approximately 400°C and then fluid is used for production of steam in a heat exchanger. The steam rotates the steam turbine and electricity is produced. A total capacity of 418,8 MW_e [24] is built in the USA and a company (Solel Inc.) is planning to build a solar thermal power plant in Mojave Desert of California with a capacity of 533 MW [25][5].

The second type of CSP technology is "Central Receiver". A Central Receiver (solar tower) system consists of flat, sun tracking mirrors and a tower. The mirrors are placed around the tower in a circular array and the sunshine is concentrated on the receiver which is placed on top of the tower and contains molten salt. The reason of usage of salt is that it can be efficiently stored for electricity generation at night (The molten nitrate salt used in SOLAR TRES project in Spain reaches a

[5] Information on Parabolic-Trough systems is gathered from [26]

temperature of 565°C and its temperature drops only 1-2°C/day). Hot liquid salt is used for producing steam which will rotate the turbines of steam generator. PS10 solar thermal power plant based on this principle located at Sanlúcar la Mayor in Spain is the world's first solar tower plant with a capacity of 11,02 MW_e and planned annual electricity generation of 23 GWh. The cost of the plant was € 16.65 million, € 5 million of which was met by European Union (EU). Considering € 0.18/kWh is paid by Spanish Government, the total investment costs will be covered in approximately 4 years[6].

The third CSP technology is Dish/Engine systems. System consists of a dish shaped reflector and a Stirling generator placed at the focus of the dish. The heat required to push the pistons of the generator is provided by the concentrated solar power. The capacity of the dish/Sterling units can be up to 25 kW_e [27]. A company (Stirling Energy Systems) has applied for building the world's largest solar thermal plant in Mojave Desert in California using dish/Stirling technology with a capacity up to 750 MW_e [28]. The estimated electricity generation costs of CSP technologies are given in Figure 6.

Electricity generation from solar energy is also possible using photovoltaic (PV) cells. The basic principle lying under the photovoltaic concept is that when light shines on a photovoltaic cell, the excess electrons on one of the two layers gain energy and move to the other layer. Movement of electrons creates a direct current (DC). Although there are various photovoltaic cell technologies, the ones that are commercially available in PV sector are Crystalline Silicon and thin-film technologies. The efficiency of Crystalline Silicon cells ranges between

[6] Information on Central Receiver systems is gathered from [26]

12 % and 17 % whereas the efficiency of thin-film cells ranges between 6 % and 11 % [30]. The change of total installed photovoltaic capacity worldwide and in Europe through years is given in Figure 7.

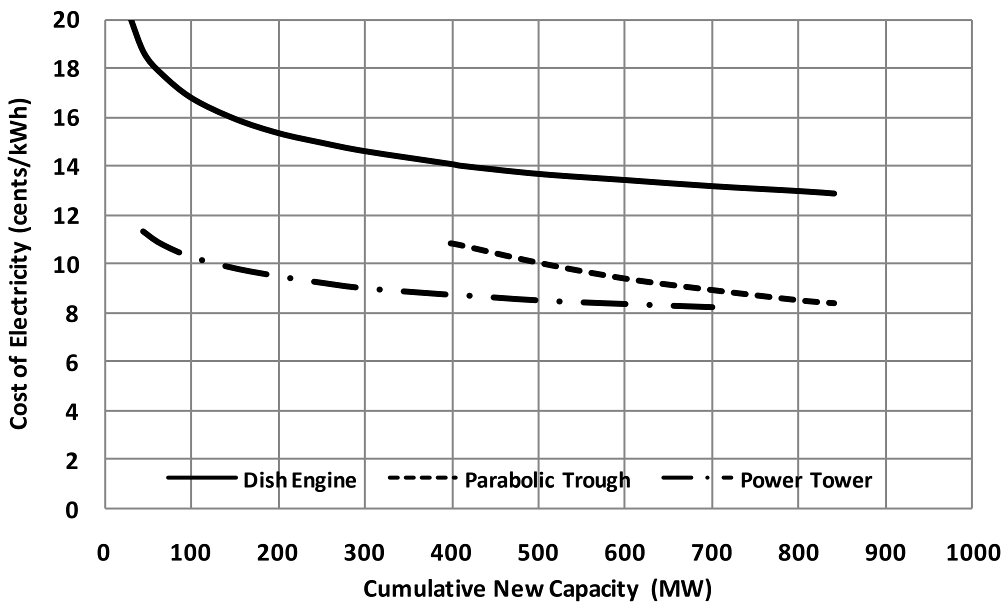


Figure 6 Estimated Electricity generation costs of CSP technologies [29]

The electricity generation costs from solar energy change depending on the sunshine conditions of the area. The expected electricity generation costs for various cities per kWh are given in Table 3. No large scale photovoltaic plants have been installed in Turkey yet. However, there are small photovoltaic installations most of which is used for research purposes. The total installed capacity has reached 1 MW [19].

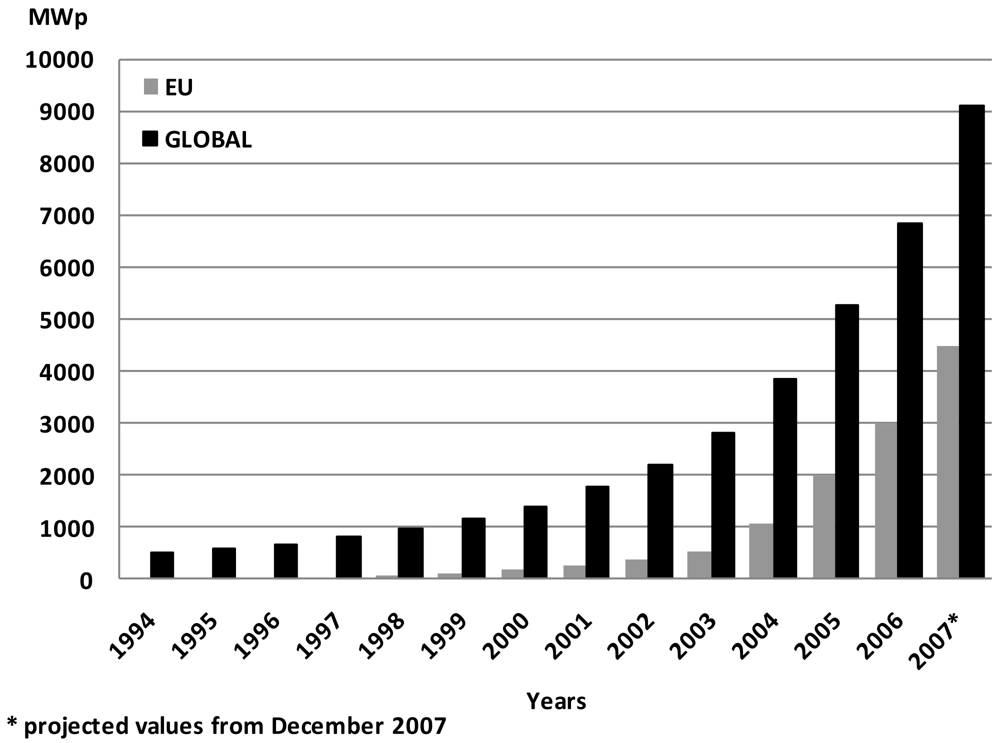


Figure 7 Cumulative photovoltaics capacity – World and EU [31]

Table 3 Expected costs of electricity generation form PV [30]

Location	Sunshine hours	2006	2010	2020	2030
Berlin	900	0,45 €	0,35 €	0,20 €	0,13 €
Paris	1000	0,40 €	0,31 €	0,18 €	0,12 €
Washington	1200	0,34 €	0,26 €	0,15 €	0,10 €
Hong Kong	1300	0,31 €	0,24 €	0,14 €	0,09 €
Sydney/Buenos Aires/Bombay/Madrid	1400	0,29 €	0,22 €	0,13 €	0,08 €
Bangkok	1600	0,25 €	0,20 €	0,11 €	0,07 €
Los Angelas/Dubai	1800	0,22 €	0,17 €	0,10 €	0,07 €

2.2 WIND ENERGY

Wind energy is actually the kinetic energy stored in the air flow. Because of solar energy, the molecules in the air gain kinetic energy and start to move thus creating wind. Since surface of the earth is not heated uniformly, different temperature levels occur on the earth and in the atmosphere. Due to these differences, the atmospheric pressure shows variation at different places. Air, like all fluids, tends to move from a place with high pressure to a place with lower pressure. This movement is called as wind.

The history of wind energy usage extends to 5000 B.C. Simple windmills were used in China by 200 B.C. [33]. The first well-documented windmill usage belongs to Persians in 947 A.D. [34]. With the developments in technology, windmills started to be used for generating electricity. It was 1887-1888 when Charles F. Brush built the first windmill producing electricity automatically [35]. In 1941, the world's first megawatt-size wind turbine (1.25 MW) was connected to the local electrical distribution system on Grandpa's Knob in Castleton, Vermont, USA [36].

The basic principle of using wind as a renewable energy source is transforming the kinetic energy of air into electrical energy. This is achieved by wind turbines. Wind causes the blades of the wind turbine to rotate and the kinetic energy is converted into electrical energy by the electric generators connected to the blades.

Given that m is the mass flow and v is the wind speed (unit: m/s), the kinetic power of the wind, P_{kin}, is calculated as given in Equation 1. The unit of P_{kin} is W or J/s. [34]:

$$P_{kin} = \frac{1}{2}mv^2 \qquad \text{(Equation 1)}$$

$$m = \rho A v \qquad \text{(Equation 2)}$$

where ρ is the air density (unit: kg/m^3) and A is the area (unit: m^2). Using Equation 2, Equation 1 becomes

$$P_{kin} = \frac{1}{2}\rho A v^3 \qquad \text{(Equation 3)}$$

From Equation 3, it is clear that power per unit area (m^2) is proportional to the cube of wind speed. Therefore, if wind speed doubles, the power increases by a factor of 8.

There are mainly two types of wind turbines depending on their axis orientation, Horizontal Axis Wind Turbines (HAWT) and Vertical Axis Wind Turbines (VAWT). Depending on the design features, these two main types include various sub-types. The most commonly used type is the 3-bladed HAWT.

Although most of the wind turbines are installed on land, offshore wind turbine installation is rapidly increasing, because of the stronger wind potential on seas. According to the European Wind Energy Association (EWEA), 4.3 % of the wind power produced in 2010 will be supplied from offshore wind farms. The target set for offshore wind plant capacity in 2020 is 19.44 % of total installed wind plant capacity (180 GW). A target of 40 % of the total installed wind plant capacity (300 GW) is set for 2030 [37]. Evolution of cumulative and annual wind power capacities of the EU and the world are shown in Figure 8 and Figure 9. Annual and cumulative wind power capacities of Turkey are shown in Table 4.

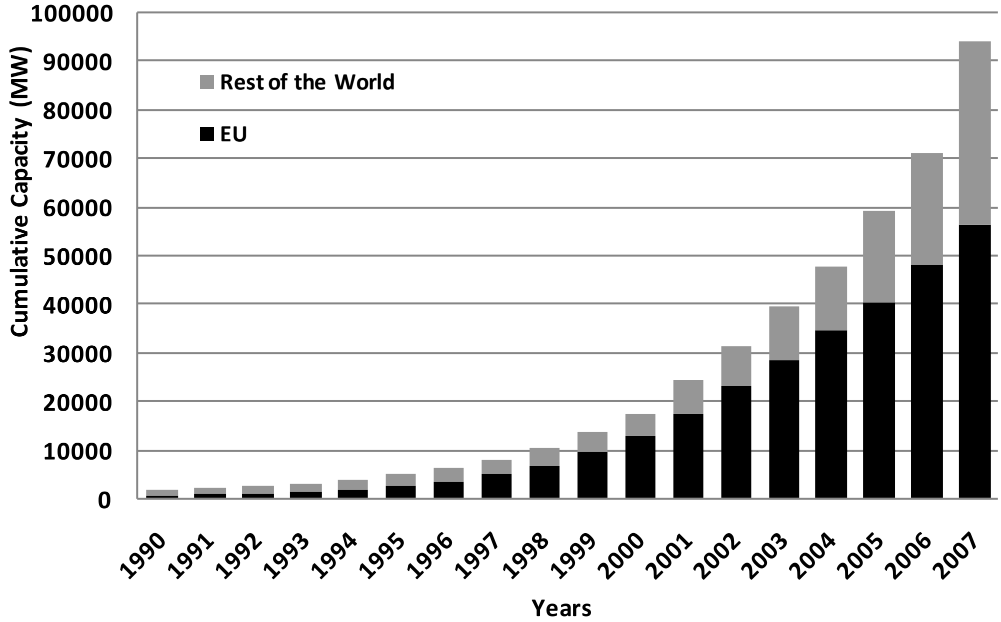


Figure 8 Cumulative wind capacity – EU and World [37]

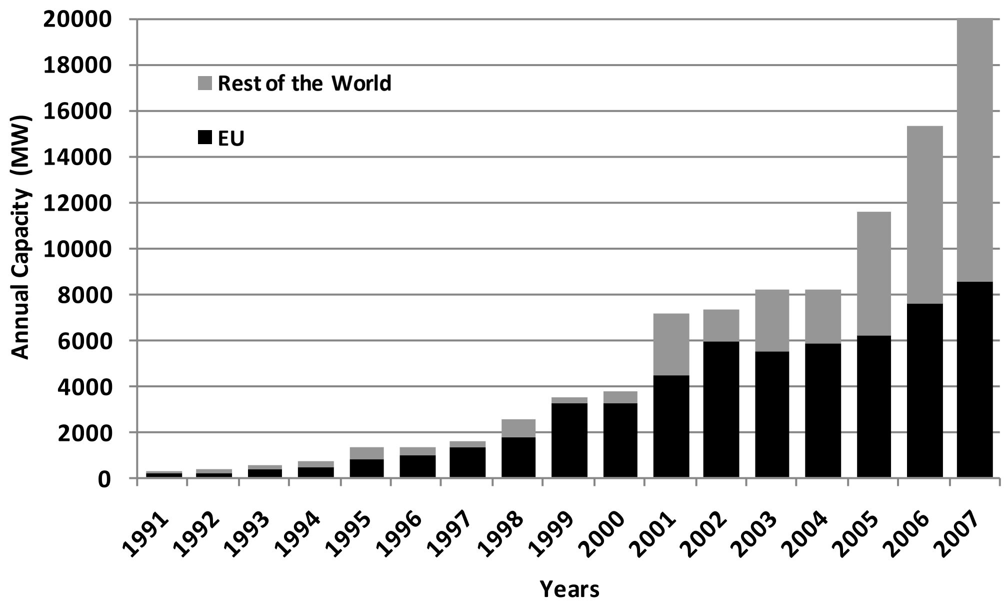


Figure 9 Annual wind capacity – EU and World [37]

Table 4 Annual and cumulative wind capacity – Turkey[7] [40]

Year	Cumulative Capacity (MW)	Annual Installation (MW)
1998	8,7	8,7
1999	8,7	0
2000	18,9	10,2
2001	18,9	0
2002	18,9	0
2003	20,1	1,2
2004	20,1	0
2005	20,1	0
2006	51	30,9
2007	146	95,3
2008	599	453
2009	1199	600
2010	1546	347

According to the Global Wind Energy Council (GWEC), up to 29.1 % of total world electricity demand in 2030 and 34.2 % could be supplied from wind power. EU target for 2030 is meeting 20.8 % - 28.2 % of the total electricity demand by wind power [37]. The results of an exercise carried out as collaboration between GWEC, Greenpeace International and the German Aerospace Centre (DLR) in order to determine possible wind power scenarios up to 2050 are shown in Figure 10 and Table 5[8] [38].

[7] Note that while this thesis was being written, total capacity under operation was 333.35MW meaning only 187.1MW of the capacity belonging to 2008 was built. 142.8MW of capacity belonging to 2008 was under construction at that time and 123.1MW belonging to 2008, 599.5MW belonging to 2009 and 374.4MW belonging to 2010 was projects with turbine supply contracts signed. While this thesis was being written, 725 license applications for a total wind power capacity of 73.166GW were being evaluated by EPDK (Energy Market Regulation Authority - EMRA).

[8] 3 different scenarios are used when carrying out the exercise. The “Reference” scenario is based on the projections made by IEA in “World Energy Outlook” in 2004 and assumes the

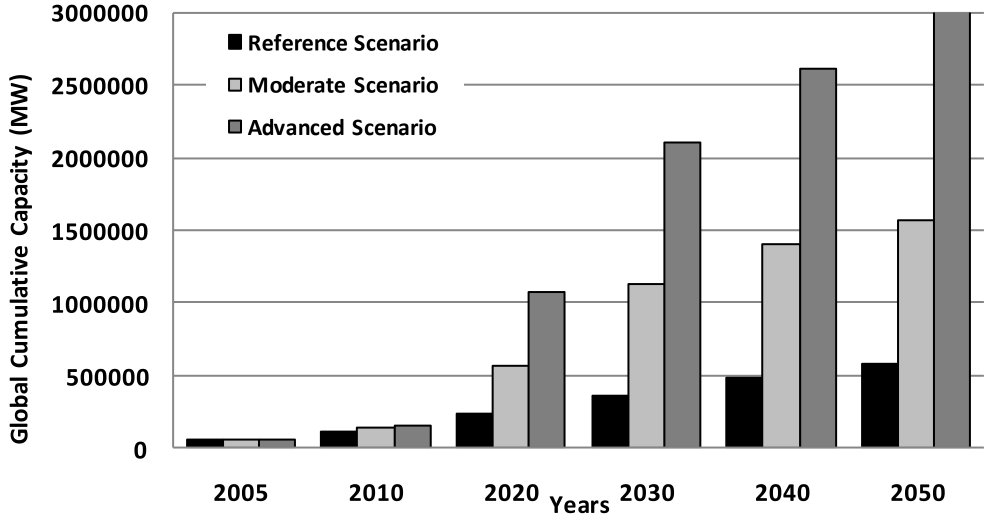


Figure 10 Cumulative Wind Capacity Projections – World [38]

Table 5 Expected costs of wind installations [38]

Costs (€/kW)			
Years	Reference Scenario	Moderate Scenario	Advanced Scenario
2005	1000	1000	1000
2010	933	912	899
2020	879	807	756
2030	854	766	719
2040	845	766	719
2050	842	764	717

growth of all renewables up to 2030 (later revised as 2050). The "Moderate" scenario assumes the successful implementation of renewable targets worldwide on nations level. The "Advanced" scenario assumes that all recommendations made on the report will be carried out by supportive policies. For details of the scenarios please check the report (Global Wind Energy Outlook 2006).

EWEA (European Wind Energy Association) issued projections for cumulative wind power capacity in EU up to 2030 based on 3 different scenarios (Low, Reference and High). The projected capacities for EU are shown in Figure 11 and the expected annual installations based on the reference scenario are given in Figure 12. The projections for Turkey are prepared by Turkish Electricity Transmission Company (TEİAŞ) and are shown in Figure 13[9].

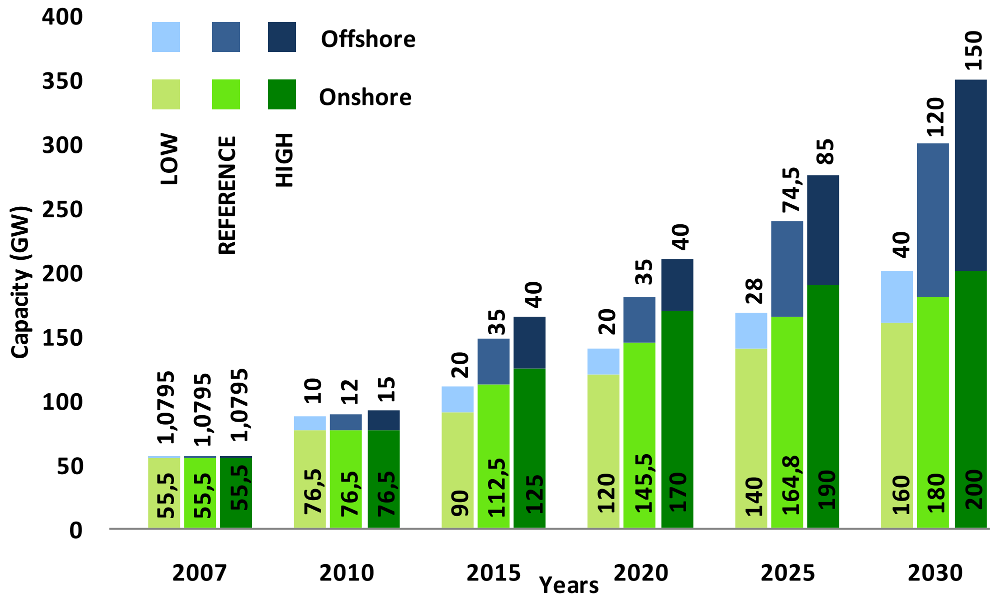


Figure 11 Cumulative wind capacity projections – EU [37]

[9] Note that the report that the projection data is taken from is published in July 2007. Since applications with a total capacity of over 78GW was made in November 2007, the projections prepared by TEİAŞ may need to be revised. Please see Table 4 for wind power projects which have obtained license.

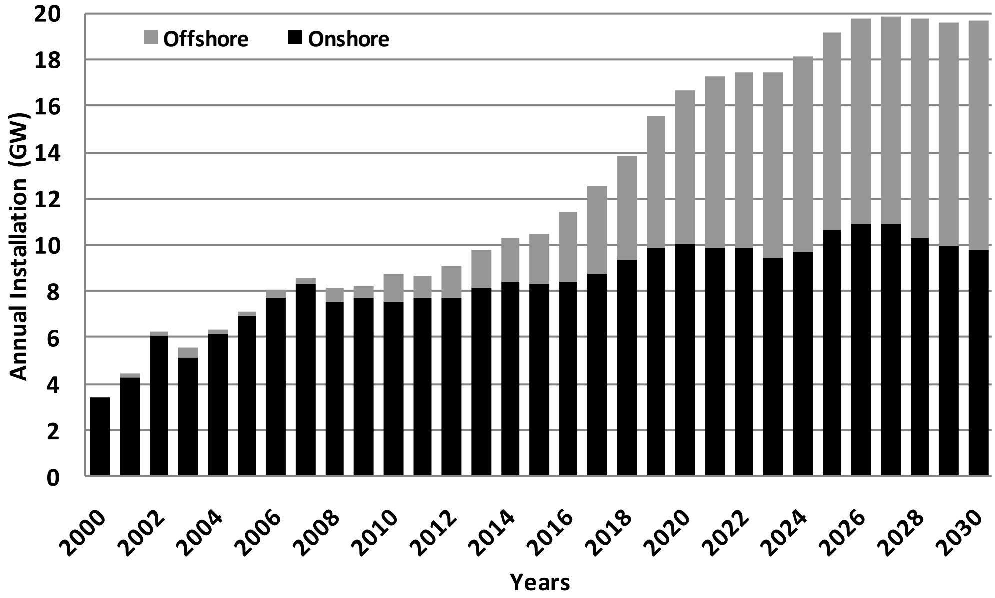


Figure 12 Annual wind capacity projections – EU [37]

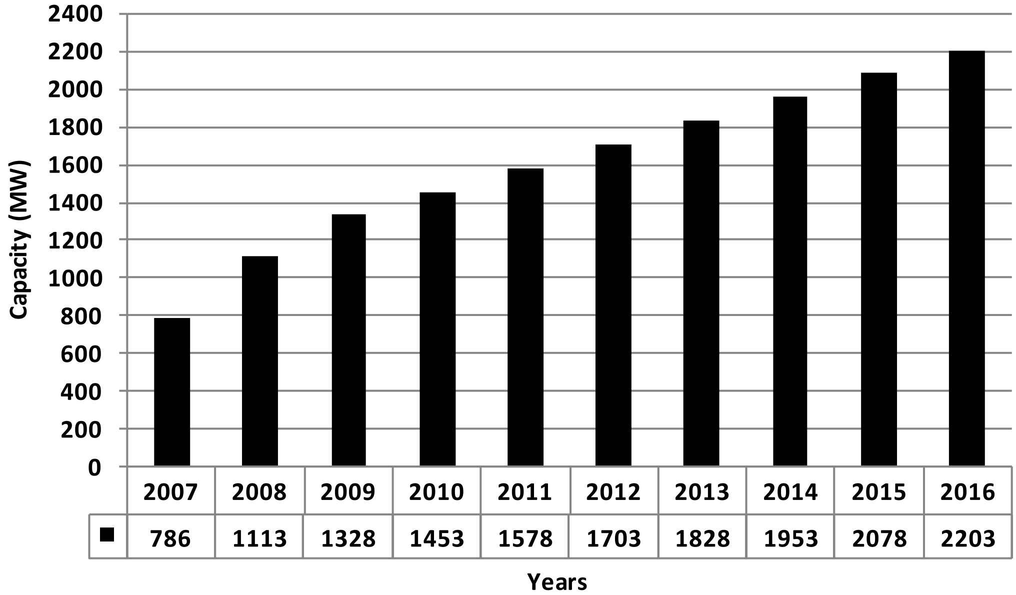


Figure 13 Cumulative wind capacity projections – Turkey [39]

2.3 HYDROELECTRIC POWER

Hydro power has been used for over two thousand years. The earliest record on hydro power usage is a Greek poem from 85 B.C. [41]. The world's first hydroelectric power plants began operation in 1882, in Appleton, Wisconsin, USA [42].

The main principle of hydroelectric power is the same as the main principle of wind power: capturing the kinetic energy of flowing water. This time, the reason of the flow is the gravitational force instead of pressure differences in the atmosphere. The rivers flow from higher altitudes to lower altitudes due to gravitational force and their potential energy is converted into kinetic energy. This kinetic energy is then converted into electric energy by turbines. There are mainly two types of hydro-electric plants: Run-of-river plants and reservoir plants.

Run-of-river plants are simple and they have low installation costs. The water flow is directed to turbines through pipes, called penstocks and electricity is produced by the turbines. Since no dam is needed to be constructed, their environmental effects are at minimum. The only effect of this type of plants on the environment is that the water is taken into a pipe; hence it is no longer available to the people and environment for the overall distance between the head and tail of the pipe. Despite its advantages like low installation cost and minimum environmental effects, this types of plants have the disadvantage of depending on the seasonal regime of the river flow. Their performance is proportional to the seasonal changes in flow rates of the rivers. The performance of run-of-river plants located on the downstream of a reservoir plant however is significantly improved, since the reservoir plants collect water in dams and release it whenever it is necessary, the seasonal river flow regime of this type of run-of-river plants is not as much as influenced as of the ordinary run-of-river plants'. The construction costs of reservoir plants are higher and they have massive effects on environments. Construction of large dams creates a large lake which may cover villages and towns and hence people leave their homes and may destroy the wildlife in the construction area. World and EU hydroelectricity consumption is given in Figure 14.

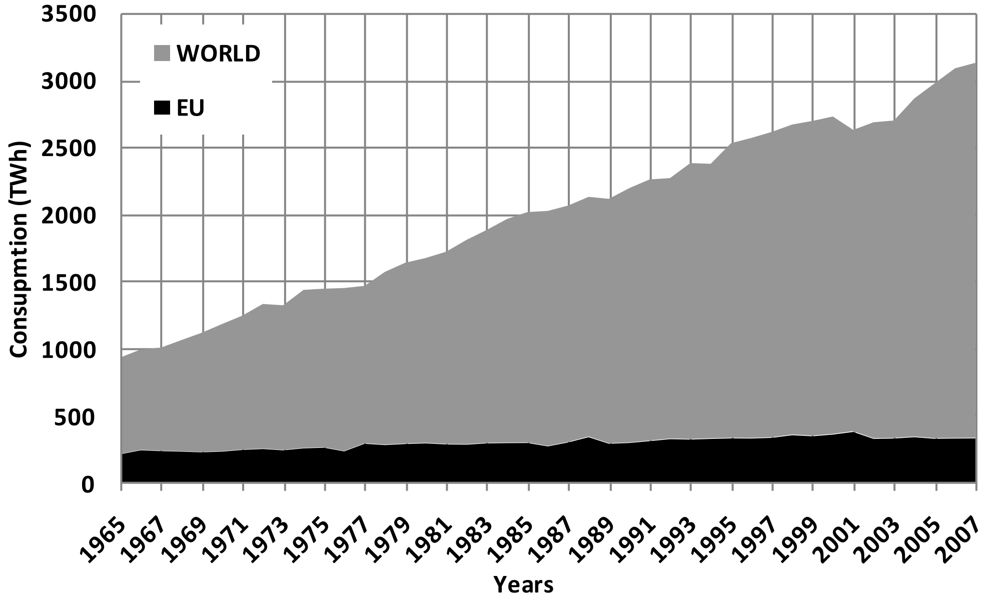


Figure 14 Hydroelectric consumption – EU and World [6]

The evolution of annual and cumulative hydroelectric power installations in Turkey are shown in Figure 15 and total hydroelectric generation (in GWh) is given in Figure 16.

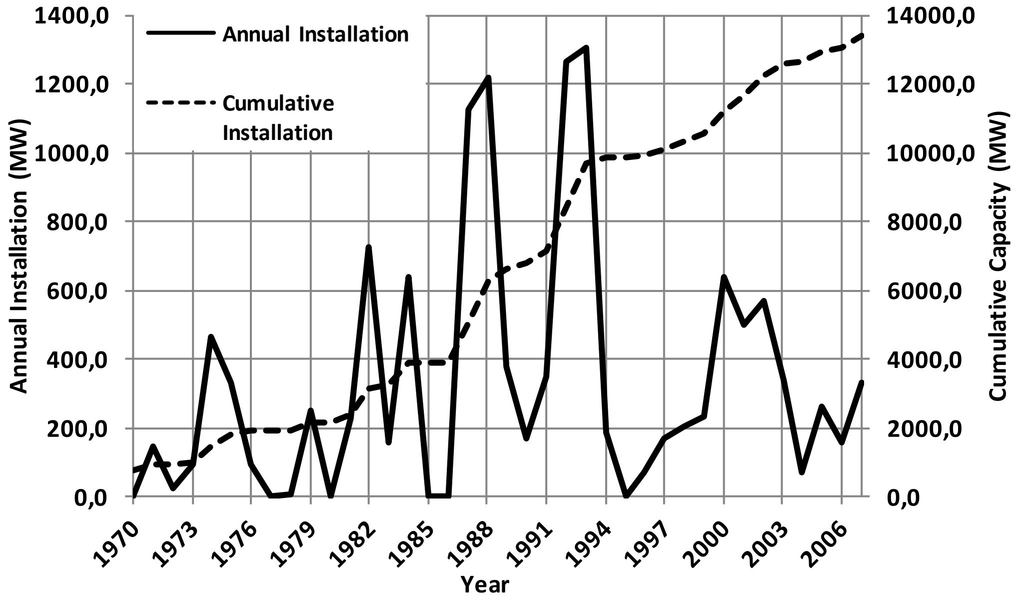


Figure 15 Hydroelectric installations – Turkey [43]

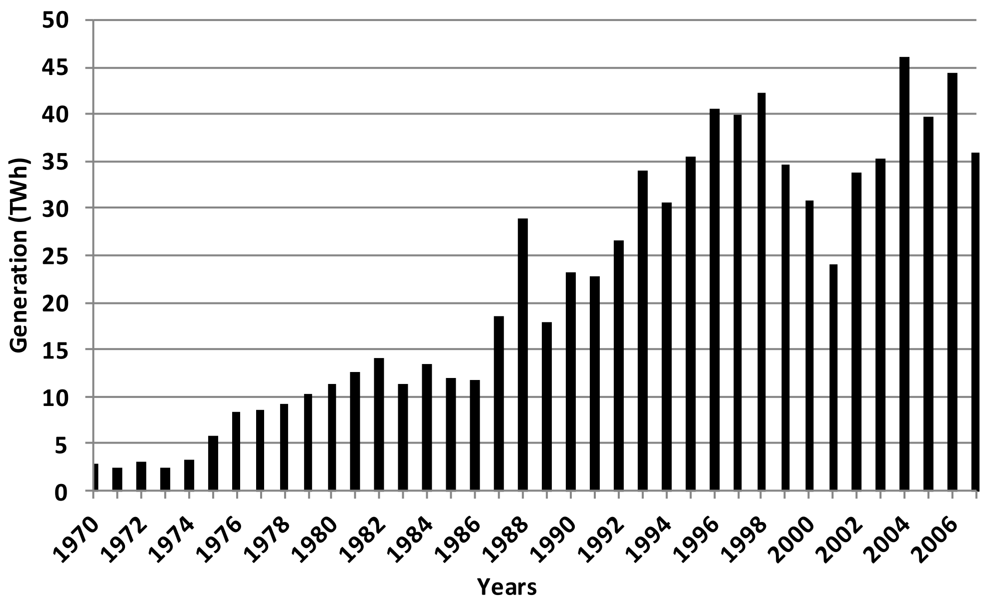
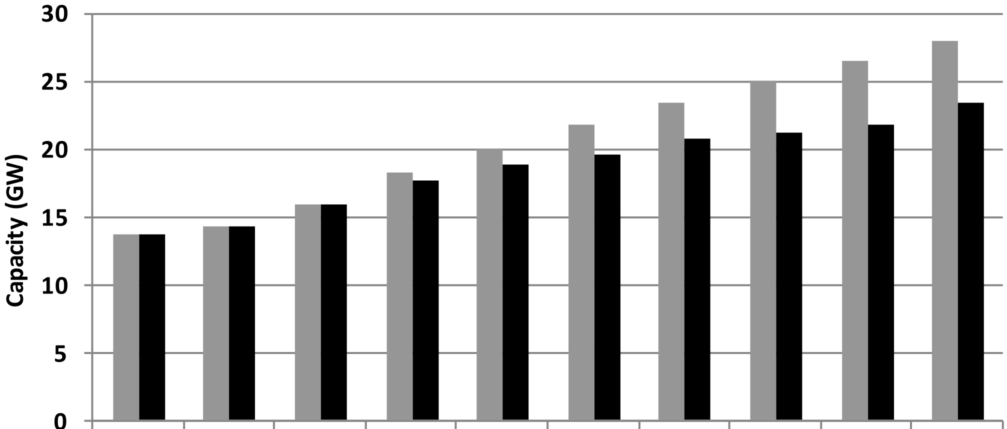


Figure 16 Hydroelectric generation – Turkey [7]

The capacity projection prepared by TEİAŞ for Turkish hydroelectric power based on 2 different scenarios is shown in Figure 17.



	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016
■ (grey)	13,614	14,302	15,899	18,209	20,044	21,814	23,412	24,97	26,415	27,898
■ (black)	13,614	14,302	15,899	17,666	18,77	19,605	20,722	21,21	21,814	23,412

Years

Figure 17 Hydroelectric capacity projection – Turkey [39]

2.4 WAVE AND TIDAL POWER

Electricity generation from wave is such a new technology that “there are as many designs as companies active in this field” [44]. Some of the designs use reservoir systems which collect water brought by waves above sea level and release the water through turbines generating electric power. One other design is producing electric power using hydraulic systems swinging by the waves and absorbing some of the wave power. There are also innovative designs like Pelamis (designed by a company named Pelamis Wave Power) which consists of connected cylinders which swing by the wave force and produces electrical energy using hydraulic motors. Wave power installations and projects in various countries are given in Table 6.

Tides happen due to gravitational activities between the sun, the earth and the moon. Because of unsymmetrical mass distribution on the earth, the effects of gravitational activities are not the same on every location on earth. This is why sea level is not uniform everywhere. Typical mid-ocean tidal range is 30cm [45]. However in some regions the tidal range is more than 5m. For example, the average tidal range in Bay of Fundy, Canada is 11.7m [11].

There are mainly two types of tidal resources: tidal stream and tidal range. Tidal stream energy is the kinetic energy of the sea moving due to tidal currents. Since tidal power technology is in its early development stages, there are various alternative designs aiming to convert tidal power into electrical energy most efficiently. The developments in both technology and the market will eventually reach the most efficient and feasible solution.

There are a variety of tidal stream device designs. There are some designs very similar to horizontal and vertical wind turbine designs. Some innovative approaches also exist like placing the turbine in a duct (designed by a company named Lunar Energy^{TM}) or using components swinging by the power of underwater waves.

Table 6 Wave power installations and projects – World [11]

Country	Location	Power	Description
Australia	Port Kembla	500kW	prototype
	Portland	10x1.5MW	planned
China	Chinese coast	650x60W	
	Shanwei	100kW	operation date: 1999
		5kW	in association with Japan
	Dawanshan Island	3kW	experimental (it is being upgraded to 20kW)
Denmark	Nissum Bredning	20kW	more than 19 500 hours of operating hours experience
		5.5kW	operation date: July 2006
		500kW	planned, operation date: 500kW
India	Vizhinjam	150kW	operation date: 1991
	Vizhinjam	1.1MW	operation date: April 1996
Ireland		1MW	prototype planned
Japan	Sanze	40kW	operation date: 1983
	Sakata Port	60kW	operation date: 1989
	Kujukuri beach	30kW	operation: 1988-1997
	Fukushima Prefecture	130kW	operation: 1996
Norway		200kW	construction start: 2007
		4x2.5MW	planned
Portugal		20MW	project
		2MW	pilot project
	island of Pico	400kW	pilot project
	Foz do Douro	700kW	
		4.25MW	confirmed projects
Spain	Bilbao	1MW	
	Santoña	40kW	to be increased by 9x150kW
	Basque	16x30kW	
USA	California	500kW	plannned
Wales		4-7MW	demonstration

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There are a variety of tidal stream device designs. There are some designs very similar to horizontal and vertical wind turbine designs. Some innovative approaches also exist like placing the turbine in a duct (designed by a company named Lunar Energy™) or using components swinging by the power of underwater waves.

Tidal range energy is the potential energy due to tidal sea level fluctuations. Basic collection method for this type of energy is storing the water in reservoirs when the sea level is high and releasing the water when the sea level is low. Even bays can be used as reservoirs by constructing barriers. This approach is similar to hydroelectric power plant technology. A summary of tidal power status in several countries is shown in Table 7.

Table 7 Tidal power installations and projects – World [11]

Country	Location	Power	Description
Canada	Annapolis Royal	20MW	operation date: 1984
China		12kW	operation date: 1958
		3,2MW	1980: Jiangxia Tidal Power Station
		1,3MW	1980: Xingfuyang Tidal Power Station
		11MW	current plants in operation
	Zhejiang and Fujian	10MW	experimental project with feasibility studies completed
France	Rance estuary	240MW	operation date: 1966
India	Durgaduani Creek	3,65MW	$10 million, construction will begin soon
Korea (Republic)	Sihwa-Lake	254MW	operation date: July 2008
	Ganghwa	812MW	operation date: 2015
Norway	Kval Sound	300kW	demonstration project, installation date: September 2003
	Tromsø	1MW	demonstration project, installation date: 2007-2008
Russian Federation	Kislaya Bay	400kW	operation date: 1968
	Kislaya Bay	1,5MW	pilot project, installation started: 2007
	Mezenski Bay	15GW	proposed project, depending on the success of 1,5MW pilot project
	Tugurki Bay	7,98GW	proposed project, depending on the success of 1,5MW pilot project
United Kingdom	Yell Sound	150kW	prototype, installation date: 2002
	Lynmouth, Devon	300kW	project started in 2003, installed 3km offshore
	Strangford Narrows	1MW	Grid connected, installation date: 2007-2008
	Anglesey	10MW	operation date: 2009
USA	Roosevelt Island	10MW	intended project, depending on the prototype test results

IEA states in its “World Energy Outlook 2006” that commercial forms of the wave and tide energy generation will not appear until 2015. The total installed wave and tide capacity in 2030 is projected to be 3 GW in 2030 in the same report [8].

2.5 GEOTHERMAL ENERGY

Geothermal energy has been used for a long time, since the ancient ages. Romans and ancient Chinese used geothermal hot water for bathing and therapy purposes. A geothermal district heating system was installed in France in the 14.century [41]. The first geothermal power production took place in Italy by Prince P. G. Conti in 1904 [10]. Since then many power stations using geothermal energy have been installed worldwide.

Geothermal energy is the intrinsic heat of the earth. The temperature at the core of the earth is about 6,000°C [47]. Heat is transferred from the core towards the surface by conduction. Depending on the geological structure, magma may flow near earth surface; even it may reach sometimes the outer surface creating volcanoes. The temperature of magma only a few km under surface is approximately 1,000°C. Heat transported near surface is transferred to underground water resources and either hot water or steam reaches the surface (naturally or by drilling the ground). These resources can be used for heating or electricity generation purposes. Unlike the other renewable energy resources, geothermal resources are not affected by daily or seasonal changes like weather or day/night status.

Although steam can be obtained from some geothermal resources, mostly hot water is obtained. Deep geothermal resources (up to 2km underground) include water with temperatures ranging 120-350°C and these resources are mainly used for electricity generation. Temperature of near-surface resources are typically below 150°C and these resources are used for heating purposes usually [41].

According to IEA statistics, worldwide geothermal electricity generation in 2005 was 57,579 GWh accounting for 0.31 % of total electricity generation and geothermal heat production was 11,569 TJ accounting for 0.086 % of total heat production [47]. The total installed geothermal electric plant capacity in 2005 was 8,932.7 MW_e and this capacity would increase to 9,737 MW_e in 2007 with the addition of plants under construction [48]. IEA estimates the total installed geothermal power capacity of 15 GW for 2015 and 25 GW for 2030 with annual growth rates of 5.4 % for 2004 - 2015 period and 4.4 % for 2015 - 2030 period [8]. With these growth rates the share of geothermal power generation increases from its share in 2004 as 0.3 % to 0.5 % in 2030 [8].

In 2006, total installed geothermal heat plant capacity was 9,564.6 MW_{th} (7,328.3 MW_{th} of which is from geothermal heat pumps) and the total installed geothermal electric plant capacity was 854.6 MW_e in the EU [49]. Again in the same year, geothermal heat and electricity generation in the EU were 685.3 ktoe (not including heat pump contribution) and 5,693.4 GWh respectively [49]. The estimates for electricity and heat production using geothermal energy in EU for 2010 are given in Figure 18.

Turkey has 12,5 % of world's total geothermal potential with an electric potential of 4.5 GW_e and thermal potential of 31.1 GW_{th} [50]. By 2007, the total installed geothermal electric plant capacity was only 30 MW_e plus the continuing projects with a total capacity of 86.85 MW_e and geothermal heat capacity was 1,385 MW_{th} in Turkey [51]. According to the report prepared by the Geothermal Work Group for Turkish State Planning Organization (DPT), geothermal power capacity will be 550 MW_e and geothermal heat capacity will be 8,000 MW_{th} in 2013. This could happen with an investment of $ 3.25 billion resulting in an economic value of $ 16 billion/year and employment increasing from 40,000 people to 200,000 people [52]. Total geothermal energy generation and projection of Turkey for 1999-2013 is given in Figure 19.

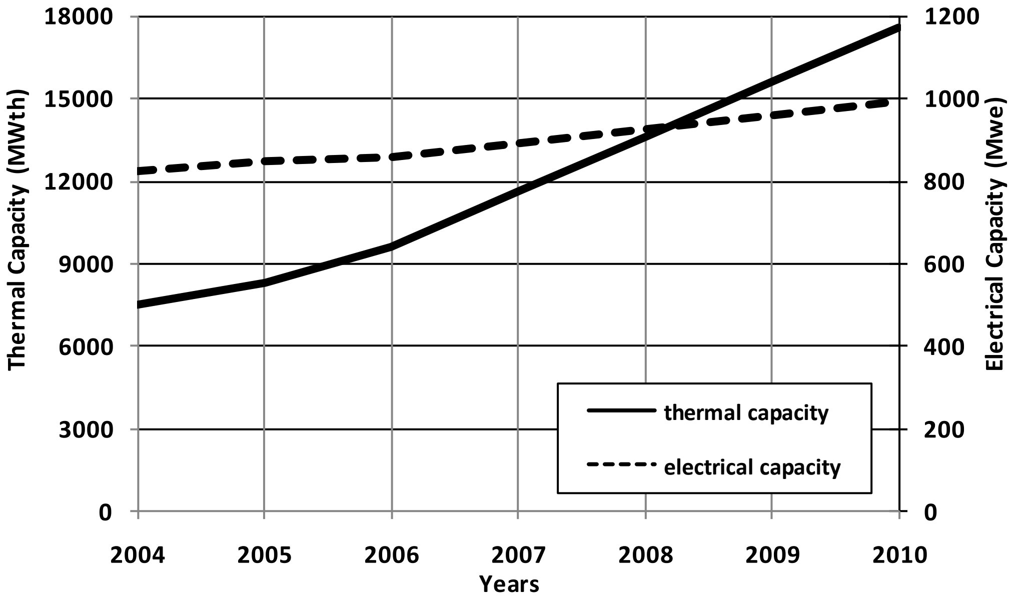


Figure 18 Cumulative geothermal capacity – EU [48]

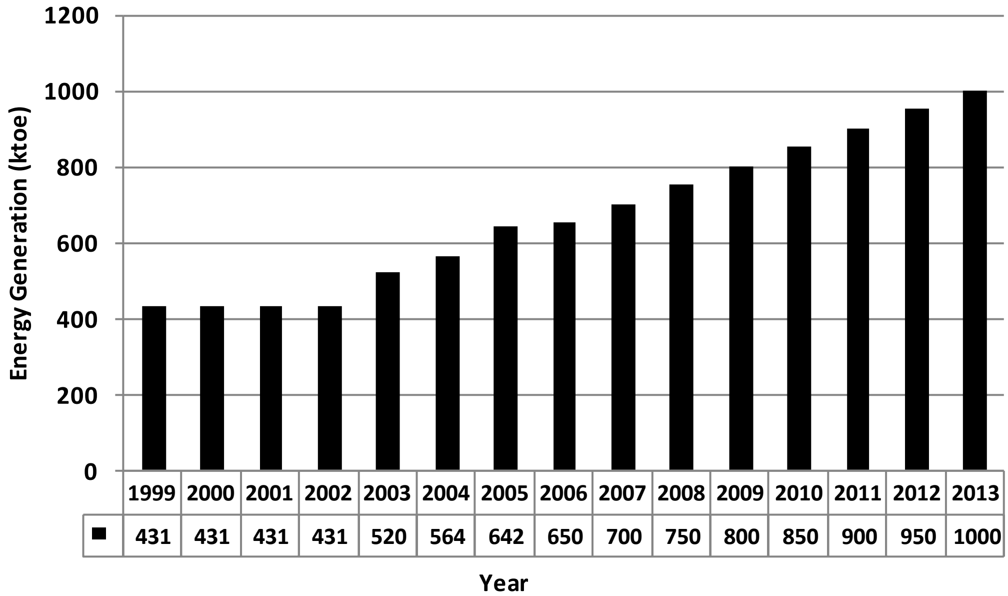


Figure 19 Geothermal Capacity – Turkey [214]

2.6 BIOENERGY

Bioenergy is the energy derived from biological products and waste. There are mainly two types of biomass: wastes and crops. Wastes can be agricultural, organic municipal, animal or forestry wastes. Crops are plants chosen especially for bioenergy generation. Various crops like poplar or willow are used in bioenergy sector. Fast growing, annually harvested plants are chosen and planted mostly. Bioenergy can be used for heating purposes, electricity generation or transportation purposes. It can be in solid, liquid or gaseous forms. Solid and gaseous forms are mainly used for heating or electricity generation purposes whereas liquid forms are mostly used as fuels for vehicles. They can be used directly or by mixing with other energy resources like coal or petrol. Bioenergy has different properties from other renewable energy resources. The resource is not free like wind or solar radiation and the resource is not unlimited so that it should be produced before it is used. Since same amount of CO_2 is released during the combustion of biomass as the amount collected during the growth of it, biomass usage does not cause CO_2 accumulation in the atmosphere due to this recycling. Of course, carbon-neutrality of biomass depends on the condition that: "***The consumption of biomass does not exceed its production, then the end products would not be more than they would have been in a natural process***" [53]. Biomass can be stored unlike any other renewable energy resources.

In 2006, 13 % of global final energy consumption is supplied from traditional biomass. Considering that the total share of renewable in final energy consumption was 18 %, traditional biomass has the largest contribution among renewable energy resources [54]. Worldwide total capacity of power generation from biomass was 45 GWe (excluding municipal solid waste contribution), thermal biomass capacity was 235 GWh and total biodiesel and ethanol production was 45 billion liters in 2006 [54]. International Energy Agency's biomass projections for 2015 and 2030 are shown in Table 8. Bioenergy production in Europe is constantly increasing. The bioenergy production in EU is shown in Figure 20.

According to the scenario given in Biomass Action Plan which was published in 2005, 149 Mtoe of biomass usage is projected for 2010. 55 Mtoe of this will be used in electricity generation, 75 Mtoe will be used for heating and 19 Mtoe will be used in transportation sector [56].

According to the trends published in barometers prepared by Observ'er in the scope of "EurObserv'ER" project, 102.3 Mtoe of solid biomass consumption, 8.6 Mtoe of biogas consumption and 17.5 Mtoe of biofuel consumption will occur in 2010 [57], [58], [59]. European Biomass Association (AEBIOM) has set a target of 220 Mtoe of biomass consumption for 2020 (120 Mtoe for heat, 60 Mtoe for electricity and 40 Mtoe for transportation) [60].

Table 8 Bioenergy Projections – World [8]

BIOENERGY OUTLOOK		1990	2004	2015	2030
BIOMASS & WASTE	Primary Energy Supply (Mtoe)	923	1176	1375	1645
	Electricity Generation (TWh)	125	227	422	805
	Capacity (GW)	-	36	68	129
BIOFUELS	Transportation Consumption (Mtoe)	6	15	54	92

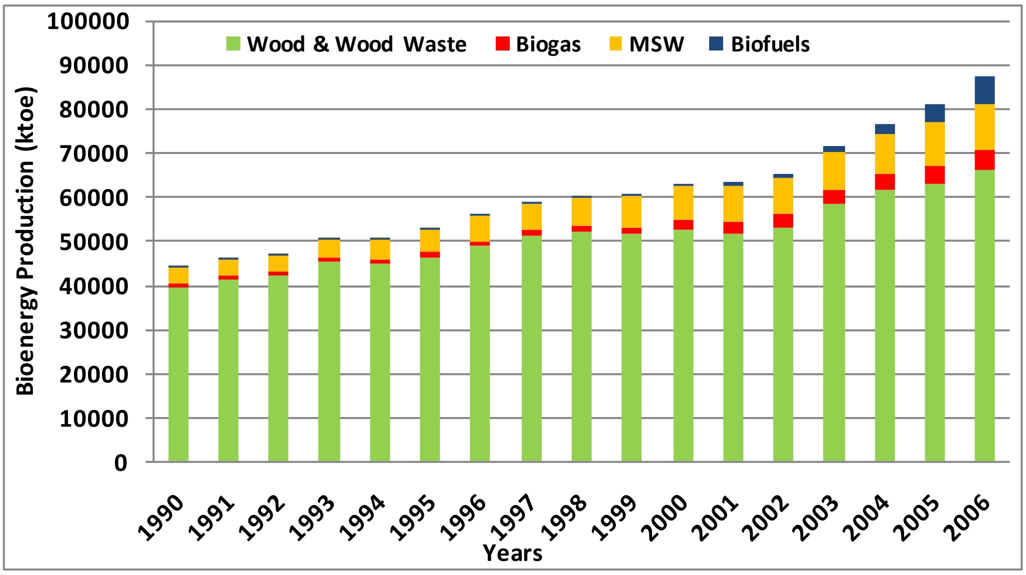


Figure 20 Bioenergy production – EU [55]

Approximately 15 % of the total energy demand in Turkey is supplied from wood and animal-plant residues currently. Although in some years the share of energy production from wood and animal-plant residues increased, the general trend has been decreasing. The energy supply from wood and animal-plant residues and their share in total energy supply between 1970 and 2006 and the projected values for 2007-2020 is shown in Figure 21.

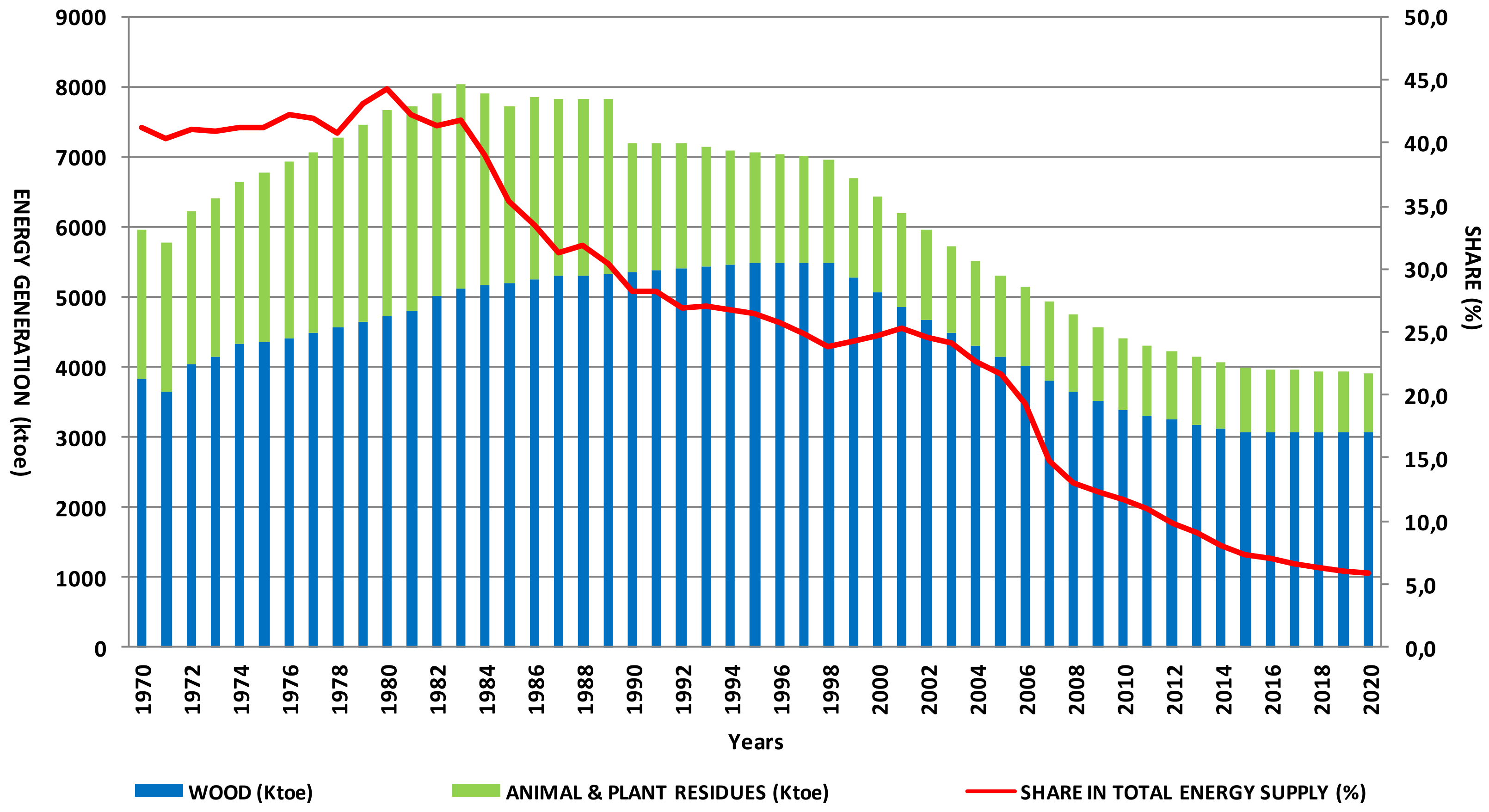


Figure 21 Biomass energy production – Turkey [61], [62]

CHAPTER 3

CHARACTERISTICS OF RENEWABLE ENERGY RESOURCES

3.1 ENVIRONMENTAL FRIENDLINESS

One of the main reasons why renewable energy usage has been increasing in the last decade is the environmental concerns about fossil fuels that are leading the world primary energy supply with a share of 80 % in 2004 [8]. According to EIA statistics, fossil based fuels-related CO_2 emission in 2005 was 28,192.74 million metric tons [63]. According to IPCC, it is very likely that most of the observed rise in the global average temperature is due to greenhouse gas (GHG) emissions caused by human activities [1]. Considering the share of fossil based CO_2 emission has been the greatest [1] among other GHG emissions since 1970 and CO_2 is not the only greenhouse gas emitted due to fossil based fuel usage, it is not wrong to say that usage of fossil fuels is the main reason of global warming.

Despite high CO_2 emission of fossil fuels, renewable energy sources either do not cause CO_2 emission or they are carbon-neutral [64].

Annual CO_2 reduction due to renewable energy usage was reported as 0.9 billion tons (plus 3.7 billion tons from hydroelectric energy) [65]. Biomass is the only renewable energy resource that causes large amounts of CO_2 emission. However, since the same amount of carbon would be used during the regeneration of the resource, bioenergy resources are said to be carbon-neutral. Although some argue that biomass is environmentally not benign [66], carefully planned regeneration of resources will make it carbon-neutral.

There are also some issues regarding CO_2 emissions due to manufacturing and transportation processes of renewable energy generation, especially of photovoltaic cells. Life-cycle CO_2 emission of solar PV ranges between 97 and 167 g/kWh, which is the highest emission rate among other renewables. Except for geothermal with a life-cycle CO_2 emission of 97 g/kWh, the other renewables (energy crops, hydroelectric, solar thermal or wind) causes CO_2 emissions ranging 3.6-38 g/kWh. However fossil fuel usage causes CO_2 emissions ranging 772-987 g/kWh except for gas with an emission of 430 g/kWh. A similar case is valid for SO_2 and NO_x emissions [67]. In order to achieve European Union’s target of limiting global warming to 2°C, $ 33.3 trillion should be spent for CO_2, CH_4 and N_2O reduction [68]. It is obvious with the emission rates given above that GHG emission reduction is possible by renewable or nuclear energy usage.

There are other environmental issues related to renewable energy. Wind turbines have always been blamed for causing bird deaths. However, it is estimated that only 1 of every 5,000-10,000 bird fatalities (99 % of which is caused by human activities) is caused by wind turbines [69]. Another issue against renewable energies is that solar plants need large areas for installation which can also be used for agriculture. Although they need large areas, solar plants are usually installed on unused desert lands which are rich in solar energy capacity. An issue raised against geothermal energy plants is that the high temperature waste water with rich combination of toxic components, such as boron, arsenic, H_2S is usually released to open environment without any treatment, thus destroying all kinds of life in this environment. There are other environmental issues related to renewable energy, however their effects are very small compared to fossil fuel effects. It is important to keep in mind that "***no man-made project can completely avoid some impact to the environment***" [70] and the important aspect is that this impact should be minimized. As it is stated in a thematic background paper prepared for the International Conference for Renewable Energies (Bonn 2004), "***There is a need to reduce the environmental impacts of renewables.***" [71] Renewable technologies are still evolving and with further developments in technology, it is possible to minimize the environmental effects of renewable energy.

3.2 SUSTAINABILITY

Sustainability is defined in the "Brutland Report" published by World Commission on Environment and Development in 1987 as "***Development that meets the needs of the present without compromising the ability of future generations to meet their own needs***" [72]. The importance of this term in energy sector has been increasing since fossil fuels are threatening the nature and fossil resources are limited. In the search of alternative fuels for the conservation of energy security after the oil crises in 1970s, renewable energy has become one of the solutions. Especially considering the increases in oil prices in 2008 (over $ 145/barrel in July 2008) [73], renewable is one of the main alternatives of fossil fuels.

Sustainability is one of the main characteristics of renewable energy. This is mainly due to the regeneration property of renewable resources. Energy from solar radiation, wind, waves or tide will be available as long as natural balance is not destroyed. Biomass usage, however has the potential of causing depletion of natural resources and regeneration have to be established by careful re-plantation of consumed crops.

Several technologies have been developed in the renewable energy sector. Renewable Energy technologies can be divided into three categories depending on their technological maturity: first generation includes hydroelectric, biomass and geothermal; second generation includes solar heating, wind, solar PV; third generation includes CSP, wave and tidal [46]. IEA concludes that first and second generation renewables have entered the market and third generation needs further research support in order to become competitive [46]. Although oil prices are increasing, cost of energy generation from renewable resources are decreasing. Soon renewable resources will be cost competitive with fossil fuels [74].

3.3 INTERMITTENCY

Energy generation depends on resource availability and some of the renewable resources' availability changes due to weather or daylight conditions. The power production decreases and even stops when wind velocity is low for wind turbines or when waves or tide are weak for ocean power systems or when it is night for solar PV systems. Because the availability of the resources depends on natural conditions, it is not possible to maintain a constant power level for renewable resources.

Intermittency of renewable resources like wind is a problem for their grid integration. However, they can be supported by other dispatchable renewable resources like large hydroelectric power plants [46]. Of course, this requires a complex electricity system planning and operation. Some newer technologies like CSP provide the opportunity of energy storage. Molten salt used in some CSP plants have the ability to store heat for hours, or even days. Energy storage of this system lowers the dependency of solar technologies on solar radiation so that energy can be produced even at nights. Biofuels or biogas can also be stored and geothermal energy has no intermittency issues.

3.4 PLANT LOCATIONS

It is possible to choose the location of a conventional plant for installation to some extent. Depending on the transportation costs of the fuel, it is possible to build a plant away from the fuel source. It is also possible to select another location for installation due to environmental considerations. However for renewable energy plants, the location of installation is not flexible. Since most of the renewable resources (like wind or wave) cannot be transported to another location, the renewable energy plants should be installed in locations where resources are available.

The limits in choosing a location for a renewable energy plant leads to various problems. One of the problems arising from this situation is that in some cases connection of the renewable energy plants may become extremely expensive due to the distance and/or geographical conditions that make installation difficult between the plant and location of the grid to be connected. The reason of high connection costs may be due to cliffs of valleys, rivers to be crossed or any other tough land conditions, long distances between the plant and the bay[10] in nearest transformer or the need for equipment upgrades.

Another problem is that there may be excessive license applications for the same region. In such a case, the regulatory authority may fall in a difficult situation in choosing the applicants to be granted by license. An example of this kind of a situation has taken place recently in Turkey. On 01.11.2007, the license applications for wind power plants were accepted by EMRA (Energy Market Regulatory Authority) and the total capacity applied for was 78 GW [76]. Later with Law No: 5784 (ratification date: 09.07.2008), an amendment was made to the Electricity Market Law (EML) to choose among the applications by a tender in which the applicant offering the highest contributions to Turkish Electricity Transmission Company (TEİAŞ) is determined.

3.5 LOW CAPACITY FACTORS

Capacity factor of a plant is the ratio of actual energy produced to the theoretical maximum energy that can be produced. Capacity factors of renewable power plants are relatively low compared to capacity factors

[10] A location in a substation reserved for connection of incoming (generation) feeders.

of conventional power plants. Similar to intermittency, low capacity factors are also caused by the natural variations. In order to increase capacity factors, a careful analysis on resource availability should be made before the installation of a renewable plant.

Low capacity factor in renewable plants creates serious difficulties in the return rate of the investment since the production and revenue recovered from the plant drops in proportion with the capacity factor, thus increasing the pay-back period of the investment.

The capacity factors of renewable plants depend on the type of plant and location. For example for geothermal plants, capacity factor ranges between 3 % in Albania and 99 % in Mongolia among 71 countries [45]. Capacity factors for renewable energy plants given in National Renewable Energy Laboratory's (NREL) "Power Technologies Energy Data Book" are given in Table 9.

Although capacity factors of renewable power plants are low, there are ways to increase the capacity factors by a certain extent. Capacity factor of a wind turbine can be increased by 10 % to 35 % by 5 % to 16 % increases in blade lengths of the turbine [78]. Tower height of a turbine also affects the capacity factor with high tower heights causing greater capacity factors. Although today's wind turbines have a capacity factor between 30 % and 40 %, capacity factors of wind turbines are expected to increase up to 50 % [78].

Table 9 Capacity factors of renewables [77]

Energy Source	Capacity Factor (%)
Wind	36
Geothermal	90
Biomass	80
Hydropower	44,2
PV	22,5
Solar Thermal	24,4

3.6 HIGH COSTS

High investment and generation costs of renewable energy are one of the main barriers to its development. High investment cost will in turn be reflected to generation cost as the fixed cost. The experience curve shows the development of generation costs with respect to cumulative energy production. It is seen in the Figure 22 that the generation costs decrease, according to the “principle of economy of scale” as the cumulative production increases. Since most of the renewable energy technologies’ cumulative energy productions are relatively much smaller than the cumulative energy productions of conventional plants, their costs turn out to be higher.

Another data reported in World Energy Outlook 2006 of IEA presents the comparison of the costs of electricity generation from nuclear, fossil based fuels and wind. The data presenting this comparison is given in Table 10.

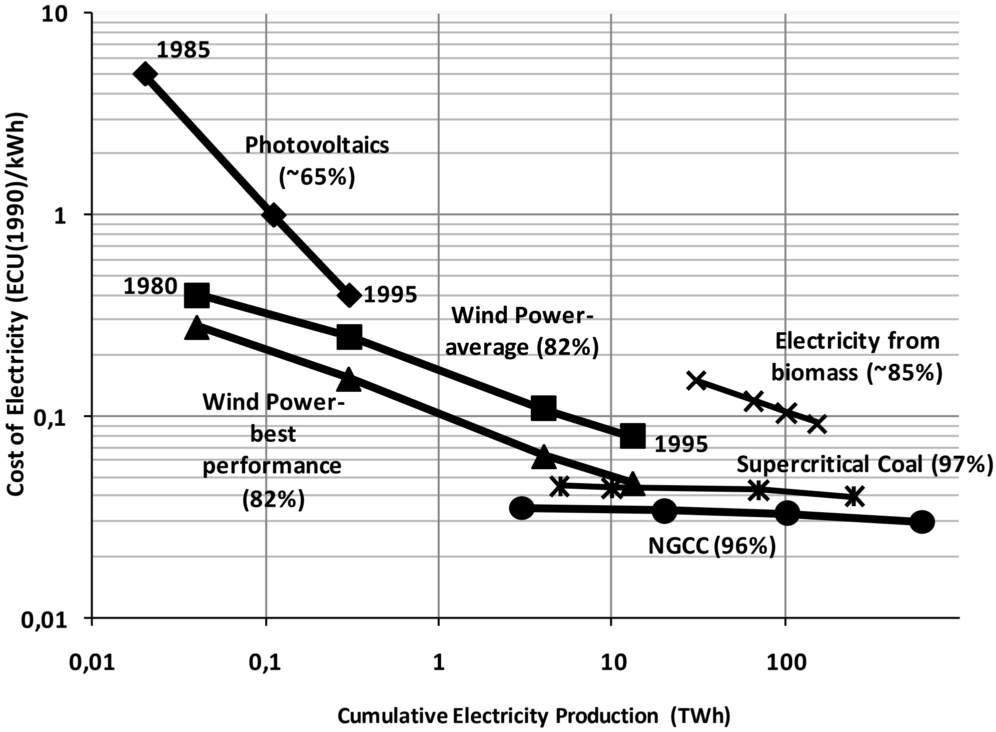


Figure 22 Evolution of the generation costs of renewable and fossil plants [79]

Table 10 Wind-Fossil generation cost comparison [8]

Technology	Electricity Generation Costs €cents/kWh
Nuclear	3 - 3.64
CCGT	3.1 - 4.17
Coal Steam	2.53 - 3.48
IGCC	2.78 - 3.67
Wind	3.16 - 4.81
CCGT: Combined Cycle Gas Turbine IGCC: Integrated Gasification Combined Cycle NOTE: Values are approximate and original data is divided by 1.58 in order to obtain costs in terms of € cents	

It is seen in Table 10 that the generation costs of wind power plants are nearly at the same level with the costs of nuclear, coal and combined cycle gas plants. This increases the competitiveness of wind power. However the case for other renewables is not the same. Most of the other renewable power plants have higher costs than the costs of wind power plants. The generation costs of renewable energy plants in 2004 and expected costs in 5, 10 and over 15 years are shown in Table 11.

Table 11 2004 and future generation costs of renewables [80]

	Electricity Generation Cost (€cent/kWh)			
Technology	**2004**	**5 years**	**10 years**	**>15 years**
Photovoltaics*	20 - 50	-	-	10 - 20
Wind (onshore)	5 - 6	-	3.9 - 5.6**	-
Wind (offshore)	5 - 8	-	3 - 4	-
CSP (Trough)	16	12	8 - 9	5 - 6
CSP (Tower)	18 - 24	14 - 16	8 - 9	4 - 5
Ocean (OWC/IPS)	10 - 40	-	6 - 14	-
Ocean (Current Turbines)	30	15	6	-
Geothermal (electricity cost)* **	20 - 30	-	10 - 15	-
Geothermal (heat cost)* **	3 - 8	-	2 - 5	-
Biomass (Ethanol Cost) (€/GJ)	22	-	-	12
Biomass (Methanol Cost) (€/GJ)	12	-	-	9

*Monocrystalline solar cells (wafer) and Multi-crystalline solar cells (wafer)
**Depends on doubling time
***Costs belong to Hot Dry Rock and Hot Fracture Rock technology

As seen in Table 10 and Table 11, the electricity generation costs using renewable resources are greater than the electricity generation costs using traditional resources. At this point it is important to note that the external costs associated with the usage of traditional resources are not included in these prices. Depending on the assigned price for each ton of CO_2, the costs of electricity produced using fossil based fuels increase. For each € 6.33($ 10)/ton CO_2 assigned; the costs of electricity generation in CCGT plant increases by 0.24 € cents, the costs of electricity generation in Coal Steam plant increases by 0.57 € cents and the costs of electricity generation in IGCC plant increases by 0.5 € cents [8]. Fossil based electricity generation is also highly affected by fuel prices. 50 % increase in fuel price causes approximately 20 % increase in coal based electricity costs and 38 % in CCGT generation costs [8].

Another reason why renewable energy costs are higher than conventional energy costs is that the large share of fossil fuels in total energy subsidies. Today, estimated value of total annual energy subsidies is about $ 250-300 billion of which only $ 16 billion belongs to renewable energy which is very small compared to $ 180-200 billion share of fossil fuels [81]. As J. Pershing and J. Mackenzie stated in their report “Removing Subsidies - Leveling the Playing Field for Renewable Energy Technologies”, the subsidies to fossil fuels should immediately be removed in order to “**level the playing field**” for renewable energy [71].

Apart from subsidies, the R&D support for renewable energy is also less than the support for other energy sources. In 2007, total (corporate + government) R&D expenditures on renewable energy and energy efficiency was $ 16.9 billion [81]. The data taken from IEA Data Services show that total R&D budget available for renewable energy sources is only one-fifth (20.69 %) of total budget available for fossil and nuclear in 2006. The data for 1974-2006 is shown in Figure 23. R&D budget of Turkey between 1986 and 2006 is shown in Figure 24.

It is seen in Figure 24 that the average R&D budget of Turkey for energy research is approximately € 5 million, which is a very small amount, especially when the high volume of the investment to be made for the energy sector is considered. Considering that the energy industry is a billion € industry in Turkey, the available R&D budget should be increased in order to achieve developments in energy industry, especially in renewable energy industry. It is also observed that the share of renewable energy in total R&D budget is approximately 20 %. The share of renewable energy sources in total R&D budget in Turkey is above world average. However, considering the R&D budget available for fossil fuels and nuclear energy, the share of renewable energy should be increased to create competitiveness.

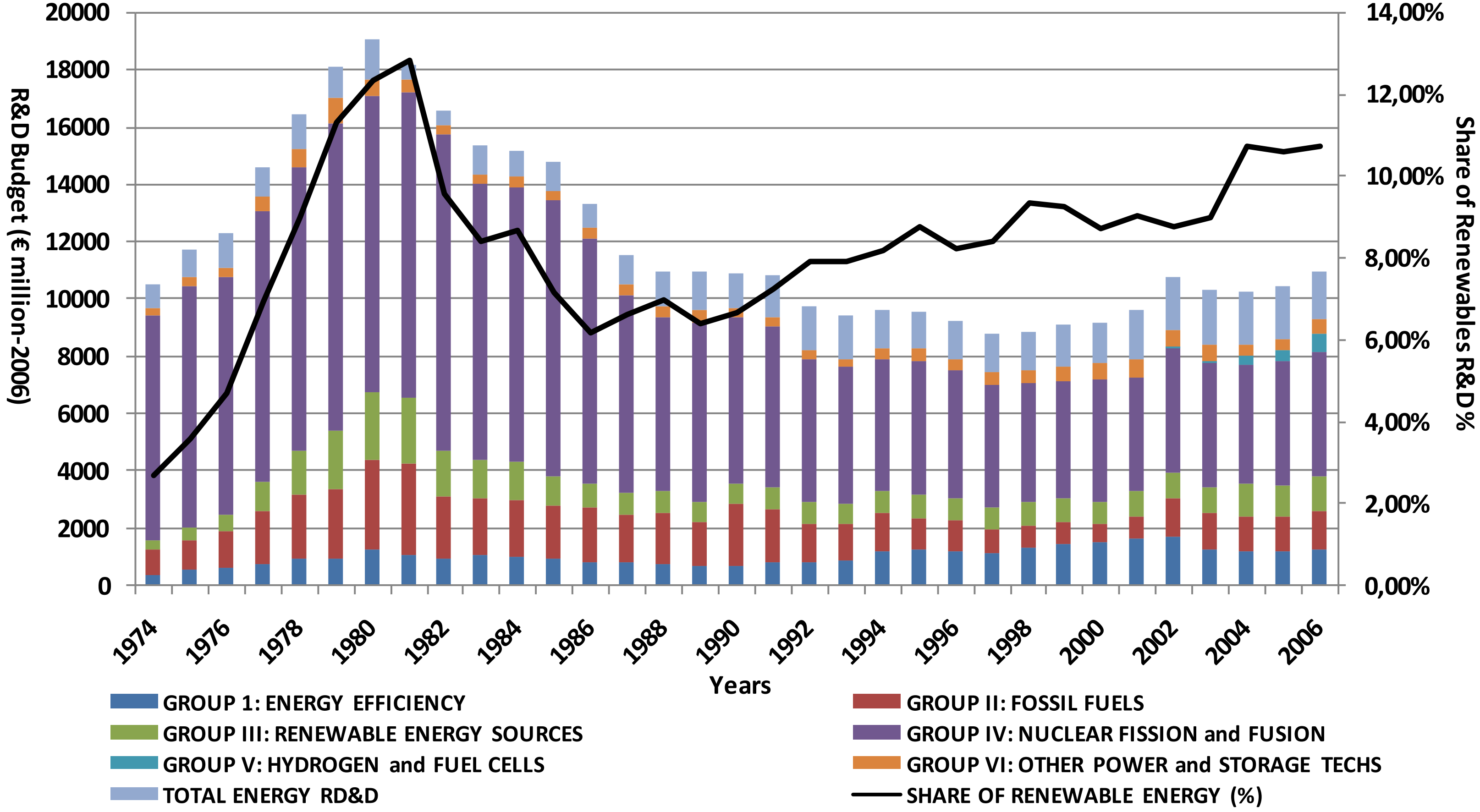


Figure 23 Energy R&D budgets - World [81]

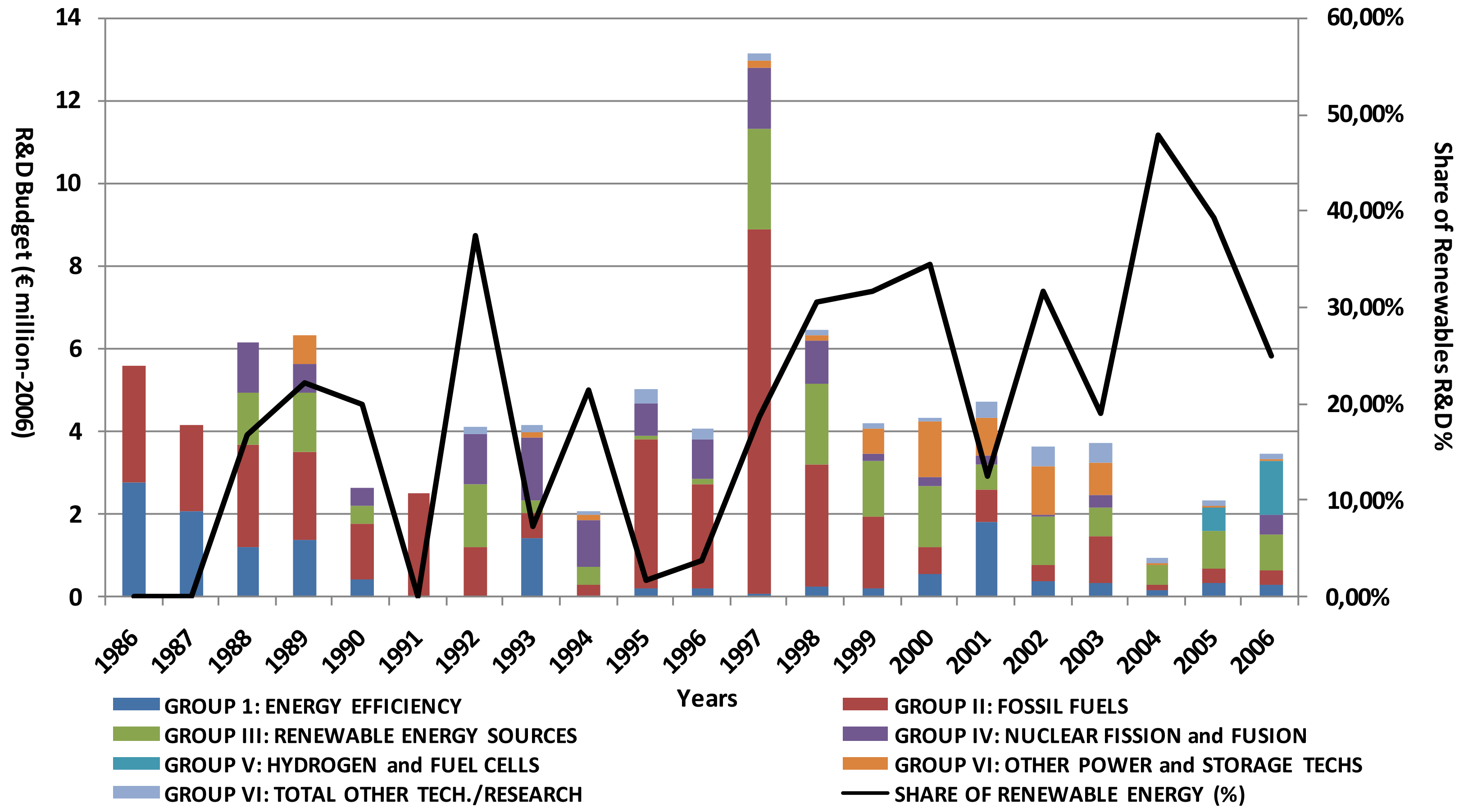


Figure 24 Energy R&D budgets – Turkey [81]

3.7 FINANCIAL RISKS

Because of many reasons, renewable energy investments are financially more risky compared to conventional energy investments. In the study "Financial Risk Management Instruments for Renewable Energy Projects" commissioned by United Nations Environment Programme (UNEP) Division of Technology, Industry and Economics, the barriers associated with renewable energy investments are summarized into four categories: cognitive, political, analytical and market barriers.

- Cognitive barriers cover low level awareness in RE financing,
- political barriers cover the inadequate energy policies,
- analytical barriers cover insufficiency of data available for analytical risk analysis,
- market barriers cover the lack of financial, legal and institutional frameworks [82].

Because of its capital intensive structure, a renewable investment, except for small-scale projects, needs a large amount of investment. Since there is limited knowledge in the renewable energy sector, the risk analysis requires a lot of effort resulting in high transaction costs. Adding the risks related to policy issues like the uncompetitive status of renewable energies in the energy market caused by high costs, intermittency and low capacity factors results in loans with relatively higher-interests and shorter loan periods. Because of these factors, cost of renewable energy increases and it becomes difficult to compete with the conventional energy sources. However, there are certain ways of changing the situation in favor of renewables. Power purchase agreements reduce the risks resulting in low interests and long payback periods. Some government owned banks like KfW Förderbank in Germany, provides low-interest, long-term loans for renewable energy projects. General risk types of a renewable energy project are given in Table 12.

Table 12 Risk types of RE projects [83]

RISK TYPES OF RE	
Fuel Supply Risk	The risk that the fuel supply will be unreliable, resulting in the inability to generate energy in a predictable and dependable manner
Performance Risk	The risk that the plant will not operate according to the contractually prescribed requirements in terms of time and quantity
Demand Risk	The risk that the energy that has been contracted for will not be needed as anticipated
Macroecon. Risks	as local currency devaluation, inflation or interest rates increase
Environmental Risk	financial risk stemming from both existing environmental regulations and the uncertainty over possible future regulations
Regulatory Risk	The risk that future laws or regulations, or regulatory review or renegotiation of a contract, will alter the benefits or burdens to either party
Political risks	political violence, expropriation or convertibility
Nature	Force Majeure events
Other Risks	The parties to an energy contract face numerous other sources of uncertainty, including the risk that the transmission system will be unreliable, and the risk that a party to the contract will default on the contract, for example by entering into bankruptcy

The risks given in Table 12 are general and there are also project specific risks like flooding for small hydroelectric power plants or theft/vandalism for large PV plants [84]. Existence of various risk factors leads the renewables sector to invent risk reduction tools. The example applied in Nicaragua shows how to reduce risk related to intermittency by applying priority access, long-term power purchase agreements and purchase obligation on retailers [83]. As renewable energy sources' learning curves advance, the barriers to renewable energy will diminish.

CHAPTER 4

INVESTMENT COSTS OF RENEWABLE ENERGY PLANTS

Like any other investments, renewable energy investments have a complicated process. However, the process can be outlined under 4 steps: Concept, Feasibility, Construction, and Operation & Maintenance. The summary of the steps of a large-scale renewable energy plant project is given below:

1. Concept
    - Scope
    - Objective
    - Pre-feasibility
        - Pre-project planning
        - Resource planning
2. Feasibility & Implementation
    - Technical
        - Siting (Measurements, yield analysis, etc.)
        - Equipment
        - Network connections
        - Environmental impact analysis

- Financial
    - Risk analysis
    - Financing (Equity, loan, grants, etc.)
- Legal
    - License & Renewable Certificate
    - Contract

3. Installation & Construction
    - Plant
    - Access roads
    - Network connection
4. Operation & Maintenance
    - Operation & Monitoring
    - Periodic check
    - Repair (if necessary)
    - Insurance

Each of the above steps includes several sub-steps. Therefore, there are many factors affecting the investment costs. The investment costs of renewable energy plants include all costs related to the first three main steps. The main components of the investment costs are equipment costs (wind turbines, PV cells, etc.), installation & construction costs and financing costs.

The equipment costs of renewable energy plants show great variation among different renewable resources depending on the technology employed. Although it changes depending on the land conditions, the installation & construction costs accounts for a large portion of the total investment costs. For example, 30 % of turbine cost is a fair average for construction costs in Denmark [85]. In a survey conducted among 12 large buildings heated with biomass, it was reported that construction costs accounted for 23 % and electrical and water installation costs accounted for 12 % of the investment costs [86].

The other largest contributor of investment cost is financing costs. Generally, most of the investment capital is supplied from loans obtained from banks or private investors. The costs arising from the applied interest rates added to the other costs as a component of the investment cost. The interest rates vary depending on the risks and the loan terms. Although some national or bilateral development banks provide lower interest rates, the loans provided by commercial banks account for approximately 10 % of the investment costs.

The investment costs of renewable energy plants are more capital intensive compared to conventional plants. As explained earlier, risks involved in renewable energy projects results in high interest rates for short loan terms which increase the costs of renewable energy. Parallel to technological improvements, along with the accumulation of financial information on renewable energy, the risks reduce leading decreases in interest rates and extension in loan terms. As a result, the costs of renewable energy decrease. An analysis published in the “World Energy Outlook 2006” by IEA shows the costs of renewable-based power generation and the projected costs in 2030. The current and projected investment costs for the renewable power plants are given in Figure 25.

Although in Figure 25, fixed costs are given for 2004 and 2030, actually the costs of renewable energy plants may vary from one project to another. Moreover, the variation is not the same for each renewable technology. Since costs of wind power plants are low, compared to solar PV plants, the variation observed in wind power costs is expected to be small compared to the variation for solar PV costs. The reason of these variations may be financial, technological or site related complexities. A low interest loan, an innovative technological approach or a site with very good resources cause the investment costs of renewable energy projects to decrease. The results of a study on investments costs of renewable energy plants in Austria given in Figure 26 show how the investments costs change for different renewable technologies. Investment cost of natural gas plant is given for comparison.

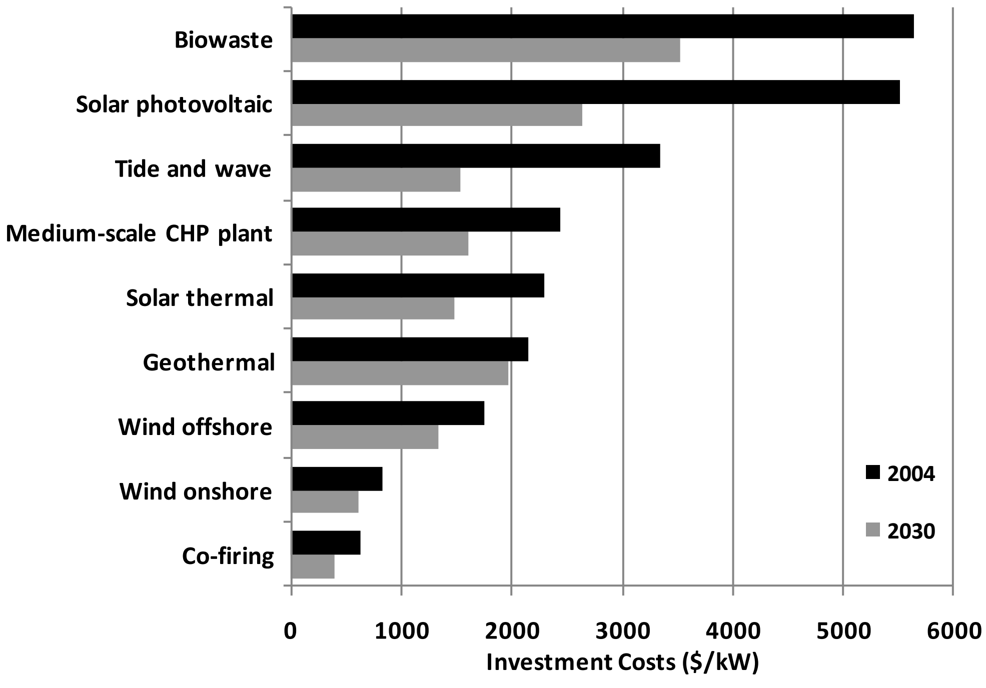


Figure 25 Investment costs of renewables 2004-2030 [8]

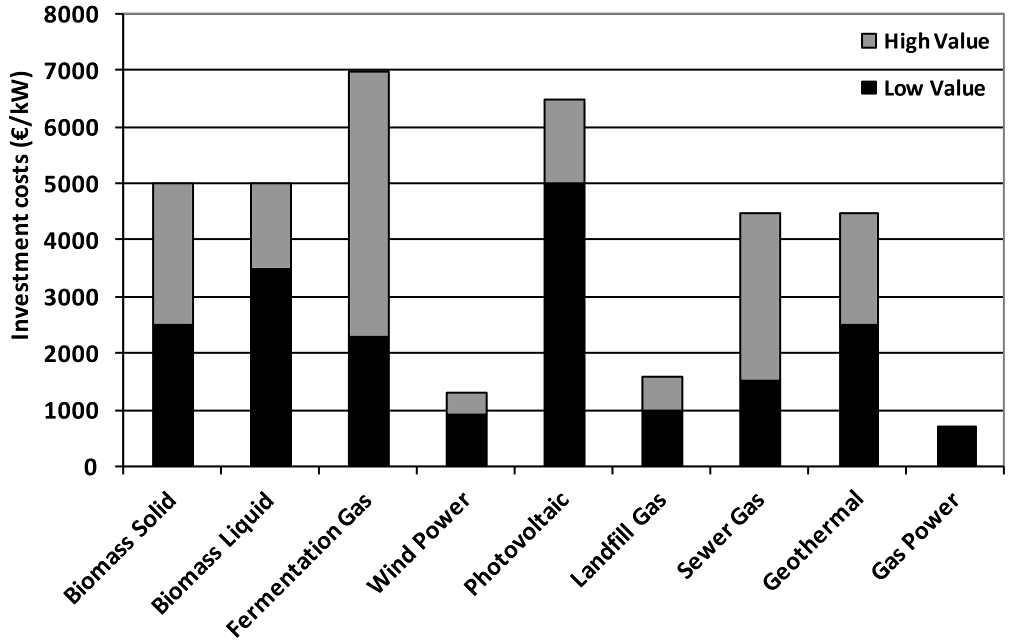


Figure 26 Variation in investment costs [87]

Apart from the variations of the investment costs between different renewable technologies, there are also country related variations. Development of wind power investment costs in Germany, Denmark and UK given in Figure 27 shows how the costs vary between these 3 countries. The decreasing trend in the investment costs can also be seen in the figure. The costs given in Figure 27 include costs like grid connections, foundations, electrical connections in addition to turbine costs [88]. Turbines' share in total costs range between 74 % and 82 % [89].

The data in Table 13 compares the difference between the investment costs of various energy generation technologies. The data is gathered from 2 different sources, European Commission and Nuclear Energy Agency. It is seen in the figure that the investment costs of coal, gas, nuclear or CHP plants are lower than the costs of renewable energy plants. The investment costs of wind and hydroelectric power plants are close to competitiveness. However, it is seen from the data provided by European Commission that emerging technologies like concentrating solar power (CSP), ocean energy, or geothermal energy based on hot dry rock or hot fracture rock (HDR/HFR) still have high investment costs.

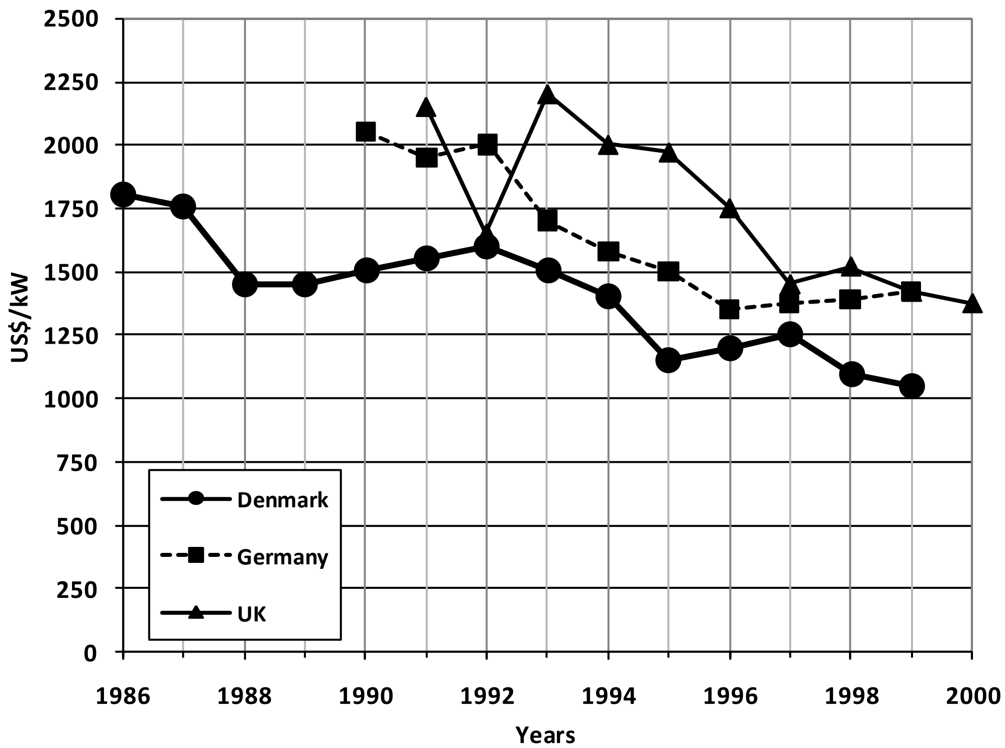


Figure 27 Development of investment costs Germany-Denmark-UK [88]

Table 13 Investment costs of RE, fossil, nuclear plants [87], [90]

Investment Costs		
EUROPEAN COMMISSION	Wind (onshore) (€/kW)	900-1200
	Wind (offshore) (€/kW)	2000
	CSP (Trough) (€/kW)	3500
	CSP (Tower) (€/kW)	3500-5000
	Ocean (OWC/IPS) (€/kW)	1680-3000
	Geothermal (HDR/HDF) (€/kWe)	6000-18000
	Small Scale CHP (<100kWe wood combustion) (€/kWe)	2500
NUCLEAR ENERGY AGENCY	Coal Fired Plants ($/kW)	1000-1500
	Gas Fired Plants ($/kW)	400-800
	Nuclear ($/kW)	1000-2000
	Wind (onshore) ($/kW)	1000-1500
	Wind (offshore)* ($/kW)	1500-2000
	Hydro** ($/kW)	1500-3000
	Solar*** ($/kW)	3000-6000
	CHP ($/kW)	560-1700
	CHP (combustible renewable) ($/kW)	2500-3700
	Waste ($/kW)	3500-7000
	Geothermal ($/kW)	2160
*The investment cost of the plant in the Netherlands is around 2700$/kW **The investment cost of the plants in Germany and Japan is around 7000$/kW ***The investment cost of the plant in Czech Republic is 10164$/kW		

Although the investment costs of renewables are relatively higher, it is possible to reduce the costs via some tools. These tools include tax-duty exemptions, government purchases or subsidies like low-interest loans or investment grants. Addressing the high cost of new renewable energy technologies was one of the policy recommendations made at the end of International Conference for Renewable Energies which was held on 1 – 4 June 2004, in Bonn, Germany. Although in general, performance based subsidies are better, investment subsidies are more appropriate for new emerging markets like RE [91]. Germany has successfully used these tools for promoting renewable energy. Programs like "Market Incentive Programme" and "100,000 Roofs Programme" provided over € 1 billion for renewable projects, mainly solar and biomass [92]. In Spain, investment subsidies up to 40 % of the investment costs with a maximum of $ 2.8 million were given to renewable energy projects [83] and these incentives resulted in rapid growth of wind capacity in Spain [93]. Another subsidy used is low-interest loans. Solving the financial problem, low interest loans reduce the investment costs. Germany, Japan and US states have used low interest loans for promoting RE [94].

Tax exemptions are another tool used for reducing the investment costs of renewable projects. Sawin comments on investment tax credits as ***"They can be helpful early in the diffusion of a technology, when costs are still high, and/or to encourage their installation in off-grid, remote locations."*** [94] Government purchases cover above-market rate purchases of renewable projects [93] and they may increase market demand on renewable energy [95].

In the first quarter of 2008, available investment funds worldwide reached $ 67.3 billion in sustainable energy sector. Comparing with the first quarter of 2007, the funds have increased by nearly 4 times. Approximately 30-40 % of these funds are invested in renewable energy [82].

CHAPTER 5

RENEWABLE ENERGY FINANCE

The main financing mechanisms of renewable energy projects are equity, loans or grants. Equity investments are risky for the investors; however, they participate in the decisions about the project. Loans may be provided for renewable energy projects under certain conditions. In some cases loans may require guarantees. The loan conditions (interest rates, tenors, grace periods, etc.) are project or country specific. Grants are generally provided by governmental or international organizations for scientific, social or economic purposes.

The sources of equity financing may be project developers, venture capitalists investing in business initiatives, equity fund investors, equipment suppliers providing finance for equipments, regional development banks like Inter-American Development Bank (IDB) or institutional and individual investor. Loans are provided by national and international banks, multilateral development banks or private investors. Grants are provided by Global Environment Facility (GEF), development agencies like United Nations Development Programme (UNDP) or Danish Development Assistance Agency (DANIDA), foundations like the Rockefeller Foundation or national and local agencies[11].

Considering the variety and availability of resources, renewable energy offers a sustainable future for energy. However, the capital intensive nature of renewable energy needs special financial approaches. One of these financial approaches is special loan programs provided by various funds worldwide. Loans with low interest rates or grants are provided for renewable energy investments. Funds may be provided by international, governmental, public or private organizations. The main funding organizations are The World Bank Group, the Global Environment Facility (GEF), and the German Development Finance Group (KfW), providing the majority of funding in developing countries [97].

- Global Environment Facility (GEF) [12]

  Global Environment Facility is an independent organization providing grants for environmental projects in developing countries. The facility funds are supplied by donor countries. $ 3.13 billion is to be given by donor countries in 2006-2010 period. GEF projects are implemented by United Nations Development Programme (UNDP), the United Nations Environment Programme (UNEP), and the World Bank. Management and execution of GEF projects are performed by seven executing agencies like The European Bank for Reconstruction and Development (EBRD) or The African Development Bank (AfDB). Non-governmental organizations

[11] The information on financing sources is obtained from [96]

[12] The information about GEF is obtained from [98]

(NGOs) also participate in project execution. GEF has 15 operational programs and 2 of these programs ("Promoting the Adoption of Renewable Energy by Removing Barriers and Reducing Implementation Costs" & "Reducing the Long-Term Costs of Low Greenhouse Gas Emitting Energy Technologies") provides funding especially for renewable energy projects.

- World Bank

  World Bank Group is established in 1944 and it is owned by 185 member countries [99]. Since 1990, $ 11 billion is provided for renewable energy and energy efficiency projects by World Bank [100]. World Bank provides funding for renewable energy projects through various programs. The newest of these programs are "Climate Investment Funds (CIF)" which is introduced in July 1, 2008. A total of $ 5 billion is expected to be provided under the program. The program includes two funds: the Clean Technology Fund and the Strategic Climate Fund [101]. Especially the first program provides funds for renewable energy projects as they provide greenhouse gas reductions. Loans, grants or risk reduction tools like guarantees for governmental or technology related risks are used as tools by these funds. World Bank group provides many other funds for renewable energy projects like Asia Alternative Energy Program (ASTAE) or Carbon Finance which are either managed by World Bank or in collaboration with multilateral development banks like European Bank for Reconstruction and Development, Asian Development Bank or Inter-American Development Bank.

- KfW Bank Group (KfW Bankengruppe)[13]

  KfW Bank Group is 80 % government and 20 % federal states owned bank in Germany which is founded in 1948. KfW provides long term loans with low interest rates through various programs. Approximately $ 29 billion was provided between 2003 and 2005 for environmental and climate protection purposes. Renewable energies had a share of $ 8.428 billion in provided loans. KfW Funding Bank (KfW Förderbank) currently provides four different programs to provide loans for environmental protection projects [103]: ERP Environmental Protection and Energy Saving Programme, The KfW Environmental Protection Programme, BMU Programme for the Financing of Demonstration Projects, Renewable Energies Programme. These programs provide loans with low interest rates up to 100 % of investment costs with tenors of up to 30 years.

- European Investment Bank (EIB)

  EIB provided loans with a total value of € 6.8 billion in 2007. € 2 billion of these loans were provided for renewable energy projects [104].

Although interest rates of loans for renewable energy projects can be higher (1 % or more) than the interest rates of loans for conventional energy projects due to high risks, government-subsidized loans may offer interest rates below market rate and tenors may vary depending on the project, but typical tenors are 10 years [105].

[13] Information about KfW Bank Group is obtained from [102]

Asian Development Bank (ADB) provided a loan of $ 100 million to Indian Renewable Energy Development Agency (IREDA) for renewable energy project on building 125 MW power plants based on bio-methanation, bagasse-based cogeneration, wind energy and solar-thermal systems. The loan term was 25 years including a grace period of 5 years and interest rate was 6.82 % in accordance with the Bank's variable rate for US dollar loans [106].

In the pre feasibility report prepared by the PREGA National Technical Experts from Institute of Energy, Viet-Nam for Bagasse and other Biomass-fired Power Plant in Ben Tre Sugar Company, it was stated that 70 % of the project costs would be funded by loans. 30 % of the total costs would be provided from domestic loans with an interest rate of 12 % and the remaining 40 % of the total costs would be provided from Asian Development Bank (ADB) loans with an interest rate of 6.8 % [107]. In another pre feasibility report again prepared by the PREGA National Technical Experts from Institute of Energy, Viet-Nam for Demonstration of Rice Husks-fired Power Plant in An Giang Province, 30 % of the total costs would be funded by domestic loans with an interest rate of 12 %, another 30 % of total costs would be provided by ADB loans with an interest rate of 6.7 % and 10 % of total project costs would be provided by other foreign loans with an interest rate of 7.5 % [108].

Although organizations like GEF, World Bank or other multilateral development banks provide long term loans with low interest rates, their contribution will not be enough for a growing renewable market considering that the total investment needed in energy sector for 2005-2030 will be $ 20 trillion [8]. Without incentive tools the payback durations of renewable energy investments become longer causing risk increases which results in increased interest rates. The case studies performed under a UNDP project in Uzbekistan summarizes the situation with the payback periods. The results of the case studies are shown in Table 14.

Table 14 Payback duration- Uzbekistan case study [109]

Renewable Energy Technology	Case Study	Payback Periods (years)				
		Investor Requirement (years)	Low Price Scenario		High Price Scenario	
			No Carbon Credits	With Carbon Credits	No Carbon Credits	With Carbon Credits
Small Hydro Plants	Gulba	12,0	25,4	19,6	7,2	6,8
	Pionerskaya		12,3	9,7	3,9	3,6
	Karkidonskaya		10,0	8,0	3,2	3
	Shaudarskaya		19,8	15,5	6,0	5,6
	Bagishamalskaya		22,4	17,4	6,7	6,1
Wind-driven generator	Mashiduk facility, Navoiy province	6 (10-12)	66,3	47,2	15,3	14
Solar photovoltaic system	Village of Kostruba, Karakalpakstan	1,0	Incalculibly greater			
Biogas generator	Farm, Tashkent oblast with 25% of fertilizer sold	3,0	6,7	5,9	4,5	4,1
	with 100% of fertilizer sold		158,0	1,5	1,4	1,4
Solar water heating installation	Replacing natural gas	1,0	158,0	72,0	13,0	12
	Replacing electricity		13,1	11,3	6,0	5,6

In 2007, the total investments in sustainable energy reached $ 148.4 billion increasing 60 % from the investments in 2006. The new investments in Europe in 2007 were $ 55.8 billion which is more than double the new investments in the USA [82]. Considering that the EU has a target of reaching 20 % share of renewable energy in total energy consumption by 2020, the loans that will be needed for renewable energy projects are likely to increase.

In the analysis, low energy prices scenario is based on the energy prices in Uzbekistan and high energy scenario is based on world energy prices. The studies show that the payback periods of especially wind and solar projects are very long even with carbon credits and high energy price scenario.

Another instrument used for supporting renewable energy investments is guarantees supported by especially multilateral agencies. Some guarantee instruments offered by multilateral agencies are given in Table 15. Guarantee instruments have positive effects on interest rates of renewable energy loans and maturities of the renewable energy markets. Partial risk guarantees may include political risks related with tariffs and regulatory framework or breach of contract. As a result of partial risk guarantees, enhancement in creditworthiness and improvement in lending terms can be observed [83]. The positive impacts of partial risk guarantees are shown in Figure 28.

There are also some banks providing loans for projects with environmental objectives. Triodos bank, a bank that has offices in Belgium, the Netherlands and the United Kingdom is providing loans for organizations and businesses having social and environmental objectives. Loans are offered for projects up to 25 MW. The typical interest rates applied by the bank are 1.25 % – 1.75 % over base rate and the loan tenors of up to 15 years are offered [110].

Table 15 Some guarantee instruments [83]

Entity	Instrument	Degree of Participation	Tenor	Private Paticipation	Main Requerement
MIGA	Political Risk Insurance	Up to US$ 150 million	Up to 20 years	Direct or Indirect	Requires letter form approval from the host country
World Bank	Partial Credit and Partial Risk Guarantees	Up to US$ 150 million	Up to 20 years	Direct or indirect	Requires a formal counter-guarantee from the host Government
IFC	Funding and Financial Guarantees	Up to US$ 150 million	Up to 20 years	Direct	Requires that the private sponsor have the majority stake in the project
IADB	Funding, Political Risk Insurance and Partial Credit Guarantees	Up to US$ 75 million or 25% of total debt finance	Up to 20 years	Direct	Requires that the private sponsor have the majority stake in the project

KfW Förderbank also provides loans with low interest rates and long tenors for environmental projects. It provides various tenor/grace period options with interest rates depending on these and the risk category of the project. The loans are provided under several programs with purposes of providing finance for environmental protection, energy efficiency and renewable energy projects. Under its renewable energy promotion program[14], KfW Förderbank provides loans with tenors of 20 years and grace periods of 3 years. The effective interest rates offered for commercial applicants vary between 5.07 % and 8.14 % depending on the price category of the project. Under the solar power generation program, loans with tenor of up to 20 years and interest rates between 5.57 % and 5.78 % are offered [111].

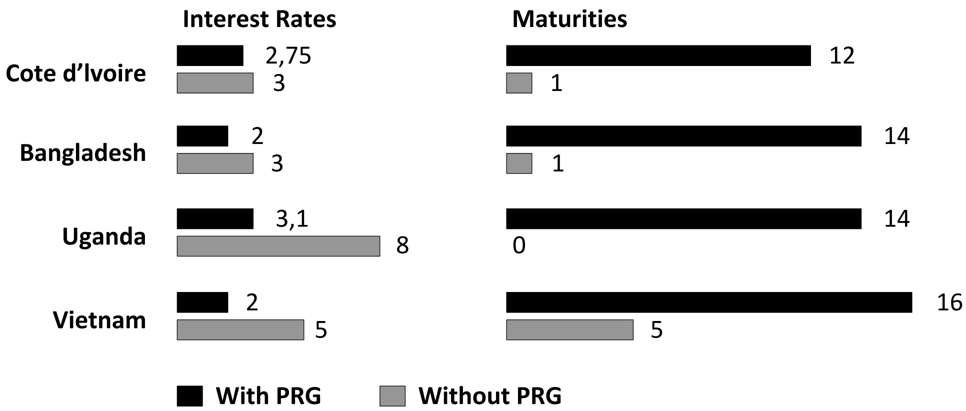


Figure 28 Impact of partial risk guarantee [83]

Currently the average loans provided by commercial banks in Turkey have interest rates of approximately LIBOR+4 %[15]. Generally repayments are made in periods of 6 months and LIBOR of 6 months are used. As of 04.08.2008, the LIBOR for Euro for 6 months was

[14] Programme to Promote Renewable Energies

[15] LIBOR is as the abbreviation for London Interbank Offered Rate and is defined by the British Bankers' Association as "the rate of interest at which bans borrow funds from each other, in marketable size, in the London interbank market".

5.15625 [112]. The tenors of the loans are approximately 10 years with a grace period of up to 2 years[16].

In summary, renewable energy needs financial support and incentives in order to develop. Risks related to renewable energy will reduce with the improvements in renewable technology and advance in the learning curves. Financiers need risk reduction for investing in the renewable projects. Since risk reduction will develop in time with increasing investments, some mechanisms should be developed for the promotion of financing renewable energy projects. Developing special financial instruments like alternative risk transfer products, specialist underwriting vehicles, weather derivatives, credit derivatives, and political risk insurance may meet the financing needs of renewable energy projects[17]. Incentives applied through national energy programs may also reduce risks of renewable energy projects. The incentive mechanisms are discussed in the next chapter.

[16] The information on loans offered in Turkey is obtained from [113]

[17] For information about the financial instruments please see: “Financial Risk Management Instruments for Renewable Energy Projects” by United Nations Environment Programme (UNEP), 2004, “Financial Risk Management Instruments for Renewable Energy Projects.pdf”, sayfa31

CHAPTER 6

INCENTIVE MECHANISMS

Sustainability has become an important concept in energy sector in the last few decades. This is because fossil based fuel resources are finite and alternative resources should be developed before they become scarce. Another issue gaining importance in energy sector is the climate change caused by fossil based fuel usage. Environmental issues are one of the reasons for the search of alternative energy resources. Renewable energy resources address both sustainability and environment related issues. Although renewable energy addresses these issues, it is not possible for renewable energy to compete with conventional energy resources under current market conditions without some support and incentive mechanisms.

There are technological, financial and political barriers to renewable energy which prevents competition with conventional energy. Since some renewable energy resources like ocean or solar power do not have a long history, their technologies are not mature enough for commercial applications. Since the technologies are new, their costs are relatively higher compared to conventional energy and these make the investments financially risky. In order to bring renewable energy costs to a competitive level, some tools have to be developed. These tools are used in the state, government or international levels.

6.1 FEED-IN TARIFFS (PRICING SYSTEM)

Feed in tariffs are price based systems in which the price for the renewable energy is determined. The basic principle of feed in tariffs is introducing legal obligations on power utilities to buy the electricity supplied by renewable power producers. The rates are generally fixed for a specified period.

In some systems premium approach is used. In the premium approach, a fixed premium is paid above the base rate (market price) which results in fluctuation in payments parallel to the developments in the market. "***An important difference between the feed-in tariff and the premium payment is that the latter introduces competition between producers in the electricity market.***" [114]. The prices to be paid and specified durations can vary depending on the renewable technology used and the capacity of the power plant. However the rates are generally higher than regular market rates. The extra costs arising from the difference between the paid price and the market price is shared among consumers according to various approaches. One approach is sharing the cost among all consumers, another approach is sharing the cost among consumers of the utilities that are obliged to buy renewable electricity in a certain area in which the renewable plants are established and another approach is sharing the cost among taxpayers in the entire country [94]. These approaches may also be applied together.

With prices above market rate and purchase obligations, feed in tariffs alter the uncompetitive market problem of renewables. Feed in tariffs address the financial barriers to renewable energy. Because the price of renewable power is guaranteed by law for a specified period, the risks are reduced resulting in an increase in renewable energy investments with lower interest rates.

Feed in systems have been employed for a long time in various countries. USA adopted the Public Utility Regulatory Policies Act (PURPA) in 1978. PURPA introduced purchase obligations on utilities on avoided cost principle. Since the avoided costs were high due to high oil prices, PURPA resulted in installation of renewable plants (wind, geothermal, CSP) with a total capacity of 12 GW during 1980s and 1990s [93]. After the first introduction in USA, many countries have used feed-in systems. The countries that have enacted feed-in-policies are given in Table 16.

Although there are various applications of feed-in systems, some key elements are common in each system. All of the systems introduce purchase obligations on utilities and prices for renewable energy are determined in these systems. Some of the systems use fixed tariffs whereas the others use market price based (premium) tariffs. Mostly, the tariffs set by feed-in systems are valid for at least 10 years. As the conditions are not same for every country, tariffs and durations are not the same for all countries.

As it is seen in Table 17, the tariff rates are generally different for each renewable resource. Different rates are not only applied for different renewable technologies, but also applied for the same renewable technology with different properties. Since the costs of electricity generation change depending on properties like plant size or site location, stepped tariffs are applied in some countries in order not to over-subsidize the plants with low generation costs [115].

Table 16 Countries using pricing system [54]

Year	Cumulative Number	Countries/States/provinces Added That Year
1978	1	United States
1990	2	Germany
1991	3	Switzerland
1992	4	Italy
1993	6	Denmark, India
1994	8	Spain, Greece
1997	9	Sri Lanka
1998	10	Sweden
1999	13	Portugal, Norway, Slovenia
2000	13	-
2001	15	France, Latvia
2002	21	Algeria, Austria, Brazil, Czech Republic, Indonesia, Lithuania
2003	28	Cyprus, Estonia, Hungary, South Korea, Slovak Republic, Maharashtra (India)
2004	34	Italy, Israel, Nicaragua, Prince Edward Islan (Canada), Andhra Pradesh and Madhya Pradesh (India)
2005	41	Karnataka, Uttaranchal, and Uttar Pradesh (India); China; Turkey; Ecuador; Ireland
2006	44	Ontario (Canada), Argentina, Thailand
2007	46	South Australia (Australia), Croatia

Note : Cumulative number refers to number of jurisdictions that had enacted feed-in policies as of the given year. A few feed-in policies shown have been discontinued. *Source:* All available policy references, including the IEA on-line Global Renewable Energy Policies and Measures database and submissions from report contributors.

Germany has been successfully using feed-in system for a long time and Germany has 23.7 % of total wind power plant capacity in the world with an installed capacity of 22,247 MW by the end of 2007 [116]. German feed-in system has evolved by the market needs and with successful energy policies Germany has become one of the greatest[18] renewable markets in the world.

Table 17 Feed-in tariffs in various countries in the EU [115]

Tariff level in 2008 [€ Cents/kWh] and duration of support for different technologies[1]								
Country		**Small Hydro**	**Wind onshore**	**Wind offshore**	**Solid biomass**	**Biogas**	**PV**	**Geothermal**
Austria		3.8-6.3 *13 years*	7.8 *13 years*	-	10.2-16.0 *13 years*	3.0-16.5 *13 years*	47.0-60.0 *13 years*	7.0 *13 years*
Cyprus		6.5 *no limit*	9.5 *15 years*	9.5 *15 years*	6.5 *no limit*	6.5 *no limit*	21.1-39.3 *15 years*	-
Czech Rp.	**fix**	8.1 *15 years*	8.5 *15 years*	-	7.9-10.1 *15 years*	7.7-10.3 *15 years*	45.5 *15 years*	15.5 *15 years*
	premium	10.5 *15 years*	12.5 *15 years*	-	10.0-12.0 *15 years*	9.9-12.5 *15 years*	49.0 *15 years*	18.0 *15 years*
Denmark		-	7.2 *20 years*	-	8.0 *20 years*	8.0 *20 years*	8.0 *20 years*	6.9 *20 years*
Estonia		5.2 *7 years*	5.2 *12 years*	5.2 *12 years*	5.2 *7 years*	5.2 *12 years*	5.2 *12 years*	5.2 *12 years*
France		5.5-7.6 *20 years*	8.2 *15 years*	13.0 *20 years*	4.9-6.1 *15 years*	4.5-14.0 *15 years*	30.0-55.0 *20 years*	12.0-15.0 *15 years*
Germany		6.7-9.7 *30 years*	8.4 *20 years*	9.1 *20 years*	3.8-21.2 *20 years*	6.5-21.2[2] *20 years*	40.6-56.8 *20 years*	7.2-15.0 *20 years*
Greece		7.3-8.5 *12 years*	7.3-8.5 *12 years*	9.0 *12 years*	7.3-8.5 *12 years*	7.3-8.5 *12 years*	40.0-50.0 *12 years*	7.3-8.5 *12 years*
Hungary		9.4 *no limit*	9.4 *no limit*	-	9.4 *no limit*	9.4 *no limit*	9.4 *no limit*	9.4 *no limit*
Ireland		7.2 *15 years*	5.7-5.9 *15 years*	5.7-5.9 *15 years*	7.2 *15 years*	7.0-7.2 *15 years*	-	-
Italy		-	-	-	-	-	44.5-49.0 *20 years*	-
Lithuania		5.8 *10 years*	6.4 *10 years*	6.4 *10 years*	5.8 *10 years*	5.8 *10 years*	-	-
Luxembourg		7.9-10.3 *10 years*	7.9-10.3 *10 years*		10.4 - 12.8 *10 years*	10.4-12.8 *10 years*	28.0-56.0 *10 years*	-
Netherlands		14.7 *10 years*	12.7 *10 years*	14.7 *10 years*	12.0 - 14.7 *10 years*	7.1-14.7 *10 years*	14.7 *10 years*	-

[18] In 2006, Germany had the second greatest renewable power capacity worldwide. [5]

Table 17 (cont'd) Feed-in tariffs in various countries in the EU [115]

Portugal		7.5 *15 years*	7.4 *15 years*	7.4 *15 years*	11.0 *15 years*	10.2 *15 years*	31-45 *15 years*	-
Slovakia		6.1 *1 year*	7.4 *1 year*	-	7.2-8.0 *1 year*	6.6 *1 year*	21.2 *1 year*	9.3 *1 year*
Slovenia	**fix**	6.0-6.2 *10 years*	5.9-6.1 *10 years*	-	6.8-7.0 *10 years*	5.0-12.1 *10 years*	6.5-37.5 *10 years*	5.9 *10 years*
	premium	8.2-8.4 *10 years*	8.1-8.3 *10 years*	-	9.0-9.2 *10 years*	6.7-14.3 *10 years*	8.7-39.7 *10 years*	8.1 *10 year*
Spain	**fix**	6.1-6.9 *no limit*	6.9 *no limit*	6.9 *no limit*	6.1-6.9 *no limit*	6.1-6.9 *no limit*	23.0-44.0 *no limit*	6.9 *no limit*
	premium	8.6-9.4 *no limit*	9.4 *no limit*	9.4 *no limit*	8.6 - 9.4 *no limit*	9.4 *no limit*	25.5 *no limit*	9.4 *no limit*
1) For the countries using a different currency than Euro, the exchange rate of the 1st of January 2006 is used [OANDA Corporation 2006] 2) The maximum value given for Germany is only available if all premiums are cumulated. This combines the enhanced use of innovative technologies, CHP generation and sustainable biomass use.								

6.2 QUOTA SYSTEM

Unlike feed-in systems, quota systems do not determine tariffs for renewable energy, but determine the minimum share of generation or capacity that is to be supplied from renewable energy resources in total generation or capacity. The price of the renewable energy on the other hand, is purely determined by the market conditions. Quota systems encourage the development of renewables at the lowest cost [93], since it provides incentive only to those renewable plants with the lowest cost. Depending upon their preferences, the utilities may generate the required amount of energy themselves, or purchase from any other producers or make agreements that allow third parties to sell energy to their customers [105].

One of the earliest usages of quotas is in 1975 with the introduction of Brazilian National Alcohol Program (PROÁLCOOL). In 1985, 95.8 % of total cars sold were running on ethanol but in 1996, the share of ethanol cars reduced to 0.8 % [117]. This was mainly due to the decline in oil prices and the ethanol shortage in 1989 [94]. Currently at least 36 states/provinces and 17 countries at the national level have enacted biofuel mandates [54].

Quota systems are not used as widely as feed-in systems in the national level in the EU or the USA. Most of the quota systems are applied in the states of USA with the name “Renewables Portfolio Standard (RPS)”. 7 countries apply the quota systems in national level, however USA, Canada, Belgium and India applies the system in state/province levels. The countries, states and provinces applying quota based systems by 2007 are shown in Table 18.

Table 18 Countries using quota system [54]

Year	Cumulative Number	Countries/States/provinces Added
1993	1	Iowa USA)
1994	2	Minnesota (USA)
1996	3	Arizona (USA)
1997	6	Maine, Massachusetts, Nevada (USA)
1998	9	Connecticut, Pennsylvania, Wisconsin (USA)
1999	12	New Jersey, Texas (USA); Italy
2000	13	New Mexico (USA)
2001	15	Flanders (Belgium); Australia
2002	18	California (USA); Wallonia (Belgium); United Kingdom
2003	19	Japan; Sweden; Maharashtra (India)
2004	34	Colorado, Hawaii, Maryland, New York, Rhode Island (USA); Nova Scotia, Ontario, Prince Edward Island (Canada); Andhra Pradesh, Karnataka, Madhya Pradesh, Orissa (India); Poland

Table 18 (cont'd) Countries using quota system [54]

2005	38	District of Colombia, Delaware, Montana (USA); Gujarat (India)
2006	39	Washington State (USA)
2007	44	Illinois, New Hampshire, North Carolina, Oregon (USA); China
Note : Cumulative number refers to number of jurisdictions that had enacted RPS policies as of the given year. Jurisdictions listed under year of first policy enactment; many policies are revised in subsequent years. *Source:* All available policy references, including the IEA on-line Global Renewable Energy Policies and Measures database and submissions from report contributors. For U.S. RPS policies, see Wiser et al.(2008).		

There are mainly two types of mechanisms used in quota based systems: Tendering and Certificate Systems.

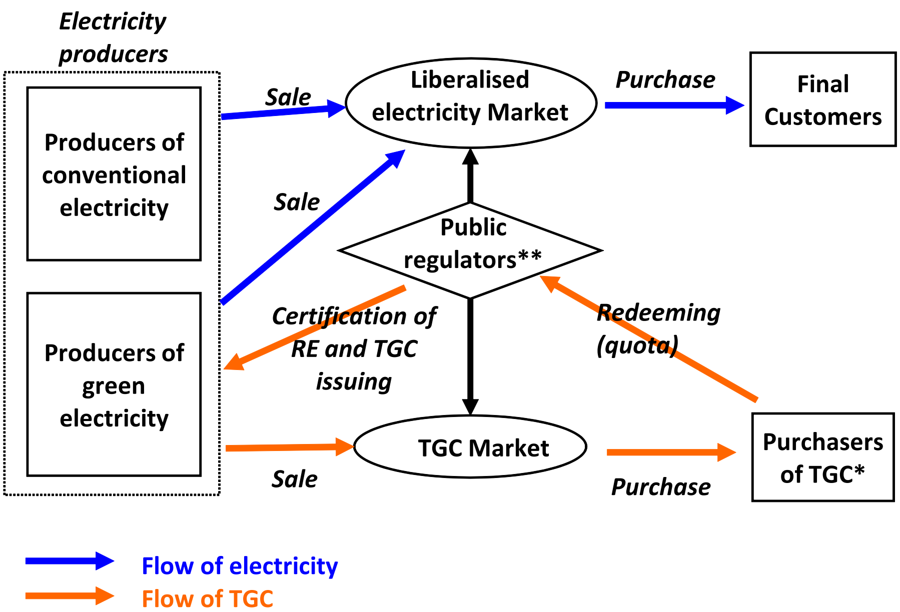
6.2.1 TENDERING SYSTEMS

In tendering systems, the prices to be paid for renewable energy are determined by competitive bidding procedure. The regulator determines the minimum capacity or generation that should be supplied from renewable energy and the price of the energy or capacity is determined by the bidding system. The bids with the lowest prices win until the required capacity of generation is achieved. The prices are guaranteed for a specified period (usually 15-20 years) which helps reducing the investment risks [118]. Sometimes regulators may require separate bids for different renewable resources in order not to prevent the development of technologies with high costs like PV. Similar to feed-in systems, the extra costs above market price may be financed by taxpayers or all consumers [94].

United Kingdom is one of the earliest users of tendering systems for increasing the usage of renewable. Between 1990 and 1999, five bids were implemented under Non-Fossil Fuel Obligation (NFFO) [119]. Tendering system has the advantage of causing rapid decreases in renewable energy prices. In UK, wind power prices declined from 10p/kWh in 1990 to 4.5p/kWh in 1997 [105]. However, there has been a criticism on the system for causing the projects to bid prices below their costs in order to win the bids [105]. NFFO did not result in many projects built and the British Government abandoned the program because of its ineffectiveness [118].

6.2.2 CERTIFICATE SYSTEMS

In certificate based quota systems, again a minimum share that should be supplied from renewable energy resources is specified by the regulator. Certificates are given to obliged utilities or consumers as a proof of their fulfillment of obligations. The price for the renewable energy or capacity is determined by two markets. First market is the common energy market that determines the price of energy (like electricity) and the second market is the green certificate market which determines the extra costs of renewable energy (costs over market price). Green certificates have their own market and their price is determined by basic market principles on demand-supply relationship. If demand is over supply, then the certificate prices increase. However this situation causes fluctuations and uncertainty in renewable energy prices and increases the risks for investment [120]. The basic green certificate market operation is shown in Figure 29.



* The purchasers of TGC may be diverse: electricity producers, suppliers, system operators, final customers

** The public regulators may be diverse according to the functions of the regulation (competition regulation, compliance with public service obligations, free access to the electricity network, etc.).

Figure 29 Tradable Green Certificate Market [121]

The certificates can be obtained by producing renewable energy, purchasing renewable energy, or only purchasing the green certificates [118]. As seen in Figure 29, the ownership of the certificate passes through sales in TGC market. This type of market approach leads to supply of needs from the renewable technologies with the least costs. Technologies like PV are not competitive in a certificate based system [122]. The interest in green certificate market is increasing in the past few years [123]. European Energy Certificate System (RECS) has been established in 2000 with the test phase and currently 200 companies from 24 European countries are members of the system [124]. The progress of RECS is shown in Figure 30.

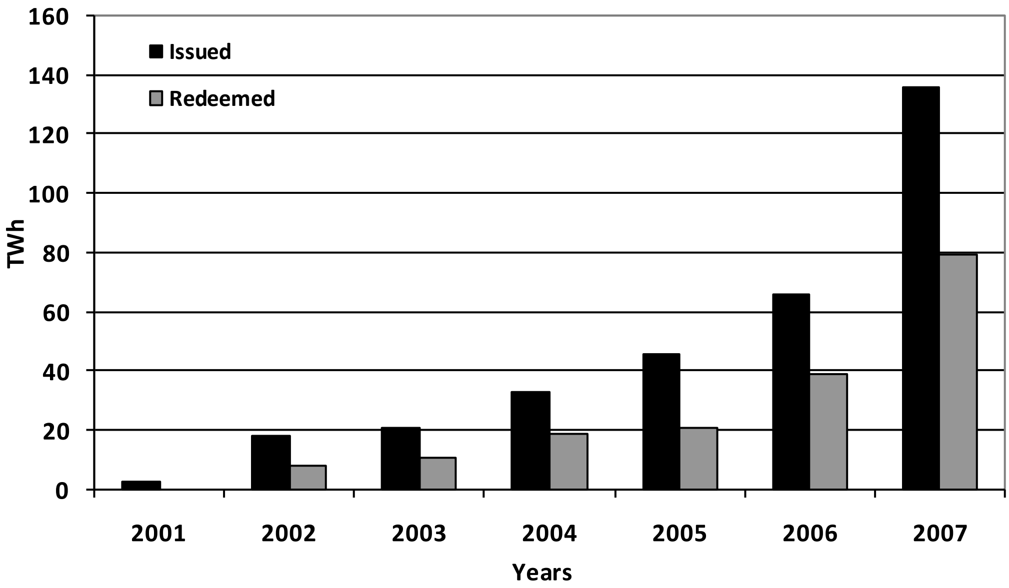


Figure 30 Progress of RECS [125]

6.3 COMPARISON OF PRICING SYSTEM AND QUOTA SYSTEM

Although the goals of both systems are the same, increasing the share of renewable energy, they use different approaches to achieve that goal. Quota systems determine the share of renewable energy to be achieved and leave the determination of pricing to the market; whereas, feed-in systems determine the price to be paid for renewable energy and the total renewable energy generation is determined by the market conditions.

Quota systems provide cost reduction in renewable energy generation through competition. The competition is established by bidding mechanisms. The renewable energy producer offering to accept the lowest price wins the bid and signs a contract for a purchase guarantee from a guaranteed tariff. However, this approach results in risks for the investments since purchase is not guaranteed until the bid is won. The price that is offered in order to win the bid may extend the pay-back duration and this will cause increased interest rates for the loans. Therefore, although this mechanism aims at reducing the price of renewable energy, it may not.

Feed-in systems offer fixed prices over a specified period and aim at reducing the costs by applying a reducing price scheme. Since purchase and price are guaranteed for the specified period, investments of renewable projects under feed-in systems are less risky. In addition to reducing pricing schemes, risk mitigation also causes cost reductions. The comparison of wind electricity prices are shown in Figure 31. It is seen in Figure 31 that the prices in countries using quota system (Italy and United Kingdom) are higher than the prices in countries using pricing systems.

Developed feed-in systems like the one in Germany implement flexible pricing mechanisms. With developed mechanisms, the prices to be paid for renewable energy vary depending on the size, location, resource type or even the technology used. Therefore, all renewables are promoted under these systems. However, quota systems promote the technologies with the least costs. Unless special bidding procedures or quotas are specified for technologies with high costs, they are not promoted naturally under quota systems. Small scale renewable plants may also be disadvantageous under quota systems. From Figure 32, it can be concluded that feed-in systems are more effective in increasing the renewable energy capacity since feed-in policies in most of the countries result in higher watts per inhabitant (except France).

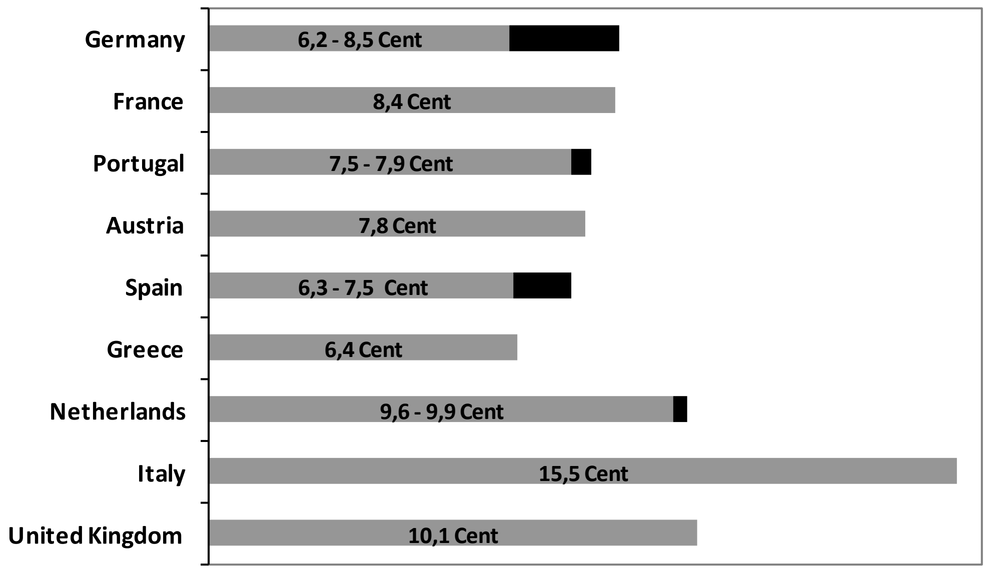


Figure 31 Comparison of wind electricity prices [126]

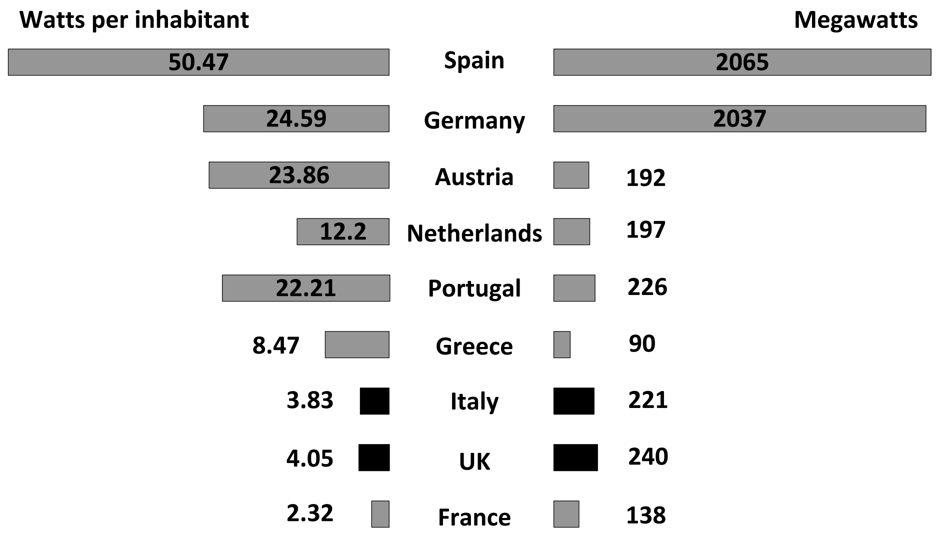


Figure 32 Comparison of newly installed capacity [126]

Whichever system is used, feed-in or quota, it should be noted that these systems should be supported with other incentive mechanisms for increasing their effectiveness. In a comparison study performed by A. Held et al. on feed-in systems in Germany, Spain and Slovenia, it is stated that supplementing feed-in tariffs by additional support measures like tax reductions, soft loans or investment incentives is the key factors for the success of applied scheme [127].

In conclusion, each system has its own advantages. Feed-in system has already proved its success in various countries in supporting the development of renewable energy, especially wind energy. The tendering mechanism in Denmark has been the most effective system to support offshore wind in Europe [114]. Tendering mechanisms are based on competition and cost reduction. However, the projects under tendering mechanisms have the risk of not being implemented. This is mainly because the low prices offered to win the bid are not enough to realize the project in some cases. Moreover, most of the renewable resources have higher prices than wind energy and are not competitive under quota systems with tendering mechanism unless supported by other mechanism like tax credits. Therefore, tendering mechanisms would only be appropriate for renewable resources with competitive prices. The examination of the frameworks in the EU and the USA in Chapter 8 shows that the development of renewable energy in the EU is more determined than it is in the USA. Considering that most of the countries in the EU are using feed-in tariffs, whereas most of the states in the USA applies quota systems (renewable portfolio standards), it can be concluded that feed-in systems are more effective. This conclusion is also determined in a European Commission report as "…***historic observations from EU Member States suggest that feed-in tariffs achieve greater renewable energy penetration, and do so at lower costs for consumers***" [114].

6.4 TAX INCENTIVES

Tax incentives are another commonly used financial tool for supporting renewable energy. Most of the states in USA and more than 40 countries use tax incentive tools [54]. There are various tax incentive applications, however here they will be grouped into three categories: Investment, Production and Other (like Eco-tax or VAT). Tax incentives may be in the form of partial of full tax credits or deductions.

6.4.1 INVESTMENT TAX INCENTIVES

Investment tax incentives aim at reducing the investment costs of renewable plants. This approach reduces risks giving rise to renewable investments. Tax deductions reduce the amount of income subject to tax whereas tax credits reduce the tax itself. The offered tax deductions or credits may change depending on the renewable technology used or the plant size. For example, Business Energy Tax Credit in USA offers tax credits of 30 % for solar systems, whereas the credit offered for microturbines and geothermal systems is 10 %. Maximum microturbine size eligible for credit is specified as 2 MW and microturbine credits are limited at 200 $/kW. However, there is no such limitation for solar systems[19]. In the 1980s, in California, some investors built wind plants in order to take advantage of investment subsidies and some plants even not produced any power [94]. In order to maintain long-term successful operation of renewable plants, performance standard should be introduced especially for investment based tax incentives [129].

6.4.2 PRODUCTION TAX INCENTIVES

Production tax incentives provide tax deductions or credits for every unit of renewable energy generation (for example, kWh for power or gallon for biofuel). Production incentives result in high efficiency since the profit is dependent on the amount of energy generation. Production Tax Credit (PTC) is first enacted in USA in 1992 aiming to support mainly wind power [130]. Since 1992, PTC program has expired and extended

[19] Systems should satisfy some conditions specified by the act. Information on Business Energy Tax Credit in USA is obtained from [128]

several times. Production tax credits not only cause efficient installations, but also increase the investments in renewable energy. The effect of the availability of PTC on wind power sector in USA is shown in Figure 33.

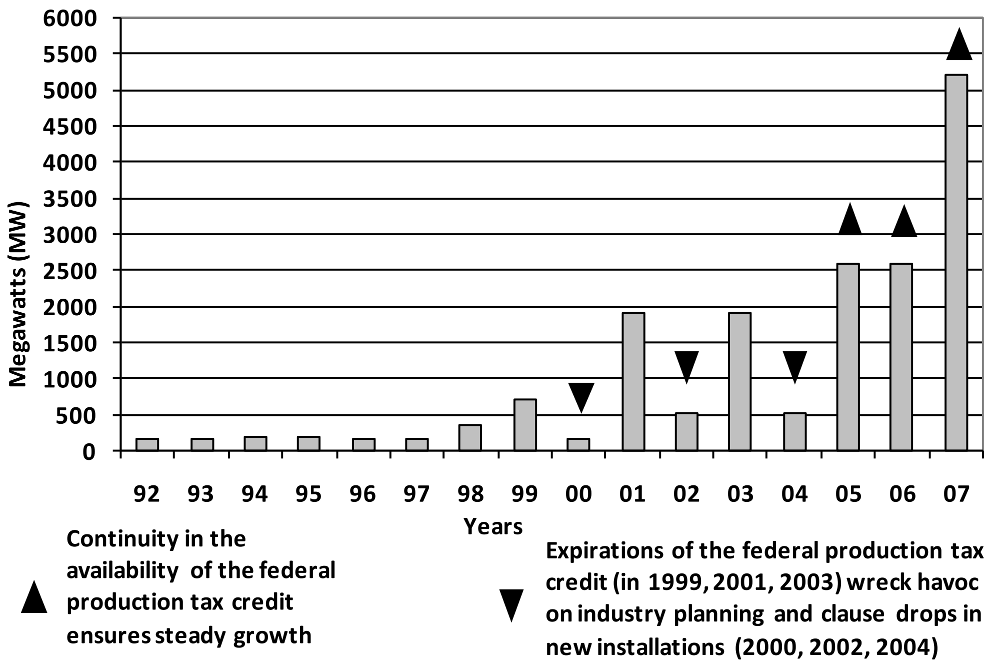


Figure 33 effect of PTC on wind power sector in the USA [131]

6.4.3 OTHER TAX INCENTIVES

Property tax incentives are similar to investment incentives as they reduce the investment costs and capital intensity of renewable projects.

The tax reduction may be up to 100 %. In USA 33 states offer various property tax incentives up to 100 % exemption [132]. In Nagpur, India, 10 % property tax rebate is offered [54]. Similar to property tax incentives, personal income, VAT and sales tax incentive are also available up to 100 % exemptions. Duty reductions for equipments used for renewable plant construction or renewable products like ethanol are also used as incentives. According to Sawin, import duties on renewable energy "should be significantly reduced if not eliminated, at least until a strong domestic manufacturing industry can be established" [94]. All of the taxes mentioned above give direct support to renewable energy generation. There are also other tax applications supporting renewable energy indirectly. Taxation of environmentally harmful energy generation reduces the uncompetitive structure between conventional and renewable energy. British Columbia in Canada introduced a carbon tax in July 1, 2008 which increases gasoline prices by 2.4 cents/liter and the tax will increase gradually reaching 7.2cents/liter in 2012 [133].

6.5 GRANTS

Many countries have been using grants as an incentive mechanism. It is commonly used especially for supporting small-scale renewable installations. Under "Clear Skies Program" in UK, £ 12.5 million was allocated to support household or community renewable projects. Grants of £ 1,000/kWe with a maximum of £ 5,000 for residential and up to £ 50,000 or 50 percent of installed costs for community projects were supplied under this program [134]. The use of grants in Germany has been increasing since the introduction of "100 MW Wind Program" in

1989. Especially the support for solar installations starting with “1000 Roofs Program” has lead to “Market Incentive Program” with a planned budget of € 500 million in 2009 [135]. Under this program, solar, biomass and heat pump installations are awarded with various rates of basic aids, fixed bonuses and efficiency bonuses. Grants are also used in USA in the federal and states levels. A federal Program, “USDA Rural Energy for America Program (REAP)”, provides 25 % of the project costs as grants [136]. Another grant program in New York, “NYSERDA - Distributed Generation as Combined Heat and Power (DG-CHP)”, provides up to 75 % of project costs with a maximum of $ 100,000, if the project is a technology transfer study [137].

6.6 LOANS (LOW INTEREST, LONG TERM)

High capital costs of renewable projects are the major obstacles to renewable energy investments. High capital costs cause high generation costs resulting in uncompetitive market position, thus financial risks. Providing low interest, long term loans reduces the costs and risks. However, because of insufficient market information, commercial banks may not be willing to provide long term loans with low interest rates. Some international organizations provide loans with long tenors and low interest rates. Development banks like International Bank for Reconstruction and Development (IBRD) which is a branch of World Bank Group, African Development Bank (AfDB) or Asian Development Bank (ADB) provide loans with low interest rates and long tenors.

There are many applications of long term loans with low interest rates supplied by government supported programs. For example in Tunisia, a program named PROSOL (Programme Solaire) was implemented by United Nations Environment Programme/Division of Technology, Industry and Economics (UNEP/DTIE) in 2004. Loans were provided to residential consumers for solar water heater installations with interest rates of 7 % (which is less than one-third of consumer loan rates in 2006) and tenors of 5 years. Until April 2006, 7 % interest subsidy was given and after that time the subsidy rate has been reduced to 4 %. In order to create a subsidy free market, phasing out the subsidies is planned. Installations with a total area of 220,000 m^2 are expected until 2011 by a total fund of $ 2 million[20]. The effect of PROSOL can be seen in Figure 34.

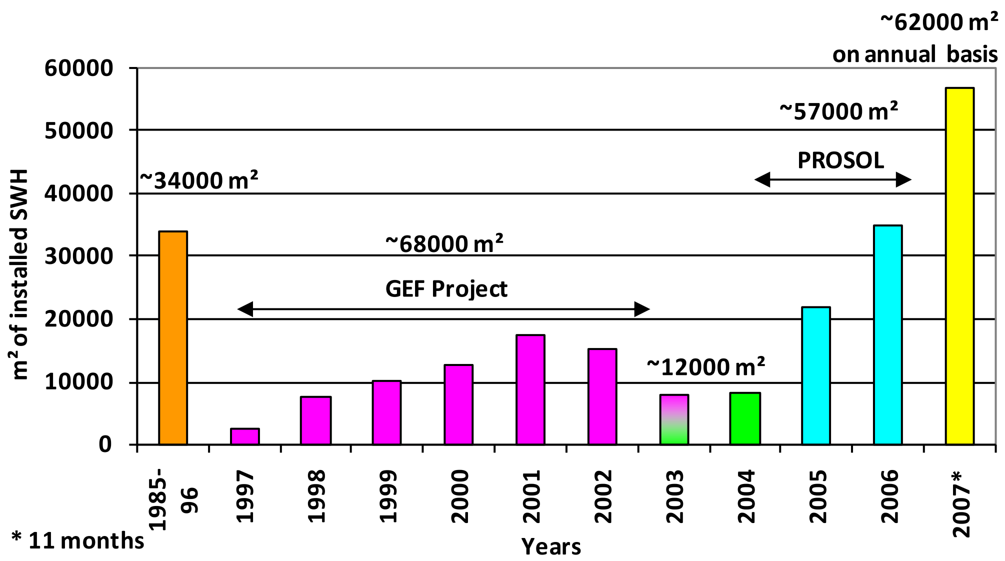


Figure 34 Solar water heaters market growth in Tunisia [139]

[20] Information on PROSOL is obtained from [138]

German Government used low interest loans for renewable market development several times. Under “100,000 Solar Roofs Program” which started in 1999, zero interest loans were provided for the installation of solar PV systems with power greater than 1 kW_e by German Credit Institution for Reconstruction (Kreditanstalt für Wiederaufbau - KfW). The repayment period was 10 years with no repayment in the first 2 years[21]. Since the applications exceeded the expected capacity, an interest rate of 3.95 % (less than half of the market rate) was introduced [141]. These and other examples prove the success of low interest loans in increasing renewable installations.

6.7 LOANS GUARANTEES

Sometimes a loan guarantee is needed in order to obtain loans, especially for new businesses. A fee should be paid for loan guarantee. Because of the risks of renewable energy investments, loan guarantee instrument is used for cost reduction. Guarantees cause decreases in interest rates and increases in tenors. In USA, under the Energy Policy Act of 2005 (EPAct05), a loan guarantee program was introduced. With this program U.S. Department of Energy (DoE) provides loan guarantees for projects that "avoid, reduce, or sequester air pollutants or anthropogenic emissions of greenhouse gases" and "employ new or significantly improved technologies as compared to technologies in service in the United States at the time the guarantee is issued" [142]. The eligible renewable technologies are wind, hydroelectric power, solar and biomass. According to a study carried by EIA, 26 % of cost reduction is expected for wind power by 2015 [143]. In April 11, 2008,

[21] The information on 100,000 Solar Roofs Program is obtained from [140]

U.S. DoE announced introduction of loan guarantees with a total of $ 38.5 billion, $ 10 billion of which will be available for renewable energy and electric transmission projects [144].

Multilateral Investment Guarantee Agency (MIGA) under World Bank Group provides guarantees for investments since 1988. MIGA can provide guarantees up to 15 years (in some cases 20 years). MIGA has issued a loan guarantee of $ 88.3 million for a 48 MW geothermal power plant project in Kenya in 2008. A guarantee of 15 years is given, covering war and civil disturbance, transfer restriction, and expropriation related risks [145]. A guarantee of $ 191.99 million is proposed for a hydroelectric power project in Akıncı, Turkey. Landesbank Baden-Wurttemberg from Germany has applied for a guarantee of 15 years covering transfer restriction, expropriation, war, civil disturbance and breach of contract risks [146].

6.8 KYOTO MECHANISMS

Kyoto protocol aims at greenhouse gas (GHG) emission reductions. During 2008-2012, the developed and transition countries (Annex B countries) are required to reduce emissions by 5 % below the 1990 levels. The protocol introduces 3 mechanisms for the realization of emission reductions: Clean Development Mechanism (CDM), Joint Implementation (JI) and Emissions Trading (ET). CDM allows Annex B countries to implement emission reducing projects in developing countries and obtain Certified Emission Reductions (CERs) in return. JI allows Annex B countries to obtain Emission Reduction Units (ERUs) from an emission reducing project in another Annex B country. Each

CERs and ERUs are equivalent to 1 ton of CO_2 reduction. ET allows countries with excess emission reductions to sell these reductions creating a market. The prices of emission reductions were € 3/ton of CO_2 in 2004 [147]. An average of € 19.5/ton of CO_2 for 2008 and € 27/ton of CO_2 for 2012 is expected by Societe Generale, French investment bank [148].

Kyoto protocol sets binding targets for developed and transition countries and forces these countries to reach their targets. Kyoto mechanisms allow these countries to implement emission reducing projects in developing countries and fulfill their commitments. This approach supports renewable energy investments in developing countries helping renewable market development and reducing investment risks.

Kyoto mechanisms create financing for renewable projects. However, the potential is not as high as expected. This is because Kyoto protocol requires the reduction of GHGs and renewable projects mostly reduce CO_2. With global warming potential being higher than that of CO_2; HFC or CO_2 reducing projects like methane flaring or HFC destruction are more favorable and they obtain two-third of available CERs [149]. Reducing the financial risks related to renewable projects can increase the contribution of renewable projects in emission reduction.

6.9 WHITE CERTIFICATES

Another certificate used in energy markets is white certificate which is a measure of energy efficiency. Similar to Kyoto mechanisms, white certificates aim at energy consumption reduction. White certificates forces the energy users to use energy efficient products. Although an EU-wide white certificate trading system has not been implemented yet, some countries in Europe are already applying white certificate schemes with obligations on suppliers or distributers of gas, electricity, etc. The energy efficiency targets of 5 European countries are given in

Table 19 Energy efficiency targets of 5 EU countries [150]

Country	Target and Period	% of Annual Demand
Denmark	7.5 PJ/year in 2006-2013	1.7 % (end year)
France	194 PJ total in 2006-2008	1 % (average)
Great Britain	468 PJ total in 2005-2008	1 % (average)
Italy	230 PJ total in 2005-2009	0.5 % (average)
Netherlands	65 PJ total in 2020	1.8 % (end year)

As a result of his study, Mundaca concludes that EU-wide white certificate trading is possible with economic and environmental effectiveness; however effectiveness of other policy instruments is necessary for cost effectiveness [151]. Aim of white certificate systems is to increase energy efficiency and installation of renewable systems like solar hot water systems may be the choice as energy efficient solution giving rise to renewable energy usage.

6.10 NET METERING

Net metering is a system which allows electricity users to generate their own power and sell the excess amount of generation to the utility.

Usually small-scale renewable energy generation is supported by net metering systems. Currently, 46 states in USA have net metering policies [152]. With each state having its own policy, supported renewable resource, maximum plant size or tariffs applied for the excess energy can vary from state to state. Although in some states, retail price is paid for the excess electricity, in some states avoided costs are paid. The number of net metering participants has been increasing since 2002. The change in the number of net metering users in USA is shown in Table 20.

Table 20 Progress in the number of net metering users in the USA [153]

Year	Electric Industry Participants	Participating Customers		
		Customer Class		Total
		Residential	Non-Residential	
2002	96	3,559	913	4,472
2003	127	5,870	943	6,813
2004	166	14,114	1,712	15,826
2005	188	19,244	1,902	21,146
2006	232	31,323	3,146	34,469

Net metering helps development of distributed renewable systems. If retail price is paid, the recovery time of capital becomes short. Although net metering promotes users for installing renewable systems, Sawin states that net metering would not be enough to advance market penetration without support of other financial incentives [94].

6.11 CARBON CREDITS

Carbon credits allow financing renewable energy projects creating tradable emissions reductions. Emission reduction quotas under various schemes force the use of emission reducing options like energy efficiency or renewable energy. Carbon credits assigned under these schemes forms a market in which emissions reduction is traded. Carbon credits can be in the form of allowances or offsets. Allowances are mandated under international agreements like Kyoto Protocol or national emission quotas, whereas offsets are additional emission reductions. Carbon credits can be bought, sold and exchanged. Detailed information on carbon finance will be given Chapter 7.

CHAPTER 7

ENVIRONMENTAL POLLUTION

Environmental pollution is a result of most of the anthropogenic activities. The excessive usage of natural resources or excessive accumulation of wastes emerging due to human activities in the nature shifts the environmental balance. This shift causes many changes like acid rains or global warming in the environmental processes which result in a threat for the living.

Energy generation is one of the main causes of environmental pollution. Especially, the use of fossil fuels causes an increase in the concentration of the greenhouse gases like CO_2 and CH_4 in the air which leads to an increase in the global average temperature. The increase in the temperature triggers many changes in the nature. The melting of glaciers results in an increase in the sea level which threatens the living in the coastal regions and the climate shift in some regions causes drought, again threatening the living. Even the survival of some species may be endangered with the global warming.

Although nuclear power generation does not produce greenhouse gases, it involves the risk of radioactive emission. The safety of the nuclear power plant is critical and if an accident occurs, it may result in severe damages in nature. The so-called "Chernobyl Disaster" which happened in 1986, caused acute radiation syndrome (ARS) in 134 emergency workers, 28 of which died in 1986 and 19 of which died in 1987-2004 [216]. Apart from ARS, thousands of people suffered from cancer due to radioactive contamination. Although mostly Belarus, Ukraine and Russia were affected, the radiation spread over Europe. 18,000 m^2 of agricultural land was contaminated, 2,640 m^2 of which can no longer be farmed [217]. Waste disposal of nuclear facilities also involve risks. Although the half-times of radioactive materials vary, especially for radioactive materials with half-times of more than thousands of years, the safety of waste disposal facilities becomes more critical. Even if high-level precautions are taken in nuclear facilities, the safety issues are likely to remain as the main drawback of nuclear power plants.

One of the main barriers to renewable energy development is that the external costs of conventional energy resources are mostly not included in their generation costs. The external cost is defined in a European Commission report as:

> ***An external cost, also known as an externality, arises when the social or economic activities of one group of persons have an impact on another group and when that impact is not fully accounted, or compensated for, by the first group.*** [218]

The impacts related to greenhouse gas emissions from energy generation plants may be climate change, health damages or material deformation. Especially the climate change or health damages form the main components of the external costs. In a report prepared by German

Aerospace Centre (DLR) and Fraunhofer Institute for System and Innovation Research (FhG-ISI), the external costs of different electricity generation technologies are estimated based on the damage cost assumption from CO_2 emission of 70 €/t_{CO2}. The estimation results are given in Figure 35.

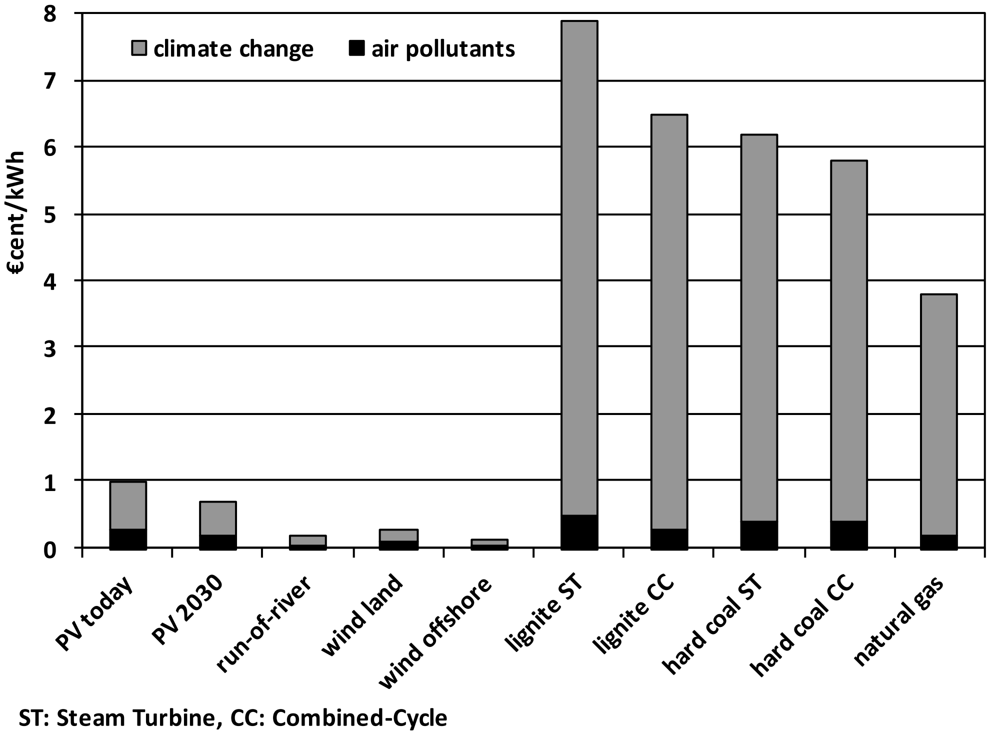


Figure 35 External costs of electricity generation technologies [219]

As it is seen in Figure 35, the main component of the external costs is the climate change costs whereas the contribution of the health damage costs caused by the air pollutants is smaller compared to climate change costs. It is also seen that the external costs of fossil-based electricity generation is much higher than the external costs of renewable electricity generation.

In another study carried under "ExternE[22]" project, the external costs of different energy technologies are evaluated and listed according to their damage and avoidance costs. This study assumes a CO_2 avoidance costs of 19 €/ t_{CO2} and the results of this study is shown in Table 21.

Table 21 External cost components of electricity generation technologies [218]

	Coal	**Lignite**	**Gas**	**Nuclear**	**PV**	**Wind**	**Hydro**
Damage Costs							
Noise	0	0	0	0	0	0.005	0
Health	0.73	0.99	0.34	0.17	0.45	0.072	0.051
Material	0.015	0.020	0.007	0.002	0.012	0.002	0.001
Crops	0	0	0	0.0008	0	0.0007	0.0002
Total	0.75	1.01	0.35	0.17	0.46	0.08	0.05
Avoidance Costs							
Ecosystem	0.20	0.78	0.04	0.05	0.04	0.04	0.03
Global Warming	1.60	2.00	0.73	0.03	0.33	0.04	0.03

Although the results of the two studies are not the same, it is clear that the external costs of fossil based power generation are greater than that of renewable energy generation. It is seen in Table 21 that the external costs of nuclear energy are also lower than the external costs of fossil based energy. The costs related to possible accidents are included in the external costs of nuclear power generation, however the external

[22] Externalities of Energy – A research project of the European Commission

costs of nuclear energy is higher than the costs of wind and hydro-energy. At this point, it should be noted that nuclear energy R&D projects have been supported for a long time and with the increasing support in renewable energy R&D projects the external costs have the potential of decreasing in time. The projected external costs of photovoltaics can be seen in Figure 35.

There are mainly two mechanisms used for emissions reduction: cap and trade system and carbon tax system. Cap and trade systems are similar to quota systems. These systems impose mandatory emission limits which are reduced in time to reduce the emission levels and the allowances for documenting the emission reductions. The emission caps are generally reduced in time to reduce the total emissions. Allowances are tradable like the green certificates under quota systems. Those who are able to reduce their emissions more than the specified target are able to sell allowances to those who are not able to meet the emission targets. Under cap and trade system, the obligated parties are free to choose the emissions reduction methods that are more appropriate for themselves (like renewable energy, reforestation or energy efficiency). Environmental Protection Agency (EPA) specifies the key issues of allowance trading (cap and trade) systems as [220]:

- An emissions cap
- Allowances
- Measurement (of emissions)
- Flexibility (ability to choose the appropriate method for emission reduction)
- Allowance trading
- Compliance (with the emission reduction obligations)

Another concept in emissions reduction is carbon offsets. Carbon offsets are similar to allowances, they represent emissions reduction. Offsets are usually sold on a year-to-year basis [221]. However, unlike allowances, the carbon offsets are not given for projects that are mandated by law or for projects that can be implemented without financial tools like offsets.

> ***Offsets have to be "additional", which means that the project that created them would not have proceeded without the funding provided by the sale of the GHG reductions.*** [222]

Carbon credits can be in the form of either allowances or offsets. Credits can be bought, sold and exchanged. Kyoto mechanisms allow countries which have ratified the protocol to trade carbon credits among each other for achieving the targets specified by the protocol. The European Union Greenhouse Gas Emission Trading Scheme (EU ETS) which has started operation in 2005 allows the member states trade allowances. The value of the worldwide carbon market was $ 64 billion in 2007, $ 50 billion of which belonging to EU ETS. Worldwide and EU ETS carbon market values in 2006 were $ 31 billion and the $ 24 billion, respectively [223]. These values demonstrate the growth potential in the carbon market. It is also obvious that European Union dominates the carbon market.

The other mechanism for emissions reduction is carbon tax system. Under carbon tax systems, governments impose some taxes on carbon emissions which increase in time so as to decrease the emission levels. The revenue from taxes would ideally be used for compensating other taxes in order to minimize the damage to economy, especially households with low income [224]. Carbon taxes increase prices of fossil fuels and make the prices of renewable energy resources competitive.

The taxation can be either upstream or downstream. In an upstream taxation, the tax is paid by the producers, shippers, or processors before the fuel is consumed whereas, in a downstream taxation, the tax is paid by the power producers or individual electricity or fuel consumers at the time of fuel consumption [225]. The upstream and downstream approach is also valid for cap and trade systems. In either application, final consumers would pay the price.

There are various arguments on which of the two systems (cap and trade or carbon tax) would be more effective. According to a recent poll by the Wall Street Journal, a majority of the 47 economists participating in the poll considered that a tax on fossil fuels would be the most economic way of encouraging the alternative fuel usage [226]. A tax system provides cost certainty whereas; a cap and trade system provides environmental certainty [227]. The cost certainty provided by tax systems are considered as an incentive for investing in projects with low greenhouse gas emissions. The Carbon Tax Center (CTC) which supports carbon tax systems instead of cap and trade systems claim that there are 6 fundamental reasons for tax systems being superior to cap and trade systems [228]:

- Price predictability
- Shorter implementation duration
- Transparency and understandability
- Less opportunity for manipulation

- Addressing emissions from all sectors (cap and trade systems are claimed to address only electricity sector)
- Returning the revenues to the public by tax shifting

The cap and trade systems are claimed to have advantages over carbon tax systems. Since cap and trade systems impose emission targets, they are considered to be environmentally more effective by their opponents. Cap and trade systems are also considered as flexible since they allow linking the national system to other countries' systems [227]. Although cap and trade systems are claimed not to address emissions from all sectors, Stavins argue that coverage of emissions throughout the economy is possible with an upstream approach [229]. Both carbon tax and cap and trade systems cause market distortions, however if revenue of the carbon taxes are used for compensation of other taxes, the distortions are minimized and environmental targets can be achieved at lower costs [230].

The concept of external costs of greenhouse gas emissions does not have a long history. Therefore there is not enough knowledge to prove which system is more effective in emissions reduction. Especially, carbon trading is a very new concept and the information on carbon trading is improving with the development of the carbon market. But there is one thing that is agreed on: In order to level the playing field for renewable energy generators and not to support polluting technologies, the external costs related to greenhouse gas emissions should be included in energy generation costs.

CHAPTER 8

LEGISLATIVE FRAMEWORK IN THE EU AND THE USA

8.1 LEGISLATIVE FRAMEWORK IN THE EU

In 1986, European Council stated that the contribution of renewable energy should be promoted by employing proper incentives [154]. Later on 29.06.1992, the Commission of the European Communities issued the communication "Specific actions for greater penetration for renewable energy sources[23]". The communication was prepared for proposing measures to promote renewable energy development in response to the request of the Commission [154]. The targets given in the communication for 2005 was renewable energy share of 8 % in total energy, 27 GW of renewable electricity capacity and biofuels share of 5 % in total fuel consumption. To promote renewable energy in the Community, a program named ALTENER with a budget of 40 MECU was proposed for 1993-1997 with the communication. Later, the second program, ALTENER II, launched for the period 1998-2002.

[23] COM(92) 180

On 13.12.1995, the Commission issued a white paper named "An Energy Policy for the European Union[24]". In the white paper it was stated that renewables needed supportive regulations for competing with other energy sources and the Commission announced that a strategy would be presented in the form of a communication. On 20.11.1996, a green paper named "Energy for the future: renewable sources of energy[25]" was issued and as a result of the public debate on the green paper, the communication "Energy for the Future: Renewable Sources of Energy[26]" was issued on 26.11.1997. It was stated in the white paper that a coherent and transparent strategy was essential for renewables since the non-technological barriers could not be broken down by the technological progress itself. Therefore, an action plan is presented in the communication with some measures. A target of renewable energy share of 12 % in total energy by 2010 was set by the commission and the necessary measures that should be taken in order to achieve this target were given under four titles: Internal Market Measures (Fair Access for Renewable Energy to the Electricity Market, Fiscal and Finance Measures, etc.), Reinforcing Community Policies, Strengthening co-operation between Member States and Support Measures. A campaign was also proposed in the white paper. The four actions proposed under the campaign were 1,000,000 PV systems, 10,000 MW Wind Farms, 10,000 MW_{th} Biomass and Integration in 100 Communities. The total cost of these actions was estimated to be 25 billion ECU and a public funding of 4 billion ECU was suggested. The member states were expected to determine their own targets and develop their own strategies.

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[24] COM(95) 682
[25] COM(96) 576
[26] COM(97) 599

The commission issued another green paper named "Towards a European strategy for the security of energy supply[27]" on 29.11.2000. In the paper that is issued to underline the increasing energy dependence on imports and start a debate on energy security, usage of financial measures like aids or tax reductions are proposed for reaching the 12 % target for renewable share and financing renewable energy from coal, gas or nuclear is presented as an alternative which could be explored [155].

On 27.10.2001, the directive on "the promotion of electricity produced from renewable energy sources in the internal electricity market[28]" was adopted. This was the first directive explicitly aiming at renewable energy development [156]. The 12 % target set in the white paper of 1997 was also adopted in the directive and national targets are set for each country to achieve this target. The target for the share of electricity produced from renewable resources was set as 22.1 %. With the enlargement of the Union in 2004, this target was reduced to 21 %[29].

The directive underlined the necessity of a legislative framework for renewable energy sources. It was also stated that it was early for a community-wide framework to be decided on since there is not enough experience on the support mechanisms and the member states are allowed to choose their own supporting mechanisms. After observing the progress of the support mechanisms in the member states, the Commission should present a report and might propose a framework for the Community, if deemed necessary.

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[27] COM(2000) 769
[28] Directive 2001/77/EC
[29] See the official journal: OJ L 246 23.10.2003

The directive outlined the necessary regulations to be adopted by the member states for market penetration of electricity produced from renewable energy resources. Necessity of objectivity, transparency and non-discrimination principles for the regulations to be adopted by the member states is stated in many paragraphs of the directive. The outlined necessities were as follows:

Member states should take necessary measures to reach the national objectives stated in the annex of the directive. The progress should be reported by the member states and the reports should be analyzed by the Commission and mandatory targets should be proposed, if necessary. The support mechanisms should be analyzed by the Commission and community-wide support scheme should be proposed, if necessary. Member states should issue guarantee of origins for electricity produced from renewable energy resources to demonstrate the resource, date and place of production. The member states should also ensure that the network access of renewable electricity producers is guaranteed. Renewable plants should be given priority by the transmission system operators while dispatching. Priority access might also be provided. Standard rules on bearing the costs of connections or system upgrades should be established. Network operators might be required to bear these costs. Member states should ensure that the network charges do not cause discrimination against renewable plants. Necessary legislations should be completed until 27.10.2003 by the member states.

The directive stated that the progress in the market should be issued by the member states and the Commission in various reports. The reports that should be published are given in Table 22.

Table 22 Report responsibilities of the member states and the Commission[30]

Responsibility	Start	Frequency	Purpose
Member States	27.10.2002	5 years	Setting the national targets for the share of renewable electricity for the next 10 years and outlining the necessary measures planned to reach these targets
Member States	27.10.2003	2 years	Analyzing the success of meeting the targets
Commission	27.10.2004	2 years	analyze the reports from member states in terms of meeting the Community targets and propose necessary measures to be taken for achieving the targets
Commission	27.10.2005	-	Analyzing the success of different mechanisms applied in the member states and proposing community-wide framework if necessary
Member States	27.10.2003	-	evaluating the existing frameworks with regard to Directive 96/92/EC
Commission	31.12.2005	5 years	summarizing the progress in implementing this directive based on the reports prepared by the member states on the success of meeting the targets and evaluation of the frameworks with regard to 96/92/EC

On 07.12.2005, the Commission issued the report “The support of electricity from renewable energy sources[31]”, analyzing the progress in the member states. The renewable contribution in the total electricity generation in 2003 was reported as 14 %. Various support schemes were applied in the member countries. In the report, these mechanisms

[30] Table is adapted from the Directive 2001/77/EC
[31] COM(2005) 627

were classified into four groups: feed-in tariffs, green certificates, tendering systems and tax incentives. The advantages of feed-in tariffs are stated as investment security, the possibility of fine tuning and the promotion of mid- and long-term technologies. The report also noted that they are difficult to harmonize at EU level and involve a risk of over-funding. Although green-certificate systems could work well as a European-wide mechanism, it was noted that the system would not be appropriate for currently high-cost technologies. The risk of not being implemented for projects under tendering systems was also underlined.
In the report, the feed-in systems in Germany, Spain and Denmark were presented as the most effective systems for wind energy. It was also stated that feed-in tariffs in Denmark and tax exemption combined with investment incentives in Finland were the most effective methods for biomass. Four of the six countries having the most effective policies for biogas were using feed-in tariffs.

As a result of the analysis of support mechanisms in the member states, the Commission presented some recommendations for further developing the mechanism. The recommendations are as follows:

- Cooperation between countries (like the Feed-In Cooperation between Germany, Spain and Slovenia)
- Optimization of national support mechanisms
    - Increasing legislative stability and reducing investment risk
    - Reducing the administrative barriers (like reducing the relevant authorization agencies)

- Addressing grid issues (it was recommended that grid upgrade costs should be covered by the transmission system operators)
- Encouraging technology diversity
- Using tax incentives
- Ensuring the integration with the internal market
- Encouraging employment
- Supporting with energy efficiency and demand management

It was considered as early by the Commission to compare the advantages and disadvantages of support mechanisms as they have rather short history and as a result of the analysis, the Commission concluded that it would not be appropriate to propose a European wide support scheme.

On 10.01.2007 another communication, “Green Paper follow-up action Report on progress in renewable electricity[32]”, was issued by the Commission. It was announced in the report that a share of 15 % of renewable electricity was achieved in 2005 and 19 % was expected by 2010. The development was considered not good enough with many Member States lacking far behind their national targets. It was also reported that all member states had adapted the requirements presented in the Directive 2001/77/EC to their national legislations. However, the need for secondary legislations in many countries was

[32] COM(2006) 849

addressed. As a result of the analysis of the developments in the member states, the recommendations presented in the COM(2005) 627 was repeated and a new framework for the promotion of renewable energy was announced to be presented.

The announced framework proposal was issued as “Renewable Energy Road Map Renewable energies in the 21st century: building a more sustainable future[33]” on 10.01.2007. The road map proposes a legally binding target of 20 % share of renewable energy in total energy consumption by 2020. A new legislative framework was also proposed which is expected to provide long-term market stability and increase the investments in renewables sector. The expected cost for reaching the target was calculated as € 10-18 billion per year.

It was stated in the document that the target of 12 % renewable energy share by 2010 would not be met and 10 % share is to be expected by 2010. The Commission considered the 12 % target as insufficient and emphasized the necessity of clearly defined, focused and mandatory targets. Emphasizing the position of biofuels as the only renewable source in transport sector, a target of 10 % share in total transport fuels by 2020 was set for biofuels. In order to achieve the targets, setting binding national targets are proposed. The reason for proposing mandatory targets is the inefficiency of the non-binding targets set in 1997 in achieving 12 % share by 2010. Member states are required to set their own renewable electricity, biofuels and heating/cooling targets.

[33] COM(2006) 848

As a result of achieving the targets, annual CO_2 emission reductions of 600-900Mt is expected in 2020 with a total benefit of € 150-200 billion[34]. The annual reduction in fossil fuel consumption is expected as 252 Mtoe by 2020. The status of renewable sector with a total turnover of € 20 billion and employees of 300,000 was noted and the necessity of reaching the targets is emphasized to keep the leadership of EU in the sector volume. Finally, the commission announced that a new legislation would be proposed.

On 23.01.2008, a proposal[35] for the Directive “on the promotion of the use of energy from renewable sources” was issued. The purpose of the proposed directive is rebuilding the legislative framework in order to reach the targets proposed in the road map. The proposed directive sets overall EU target of 20 % renewable share and individual member state targets of 10 % biofuels by 2020.

Member states are required to prepare national targets by 31.03.2010 and if the annual progress of the national renewable share does not meet the requirements specified in the directive in the preceding 2 years, the member states are required to present new action plans and measures to be taken to the Commission by 30 June of the following year.

The origin of each MWh produced in renewable electricity or heating/cooling plants above 5 MW_{th} capacity should be certified by a document called “Guarantee of Origin”. The minimum information to be presented in this document is the resource type, category of the

[34] CO_2 price was assumed as €25/tonne
[35] COM(2008) 19

resource (renewable or heating/cooling), plant information (capacity, installation date, etc.), date and country of issue and a unique ID number and the investment aid information (amount and type). An organization (probably a regulatory authority) shall be established in each country to manage issuance, transfer and cancellation of the guarantee of origins ensuring that a guarantee of origin is not held by more than one register at the same time. Submission of the guarantee of origins will be required for receiving feed-in tariff or premium payments, payments from tenders or tax reductions.

Member states are required to define specifications for the equipments that are to be used in renewable installations. Local or regional bodies shall be required to consider heating/cooling installations. Minimum requirements of renewable energy usage shall be introduced in the building codes. Biomass conversion plants with a minimum efficiency of at least 85 % for residential or commercial and 75 % for industrial applications and solar plants with a minimum efficiency of 35 % shall be promoted. The minimum greenhouse gas emission reduction from the use of biofuels or bioliquids shall be 35 %.

Again on 23.01.2008 the Commission issued a report[36] updating the 2005 report[37] on evaluating the performances of support mechanisms applied in the member states[38]. In the report, “**well-adapted**” feed-in tariffs were considered to be the most effective and efficient support mechanisms and production support was considered as “**far more important**” than the investment support. In terms of effectiveness

[36] SEC(2008) 57

[37] COM(2005)627

[38] The information on the support mechanisms used in the member states are given in Annex-2 of [114].

(increasing the generation), feed-in tariffs in Germany, Denmark and Spain were reported as the most effective for onshore wind, whereas, the tendering scheme in Denmark was stated to be the most effective mechanism for offshore wind. It was also stated in the report that most of the countries with the highest growth in biogas used feed-in tariffs and Germany, with feed-in tariffs, had the highest growth in PV.

As a result of the analysis, it was again concluded that it would not be appropriate to propose an EU-wide RE tariff support mechanism. However, removing the administrative barriers as a priority and improving the grid access were suggested by the Commission. The development of renewable energy share in total energy consumption in the EU is given in Figure 36 and the share of renewable electricity in total electricity consumption is given in Figure 37.

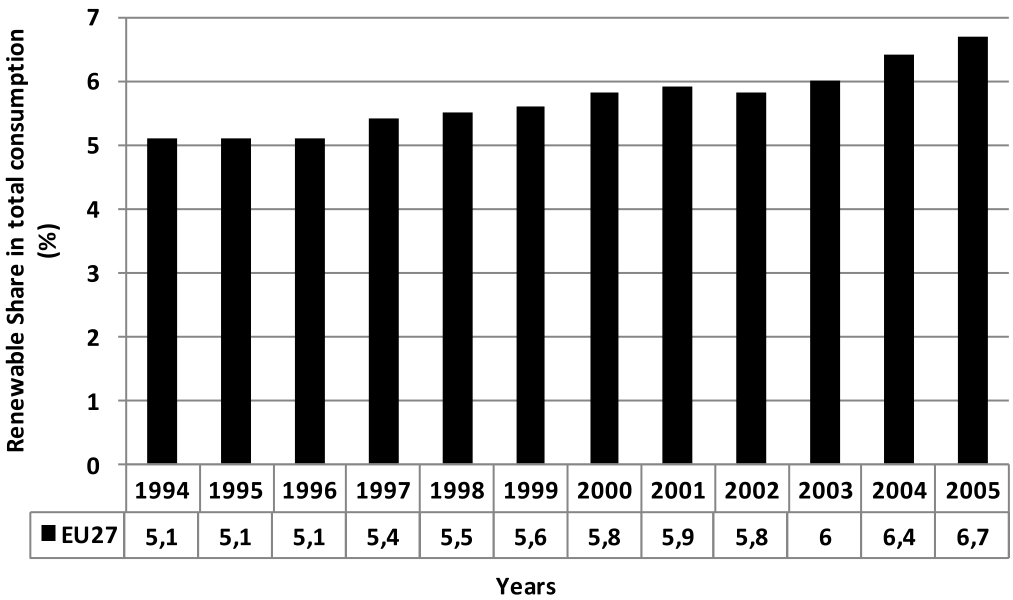

Figure 36 share of renewable energy in total consumption – EU [157]

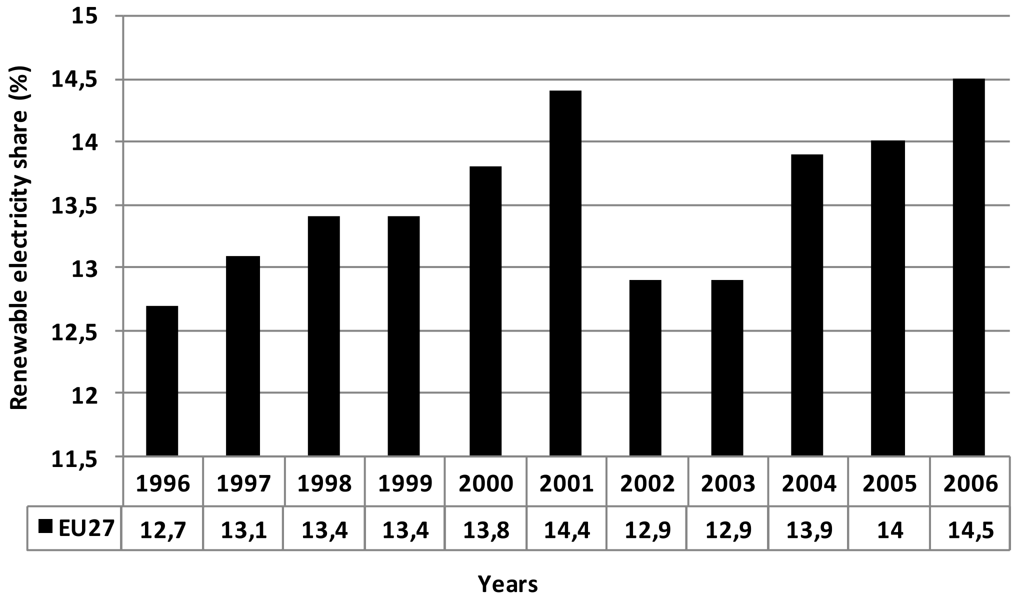

Figure 37 share of renewable electricity in total consumption – EU [158]

8.2 LEGISLATIVE FRAMEWORK IN THE USA

8.2.1 FEDERAL MECHANISMS

In 1978, the National Energy Act (NEA) was enacted in order to decrease the dependency on oil import and increase the domestic energy conservation energy efficiency. As one of the 5 parts under the NEA, the Public Utility Regulatory Policies Act (PURPA) was a major regulatory mandate promoting renewable energy [159]. Under PURPA, utilities were obliged to provide interconnect with the generation facilities meeting the qualification criteria (cogeneration or renewable generation facilities). The utilities were also obliged to purchase the electricity generated from the plants meeting the criteria at an avoided cost principle. PURPA was successful such that the cogeneration capacity in 1991 reached 59 % of the total non-utility capacity [160]. The total capacity of the renewable plants connected to the grid under PURPA accounted for 12 GW by the end of 1998 [93]. In 1986, bidding mechanism is introduced by the Federal Energy Regulatory Commission (FERC) for competition and many states applied this mechanism [161].

Another component of the NEA was the Energy Tax Act (ETA). Under the act, residential and business tax credits were offered. Businesses investing in solar, wind or geothermal projects were granted with a 10 % tax credit. Income tax credits of 30 % for the first $ 2,000 and 20 % for the next $ 8,000 were offered for households buying solar or wind power equipments. These tax credits were planned to expire at the end of 1982, but extended several times causing uncertainty in the market. The ETA also provided a tax exemption of $ 0.04 per gallon of gasoline for ethanol/methanol blending [93].

In 1992, the Energy Policy Act (EPACT) was enacted. The 10 % tax credit offered for businesses under the ETA was extended permanently for solar and geothermal projects. Private wind and closed-loop (using dedicated crops) biomass plants were offered 1.5 Cents/kWh production tax credits (PTC) for 10 years. Plants owned by Public utilities and rural cooperatives using biomass (except municipal solid waste), geothermal (except dry steam), wind and solar resources were offered 1.5 Cents/kWh under Renewable Energy Production Incentive (REPI) program. Tax credits were also offered for alcohol-fueled vehicles [159]. The PTC was extended twice, expiring at the end of 2003 and the REPI expired in September 2003. The on-off structure of the PTC caused uncertainty in the market similar to the ETA [93].

In 2005, the Energy Policy Act of 2005[39] (EPACT 2005) came into force. The act requires the share of renewable electricity in total electricity consumption of the Federal Government to be minimum 3 % in 2007-2009 period, minimum 5 % in 2010-2012 period and minimum 7 % in and after 2013. A target of achieving 10,000 MW of renewable installations in 10 years was set by the act. The target for renewable fuels use was set as 4 billion gallons for 2006, increasing through the years and reaching 7.5 billion gallons for 2012.

Various programs were introduced under the EPACT 2005 to promote renewable energy. The "Photovoltaic Energy Commercialization Program" to develop photovoltaic industry and to acquire data for future programs. The target of this program was to achieve a capacity of 150 MWp in 5 years. The budget of the program was $ 50 million for each year in 2006-2010 period. Another program introduced by the EPACT 2005 was the "Rebate Program" which offers rebates for households and businesses installing renewable equipments. 25 % or $ 3,000 (whichever is less) was offered. The budget of the program was $ 150 million for 2006 and 2007 (annually), $ 200 million for 2008 and $ 250 million for 2009 and 2010 (annually).

Apart from the rebates, grants were also offered under EPACT 2005. Grants of a total of $ 20 million (annual) were offered for renewable installations in rural areas (population less than 10,000) in the period 2006-2012. $ 50 million were allocated for each year in the period 2006-2016 for increasing the biomass usage and research. Under "Biomass Commercial Use Grant Program", $ 20/ton of biomass; and under

[39] Public Law 109-58 date:08.08.2005

"Improved Biomass Use Grant Program", up to $ 500,000 were offered. For research and development activities on renewable energy, the act allocated $ 632 million for 2007, $ 743 million for 2008 and $ 852 million for 2009. Under separate programs, biomass and solar research projects are also supported under changing budgets for the period 2007-2009.

The non-discriminatory rules in the Federal Power Act and the EPACT 2005 provide competitiveness for renewable energy producers. Under EPACT 2005, the PTC was extended until 31.12.2007 and this was the first time that the extension was made before the expiration date [162]. The act obliges electric utilities to issue necessary regulations in 3 years to make net-metering available to all consumers.

In many states of the USA, Renewable Portfolio Standards (RPS) are used to increase the share of renewable energy. However, there is no federal RPS in the USA. Although several bills[40] were introduced proposing national RPS schemes, none of them have been enacted. The latest proposal[41] was introduced on 08.07.2007. The latest proposal projects 1 % by 2010, 2 % by 2011 and 20 % by 2020, with annual increases of 2 % between 2011 and 2020. Some argue that a national RPS would raise electricity prices and Congress should oppose the bill [163]; whereas, some comments on the bill as "***the brightest prospects we have seen in years***" [164].

[40] See: H.R. 5736 date: 14.11.2002, H.R. 1294 date: 13.03.2003, H.R. 983 date: 17.02.2005
[41] H.R. 969 date:08.02.2007

The current renewable electricity generation and the share of renewable electricity in total generation are given in Figure 38. The only sharp increases occur in 2001-2002 and 2005-2006 periods.

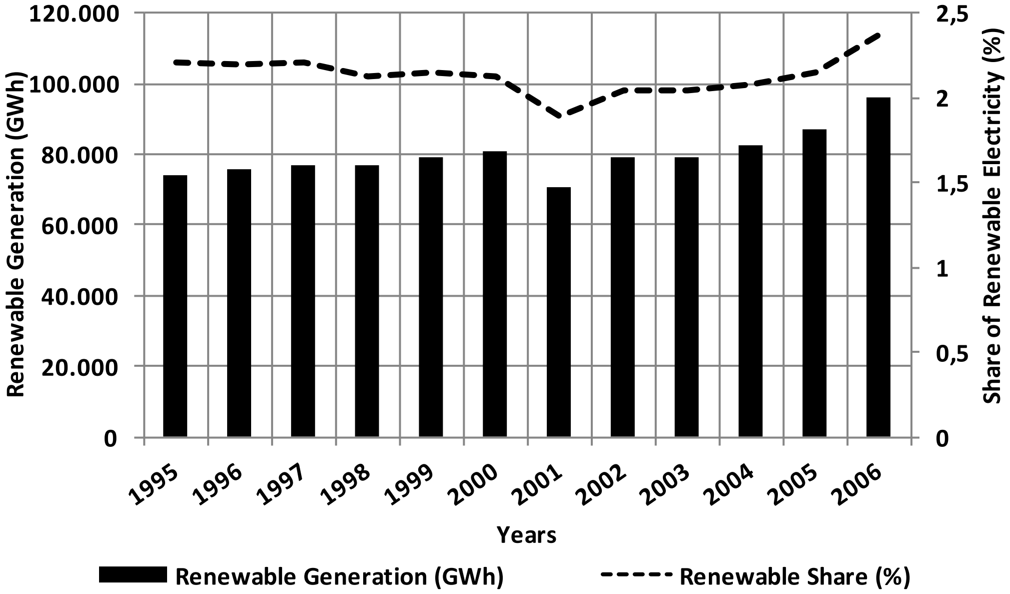

Figure 38 Renewable electricity generation and share in total generation – USA [165]

Although there are various laws regulating the renewable energy sector, only the main laws have been given up to now. This is because of the fact that each state develops its own energy policy and state policies are currently the main elements in supporting renewable energy development. In the next section, the renewable energy policies of California will be examined.

8.2.2 STATE MECHANISMS (CALIFORNIA)

California has been building the largest renewable portfolio for over 30 years [166]. In 2006, California was the second[42] state with the greatest renewable electricity generation with approximately 71.9 TWh, which accounted for nearly one fifth of the total[43] renewable electricity generation in the USA [167].

In 1996, the “Assembly Bill 1890 (AB 1890)” was adopted leading to electricity market deregulation. Under the bill, three major utilities were required to collect $ 540 million from their ratepayer for the “Renewable Energy Program”. One year later, in 1997, the “Senate Bill 90 (SB 90)” was enacted and “Renewable Resource Trust Fund” was established to collect the amount stated in the AB 1890 [168].

Four accounts were created under the Renewable Resource Trust Fund: The Existing Renewable Resources Account, New Renewable Resources Account, Emerging Renewable Resources Account and Customer-Side Renewable Resource Purchases Account. Biomass, solar thermal, waste, wind, geothermal, small hydroelectric, digester gas, landfill gas and MSW were supported by production incentives under the fund with rates and durations depending on the resource type and project. 45 % of the collected money would be used to promote existing renewable technologies, whereas 30 % was allocated for new technologies. The share of allocation for emerging technologies was 10 %. The rest of the money would be used for supporting consumers investing in renewables as rebates, buydowns or incentives [169].

[42] Washington was the first with a renewable electricity generation of 84.5TWh [167].
[43] Total renewable electricity generation in the USA was approximately 385.7TWh in 2006 [167].

In 2000, Assembly Bill 995 (AB 995) and Senate Bill 1194 (SB 1194) required the three major utilities to collect $ 135 million annually for 10 years. With the enactment of Senate Bill 1038 (SB 1038) in 2002, the allocation shares of the Existing Renewable Resources Account, New Renewable Resources Account, Emerging Renewable Resources Account and Customer-Side Renewable Resource Purchases Account were changed as 20 %, 51.5 %, 17.5 % and 11 % respectively [168].

In 2002 another mechanism, the Renewables Portfolio Standard (RPS), launched with the enactment of Senate Bill 1078 (SB 1078). At least 1 % of annual increase in renewable electricity share was required from the utilities in order to reach 20 % share in 2017 [170]. Shortening the period, the Senate Bill 107 (SB 107) required 20 % renewable electricity share by 2010 [171]. This target was proposed in the Energy Action Plan issued by the State of California in 2003 and reaching this target was estimated to require annual renewable installations of 600 MW [172]. Governor Schwarzenegger's 33 % renewable share proposal was examined and some key actions were proposed in the second action plan which was issued in 2005 [173].

California Public Utilities Commission (CPUC)[44] is required to report development of RPS projects in every 3-month. In the latest report [174] issued in July,2008 it was stated that since the introduction of the RPS program, contracts for a total of 5,900 MW capacity had been approved by CPUC. 4,480 MW of these contracts were for new projects. It was also stated that only approximately 400 MW of the contracted capacity

[44] CPUC is a regulatory organization which regulates private companies in many sectors including electricity sector.

had been realized. It was reported that 3,000 MW of installations would be needed for achieving the 20 % target by 2010. Another thing that was mentioned in the report was the decrease in the total renewable generation share from 14 % in 2003 to 12.7 % in 2007. It was demonstrated in the report that the most of the projects were not realized due to risk factors and removing the risks in project development was recommended in order to reach the targets.

With the enactment of Senate Bill 1 (SB 1) on 21.06.2006, California allocated a budget of approximately $ 3.3 billion for the support of solar projects. Of the total budget, $ 2,166.8 million was allocated for California Solar Initiative (CSI) program, $ 400 million was allocated for New Solar Home Partnership program and $ 784 million was allocated for publicly owned utilities' projects [175].

The SB 1 required Public Utilities Commission to authorize the incentives to be offered for installations of up to 1 MW. An average of 7 % annual reductions was required for incentives. The electric service providers are obliged to accept net metering applications up to 2.5 % of total peak demand. The state is required to reimburse the costs of schools or local agencies. Under the CSI program, 3,000 MW of solar installations are aimed in 10 years. The incentives under CSI are offered for solar energy systems with a minimum capacity of 1 kW and maximum capacity of 5 MW. The installed systems are required to have a guarantee of at least 10 years and the installations should comply with the relevant electrical and building standards. In order to help the builders, the commission is required to provide technical assistance and publish educative documents. The commission is also required to publish estimated generations and performance reports annually.

Publicly owned utilities are required to offer 2.8 $/W or a specified rate for each kWh. The offered incentives are required to decrease 7 % annually. For net metering applications, the customer-generators are required to bear the costs related to meters that are able to work in two directions. The commission is allowed to fund solar thermal or solar water heating projects in a total amount of up to $100.8 million and research projects in a total amount of $ 50 million.

The CSI provided two types of incentives: Performance Based Incentives (PBI) and Expected Performance-Based Buydowns (EPBB). PBI offers incentives for each kWh produced, whereas under EPBB a one-time payment is offered for each Watts of installed capacity. The minimum and the maximum capacity of eligible projects are determined as 1 kW and 1 MW respectively. Projects with a capacity between 1 MW and 5 MW are either offered payments for the first 1 MW or offered lower rates. PBI applies to installations with a capacity over 100 kW in 2007, over 50 kW in 2008 and over 30 kW in and after 2010; other projects are included in EPBB. The performance based payments are made on monthly basis and remains fixed for 5 years [176]. The annual capacity targets and payments are given in Table 23.

The number of applications between 01.01.2007 and 31.03.2008 and corresponding capacities are shown in Table 24. It is clearly seen that the applied capacity has already exceeded the projections for the second and the third year.

The change of renewable electricity generation and the share of renewable electricity between 1996 and 2006 are given in Figure 39. It is seen that the share of wind, solar and geothermal energy has not changed significantly.

Table 23 Payments under CSI [176]

MW Step	Statewide MW in Step	EPBB Payments ($/W)			PBI Payments ($/kWh)		
		Residential	Commercial	Government /Non-Profit	Residential	Commercial	Government /Non-Profit
1*	50	-	-	-	-	-	-
2	70	2.50	2.50	3.25	0.39	0.39	0.50
3	100	2.20	2.20	2.95	0.34	0.34	0.46
4	130	1.90	1.90	2.65	0.26	0.26	0.37
5	160	1.55	1.55	2.30	0.22	0.22	0.32
6	190	1.10	1.10	1.85	0.15	0.15	0.26
7	215	0.65	0.65	1.40	0.09	0.09	0.19
8	250	0.35	0.35	1.10	0.05	0.05	0.15
9	285	0.25	0.25	0.90	0.03	0.03	0.12
10	350	0.20	0.20	0.70	0.03	0.03	0.10
*The first 50 MW are allocated under the 2006 Self-Generation Incentive Program							

Table 24 CSI applications [177]

	Residential	Commercial	Government & Non-Profit	TOTAL
# of Applications	8786	780	251	9817
Applications %	89%	8%	3%	100%
MW	41.7	160.8	46.7	249.3
MW %	17%	65%	19%	100%

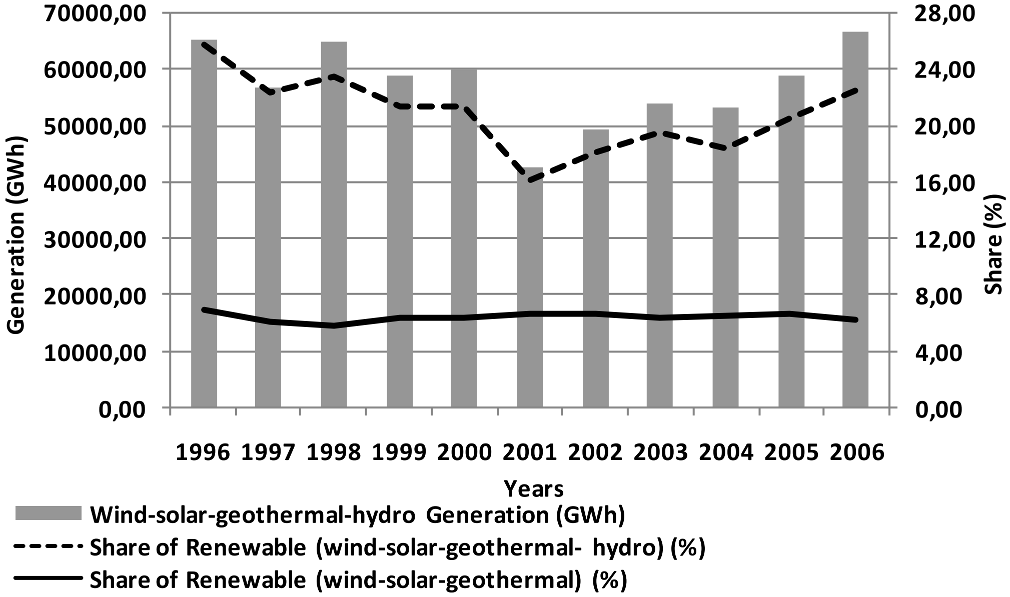

Figure 39 Renewable electricity generation and share in total generation – California [178]

CHAPTER 9

LEGISLATIVE FRAMEWORK IN TURKEY

Before starting to explain the framework in Turkey, it would be beneficial to explain the public actors in the electricity market in Turkey and the structure of the market. The public actors in the market are given in Table 25 and the market structure is given Figure 40.

There are various mechanisms used for shaping the electricity market in Turkey. The main mechanisms are the primary legislation, i.e. laws and secondary legislation, i.e. regulations. Based on the main principles outlined by laws, regulations are prepared, mainly by EMRA. EMRA also issues communiqués and decisions. Regulations, decrees in force of law and communiqués issued by the Council of Ministers are the other mechanisms regulating the energy market.

Following the principles outlined by EU Directives, Turkey has chosen the objective of establishing a competition based fully liberalized energy market. Although some steps were taken in the 1980s and 1990s on the path to a liberalized electricity market, the main step was taken in 2001 with the enactment of Electricity Market Law (EML, Law No: 4628) in 20.02.2001. This law has been changed nine times since its enactment with the last amendment being made in 09.07.2008. The main steps in the development of Turkish electricity market and the last amendment made are given in Table 26.

Table 25 Public actors in the electricity market in Turkey

Duty	Institution
Ministry	Ministry of Energy and Natural Resources (MENR)
Generation	Turkish Electricity Generation Company (EÜAŞ)
Transmission	Turkish Electricity Transmission Company (TEİAŞ)
Distribution	Turkish Electricity Distribution Company (TEDAŞ)
Wholesale	Turkish Electricity Trading and Contracting Company (TETAŞ)
Regulatory Authority	Energy Market Regulatory Authority (EMRA)

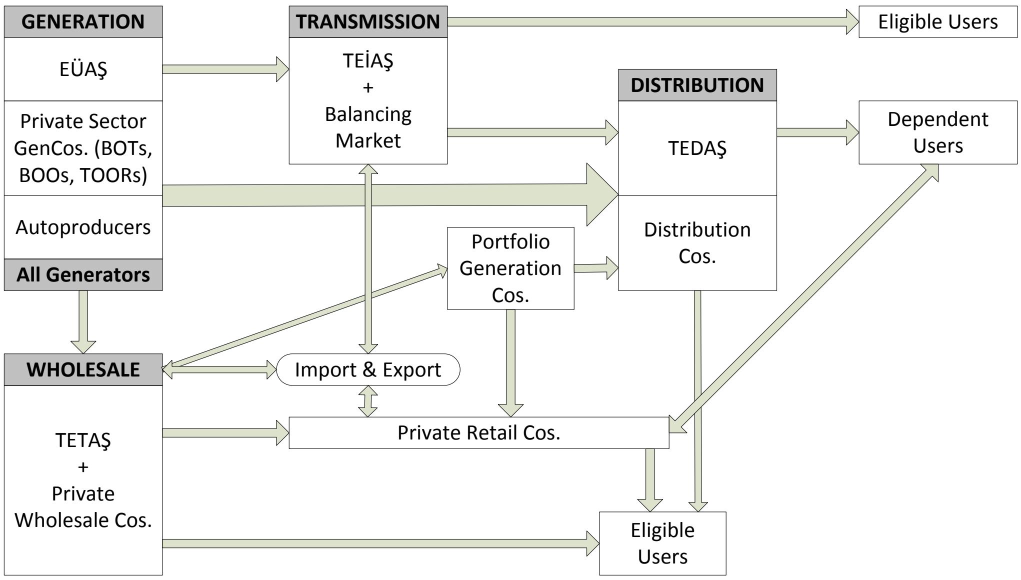

Figure 40 Electricity market structure – Turkey [179] (modified)

Table 26 Developments in the electricity market – Turkey [180] (adapted)

Year	Development
1970	Foundation of Turkish Electricity Authority (Türkiye Elektrik Kurumu, TEK)
1982	trasfer of electrical installations and networks belonging to Municipalities and Unions to TEK
1984	Law No: 3096 which defines Build Operate and Transfer (BOT) and Transfer of Operating Rights (TOOR) models for private sector participation in electricity market
1993	splitting of TEK into two seperate State Owned Enterprises: TEAŞ(Turkish Electricity Generation Transmission Company) and TEDAŞ (Turkish Electricity Distribution Company) by cabinet decree no: 93/4789
1994	Law No: 3996 which introduces some concessions like tax or fee exemptions and treasury guarantees for BOT investments
1996	Decree having the force of law no: 96/8269 introduced Build Operate Own (BOO) model
1997	Law No: 4283 which defines Build Operate Own (BOO) model giving treasury guarantees
2001	ELECTRICITY MARKET REFORM Law No: 4628 (Electricity Market Law) which aims at liberalization of electricity market
2005	Law No: 5346 (Law on Utilization of Renewable Energy Resources for the Purpose of Generating Electrical Energy) which aims at expansion of the utilization of renewable energy resources for electricity generation
2008	Law No: 5784 which introduces amendtments to various laws, mainly to Law No: 4628. Some of the amendments were related to renewable energy.

9.1 BRIEF HISTORY OF THE TURKISH ELECTRICITY MARKET

With the introduction of Ministry of Energy and Natural Resources (MENR)[45] in 1963, Turkey started developing its energy policies. The installed capacity increase from 408 MW in 1950s to 2,234.9 MW in

[45] Enerji ve Tabii Kaynaklar Bakanlığı, ETKB

1970 required a comprehensive management structure [181]. As a result of this need, Turkish Energy Authority (Türkiye Elektrik Kurumu, TEK) was established in 1970 with the responsibility of electricity generation management. All generation assets were transferred to TEK except those of Çukurova Elektrik T.A.Ş. and Kepez ve Antalya Havalisi Elektrik Santralleri T.A.Ş. In 1982, management of transmission and distribution of electricity is transferred to TEK and electricity generation by private sector is allowed with Law No: 2705[46]. Electricity was used by 23 % of the population in 1950 and this share increased to 80 % at the end of 1980 [182]. The situation in villages was different from the overall electricity usage in Turkey. The electrification of villages increased from 7 % in 1970 to 60 % in 1982 and the total installed generation capacity reached 6,639 MW [181]. Ozturk et al. present in their paper how Turkish electricity generation is affected from the oil crises in 1970s. Hydroelectric power generation increased nearly 5 GWh during 1973-1976 and 1979-1982 periods whereas thermal power generation stayed nearly constant during these periods[47].

With the structural reform program of 1980, a market based economic approach was adopted [183]. The effect of this approach is also seen in energy market and some models were developed in order to attract private investments to Turkish energy sector. During 1980s and 1990s various laws were enacted introducing Build Operate Transfer (BOT), Transfer of Operating Rights (TOOR) and Build Operate Own (BOO) models [184].

[46] Information on TEK is obtained from [182]

[47] For more information on hydroelectric and thermal power generation, please see [181]

Law No: 3096 which is ratified on 04.12.1984 allowed domestic or foreign private companies to establish power plants. It was stated in the law that the contracts would be signed for up to 99 years (later reduced to 49 years [185]) and at the end of this period, ownership of the facility and assets would be transferred to government without charge. Although the term “Build Operate Transfer (BOT)” was not used explicitly in the law, the model defined in the law was same as the model known as BOT [184]. Another model that the law introduced was the so-called “Transfer of Operating Rights (TOOR)”. The operating rights of generation, transmission and distribution systems could be transferred with this law. By the Cabinet Decree No: 85/9799 autoproduction was put into practice [181].

In 1993, by Cabinet Decree No: 93/4789, TEK was split into two separate State Owned Enterprises, namely “Turkish Electricity Generation Transmission Company” (Türkiye Elektrik Üretim, İletim A.Ş., TEAŞ) and “Turkish Electricity Distribution Company” (Türkiye Elektrik Dağıtım A.Ş., TEDAŞ) [186]. In 1994, treasury guarantees and tax exemptions were provided by Law No: 3996 and Cabinet Decree No: 94/5907 in order to increase attractiveness of BOT model [187]. Law No: 4283 which is ratified in 16.07.1997 defines Build Operate Own (BOO) model under which the investors would keep holding the ownership of the plant after the end of contract period. Only thermal power plant investments were covered and treasury guarantees were introduced by the law.

Build Operate Transfer (BOT), Transfer of Operating Rights (TOOR) and Build Operate Own (BOO) models designed for attracting investments in energy sector provided treasury guarantees and tax exemptions under take-or-pay contracts [188]. Atiyas and Dutz criticize these contracts for being the major barrier to the development of competition in electricity market [185]. Absence of tender mechanisms in BOT contracts caused difficulties in determination of the effective investment costs and resulted in high costs[48]. As fuel costs were fully reflected to consumers, producers were not encouraged for cost reduction approaches [184]. Although there have been various privatization efforts in 1980s and 1990s, these efforts failed mainly due to lack of a plan [189].

9.2 ELECTRICITY MARKET REFORM

The privatization efforts of Turkey through BOT, TOOR or BOO systems have brought a heavy financial burden on public. According to a report prepared by SAYIŞTAY on BOT and BOO projects, a total of 29[49] plants caused a public financial loss of $ 2.3 billion in 4 years period [190]. Through the privatization efforts in electricity sector, many of the attempts were annulled by the constitutional court and DANIŞTAY [179]. As a result of the debates, a new law became necessary. In order to create a competitive market structure and independent regulation in the market, Electricity Market Law[50] (EML) was enacted in 2001. This law means a reform for Turkish electricity market. The main objective of the law is stated in its first article as

[48] İzak Atiyas presents the study of IBS Research and Consultancy in his book. The investment costs of plants built under BOT and BOO contracts and the investments costs of BOT plants were approximately 1200$/kW whereas the costs were approximately 600$/kW for BOO plants. For more information, please see [184]

[49] Under the scope of the report, 25 plants built under BOT and 4 plants built under BOO contracts were examined.

[50] Law No: 4628, enactment date: 20.02.2001

establishment of a financially viable, stable and transparent electricity market under private law in a competitive environment and providing an independent regulation in this market.

TEAŞ was split into 3 companies in accordance with the Decision of the Council of Ministers No: 2001/2026 (date: 05.02.2001) which was issued as per the Article 3 of the Decree-in-Law No:233 and the Electricity Market Law No:4628: Turkish Electricity Transmission Company (Türkiye Elektrik İletim Anonim Şirketi, TEİAŞ), Turkish Electricity Trading and Contracting Company (Türkiye Elektrik Ticaret ve Taahhüt Anonim Şirketi, TETAŞ), Electricity Generation Company (Elektrik Üretim Anonim Şirketi, EÜAŞ) [191]. TEİAŞ is responsible for taking over existing public owned transmission facilities, preparing investment plans for projected facilities, building new facilities and operating the facilities. TEİAŞ is also responsible for real-time system control. TETAŞ takes over existing wholesale contacts from TEAŞ and TEDAŞ. TETAŞ can sign purchase or sale contracts and carries out the contracts. EÜAŞ takes over existing generation plants that are not transferred to private companies and operates these facilities. EÜAŞ can also build, rent or operate new plants when necessary.

Under EML, private sector participation in generation, distribution, wholesale, retail, import and export is possible. Generation would be provided by EÜAŞ, private sector generation companies and autoproducers or autoproducer groups. Transmission activities would be performed by TEİAŞ. Distribution companies (public and private) would provide distribution. Wholesale activities would be carried out by TETAŞ and private sector wholesale companies, whereas retail would be performed by retail companies or distribution companies with retail licenses. TETAŞ, private sector wholesale companies, retail companies and distribution companies with retail license could import and/or export electricity.

For the regulation of the market, an independent regulation authority, Energy Market Regulatory Authority[51] (Enerji Piyasası Düzenleme Kurumu, EMRA) is established by EML. The authority is mainly responsible for licensing, preparing and implementing necessary regulations, determining the tariff criteria and the necessary tariff formulas, preparing, amending, enforcing and supervising performance standards and regulations on distribution and customer services and applying sanctions where necessary. License related fees (licensing, renewal, modification, duplication, annual license fees), publication revenues, international grants, 25 % of the fines, up to 1 % of transmission surcharges will form the authority's revenues and the expenditures should be covered by these revenues.

It was first envisaged in EML that 9 GWh was the eligibility limit for consumers and consumers whose annual consumption is over this threshold were free to choose their suppliers. This threshold is reduced to 1.2 GWh with Board[52] Decision No: 1472 (decision date: 24.01.2008). Eligible consumer definition brings market opening for demand side. Autoproducers are able to sell up to 20 % of their annual generation under competitive environment and this limit could be

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[51] The name of the authority was first established as Electricity Market Regulatory Authority and later on it was renamed as Energy Market Regulatory Authority (Enerji Piyasası Düzenleme Kurumu) by Natural Gas Market Law (Law No: 4646, enactment date: 18.04.2001) and the authority was given the responsibility of regulation of natural gas market in addition to electricity market. Later, with the enactment of Petroleum Market Law (Law No: 5015, enactment date: 04.12.2003) and Liquefied Petroleum Gas Market Law (Law No: 5307, enactment date: 02.03.2005), EPDK was given the responsibility of these markets as well.

[52] Energy Market Regulatory Board (Enerji Piyasası Düzenleme Kurulu)

increased by half of it by the Board. Autoproducers selling more than the defined limit in a calendar year are obliged to obtain generation license.

EML defines balancing and settlement mechanisms for market resolving the differences between supply and demand in a bilateral agreement at the need of a certain time period. System balancing is under responsibility of the National Load Dispatch Centre (Milli Yük Tevzi Merkezi, MYTM) whereas financial settlement is under responsibility of the Market Financial Settlement Centre (Piyasa Mali Uzlaştırma Merkezi, PMUM). These centers operating under TEİAŞ will be responsible for management of energy transactions in the market.

EML brings a reform to the market aiming at preparing the market for competition. It includes many changes from vertical unbundling to market opening for both demand and supply side. For market opening purposes, generation and distribution and retail activities presently carried out mostly under state ownership are decided to be privatized. Distribution network is divided into 21 regions. The only region in which distribution is operated by a partially private company is Kayseri[53]. The "Strategy Document[54]" published by High Planning Board[55] (HPB) in 2004 has developed a highly detailed privatization plan for generation and distribution infrastructure. The strategy paper aimed the completion of privatization procedure for distribution assets until 31.12.2006; however the tender phases of the first privatizations, BEDAŞ[56] and

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[53] The operating rights of Kayseri Region were transferred to KCETAS in 1990 [192].

[54] Electrical Energy Sector Reform and Privatization Strategy Document (Elektrik Enerjisi Sektörü Reformu ve Özelleştirme Strateji Belgesi), High Planning Board Decision No: 2004/3, date: 17.03.2004

[55] Yüksek Planlama Kurulu

[56] Başkent Electricity Distribution Company (Başkent Elektrik Dağıtım A.Ş., BEDAŞ)

SEDAŞ[57], were completed on 01.07.2008 with highest offers of $ 1.225 billion and $ 600 million respectively. Currently, their privatization implementations are at approval stage. Privatization of ARAS[58] and MERAM[59] are at tender phases and the last bidding date for these two regions is 04.09.2008 [193].

In 2006, with Law No: 5496 (enactment date: 10.05.2006), EML is amended and "National Tariff Balancing Mechanism" is introduced. The purpose of this amendment is explained in the law as "to protect consumers partially or fully from the differences in retail prices in different distribution regions". This mechanism will be valid until 01.01.2011; then the cost based pricing mechanism envisaged in EML is to be put. This date is extended to 01.01.2013 by Law No: 5784 (enactment date: 09.07.2008).

9.3 RENEWABLE ENERGY LAW

Although construction of large hydroelectric power plants has been encouraged by government initiatives for a long time, the renewable energy policy of Turkey has only been shaped recently. One of the responsibilities of Energy Market Regulation Board as stated in the EML is to take measures necessary to promote usage of renewable and domestic energy resources for electricity generation. In 2003, an amendment is made to the Electricity Market Licensing Regulation (No: 24836 date: 04.08.2002). With this amendment, the definition of power

[57] Sakarya Electricity Distribution Company (Sakarya Elektrik Dağıtım A.Ş., SEDAŞ)
[58] Aras Electricity Distribution Company (Aras Elektrik Dağıtım A.Ş., ARAS)
[59] Meram Electricity Distribution Company (Meram Elektrik Dağıtım A.Ş., MERAM)

generation plants which use renewable energy resources are included in the regulation together with some other amendments. The real beginning for renewable energy policy was the definition of renewable energy sources in this amendment [93]. On 19.07.2003, EMRA announced that some regulations had been made in order to promote installation of renewable energy generation facilities 194]. The announced promotions were as follows:

- Only 1 % of the license fees will be collected from renewable energy applications,
- Annual license fees will not be collected for the first 8 years,
- Connection of renewable plants to the TEİAŞ transmission system and/or distribution systems is a priority,
- If the price of renewable electricity is less than or equal to the wholesale electricity price in the market and if there is no cheaper supply alternative in the market, retail license holders are obliged to purchase renewable electricity for their electricity needs.
- Renewable energy plants are exempt from power transaction duties and fees in the Balancing and Settlement activities
- Wind or run-of-river type hydraulic plants are not subject to the rules in the "Communiqué Regarding the Principles and Procedures of Financial Settlement in the Electricity Market" until a regulation is announced.
- It is possible for renewable energy generation or autoproducer license holders to purchase energy from wholesale companies in order to flatten their supply curves.

Later, in the "Strategy Document[60]" published by High Planning Board[61] (HPB) in 2004, it was stated that the regulations necessary for investments of plants generating electricity from domestic resources (including large hydroelectric) would be implemented by MENR and National Planning Organization (NPO)[62]. This could be considered as a support for renewable energy.

The Law on Utilization of Renewable Energy Resources for the Purpose of Generating Electrical Energy (Law No: 5346, enactment date: 10.05.2005) was enacted to comply with EU regulations [188]. From now on, this law will be referred as "the Renewable Energy Law". The objective of the law is given in its first article as:

> ***The purpose of this Law is to expand the utilization of renewable energy resources for generating electrical energy, to benefit from these resources in 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 sector for realizing these objectives.*** [195]

The law defines renewable energy resources as: non-fossil energy resources such as hydraulic, wind, solar, geothermal, biomass, biogas, wave, current and tidal power. Also definitions of biomass and geothermal resource are mentioned in the law. The renewable energy

[60] Electrical Energy Sector Reform and Privatization Strategy Document (Elektrik Enerjisi Sektörü Reformu ve Özelleştirme Strateji Belgesi), High Planning Board Decision No: 2004/3, date: 17.03.2004

[61] Yüksek Planlama Kurulu

[62] Devlet Planlama Teşkilatı, DPT

resources covered by the law were wind, solar, geothermal, biomass, biogas, wave, current energy, and tide or run-of-river type hydraulic plants together with hydroelectric plants with reservoir areas less than 15 km^2. Under the license regulation[63] of EMRA, run-of-river type hydroelectric plants with a capacity less than 50 MW and reservoir type hydroelectric plants with a maximum reservoir capacity of 100 million m^3 or reservoir areas of maximum 15 km^2 are assumed as renewable energy plants.

The renewable resource areas are protected by the law and preparations of development plans are prohibited by the law. For the purpose of identification and monitoring of the resource type, EMRA is authorized to give Renewable Energy Resource Certificate (RES Certificate). Feed-in tariff system is implemented with the introduction of wholesale price offered for renewable energy.

The summary of the implementations stated in the Renewable Energy Law is as follows:

- Each retail license holder should purchase renewable energy considering the energy he sold in the previous calendar year to the total energy sold nation-wide.
- Until the end of 2011, wholesale price will be paid for renewable energy. The prices are not valid for plants older than 7 years starting with 2012.

[63] Electricity Market License Regulation

- Service fee exemption is given by DSİ[64] or EİE[65] for renewable installations to supply own energy needs of installation owner.
- Usage of properties of Forestry or Treasury is allowed for usage of renewable energy generation purposes and reduction or exemptions of some fees are introduced.
- Administrative fines are introduced for retail license holders who breach the provisions

In 2006, the Environment Law (Law No: 2872, enactment date: 09.08.1983) is amended by Law No: 5491 (enactment date: 26.04.2006). It is stated in the amendment that market based and financial tools together with incentives like obligatory standards, taxes, fees, contributions, promotion of renewable and clean energy technologies, emission fees and pollution fees, carbon trading for environmental protection, pollution prevention and removal can be used. Exemptions and reductions for excise duties are granted for biodiesel by Cabinet Decree No: 2006/11202.

In 2007, “Energy Efficiency Law” (Law No: 5627, enactment date: 18.04.2007) came into force. This law included some items relating renewable energy. Under the law, if an industrial enterprise signs a contract for reducing its energy intensity by 10 % in 3 years, a rebate of 20 % of the electricity expenditure corresponding to the agreement year is offered. Renewable energy usage is not included in the energy intensity calculations. Electrical Power Resources Survey and

[64] State Hydraulic Works (Devlet Su İşleri)

[65] Electrical Power Resources Survey and Development Administration (Elektrik İşleri Etüt İdaresi)

Development Administration is charged with making measurements relating to assessing energy sources with priority of renewable resources, developing projections and proposals for assessing domestic and renewable energy resources and form opinions for the license applications of wind projects. Exemption from the license obtaining and company establishment obligations is granted to owners of renewable energy plants with a maximum capacity of 200 kW and micro cogeneration plants under the condition that the plants are used only for meeting self requirements.

17th and 18th articles of Energy Efficiency Law introduced some amendments to the Renewable Energy Law. With the amendments, the price that will be paid for renewable energy is again stated as the wholesale price; however price limitations are introduced as minimum of 5 € Cents/kWh and maximum of 5.5 € Cents/kWh. The prices will be paid only to those plants which have been put into service not earlier than 10 years. The article covers plants commissioned prior to 31.12.2011; however, this date can be postponed by two years by the decision of Council of Ministers. The discount for fees related to usage of Forestry or Treasury properties is increased from 50 % to 85 % and the validity of this discount is changed as the first 10 years of investment and operation instead of investment period. Access, connection rights and connection fees for the transmission system services are included into the coverage of these discounts.

Recently, some amendments have been made to EML and the Renewable Energy Law with the Law No: 5784 (enactment date: 09.07.2008). By the law, the limit for the maximum capacity of renewable energy plants in order to be granted with exemption from the licensing and company establishment obligations is increased from 200 kW to 500 kW. It is also possible to feed the excess electricity back to the grid. If there is more than one application for wind power plants in the same region, TEİAŞ organizes a tender among applicants in which the contestant offering to pay the highest contributions per kWh is determined and EMRA is informed of tender results.

In the Law No: 5784, some tax and fee exemptions are introduced for hydraulic plants. The hydraulic investments which are covered by Law No: 5346 and needs permission to use Treasury or state-owned assets for reservoirs are granted with the permission free of charge.

CHAPTER 10

EXAMINATION OF THE LEGISLATIVE FRAMEWORK IN TURKEY

10.1 EXAMINATION OF THE TURKISH ELECTRICITY MARKET AND THE ELECTRICITY MARKET LAW

A reform for the electricity market in Turkey was inevitable since there were many reasons forcing the implementation of market liberalization. Erdoğdu summarizes the reasons of electricity market reform as follows [196]:

- Rapid growth in electricity demand combined with the inability of the government to meet that demand through previous structure based on public or Treasury-guaranteed private investments,
- Foreign influence,
- Fiscal problems,
- Inadequate planning and low operational efficiencies in public sector,

- Possibility of monopoly abuse resulting in high tariffs

The EML met the unbundling, access to transmission and distribution networks, market opening and public service obligations criteria of the European Commission's Electricity Directive of 1996 (Directive 96/92/EC date: 19.12.1996). The degree of competition envisaged by the EML is more advanced than the Directive 96/92/EC [185].

Vertical unbundling of TEAŞ into three functional companies (EÜAŞ, TEİAŞ and TETAŞ responsible for generation, transmission and wholesale respectively) was implemented for unbundling of generation and transmission. The unbundling procedure should be followed by privatizations for the realization of a competitive market. Although a plan was presented in the "Strategy Document" for privatizations of distribution and generation, most of the privatizations have not been realized yet[66]. Metin Kilci, the president of Turkish Republic Prime Ministry Privatization Administration[67], has stated that most of the distribution regions will be privatized in 2009 [197]. The plants that will be privatized and are owned by EÜAŞ are grouped under 6 portfolios. The portfolios are given in Table 27.

After the enactment of the Law No: 5784 amending EML, the privatization procedure of power generation plants has gained acceleration. Advisor proposals for the privatization method are to be taken on 11.08.2008 [198]. However, some of the power plants with a total capacity of 7.5 GW approximately are excluded from privatization in order to avoid electricity price imbalances [199].

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[66] The tender phases of the first distribution privatizations were completed on 01.07.2008.

[67] Türkiye Cumhuriyeti Başbakanlık Özelleştirme İdaresi Başkanlığı (ÖİB)

Table 27 Electricity generation portfolios – Turkey [197]

Portfolio1	Portfolio2	Portfolio3
Adıgüzel (H)	Afşin-Elbistan-A (T)	Aliağa (T)
Aslantaş (H)	Afşin-Elbistan-B (T)	Gökçekaya (H)
Çatalağzı (T)	Altınkaya (H)	Kemerköy (T)
Hirfanlı (H)	Derbent (H)	Sarıyar (H)
Kapulukaya (H)	Hopa (T)	Yatağan (T)
Kesikköprü (H)	Karkamış (H)	Yenice (T)
Menzelet (H)		Yeniköy (T)
Seyitömer (T)		
Soma-A (T)		
Soma-B (T)		

Portfolio4	Portfolio5	Portfolio6
Ambarlı Fuel-Oil (T)	Almus (H)	Çamlıgöze (H)
Ambarlı Natural Gas (H)	Bursa Natural Gas (T)	Çan (T)
Hasan Uğurlu (H)	Çatalan (H)	Demirköprü (H)
Karacaören (H)	Kangal (T)	Doğankent (H)
Suat Uğurlu (H)	Kemer (H)	Gezende (H)
	Köklüce (H)	Hamitabat (T)
	Özlüce (H)	Kılıçkaya (H)
		Kürtün (H)
		Orhaneli (T)
		Tortum (H)
		Tunçbilek (T)

T: Thermal
H: Hydroelectric

The privatization process for generation and distribution utilities has not advanced as it was projected in the "Strategy Document". The "Strategy Document" should be revised and a well designed, flexible strategy that predicts various scenarios and develops plans for each scenario should be issued. The privatizations should be realized as soon as possible according to the revised scheme for liberalization of electricity market.

Liberalization in EU started in 1997 with the Directive 96/92/EC coming into force on 19 February 1997. The directive determined key issues for liberalization and some mechanisms for these issues. The mechanisms suggested for third party access was Negotiated Third Party Access (nTPA), Regulated Third party Access (rTPA) and Single Buyer Model (SBM). In the nTPA, network access prices are determined by a negotiation between “transmission and distribution companies” and “producers and generators”; whereas, in the rTPA, network access prices are determined merely by the regulatory authority. In the single buyer model, the only buyer of electricity is the wholesale companies. Later in 2001, an amendment for the directive was proposed and rTPA usage was suggested[68].

Turkey uses rTPA model for market access. Distribution and transmission companies are obliged to provide non discriminatory network access. According to EML, the proposed access tariffs are presented by the relevant companies to the Energy Market Regulatory Board before the end of October and the Board approves the tariff if they comply with the provisions of the applicable licenses before 31 December of the same year. The tariffs regulated and the regulation methods used are given in Table 28.

There are discussions on the tariff approaches applied. Although cost based tariff structure was adopted in the EML, later in the Strategy Document, a balancing mechanism was defined leading to a national tariff system. With Law No: 5496 coming into force, the national tariff system is legally implemented [201]. Law No: 5496 stated that the transition period in which National Tariff Balancing Mechanism will be used would end on 31.12.2010. However, with Law No: 5784 which came into force on 26.07.2008 extends the end of the transition period to 31.12.2012. It is claimed that the government disregarded the cost-

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[68] Information of EU liberalization progress are obtained from [185]

based pricing due to political reasons [179]. Necessary amendments to be made to the EML and relevant regulations are recommended by TÜSİAD for the realization of a market of bilateral contracts and ensuring the security of supply without additional formations which will have irreversible effects on market structure [202].

Table 28 Regulation methods – Turkey [200]

Activity	Regulated Price/Charge	Method
Transmission (TEIAS)	Connection Charge	Project based
	Use of System Price	Revenue Cap
	System Operation Price	Revenue Cap
Distribution	Connection Charge	Project based and Standard Connection Charge
	Use of System Price	Hybrid
Retail Service	Retail Service Price	Price Cap
Retail	Average Retail Price	Price Cap
Wholesale (TETAS)	Average Wholesale Price	Cost based

Since the National Tariff Balancing Mechanism uses cross subsidization, the relatively high costs in the distribution areas where the loss and illicit utilization (theft) is common are reflected not to this area but to overall country, thus, acting as an incentive and encouragement for the theft. Although the loss/theft ratio varies among cities according to TEDAŞ's statistics, in 2007, the average loss and illicit utilization percentage came out to be 14.8 % with a total cost of $ 2 billion 223.7 million excluding the VAT. Among those provinces, Mardin came out to be the region with the highest loss and illicit utilization percentage which is 79.23 % [203]. It is obvious that, the envisaged cross subsidization mechanism will neither work properly nor voluntarily after privatizations, since the distribution companies will reflect their costs related to expenditures including the loss and illicit utilization to the eligible and non-eligible consumers in their contracts and tariffs. Thus, it seems that the cost based tariffs cannot be sustained without any support mechanism to be put in force along with the privatization procedure [184]. The important thing here is that any support mechanism to be employed, due to social and political considerations in the regions with the low-income customers should not disrupt the market structure. Sevaioğlu suggests direct income payments from the Treasury in the areas where operational costs are high due to high loss and illicit utilization percentage [204]. Of course, these payments should be reduced in time progressively in order to reduce loss/theft ratios to a reasonable level.

The EML brought unbundling to the market and as a result, generation, transmission, distribution, wholesale, and retail activities were physically, administratively and financially separated from each-other. However, the approach in an amendment made to the EML in 2005 conflicts with the unbundling principle of EML. Article 22 of Law No 5398 (enactment date: 03.07.2005) states that private distribution companies, apart from distribution and retail activities, can establish their own generation facilities, provided that generation licenses are obtained and the accounts are separately recorded and buy electrical energy from the generation company or companies that are owned by them or that they are in affiliate relationships with. These restrictions are looser than those envisaged in the EML and vertical integration based on account separation between generation and distribution activities is permitted [184]. These types of approaches are strictly against the vertical unbundling principles to implement a liberalized electricity market structure as dictated in EU Directive 2003/54/EC.

Some upper limits for the market share of generation and wholesale trading companies are defined in the EML:

- The total electrical energy installed capacity owned by the legal entities through the generation companies they control cannot be more than 20 % of the published total installed electrical energy capacity of Turkey in the previous year.
- The total amount of electrical energy that is wholesaled by wholesale companies controlled by real persons or legal entities cannot be more than the total electrical energy consumed in the market in the previous year.

These clauses aim at preventing monopoly in the market.

Another discussion on EML is that there are conflicts between some of the actors in the energy market. It is stated in Article 4 of the EML that EMRA takes the opinion of the legal entities acting in the market and relevant utilities into consideration while preparing the regulations but the law does not call for explicit cooperation between the Turkish Competition Authority[69] (TCA) and EMRA [205]. Cetin and Oguz address a recent decision of TCA that it has no jurisdiction over the issue on TRT[70] levies and ask what happens if the two authorities reach different conclusions about price fixing, restrictions over competition or

[69] Rekabet Kurumu
[70] Turkish Radio Television (Türkiye Radyo Televizyon Kurumu)

the abuse of dominant position in electricity markets [179]. It is stated in a report[71] prepared by Ülgen et al. that the law should clearly spell out the division of tasks between the TCA and independent regulation authorities (IRAs). Another suggestion is to adopt a communiqué between TCA and EMRA to delineate the respective roles of the two authorities [205]. Either in the law or by a communiqué, a possible conflict between TCA and EMRA should be prevented.

There are also doubts on the independence of EMRA as an independent regulatory authority in terms of the attitude of the government against EMRA. Although EMRA was eager to introduce a cost-based regional pricing scheme, the government did not exhibit a support to this policy for implementation because of political concerns related particularly to the votes expected from the Southern-Eastern part of Turkey and budget constraints [179]. The political volition which comes into force by elections has difficulty in sharing its authority with an independent administrative authority administered by appointed persons [206]. Another example regarding this subject is the amendment of the EML by Law No: 5398. It was explained before how the unbundling principle is abandoned by this amendment and vertical integration was permitted. It seems that either EMRA is not consulted effectively on this issue or the change is made against the opinion of EMRA [184]. For establishing a healthy market mechanism, approaches that degrade the independency and authority of EMRA should be avoided.

Although the market reform is made in 2001, progress since then has been very slow [187]. The market balancing mechanism started in 2006

[71] Please see [187]

and the first privatizations in distribution regions started in 2008. As explained above, some of the amendments made to the EML like the permission of integration of generation and distribution; and some of the applications like National Tariff Balancing Mechanism have built serious and permanent barriers to the liberalization process. Political risks also built serious barriers to the development of energy sector and cause financial problems. Considering that investments with a total amount of $ 130 billion are needed in Turkish energy sector until 2020, assurance of permanent and sustainable financing mechanism is needed for investments that will ensure the development of the sector [18]. Decisive and coherent policies would reduce the risks. In order to achieve a rapid development in the energy sector, these barriers should be seriously analyzed and removed, privatization of utilities should be completed as a priority, a revised strategy document should be issued and necessary measures should be taken for the realization of the targets stated in the strategy document.

10.2 EXAMINATION OF THE RENEWABLE ENERGY LAW

The Renewable Energy Law states that the price that will be paid for electricity generated from renewable energy resources is the average wholesale electricity price of the previous year which is determined by EMRA. In 2007, with the enactment of the Law No: 5627 (enactment date: 18.04.2008), upper and lower limits are introduced, being 5 € Cents and 5.5 € Cents respectively. This may act as an incentive when the wholesale prices are lower than 5 € Cents. However, if the wholesale prices come out to be higher than 5.5 € Cents, this amendment would not be an effective incentive for renewable energy.

Fixed feed-in tariffs are the most dominant and effective instruments for the promotion of renewable electricity generation in the EU [207]. Thus, the fixed price mechanism implemented with the Renewable Energy Law is a positive development for Turkish renewable energy industry. However, maximum price setting should be abandoned.

Feed-in tariff mechanisms are more appropriate for Turkey since the cost based wholesale prices in the market is high. Feed-in tariff mechanisms allows the pay back of renewable energy investments to be achieved in a definite time with constant exchange rates. This type of approach protects the investors from the risks. On the other hand, a premium mechanism under which price consists of a premium paid over the market price may cause over-subsidization for Turkey as the wholesale prices high due to current energy policies. Therefore a premium mechanism is not considered as an appropriate scheme for Turkish electricity market.

It was stated in the Renewable Energy Law that the legal entities holding retail licenses are obliged to buy the electricity generated by the plants covered by the law until the plant completes the first seven years of operation period. This period is later changed to 10 years with the amendment made on the Renewable Energy Law in 2007. It is also stated that this application will cover plants commencing operation before 31.12.2011. The Council of Ministers is entitled to extend this date up to two years provided that the date is published in the official newspaper until 31.12.2009. Increasing the period from seven years to ten years will also have a positive effect on renewable energy considering the high pay-back periods of renewable energy plants. However, it seems that this period needs to be further extended especially for renewable technologies with high costs like solar PV plants. In Germany, this period is 20 years (except small hydroelectric power with 30 years and large hydroelectric power with 15 years) [207].

Each renewable energy resource has its own technical and financial characteristics and different approaches should be developed for different renewable energy resources. The fixed prices to be paid for electricity generated from renewable energy resources should be determined considering the generation costs of each renewable resource. Therefore, the principle of implementing identical prices for all renewable energy plants is definitely incorrect. Considering the high costs of solar PV plants, dissemination of solar power is not to be expected with a relatively low price of 5.5 € Cents.

Another point on the feed-in tariff scheme is that the tariffs should be adjusted depending on the location and capacity of the installation. There are some attractive locations, particularly in wind energy that a large number of companies apply for establishment and connection. The grid facilities, called ‘bay’s in these locations however, may always not be adequate in number to let all those companies to submit power. Hence some kind of tendering, i.e. competition-based elimination mechanism may be necessary in order to be able to select the most suitable connection requests. In this way, a more homogenous distribution with regard to plant size and location can be achieved [208]. To balance the development between the higher yield areas and lower yield areas and to support the development of renewable energy installations in all scales, pricing system should be flexible.

Apart from increasing the capacity of renewable energy, the incentives should also aim at reducing the costs of investment. The costs of investment for renewable energy plants decrease in time with the development in renewable technologies. To boost the technology development and cost reduction, the law should apply gradually decreasing pricing program in time. For example, in Germany, a photovoltaics installation set up in 2007 (on the roof of a house, with up to 30 kW capacity), the plant operator receives 49.21 Cents/kWh, whereas if the same installation were connected to the grid in 2008, the fee paid would decrease to 46.75 Cents/kWh [207].

There are other incentives offered by the Renewable Energy Law. Legal entities (public or private) installing renewable energy plants with a capacity of up to 1 MW are granted with the exemption of service charges for the preparation of final designing, planning, master planning, preliminary surveying and first auditing by Electrical Power Resources Survey and Development Administration (EİE) or State Hydraulic Works (DSİ) provided that the plant is installed for meeting their own energy needs. This incentive is important for supporting decentralized energy generation. The law states that:

> ***The heat energy needs of the residential areas in the boundaries of the province and municipalities in the regions with sufficient geothermal resources shall be met primarily by geothermal or solar thermal resources.*** [209]

However, in this statement it is not quite clear what is meant by the terms “sufficient” and “primarily”. The statement should be strengthened and clarified in order to increase the usage of geothermal and solar thermal resources for heating purposes.

Article 8 of the Renewable Energy Law includes some regulations on land usage by renewable energy plants. This article states that the lands which are under the possession of Forestry or Treasury or under the sovereignty of the State and will be used for renewable energy generation shall be permitted on the basis of its sale price, rented, given right of access or usage permission by Ministry of Environment and Forestry or Ministry of Finance. 50 % reduction of fees and exemption of some charges were also stated in the article. In 2007, this article was amended and the scope of this grant was enlarged and the lands to be used for access roads, and the power transmission line up to the network were included in the scope. The reduction rate was further increased to 85 % for the first 10 year of the plants commissioned by the end of 2011. In 2008, with the enactment of Law No: 5784, lands covered by the article is further expanded. Pastures under coverage of Pasture Law (Law No: 4342, enactment date: 25.02.1998), is registered officially in the name of Treasury and rented on the basis of its sale price or given right of access. The last commissioning date in order to be granted with 85 % reduction is extended to the end of 2012. In addition to the above incentives, permission for the usage of the lands under the possession of Treasury or under the sovereignty of the State as reservoir areas for hydroelectric plants is given to investors for free of charge.

There are some issues that necessitate the reevaluation of Article 8 in the Renewable Energy Law. This article gives permission for the usage of forests and pastures for building plants, access road and transmission lines up to the network. However, there are no specific conditions for the forests and pastures which may lead to misuse of those lands. Some exception terms should be included to this article.

For example, it is stated in Article 7 of the Mine Law (Law No: 3213, enactment date: 04.06.1985) that the status of national parks would be determined by the decision of the Council of Ministers. The article should be revised considering the environmental considerations. In his article written before the Renewable Energy Law was enacted, Çağlar[72] claims that the law would be clearly against the 45th and 169th articles of the constitution and contradictory to 17th article of the Forest Law (Law No: 6831) and 1st article of Pasture Law (Law No: 4342) if it was enacted[73].

It has already been stated in 6.3 that feed-in systems are more effective than quota systems. Therefore, the Renewable Energy Law in Turkey is considered to be the most suitable to the Turkish case, as it implements the pricing system instead of quota system. However, the prices offered for renewable energy is lower than the market prices and currently supports only wind energy since the costs of other renewable resources are higher than 5.5 € Cents. Therefore, the pricing system should be re-designed. A pricing mechanism similar to the mechanism used in Germany is strongly recommended as it provides balanced support for all resources which does not allow one of the resources be supported more depending on the characteristics of the resource and the location of the plant[74]. However, the prices offered to renewable energies should always be compared with the wholesale prices in the market, in terms of the newly developing conditions and be corrected if necessary, in order not to over-subsidize.

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[72] Please see [210]

[73] These articles briefly state that forests cannot be subject to right of access unless it is an absolute necessity and public benefit exists; government is responsible for preventing the misuse or destruction of pastures [210].

[74] The resource availability, therefore the yield varies depending on the location of the plant

10.3 EXAMINATION OF OTHER MECHANISMS AND RECENT DEVELOPMENTS

As stated earlier, apart from laws, there are several mechanisms that influence the operation of the market. Although the Council of Ministers or MENR issues primary legislations, i.e. laws, through Parliament, almost all of the secondary legislations that support the implementation of these laws are under responsibility of EMRA. Preparation and implementation of regulations on market operation (balancing and settlement, import-export, licensing, tariffs, etc.,) are under EMRA's responsibility. Supply and demand projections and maintaining supply demand balance on the other hand, is under the responsibility of TEİAŞ, a company reporting to Ministry. Hence it may clearly be stated that maintaining supply-demand balance is under the sole responsibility of MENR, not EMRA.

In the Electricity Market License Regulation issued by EMRA, it is stated that only 1 % of the license fee is to be collected from legal entities applying for a license for electricity generation from renewable or domestic natural resources. It was also stated that annual license fees would not be collected for the first eight years following the commissioning of the plant.

Again in the regulation, it is stated that retail license holders should purchase electricity from plants based on renewable energy resources provided that the price is less than or equal to the wholesale price of TETAŞ and any cheaper electricity is not available. This is important for the promotion of renewable energy plants which are not under coverage of the Renewable Energy Law.

With the amendment to the EML on July 2008, legal entities building renewable energy resource based or micro-cogeneration plants with a capacity of maximum 500 kW are exempted from the obligation of getting license from EMRA and allowed to feed the electricity remaining from their consumption to the grid. It was stated in the law that technical and financial methods and principles would be determined by a regulation which would be issues by EMRA. Recently, the Ministry of Energy and Natural Resources, announced that 10 % of energy efficiency would be achieved by installing 10 kW for every 1,000 employees. It is also planned that Turkish Public Housing Administration (TOKİ) would be obliged to install photovoltaic cells with a capacity of 2 kW and microgeneration and ground based heat pumps per residence [213]. Similar programs have been applied in many countries, some of them being very successful[75].

Recently, in California, a program called “California Solar Initiative Program” has been launched aiming at installation of solar facilities with a total capacity of 3,000 MW by 2017. The program handbook published by California Public Utilities Commission presents the detailed structure of the program. A comprehensive incentive system has been developed under the program offering performance based incentives ($/kWh) for plants with a capacity greater than or equal to 50 kW and expected performance based buydowns for plants with a capacity less than 50 kW. The incentives vary depending on the applicant (residential, commercial or governmental or non-profit organization) [176]. Similar approaches may be considered as secondary incentive mechanisms and applied in Turkey.

[75] After the introduction of “Renewable Energy Sources Act” in 2000, approximately $0.5/kWh is paid for solar electricity and 100,000 Roofs Program was so successful that German Government had to change the loan conditions offered under the program. [141]

CHAPTER 11

CONCLUSIONS

In order to make some recommendations to improve the legislative framework for supporting renewable energy development in Turkey, the frameworks in the EU and the USA have been examined. The effects of the frameworks on the renewable energy markets in both the EU and the USA have been analyzed. The reason why the EU and the USA have been chosen is that they share a large portion of world renewable energy generation and they use different supportive mechanisms. As of 2006, with an installed capacity of 75 GW, the EU shared more than one-third of total installed renewable electric power capacity worldwide which was 207 GW[76]. The total installed capacity in the USA in the same year was 26 GW [54].

According to REN21 report, the share of renewables in global final energy consumption and electricity generation in 2006 was 18% and 18.4 %, respectively. 13 % of renewable energy generation belongs to traditional biomass. Excluding large hydropower, the share of renewable electricity generation was only 3.4 % [54]. Approximately half

[76] Note that large hydropower capacity is not included

of the renewable energy (excluding combustible renewables and waste) in the world was generated in the OECD countries in 2004. The renewable energy generation has increased 2.3 % annually in the period 1971 - 2004 resulting in an increase of more than 100 %. This increase is close to the increase in the world's total primary energy supply (2.2 %), however the annual growth rates of technologies like solar, wind and geothermal have accounted for an average of 8.2 % in the same period. IEA projects an increase of approximately 120 % in renewable energy generation in the period 2004 – 2030, whereas the expected increase in new renewable technologies like wind and solar power are approximately 1,650 % and 5,850 %, respectively [5]. In 2007, excluding large hydropower, the estimated total installed renewable electricity generation capacity worldwide reached 240 GW with an increase of 50 % from the capacity in 2004. 95 GW of this capacity belongs to wind power installations. In 2007, $ 71 billion were invested in renewable energy, 47 % of which was for wind power and 30 % of which was for solar PV installations [54].

The share of renewable energy in the EU has been increasing. Currently, more than one-third of total installed renewable electric power capacity is in the EU [54]. The EU has been setting renewable energy targets since 1992. The target set in 1992 was 8 % renewable energy share by 2005. In 2008, the proposal for a new European directive sets a target of 20 % renewable energy share by 2020 and national targets for member states. This target could imply a renewable electricity share of approximately 34 % [54]. Currently Germany, Spain, Italy and France are the main actors in Europe's renewable energy market. As of 2006, the status of renewable energy market in the EU and top three market actors are given in Table 29.

Table 29 Renewable energy market status 2006 – EU [49]

2006	#1	#2	#3	EU
Wind (MW)	Germany	Spain	Denmark	EU total
	20,621.9	11,615.1	3,135.0	48,009.8
Solar PV (MWp)	Germany	Spain	Italy	EU total
	2,863.000	118.100	57.900	3,216.911
Solar Thermal (MWth)	Germany	Greece	Austria	EU total
	6,001.8	2,301.8	1,987.1	14,280.2
Hydropower (<10MW) (MW)	Italy	France	Spain	EU total
	2,467.8	2,049.0	1,816.0	11,723.7
Geothermal (MWe)	Italy	Portugal	France	EU total
	810.5	28	14.7	854.6
Geothermal (MWth)	Hungary	Italy	France	EU total
	725	500	307	2,236.3
Biogas (ktoe)	Germany	UK	Italy	EU total
	1,923.2	1,498.5	353.8	5,142.5
Biofuel (ktoe)	Germany	France	Italy	EU total
	1,866.139	419.100	177.071	2,992.942
Biomass (Mtoe)	France	Sweden	Germany	EU total
	9.609	8.943	8.816	62.413

As it is seen in Table 29, Germany is dominant in most of the renewable energy sectors. This situation is a result of the devoted renewable energy policies that have been developed in Germany since early 1990s. As of 2006, Germany is not only the leader of the EU in wind power and solar PV sectors but also the world leader [54].

Currently, most of the non-fossil based energy generation in Turkey is obtained from hydropower (mostly large hydropower), geothermal heat and biomass (mainly wood)[77] [9]. Other renewable resources like wind power and solar PV are also used, however their shares in total renewable energy generation are small compared to the shares of hydropower, geothermal heat and biomass.

[77] See Table 2 for expected renewable energy generation values for 2007

As of 2006, with an installed capacity of 6.6 GW_{th}, Turkey is the second in total installed solar hot water capacity after China which owns 67.9 GW_{th} of the total installed capacity of 105 GW_{th} worldwide [54]. According to EİE, the annual average solar radiation duration of Turkey is approximately 2,640 hours, which corresponds to an annual average radiation of 1311 kWh/m². Annual average radiation of Turkey ranges from 1120 kWh/m² in Black Sea Region to 1460 kWh/m² in South-East Region [19]. Although Turkey is one of the global leaders in solar hot water market, its solar PV market has not been developed yet. Currently, no large-scale solar PV installations have been realized and the total solar PV capacity installed is around 1 MW [19]. Although Germany has an annual average solar radiation of 1000 kWh/m² [138] which is lower than the average radiation in Turkey, Germany is the worldwide leader in solar PV sector with a capacity of 2,863 MW_p [49]. With the help of appropriate support mechanisms, Turkey can benefit its solar potential which is higher than that of Germany.

Turkey has a technical wind power potential of around 80 – 90 GW [231], [232]. Safely realizable wind power potential of Turkey is said to be 11 – 12 GW corresponding to an annual generation of 30 – 32 TWh/year. It should be kept in mind that although TEİAŞ uses a 5 % regional limit for connections of wind power stations to the grid, this limit has been realized as 20 % in the EU [233]. Considering the increasing power demand in Turkey and the technical potential of wind power, it is possible that the realizable potential in Turkey can increase in the near future. Currently, 333.35 MW of wind power capacity is installed in Turkey and with the projects that have obtained license, the expected cumulative wind power capacity in 2010 is 1546 MW [40]. Currently Germany is the world leader in wind power sector with a total installed capacity of over 20 GW and BWE (German Wind Energy Association) states that there is still an onshore potential for new installations of 10 GW and with re-installation of wind turbines it is possible to triple the yield and double the capacity [234]. Considering the technical wind power potential of Turkey and success of German support mechanism (feed-in laws), wind energy has the possibility of having a large share in Turkey’s energy market with the support of well-designed mechanisms.

According to EİE, as of February 2007, hydroelectric capacity of Turkey is 13,356 MW including the plants under construction with a capacity of 2,616 MW. However, 10,426 MW of the active installations are dam type hydroelectric plants and only 191 MW of these plants having reservoir volume which is smaller than 100 million m^3 are considered as renewable power plants under the Electricity Market License Regulation. Similarly, 121.2 MW of total installed run of river type power plants (314.27 MW) are not considered as renewable power plants as their capacity is over 50 MW. Although the capacity of plants that are considered as renewable are small, most of the plants that will be constructed in the future meets the renewable criteria that is determined by the Electricity Market License Regulation. Plants that are currently in various project phases and will be constructed in the future with a total capacity of 8,623 MW meet the renewable criteria [32]. Current electricity generation from hydroelectric plants that are active and under construction is around 60 TWh and the technical potential is around 216 TWh [32], [235].

Even though Turkey has one-eight of the world geothermal resources, Turkey only uses 30 MW_e of its electrical potential of 4.5 GW_e and 1.38 GW_{th} of its thermal potential of 31.1 GW_{th} [50], [51]. Especially considering that the geothermal heat potential of Turkey is approximately 30 MToe with an annual value of $ 29 billion, supporting the geothermal sector will decrease dependence on fuel import and strengthen the economic structure in Turkey [51].

As of 2006, the bioenergy usage in Turkey is approximately 5,000 ktoe. The share of bioenergy in total energy supply is around 15 %, however the share has been decreasing since 1998 and the deceasing trend is expected to continue in the future. According to MENR's projections, share of bioenergy will decrease to 5 % in 2020 [61], [62]. Unlike Turkey, bioenergy usage in the EU and world has been increasing. According to IEA's projections, approximately 40 % of increase in bioenergy usage is expected in the world between 2004 and 2030 [8]. According to AEBIOM's projections 144 % of an increase is expected in bioenergy usage in the EU [60]. Considering the agricultural potential (land, water and climate conditions), Turkey should set targets to increase the share of bioenergy in total energy supply.

Renewable energy not only provides sustainability in energy sector but also achieves this in an environmental-friendly way. Greenhouse gas emission is the major drawback of fossil based energy generation and since renewable resources are either carbon neutral or cause low emissions levels, they emerge as a strong alternative against fossil fuels. However, some characteristics of renewable resources prevent the diffusion of renewable energy in energy market. The intermittent profile of some renewable resources like solar or wind result in low capacity factors and they are not preferred by the grid operators because of their intermittent profile. Since the renewable resources are not available everywhere, the plants should be constructed on lands where the highest yield can be obtained. Depending on the land conditions, the construction costs may increase. Since it is not always possible to construct the renewable energy plant close to transmission lines, often new transmission lines should be constructed to connect the plants to the grid which increases the costs of renewable plants. Considering that the costs of renewable plants are higher than the conventional energy plants, the extra costs added due to tough land conditions and distance from the transmission lines acts as a barrier to the competitiveness of renewable energy in the market. As the costs of renewable energy are higher, they can not compete with conventional energy and penetrate into the energy market. The investment costs of natural gas plants are around 400 – 800 $/kW, and coal-fired plants are around 1000 – 1500 $/kW; whereas, the investment costs of solar PV and waste plants are around 3000 – 6000 $/kW and 3500 – 7000 $/kW, respectively. Onshore wind power plants have investment costs of around 1000 – 1500 $/kW, which makes wind energy more competitive compared to other renewable resources [87]. Without market penetration and increasing generation amounts, their costs do not decrease. Therefore without any support, renewable energy sector can not develop. This situation of renewable energy causes high investment risks which in return causes increased costs.

In order to support renewable energy development, some financial support mechanisms have been developed and used in both national and international levels. Various countries have adopted special laws to support renewable energy usage and renewable technology development. There are mainly 2 mechanisms to support renewable energy: feed-in (pricing) mechanisms and quota mechanisms. Each system imposes purchase obligations on network operators and introduces priority access of renewable power plants to the network. Under feed-in mechanisms, a price which is mostly over market rate and determined by the law is paid for renewable energy for a fixed period. The price may either be a fixed price or a premium paid over the market rate. These systems aim at reducing the renewable energy costs by reducing the risks through fixed payment guarantees. The share of renewable energy in the market is not limited and determined by the market conditions. Unlike feed-in systems, quota systems do not determine a fixed price for renewable energy. The renewable energy share that has to be achieved is determined by these systems and the price that will be paid for renewable energy is determined by the market conditions through tendering or certificate mechanisms. Quota systems aim at cost reduction in renewable energy generation through competition. Although quota systems are more appropriate for liberalized market structure as they provide competition, they have not proven as successful as feed-in systems. Especially quota systems using tendering mechanisms are criticized for forcing renewable energy providers to offer low prices in order to win the bids. In the UK, under the NFFO program, many projects which had won the bids were not realized and the program was abandoned by the government because of its ineffectiveness [118]. This situation causes a risk factor for the renewable investments and its effect is observed as high generation costs. Comparing the effects of feed-in and quota mechanisms, it is seen that the costs of electricity generation from wind power in countries using feed-in systems are lower than the costs in countries using quota systems. In a report prepared by BWE, it is demonstrated that wind power prices in countries with feed-in systems are mostly around 6 – 8 cents/kWh, whereas the wind power prices in countries with quota systems are around 10 – 15 cents/kWh. Apart from their efficiency, feed-in systems are also effective. In the same report, it is shown that the installed wind capacity per inhabitant is higher in countries using feed-in systems (8.47 – 50.47 W/inhabitant) than the countries using quota systems (3.83 - 4.05 W/inhabitant) [126]. Germany has achieved the world leadership in wind and solar PV sectors by its well-designed feed-in mechanisms even though there are other countries having better wind and solar resources. Other supportive mechanisms are generally used as secondary mechanisms. Tax incentives are mainly in the form of investment or production tax incentives and they reduce the costs of renewable energy generation. Some governments or international organizations provide grants for renewable energy projects. In order to increase investments in renewable energy, loans with low interest rates and long tenors (payback durations) are provided by national and international development banks. Governments or international organizations may also provide loan guarantees in order to reduce risks in renewable energy projects. Mechanisms developed under Kyoto Protocol support renewable energy through trade of emission reductions. White certificates provided for energy efficient projects also create financial support for renewable energy projects. Net-metering allows users to feed the excess electricity generation back to the grid and support distributed renewable energy generation. Carbon credits may be in the form of either allowances or offsets. Allowances are mandated under agreements like Kyoto Protocol, whereas offsets are additional emission reductions. Trade of emissions reduction creates financial support for renewable energy projects.

The EU has been setting renewable targets since 1992 and the share of renewable energy has been increasing since then. A specific, EU-wide support mechanism has not been determined; however, binding targets are set for all member states. In 2001, the Directive 2001/77/EC (directive on the promotion of electricity produced from renewable energy sources in the internal electricity market) came into force. The directive stated 12 % renewable energy and 22.1 % (later reduced to 21 %) renewable electricity share by 2010. The directive obliged member states to prepare necessary legislations to support renewable energy. The key principles of the legislations to be prepared are determined as objectivity, transparency and non-discrimination. Under the legislations network access of renewable plants should be guaranteed and access priority might be provided. Member states are also obliged to issue guarantee of origins which demonstrate the renewable resource used and date and place of renewable energy generation. Each member state was to choose the appropriate support mechanism. The progress should be monitored by the European Commission and reported. In the report issued in 2005, the feed-in systems used in Germany, Spain and Denmark were presented as the most effective systems for wind energy. It was also stated in the report that it was early for a union-wide framework and member states should prepare secondary legislations. In a report issued in 2007, it was stated that 10 % renewable energy share is expected by 2010 and 12 % target would not be met.

In the USA, mainly tax credits are used as an incentive mechanism in the federal level. Since the National Energy Act of 1978, various tax credit programs have been introduced. However, various expiration and extension of tax credits caused an unstable development in renewable energy sector in the USA. The Energy Policy Act of 2005 (EPACT 2005) in the USA set 7 % renewable electricity consumption target for the Federal government by 2013. Similar to the European directive, EPACT 2005 also introduced non-discriminatory rules. In addition to production tax credits, EPACT 2005 includes several grants and rebate programs. Apart from the federal legislations, states develop their own supportive mechanisms for renewable energy development. In order to demonstrate the state mechanisms in the USA, California has been examined. Considering the renewable electricity generation, California was the second in 2006 with a generation of 71.9 TWh [167]. Like many other states, California uses Renewable Portfolio Standards (RPS) which is a quota mechanism. A target of 20 % renewable electricity share was set for 2017 (later changed as 2010). In a report prepared for demonstrating the progress of RPS projects, it was stated that most of the projects were not realized because of risk factors, similar to the quota systems used in Europe.

Electricity market liberalization in Turkey started in 2001 with the enactment of the Electricity Market Law (EML). Later in 2005, the Renewable Energy Law was adopted and feed-in tariff system is introduced under this law. Renewable Energy Law includes necessary articles regarding the key principles stated in the EU directive (2001/77/EC). Even though a law to support renewable energy development has been adopted in Turkey, a renewable energy target and a roadmap has not been issued yet. In order to have a long term renewable energy policy, national energy policies should be revised in terms of renewable energies and a detailed policy report should be published. The absence of a national policy in Turkey for resolving the inconsistencies between the competition based market structure and incentives to be offered to renewable energy has lead to ambiguities. Thus, a national energy policy, including the renewable energy policy as an integral, consistent and essential part needs to be developed [18].

The policy documents should include short term and long term targets, strategies to reach the targets and precautions against possible problems that could arise during the implementation of strategies. For the determined energy policies to be successful the market should be monitored regularly and the reflections of the policies on the market should be analyzed periodically. If there are deviations in the tendency of the market towards the targets, additional measures should be taken immediately. If the target comes out to be unattainable, policies should be revised in terms of the new conditions in order not to fall behind the program. Renewable energy policies should also be developed for achieving sustainability in energy sector and reducing environmental effects of energy generation. However, policies for renewable energy should be discussed and developed separately until renewable energy becomes competitive.

Considering the renewable policies, it can be said that feed-in policy is an appropriate mechanism for Turkey since the electricity market has not been fully liberalized yet for a quota system to be implemented successfully. A feed-in policy with a premium mechanism would not be appropriate for the current Turkish electricity market since there is a possibility of over-subsidization due to high wholesale prices. Therefore, the Renewable Energy Law provides a useful mechanism for renewable energy sector in Turkey as it introduces a feed-in tariff system with fixed pricing. However, the law should be improved similar to the German feed-in law and these key features should be included in the new law:

- The tariffs should be adjusted such that the development of all renewable resources are supported (current prices of 5 - 5.5 € cents would only support wind energy)

- The cap over the prices to be paid for renewable energy should be removed and prices should be determined as minimum prices
- The tariffs should be adjusted such that they decrease in time in order to promote cost reductions in renewable energy sector
- The prices should be adjusted depending on the yield and size of the plants in order not to over-subsidize or under-subsidize some of the plants. The price scheme should provide a uniform support for renewable plants.

Considering the hydroelectric, wind, solar and geothermal potential of Turkey, the Renewable Energy Law should be detailed in order to support and benefit from all these resources. Renewable energy support is not only important for decreasing the harmful effects of energy generation to the environment, but also for decreasing the dependence on fuel import. In addition to using national resources instead of foreign resources, creating a renewable energy industry also has beneficial effects on state economy as employment in the sector increases. Germany created a huge renewable energy industry and the turnover of the renewable energy market in Germany has increased from € 7 billion in 2000 to € 24.6 billion in 2007. As of 2007, the number of employees working in renewable energy sector in Germany was 249,300 [236]. Therefore it is important that national energy policies should also include necessary regulations to support national renewable industry so as to design and manufacture renewable energy equipments like wind turbines or solar panels in Turkey.

The necessity of privatizations for market liberalization was emphasized in 10.1. The completion of privatizations is also necessary for the development of renewable energy in Turkey. As it is stated in a result of a study by Szabó and Waldau, ***"without liberalization, RE support would become too expensive and would prevent achievement of the established targets."*** [211]. Thus, privatization procedures for the generation and distribution sectors should be completed as soon as possible.

In 2007, EU leaders agreed on setting binding targets of 20 % renewable energy share in total energy mix, 20 % reduction in greenhouse gas emissions and 10 % share of biofuels in total transport fuels by 2020 [212]. There is also a target of improving the energy efficiency by 20 % in 2020. Considering the effort of Turkey for being a member of EU, Turkey should assign itself targets parallel to EU targets.

The 99 % discount on license fees and exemption from the annual license fees for the first 8 years of operation for renewable plants introduced in the Electricity Market License Regulation does not cover autoproducers and autoproducer groups. In order to support renewable energy generation at all levels, this and this type of other possible incentives should also be offered to autoproducers and autoproducer groups.

It was stated in 10.3 that some programs are applied in various countries to support the development of renewable energy. For the development of renewable energy in Turkey, a regulation on feeding back to the grid should be prepared and programs similar to "100,000 Roofs Program" and "California Solar Initiative Program" should be developed.

It is stated in the Renewable Energy Law that investments on energy generation facilities, procurement of domestically manufactured electromechanical systems and research and development in solar cells, concentrated collectors or biomass can benefit from the incentives determined by the Council of Ministers. The scope of the incentives provided for research and development should be expanded such that it covers all renewable energy technologies. Such incentives should be implemented as a priority.

To conclude, the privatizations of electricity utilities should be completed as a priority and the electricity market should fully be liberalized as soon as possible. A national renewable energy policy document aiming at increasing the share of renewable energy in Turkey's total energy supply should be issued and necessary measurements should be taken to realize the targets specified in this policy document. The feed-in tariffs should be detailed and special supportive programs should be designed so as to benefit from all of the renewable energy potential in Turkey. Necessary measures should be taken in order to design and manufacture renewable energy equipments in Turkey. Finally, special supportive programs should be introduced and the research and development budget for renewable energy should be increased.

REFERENCES

[1] IPCC, 2007: Climate Change 2007: Synthesis Report. Contribution of Working Groups I, II and III to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change [Core Writing Team, Pachauri, R.K and Reisinger, A. (eds.)]. IPCC, Geneva, Switzerland, 104 pp.

[2] J. Makower et al., “Clean Energy Trends 2007”, 2007

[3] http://www1.eere.energy.gov/site_administration/glossary.html#R accessed on 18.08.2008 at 22:07

[4] Intergovernmental Panel on Climate Change (IPCC), “Climate Change and Biodiversity”, 2002

[5] International Energy Agency (IEA), “Renewables in Global Energy Supply”, 2007

[6] BP, “BP Statistical Review of the World Energy – June 2008”, 2008,

[7] “Enerji ve Tabii Kaynaklar Bakanlığı”,“(1970-2007)B.üretim.xls”, 2007, http://www.enerji.gov.tr/istatistik_belge/(1970-2007)B.%C3%BCretim.xls accessed on 18.07.2008 at 14:51

[8] International Energy Agency (IEA), “World Energy Outlook 2006”, 2006

[9] "Enerji ve Tabii Kaynaklar Bakanlığı", 2007, http://www.enerji.gov.tr/istatistik_belge/enerji_istatistikleri/projeksiyonlar/B%C4%B0R%C4%B0NC%C4%B0L%20ENERJ%C4%B0%20KAYNAKLARI%20%C3%9CRET%C4%B0M%20HEDEFLER%C4%B0(Bin%20Tep).xls accessed on 18.07.2008 at 14:51

[10] M. Kaltschmitt et al., “Renewable Energy – Technology, Economics and Environment”, 2007

[11] World Energy Council (WEC), “2007 Survey of Energy Resources”, 2007

[12] Energy Information Administration (EIA), "International Energy Annual 2005", 2005, "International Energy Annual 2005_World Petroleum Consumption.xls" http://www.eia.doe.gov/pub/international/iealf/table12.xls accessed on 19.08.2008 at 06:58

[13] http://www.californiasolarcenter.org/history_solarthermal.html accessed at 15.07.2008 10:38

[14] National Renewable Energy Laboratory (NREL), "Solar Water Heating", 1996

[15] IEA Solar Heating & Cooling Programme, "Solar Heat Worldwide", 2008

[16] European solar Thermal Industry Federation (ESTIF), brochure"Solar Thermal - Technologies for sustainable heating and cooling", downloaded from http://www.erec.org/fileadmin/erec_docs/Documents/Publications/Brochure_ESTIF_24_01_06_FINAL.pdf on 15.07.2008 at 12:05

[17] European solar Thermal Industry Federation (ESTIF), "Solar Thermal Markets in Europe - Trends and Market Statistics 2007", 2008

[18] World Energy Council – Turkish National Committee, "2005-2006 TÜRKİYE ENERJİ RAPORU", 2007

[19] http://www.eie.gov.tr/turkce/gunes/tgunes.html accessed on 16.07.2008 at 23:24

[20] European Solar Thermal Technology Platform (ESTTP), "Solar Thermal Vision 2030", 2006

[21] Energy Information Administration (EIA), "International Energy Outlook 2007", 2007

[22] http://www1.eere.energy.gov/solar/sh_basics_space.html accessed on 21.08.2008 at 12:22

[23] http://www.rise.org.au/info/Tech/lowtemp/spacecooling.html accessed on 21.08.2008 at 12:22

[24] http://www.nrel.gov/csp/troughnet/power_plant_data.html accessed on 15.07.2008 at 21:06

[25] http://www.solel.com/solel_usa/ accessed on 15.07.2008 at 20:32

[26] European Commission "Concentrating Solar Power - From Research to Implementation", 2007

[27] ESTIA, IEA Solarpaces, Greenpeace, "Concentrated Solar Thermal Power – Now!", 2005

[28] http://www.stirlingenergy.com/downloads/30-June-2008-Application-Filed-for-Worlds-Largest-Solar-Energy-Generating-Plant.pdf accessed on 15.07.2008 at 20:40

[29] A. Leitner and B. Owens, "Brighter than a Hundred Suns: Solar Power for the Southwest", 2003

[30] EPIA and Greenpeace, "Solar Generation IV – 2007: Solar electricity for over one billion people and two million jobs by 2020", 2007

[31] EPIA, "Global Market Outlook for Photovoltaics until 2012 - Facing a Sunny Future", 2008

[32] http://www.eie.gov.tr/turkce/HESproje/EIE_HES_PROJE_LISTESI_2007.pdf accessed on 05.10.2008 at 17:29

[33] http://www1.eere.energy.gov/windandhydro/wind_history.html accessed on 16.07.2008 at 10:31

[34] "Developing Wind Power Projects – Theory & Practice" by Tore Wizelius, 2007, page7, Earthscan Publishing, London, Sterling, ISBN: 978-1-84407-262-0

[35] http://www.windpower.org/en/pictures/brush.htm accessed on 16.07.2008 at 10:31

[36] http://www.eere.energy.gov/windandhydro/windpoweringamerica/ne_history_grandpa.asp accessed on 16.07.2008 at 10:31

[37] European Wind Energy Association (EWEA), "Pure Power - Wind Energy Scenarios up to 2030", 2008

[38] GWEC and Greenpeace, “Global Wind Energy Outlook 2006”, 2006

[39] TEİAŞ, “Türkiye Elektrik Enerjisi 10 Yıllık Üretim Kapasite Projeksiyonu (2007 – 2016)”, 2007

[40] EPDK, “ruzgarprojeleriningelisimi.xls” 2008, downloaded from: http://www.epdk.gov.tr/lisans/elektrik/yek/ruzgarprojeleriningelisimi.xls accessed on 16.07.2008 at 19:57

[41] P. Breeze “Power Generation Technologies”, 2005, Elsevier

[42] http://www1.eere.energy.gov/windandhydro/hydro_history.html accessed on 17.07.2008 at 14:43

[43] “T.C. Enerji ve Tabii Kaynaklar Bakanlığı”, 2007, http://www.enerji.gov.tr/istatistik_belge/(1970-2007)K.G%C3%9C%C3%87.xls accessed on 17.07.2008 at 17:00

[44] http://www.therenewableenergycentre.co.uk/wave-and-tidal-power/ accessed on 17.07.2008 at 22:49

[45] K.Heinholt et al, “Landolt-Börnstein - Group VIII Advanced Materials and Technologies – Volume 3 Energy Technologies – Subvolume C Renewable Energy”, 2006

[46] IEA, “Renewable Energy: RD&D Priorities - Insights from IEA Technology Programmes”, 2006

[47] IEA statistics, http://www.iea.org/Textbase/stats/electricitydata.asp?COUNTRY_CODE=29 accessed on 19.07.2008 at 14:52

[48] Observ’er, “Geothermal Energy Barometer" under Eurobserv’er project, 2007

[49] Observ’er, “7e report EurObserv’ER - State of Renewable Energies in Europe” under Eurobserv’er project, 2007

[50] IEA, “Energy Policies of IEA Countries – Turkey 2005 Review”, 2005

[51] http://www.jeotermaldernegi.org.tr/turkiye%20i.htm accessed on 19.07.2008 at 20:12

[52] http://www.jeotermaldernegi.org.tr/projeksiyon%20i.htm accessed on 19.07.2008 at 19:55

[53] G. Boyle, "Renewable Energy Power for a Sustainable Future", (Glasgow: Oxford University Press, 2004)

[54] REN21. 2008. "Renewables 2007 Global Status Report" (Paris: REN21 Secretariat and Washington, DC:Worldwatch Institute). Copyright © 2008 Deutsche Gesellschaft für Technische Zusammenarbeit (GTZ) GmbH

[55] EUROSTAT, http://epp.eurostat.ec.europa.eu/extraction/evalight/EVAlight.jsp?A=1&language=en&root=/theme8/nrg/nrg_1071a accessed on 20.07.2008 at 15:49,

[56] European Commission, "Biomass Action Plan", 2005

[57] Observ'er, "Biofuels Barometer", 2008,

[58] Observ'er, "Biogas Barometer", 2008

[59] Observ'er, "Solid Biomass Barometer", 2008

[60] European Biomass Association (AEBIOM), "AEBIOM Newsteller September/October 2007", 2007

[61] "T.C. Enerji ve Tabii Kaynaklar Bakanlığı", 2007, http://www.enerji.gov.tr/istatistik_belge/enerji_istatistikleri/projeksiyonlar/B%C4%B0R%C4%B0NC%C4%B0L%20ENERJ%C4%B0%20KAYNAKLARI%20%C3%9CRET%C4%B0M%20HEDEFLER%C4%B0(Bin%20Tep).xls accessed on 16.07.2008 at 17:04

[62] "T.C. Enerji ve Tabii Kaynaklar Bakanlığı", 2007, http://www.enerji.gov.tr/istatistik_belge/enerji_istatistikleri/gecmis_yillar/B%C4%B0R%C4%B0NC%C4%B0L%20ENERJ%C4%B0%20KAYNAKLARI%20%C3%9CRET%C4%B0M%C4%B0(Bin%20Tep).xls accessed on 20.07.2008 at 22:30

[63] "International Energy Annual 2005" by EIA, 2005, "International Energy Annual 2005_World CO2 emission.xls",

http://www.eia.doe.gov/pub/international/iealf/tableh1co2.xls accessed on 21.07.2008 at 20:39

[64] Environmental Protection Agency (EPA), “EPA VIEWPOINT - Renewable Energy”, 2006

[65] REN21 Renewable Energy Policy Network. 2005. “Renewables 2005 Global Status Report.”Washington, DC:Worldwatch Institute.

[66] “Renewable Energy: Not Cheap, Not "Green"” by Robert L. Bradley Jr., 1997, Policy Analysis No.280

[67] IEA, “Benign Energy - The Environmental Implications of Renewables”, 1998

[68] European Comission Directorate-General for Research, “ExternE - Externalities of Energy - Methodology 2005 Update”, 2005

[69] European Wind Energy Association (EWEA), “Wind Energy – The facts – Executive Summary”, 2004

[70] T. Tsoutsos et al., “Environmental impacts from the solar energy technologies”, Energy Policy 33 (2005) 289–296

[71] J. Pershing, J. Mackenzie, “Removing Subsidies - Leveling the Playing Field for Renewable Energy Technologies”, 2004

[72] http://www.epa.gov/sustainability/basicinfo.htm#what accessed on 22.07.2008 at 13:03

[73] http://www.ntvmsnbc.com/news/452007.asp accessed on 22.07.2008 at 15:24

[74] http://www.worldwatch.org/node/4526 accessed on 22.07.2008 at 15:37

[75] NREL, “Concentrating Solar Power: Energy From Mirros”, 2001

[76] http://www.radikal.com.tr/haber.php?haberno=238074 accessed on 10.08.2008 at 22:12

[77] NREL, "Power Technologies Energy Data Book", 2006

[78] US DoE Energy Efficiency and Renewable Energy (EERE), “20% Wind Energy by 2030”, 2008

[79] IEA, “Experience Curves for Energy Technology Policy”, 2000

[80] European Commission Directorate-General for Research Sustainable Energy Systems, “Energy Scientific and Technological Indicators and References”, 2005

[81] “IEA Data Services”, 2008, http://wds.iea.org accessed on 23.07.2008 at 16:15

[82] United Nations Environment Programme and New Energy Finance Ltd., “Global Trends in Sustainable Energy Investment 2008”, 2008

[83] “Financing Renewable Energy” by KfW Bankengruppe, Group Communications, 2005

[84] United Nations Environment Programme(UNEP) Division of Technology, Industry and Economics, “Financial Risk Management Instruments for Renewable Energy Projects”, 2004

[85] Danish Wind Industry Association, http://www.windpower.org/en/tour/econ/guide.htm accessed on 13.08.2008 at 01:20

[86] “Final Report BIOHEAT Promoting Biomass heating in large buildings and blocks” by the Austrian Energy Agency (E.V.A.), 2003

[87] OECD, “Projected Costs of Generating Electricity 2005 Update”, 2005

[88] G. Klaassen et al, “The impact of R&D on innovation for wind energy in Denmark, Germany and the United Kingdom”, Ecological Economics 54 (2005) 227– 240

[89] EWEA, "wind energy -the facts", 2002

[90] European Commission Directorate-General for Research Sustainable Energy Systems, "Energy Scientific and Technological Indicators and References", 2005

[91] International Conference for Renewable Energies, “Policy Recommendations for Renewable Energies”, Bonn, 2004

[92] Federal Ministry for the Environment, Nature Conservation and Nuclear Safety, “Indicative target of the Federal Republic of Germany for the consumption of electricity produced from renewable energy sources in 2010 and measures to achieve this target”, 2003

[93] IEA, “Renewable Energy – Market and Policy Trends in IEA Countries”, 2004

[94] J. L. Sawin, “National Policy Instruments - Policy Lessons for the Advancement & Diffusion of Renewable Energy Technologies Around the World”, 2004

[95] US DoE EERE, http://www.eere.energy.gov/states/alternatives/govt_purchase_prog.cfm accessed on 25.07.2008 at 00:11

[96] U.S. Agency for International Development, “Best Practices Guide: Economic & Financial Evaluation of Renewable Energy Projects”, 2002

[97] http://web.worldbank.org/WBSITE/EXTERNAL/TOPICS/EXTENERGY/EXTRETOOLKIT/0,,contentMDK:20755044~menuPK:2069911~pagePK:64168445~piPK:64168309~theSitePK:1040428,00.html accessed on 28.07.2008 at 16:48

[98] http://www.gefweb.org/ accessed on 28.07.2008 at 16:53

[99] World Bank, World Bank Group Brochure, 2007

[100] http://web.worldbank.org/WBSITE/EXTERNAL/TOPICS/EXTENERGY2/0,,contentMDK:21456403~menuPK:4140690~pagePK:210058~piPK:210062~theSitePK:4114200,00.html accessed on 28.07.2008 at 17:49

[101] http://web.worldbank.org/WBSITE/EXTERNAL/NEWS/0,,contentMDK:21826304~pagePK:34370~piPK:34424~theSitePK:4607,00.html accessed on 28.07.2008 at 17:32

[102] KfW, “Sustainability Report 2006”, 2006

[103] http://www.kfw-foerderbank.de/EN_Home/Umweltschutz/index.jsp accessed on 28.07.2008 at 19:43

[104] http://www.eib.org/about/press/2008/2008-013-eib-renewable-energy-loans-top-eur-2-billion-in-2007.htm accessed on 27.07.2008 at 21:25

[105] E. Martinot, F. Beck, “Renewable Energy Policies and Barriers”, 2004, Academic Press/Elsevier Science

[106] http://www.adb.org/Documents/News/1996/nr1996108.asp accessed on 28.07.2008 at 21:58

[107] Institute of Energy, Viet Nam, “Bagasse and other Biomass-fired Power Plant in Ben Tre Sugar Company - A Pre-Feasibility Study Report”, 2006

[108] Institute of Energy, Viet Nam, “Demonstration of Rice Husks-fired Power Plant in An Giang Province - A Pre-Feasibility Study Report”, 2004

[109] United Nations Development Program (UNDP) Country Office for Uzbekistan, “The Outlook for Development of Renewable Energy in Uzbekistan”, 2007

[110] e-mail from monika.paplaczyk@triodos.co.uk on 31.07.2008 at 16:49

[111] “List of terms and conditions for new commitments under the loan programmes of KfW Mittelstandsbank (KfW SME bank) and KfW Förderbank (KfW promotional bank) applicable from: 12.06.2008”, e-mail from infocenter@kfw.de on 01.08.2008 at 15:17

[112] http://www.bba.org.uk/content/1/c6/01/44/06/Aug08.xls accessed on 13.08.2008 at 08:58

[113] Personal interview with Caner Işlak on 06.08.2008

[114] COMMISSION OF THE EUROPEAN COMMUNITIES “COMMISSION STAFF WORKING DOCUMENT The support of electricity from renewable energy sources Accompanying document to the Proposal for a DIRECTIVE OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL on the promotion of the use of energy from renewable sources”, SEC(2008) 57, 2008

[115] A. Klein et al., “Evaluation of different feed-in tariff design options - Best practice paper for the International Feed-in Cooperation”, 2006, available at: http://www.feed-in-cooperation.org/images/files/best_practice_paper_final.pdf

[116] GWEC, “Global Wind 2007 Report”, 2008

[117] F. Rosillo-Calle, L. A. B. Cortez, “Towards ProAlcool II—a review of the Brazilian bioethanol programme”, Biomass and Bioenergy Vol. 14, No. 2, pp. 115–124, 1998

[118] EWEA, “Support Schemes for Renewable Energy - A Comparative Analysis of Payment Mechanisms in the EU”, 2005

[119] R. Wiser et al. “Renewable Energy Policy Options for China: A Comparison of Renewable Portfolio Standards, Feed-in Tariffs, and Tendering Policies”, 2002

[120] N. I. Meyer, “European schemes for promoting renewables in liberalised markets”, 2003, Energy Policy 31 (2003) 665–676

[121] I. de Lovinfosse, F. Varone “Renewable electricity policies in Europe: patterns of change in the liberalised market”, 2002

[122] European Photovoltaic Industry Association (EPIA), “Supporting Solar Photovoltaic Electricity, An Argument for Feed-in Tariffs”, 2008

[123] P. Bertoldi, S. Rezessy, "Tradable certificates for energy savings (white certificates)", European Commission Joint Research Centre, 2006

[124] http://www.recs.org/recs/history.asp accessed on 30.07.2008 at 16:20

[125] RECS International, “Annual Report 2007”, 2008

[126] German Wind Energy Association (BWE), “Minimum price system compared with the quota model – which system is more efficient? - Background information”, 2005, available at http://www.wind-energie.de/fileadmin/dokumente/Hintergrundpapiere/hintergrund_english/Background_Systeme_eng.pdf accessed on 12.08.2008 at 13:55

[127] A. Held et al., “Feed-In Systems in Germany, Spain and Slovenia - A comparison”, 2007

[128]
http://www.dsireusa.org/library/includes/incentivesearch.cfm?Incentive_Code=US02F&Search=TableType&type=Corporate&CurrentPageID=7&EE=1&RE=1 accessed on 30.07.2008 at 19:05

[129] D. Clement et al., "International Tax Incentives for Renewable Energy: Lessons for Public Policy", 2005, Draft Report prepared for Energy Foundation China Sustainable Energy Program

[130]
http://www.ucsusa.org/clean_energy/clean_energy_policies/production-tax-credit-for-renewable-energy.html accessed on 30.07.2008 at 19:36

[131] American Wind Energy Association (AWEA), "Wind Power Outlook 2008", 2008

[132]
http://www.dsireusa.org/library/includes/seeallincentivetype.cfm?type=Property&currentpageid=7&back=fintab&EE=1&RE=1 accessed on 30.07.2008 at 20:29

[133]
http://www.canada.com/vancouversun/news/story.html?id=ecea1487-507c-43ef-ab88-5a972898e0b7&k=38130 accessed on 30.07.2008 at 21:33

[134] Tampier, Martin and Jean-Philippe Beaulieu. Renewable Energy Financing Case Studies: Lessons to be Learned from Successful Initiatives. Commission for Environmental
Cooperation, Montreal. 2006

[135]
http://www.bafa.de/bafa/de/energie/erneuerbare_energien/index.html accessed on 31.07.2008 at 00:27

[136]
http://www.dsireusa.org/library/includes/incentivesearch.cfm?Incentive_Code=US05F&Search=TableType&type=Grant&CurrentPageID=7&EE=1&RE=1 accessed on 31.07.2008 at 00:40

[137]
http://www.dsireusa.org/library/includes/incentivesearch.cfm?Incentive_

Code=NY43F&Search=TableType&type=Grant&CurrentPageID=7&EE=1&RE=1 accessed on 31.07.2008 at 00:39

[138] S. Hack, “International Experiences with the Promotion of Solar Water Heaters (SWH) at Household-level”, 2006

[139] Presentation – “UNEP Renewable Energy Financing Examples” by Jyoti Prasad Painuly, 2008, presented in “Regional Workshop on Renewable Energy in the Carpathians” in May 6-7, 2008, in Lviv Ukraine, downloaded from http://www.unido.org/fileadmin/media/documents/pdf/Energy_Environment/carpathians_session3_3.pdf accessed on 31.07.2008 at 15:17

[140] M. Ruchser, “Financial report of Germany. Ener–IURE Project Phase III, Analysis Of The Legislation Regarding Renewable Energy Sources in The EU Member States” 2002

[141] A. Goetzberger, V.U. Hoffmann, "Photovoltaic Solar Energy Generation", 2005

[142] http://www.lgprogram.energy.gov/features.html accessed on 31.07.2008 at 16:26

[143] EIA, “Annual Energy Outlook 2007 With Projections to 2030”, 2007

[144] http://www.energy.gov/news/6152.htm accessed on 31.07.2008 at 17:18

[145] http://www.miga.org/sectors/index_sv.cfm?stid=1534&sectid=22 accessed on 31.07.2008 at 17:04

[146] http://www.miga.org/projects/index_sv.cfm?pid=759 accessed on 31.07.2008 at 17:08

[147] A. Michaelowa et al., "Clean Development Mechanism and Joint Implementation - New Instruments for Financing Renewable Energy Technologies", 2004

[148] http://uk.reuters.com/article/bankingfinancial-SP/idUKL1722627220080717 accessed on 31.07.2008 20:38

[149] Federal Environmental Agency (Umweltbundesamt), “Promoting Renewable Energy Technologies in Developing Countries through the Clean Development Mechanism”, 2007

[150] “EuroWhiteCert Project Brochure - White Certificates: concept and market experiences” downloaded at http://www.ewc.polimi.it/documents/EWC_brochure.pdf on 31.07.2008 at 23:20

[151] L. Mundaca “Markets for energy efficiency: Exploring the implications of an EU-wide ‘Tradable White Certificate’ scheme”, 2008, Energy Economics – Article in Press

[152] http://www.dsireusa.org/library/includes/type.cfm?Type=Net&Back=regtab&CurrentPageID=7&EE=1&RE=1&Search=TableType accessed on 01.08.2008 at 00:22

[153] EIA, “Green Pricing and Net Metering Programs, 2006”, 2008

[154] Commission of the European Communities, “Specific actions for greater penetration for renewable energy sources ALTENER”, 1992, COM(92) 180

[155] European Commission, “Towards a European strategy for the security of energy supply”, 2000

[156] Commission of the European Communities, “Communication from the Commission to the Council and the European Parliament - The share of renewable energy in the EU”, 2004, COM(2004) 366

[157] http://epp.eurostat.ec.europa.eu/tgm/web/download/Eurostat_Table_tsdcc110FlagDesc.xls accessed on 16.08.2008 at 12:22

[158] http://epp.eurostat.ec.europa.eu/tgm/web/download/Eurostat_Table_tsdcc330FlagDesc.xls accessed on 16.08.2008 at 12:29

[159] EIA, “Renewable Energy 2000: Issues and Trends”, 2001

[160] EIA, “The Changing Structure of the Electric Power Industry, 1970-1991”, 1993

[161] EIA "International Energy Outlook 1995", 1995

[162] http://www.awea.org/aweapriv/AWEA_Summary_of_Energy_Policy_Act.html accessed on 17.08.2008 at 08:53

[163] http://www.eei.org/newsroom/energy_news/federal_rps.htm accessed on 17.08.2008 at 12:52

[164] http://www.ucsusa.org/clean_energy/clean_energy_policies/res_campaign.html accessed on 17.08.2008 at 12:54

[165] EIA, "Electric Power Annual 2006", 2007

[166] California Energy Commission 2007, 2007 Integrated Energy Policy Report, CEC-100-2007-008-CMF

[167] EIA, "Renewable Energy Consumption and Electricity Preliminary 2007 Statistics", 2008, available at: http://www.eia.doe.gov/cneaf/alternate/page/renew_energy_consump/reec_080514.pdf accessed on 17.08.2008 at 13:57

[168] http://www.energy.ca.gov/renewables/history.html accessed on 17.08.2008 at 14:45

[169] SB 90 date: 12.10.1997 available at http://www.energy.ca.gov/renewables/documents/sb90_bill_19971012_chap.html accessed on 17.08.2008 at 15:08

[170] SB 1078 available at http://www.energy.ca.gov/portfolio/documents/SB1078.PDF accessed on 17.08.2008 at 16:33

[171] SB 107 available at http://info.sen.ca.gov/pub/05-06/bill/sen/sb_0101-0150/sb_107_bill_20050120_introduced.pdf accessed on 17.08.2008 at 16:42

[172] State of California, "Energy Action Plan", 2003

[173] State of California, "Energy Action Plan II – Implementation Roadmap for Energy Policies", 2005

[174] California Public Utilities Commission (CPUC), “Renewable Portfolio Standard Quarterly Report July 2008”, 2008

[175] http://www.gosolarcalifornia.org/csi/index.html accessed on 17.08.2008 at 18:18

[176] California Public Utilities Commission, “California Solar Initiative Program Handbook January 2008”, 2008

[177] California Public Utilities Commission (CPUC), “California Solar Initiative California Public Utilities Commission Staff Progress Report”, 2008

[178] California Energy Commission, “Electricity Generation by Resource Type (1983-2006)”, available at http://energyalmanac.ca.gov/electricity/ELECTRICITY_GEN_1983-2006.XLS accessed on 17.08.2008 at 23:58

[179] T. Cetin and F. Oguz “The politics of regulation in the Turkish electricity market” by, 2006, Energy Policy 35 (2007) 1761–1770

[180] E. Erdogdu, "Regulatory reform in Turkish energy industry: An analysis", 2006, Energy Policy 35 (2007) 984–993

[181] H. K. Ozturk at al., " Past, present and future status of electricity in Turkey and the share of energy sources", 2004, Renewable and Sustainable Energy Reviews 11 (2007) 183–209

[182] A. Hepbaşlı “Development and restructuring of Turkey’s electricity sector: a review”, 2004, Renewable and Sustainable Energy Reviews 9 (2005) 311–343

[183] Central Bank of the Republic of Turkey (Türkiye Cumhuriyeti Merkez Bankası, TCMB), "The Impact Of Globalization On The Turkish Economy", 2002, available at http://www.tcmb.gov.tr/yeni/evds/yayin/kitaplar/global.doc accessed on 04.08.2008 at 14:39

[184] I. Atiyas "Elektrik Sektöründe Serbestleşme ve Düzenleyici Reform", 2006, TESEV YAYINLARI

[185] I. Atiyas, M. Dutz, "Competition and Regulatory Reform in the Turkish Electricity Industry", 2004

[186] http://www.teias.gov.tr/istatistikler/tarihce(turk).htm accessed on 04.08.2008 at 00:21

[187] Centre for Economics and Foreign Policy Studies (EDAM) and Centre for European Policy Studies (CEPS), "Second Generation Structural Reforms: De-Regulation and Competition in Infrastructure Industries", 2007

[188] Bagdadioglu, N., Odyakmaz, N., Turkish electricity reform, Utilities Policy (2008), doi:10.1016/

[189] Ö. Özkıvrak, “Electricity restructuring in Turkey”, 2004, Energy Policy 33 (2005) 1339–1350

[190] T.C. Sayıştay Başkanlığı, "Yap-İşlet-Devret ve Yap-İşlet Modeli Kapsamında Yaptırılan Enerji Projeleri Hakkında Sayıştay Raporu (Enerji Raporu) Hakkında Özet Bilgi", 2004, available at http://www.sayistay.gov.tr/rapor/rapor4a.asp?id=48 accessed on 02.08.2008 at 20:37

[191] http://www.teias.gov.tr/ accessed on 05.08.2008 at 21:13

[192] Republic of Turkey Prime Ministry Privatization Administration “Privatization of Turkey’s Electricity Distribution Industry, Teaser”, 2008, available at http://www.oib.gov.tr/portfoy/TEDAS%20Teaser_ENG_v3.pdf accessed on 21.08.2008 at 10:50

[193] http://www.oib.gov.tr/program/uygulamalar/2008_uygulamalar/2008_companies_at_tender_phase.htm accessed on 06.08.2008 at 11:59

[194] http://www.epdk.gov.tr/duyuru/elektrik/duyuruyenilebilir.html accessed on 06.08.2008 at 21:27

[195] “Law on Utilization of Renewable Energy Resources for the Purpose of Generating Electrical Energy” available at: http://www.epdk.gov.tr/mevzuat/diger/yenilenebilir/reseng.doc accessed on 06.08.2008 at 17:00

[196] “Energy Market Reforms in Turkey: An economic Analysis” by Erkan Erdoğdu, 2005, Msc. Dissertation, University of Surrey

[197] Referans Gazetesi, 03.01.2008, http://www.referansgazetesi.com/haber.aspx?HBR_KOD=87319&KTG_KOD=147 accessed on 08.08.2008 at 09:56

[198] http://www.msnbc-ntv.com.tr/news/454837.asp accessed on 08.08.2008 at 10:32

[199] http://uk.reuters.com/article/oilRpt/idUKL1887222620080718 accessed on 08.08.2008 at 09:02

[200] EPDK, "Electricity Market Implementation Manual", 2003

[201] O. Sevaioğlu, "Dağıtımda hizmet ve enerji bedelleri", 2006, http://www.globalenerji.com.tr/yaz72-230003-102,26@2300.html accessed on 09.08.2008 at 21:18

[202] TÜSİAD, "Elektrik Piyasasının Serbestleşmesi ve Arz Güvenliğinin Sağlanması için Öneriler – Tüsiad Enerji Stratejisi Dizisi-1", 2008

[203] http://www.ntvmsnbc.com/news/450024.asp accessed on 09.08.2008 at 22:46

[204] O. Sevaioğlu, "Ulusal ve Maliyet Esaslı Tarifeler", no date, available at http://www.eee.metu.edu.tr/~sevaiogl/Maliyet%20Esasli%20Tarifeler.htm accessed on 10.08.2008 at 00:10

[205] E. S. Guney, "Restructuring, Competition, and Regulation in the Turkish Electricity Industry", 2005

[206] O. Sevaioğlu, "Phoenix'i beklerken", no date, Global Enerji, Issue: 32, available at http://www.globalenerji.com.tr/yaz72-230004-15,32@2300.html accessed on 10.08.2008 at 16:31

[207] Federal Ministry for the Environment, Nature Conservation and Nuclear Safety (BMU), "EEG – The Renewable Energy Sources Act The success story of sustainable policies for Germany", 2007

[208] M. Ragwitz, C. Hube "Feed-In Systems in Germany and Spain and a comparison", 2005

[209] "Law on Utilization of Renewable Energy Resources for the Purpose of Generating Electrical Energy" available at

http://www.epdk.gov.tr/mevzuat/digger/yenilenebilir/reseng.doc last accessed on 12.08.2008 at 15:49

[210] Y. Çağlar, “Kaş Yaparken Göz Çıkarmak”, 2008, Cumhuriyet Energy, issue 5, available at http://www.emo.org.tr/resimler/ekler/e7e22b67764ffd7_ek.pdf?dergi=520 accessed on 11.08.2008 at 11:16

[211] S. Szabó and A. J.-Waldau, “More competition: Threat or chance for financing renewable electricity?”, 2008, Energy Policy 36 (2008) 1436–1447

[212] European Commission, “European Commission - Energy - Energy for a Changing World”, available at http://ec.europa.eu/energy/energy_policy/index_en.htm accessed on 12.08.2008 at 20:09

[213] Vatan Newspaper, 29.07.2008, available at http://w9.gazetevatan.com/haberdetay.asp?Newsid=191329&Categoryid=1 accessed on 13.08.2008 at 13:33

[214] DPT, "Dokuzuncu Kalkınma Planı (2007-2013) - MADENCİLİK - Özel İhtisas Raporu", 2007, available at http://ekutup.dpt.gov.tr/madencil/oik690.pdf accessed on 19.07.2008 at 19:10

[215] https://www.theice.com/trading_records.jhtml accessed on 06.09.2008 at 18:30

[216] International Atomic Energy Agency, “Chernobyl’s Legacy: Health, Environmental and Socio-Economic Impacts and Recommendations to the Governments of Belarus, the Russian Federation and Ukraine”, 2006

[217] http://www.chernobyl.info/index.php?userhash=37334580&navid=19&lid=2 accessed on 25.08.2008 at 21:20

[218] European Commission, “External Costs Research results on socio-environmental damages due to electricity and transport”, 2003

[219] W. Krewitt, B. Schlomann, “External costs of electricity generation from renewable energies compared to electricity generation from fossil energy sources - Executive Summary -”,2006

[220] http://www.epa.gov/airmarkt/trading/basics.html accessed on 28.08.2008 at 10:38

[221] Clean Air – Cool Planet, A Consumers' Guide to Retail Carbon Offset Providers, 2006

[222] http://www.carbonzero.ca/learn/whatisanoffset accessed on 30.08.2008 at 14:59

[223] The World Bank, State and Trends of the Carbon Market 2008, 2008

[224] http://www.nytimes.com/2007/11/02/us/politics/04web-redburn.html?_r=2&oref=slogin&oref=slogin accessed on 31.08.2008 at 14:49

[225] T.Shrum, Greenhouse Gas Emissions: Policy and Economics, 2007

[226] http://online.wsj.com/article/SB117086898234001121.html?Mod=home_whats_news_us accessed on 31.08.2008 at 18:07

[227] http://www.pewclimate.org/press_room/opinion_editorials/oped_miamih07122007 accessed on 28.08.2008 at 11:36

[228] http://www.carbontax.org/issues/carbon-taxes-vs-cap-and-trade/ accessed on 31.08.2008 at 14:47

[229] R.N.Stavins , A U.S. Cap-and-Trade System to Address Global Climate Change, 2007

[230] L. H. Goulder, W. A. Pizer, The Economics of Climate Change, 2006

[231] A. Hepbasli, O. Ozgener, A review on the development of wind energy in Turkey, 2003, Renewable and Sustainable Energy Reviews, 8 (2004) 257–276

[232] M. A. Ozgur, Review of Turkey's renewable energy potential, 2008, Renewable Energy 33 (2008) 2345–2356

[233] A. Akalın, Otomobilde dört tekerlek var diye, dört stepne bulundurmuyoruz!, 2005, Enerji, http://www.ruzgarenerjisibirligi.org.tr/yayinlar/bilimsel/tureb/20-01-2006-Akalin.htm accessed on 05.10.2005 at 11:20

[234] German Wind Energy association (BWE), Wind energy – an energy source with a fantastic future, 2008-10-05

[235] EİE, Türkiye'nin Hidroelektrik Enerji Potansiyeli, downloaded from http://www.eie.gov.tr/turkce/HESproje/turkeyhidro.doc accessed on 05.10.2008 at 18:06

[236] BMU, Development of Renewable Energies in Germany in 2007, 2008