MSc Program

Renewable Energy in Central and Eastern Europe

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# Renewable Energy Potentials of Turkey: A focus on Solar Energy

A Master's Thesis submitted for the degree of
"Master of Science"

Supervised by
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# Affidavit

I, **Ali Sina User**, hereby declare

1. that I am the sole author of the present Master's Thesis, "Renewable Energy Potentials of Turkey: A focus on Solar Energy", 67 pages, bound, and that I have not used any source or tool other than those referenced or any other illicit aid or tool, and
2. that I have not prior to this date submitted this Master's Thesis as an examination paper in any form in Austria or abroad.

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## Abstract

Solar energy, like many other RES sources in Turkey, has a great deal of potential for this Mediterranean country. While not a priority, it is estimated that a potential 380 billion kWh/year could be generated using this resource. If utilized in a proper fashion, the country could be responsible for much more of its domestic energy demands and discontinue its reliance on foreign energy sources. The paper's primary purpose is to examine the solar energy potential of the country and analyze how this resource is being utilized in the construction industry as well as how this RES is being used to meet Turkey's increasing energy demands. By using contemporary sources to highlight the significance that renewables, in particular solar energy, have to the Turkish energy supply and demand matrix, a better understanding of the RES status in Turkey can be understood. The procedure for this paper consisted of three major steps: firstly, data collection, secondly, developing a research question and thirdly, targeted research based on recent solar developments in Turkey. With this extensive research the connection between Turkish energy sector needs and RES sources available can be seen.

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## List of Abbreviations

CSP: Concentrating Solar Power

EBRD: European Bank For Reconstruction and Development

EIE: Electric Works Office

EU: European Union

ITU: Istanbul Technical University

PV: Photovoltaic

RES: Renewable Energy Sources

TEIAS: Turkish Electricity Transmission Company

TURSEFF: Turkey Sustainable Energy Financing Facility

TWh: Terawatt hours per year

US: United States

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# CHAPTER 1: INTRODUCTION

This section of the paper will present the background to the paper outlining the foundational topics such as the paper's motivation, objectives, primary literature as well as structure.

## 1.1 Motivation

The motivation for this paper is based on economic, political and energetic concerns that are facing Turkey. The country has seen incredible growth in the past two decades and while it has been traditionally known for industries such as agriculture or textiles, it has recently begun to make serious investments into the construction industry. In 2009, the construction sector was responsible for nearly 4% of GDP and for employing over one million people. Moreover Turkey has begun to develop its renewable energy sector. The country's steady increase to regional prominence has been fueled by many factors causing significant growth in the construction industry.

## 1.2 Core Objectives

The primary purpose of this research is to use contemporary sources to analyze the significance that renewables and in particular, solar energy, has to the Turkish energy supply and demand matrix. The secondary purpose is to use this background information to understand how solar energy products are becoming increasing a part of the Turkish construction industry.

## 1.3 Primary Literature

The increased demand for energy in Turkey has resulted in a serious energy deficiency for the country and has meant the overall importation of nearly 70% of its energy resources. In turn the importation of so much energy means that the country's growth as well as is ability to grow its economy is incumbent on energy resource acquisition from abroad. The Turkish government has realized the significant impact that imported energy may have on the overall health of the economy. In recent years, with the economic downturn the government has come to the realization that domestically-produced energy may in fact help to alleviate many of the problems of that imported energy can create. When we consider all of these factors together it is obvious that

there is a clear need for such research that analyzes the solar energy sector and its past, present and future relationship with the construction industry. By evaluating both of these sectors together, recommendations for the future can be made.

Turkey, while blessed with a variety of different revenue producing sectors such as agriculture and tourism, is certainly challenged when it comes to energy resources. In fact the Turkish energy sector has faced serious challenges for quite some time because of the lack of traditional energy resources such as fossil fuels. In its attempt to compete in the global market place, Turkey has essentially fought a loosing battle because the energy sources that help to spur production and economic output are severely lacking in this country. In order to gain a minimal amount of economic output, the country has to import nearly three-quarters of its energy from abroad and therefore is trapped in a vicious economics and energy dependency cycle. For obvious reasons the country would like to grow its economy but this growth process requires energy which must be imported from abroad which saddle the country with debt making the economy difficult to grow. As we can see from figure 1 below energy demands are on the increase. The slight decreases that are shown coincide with global economic slowdowns as well; but the trend in the past decade has been in an upward direction.

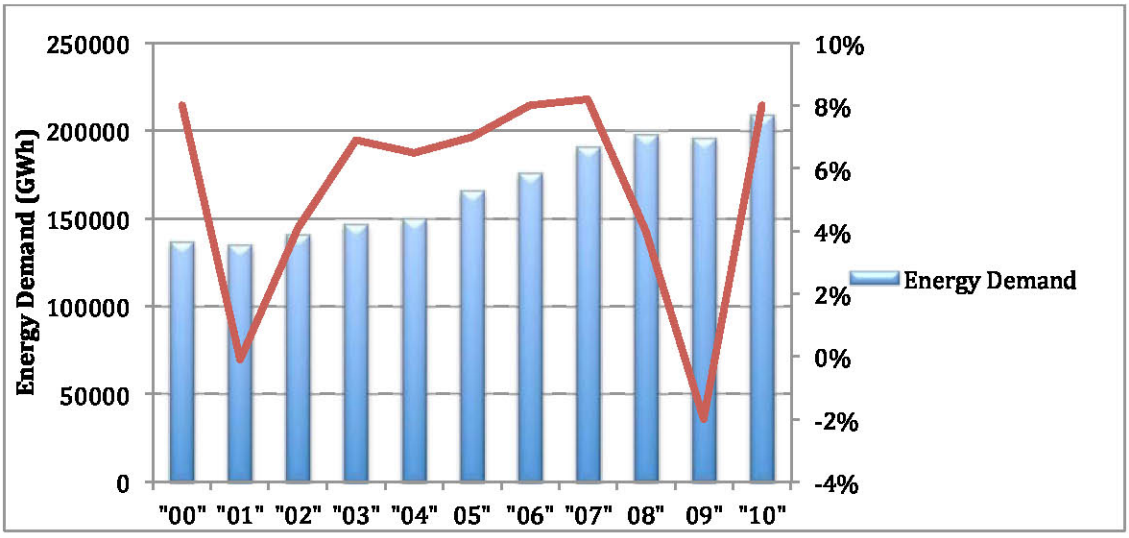



**Figure 1: Energy Demand and Rate of Increase in Turkey**

**Source: IEA, 2011**

Furthermore we must consider the three major reasons for the increasing demand for energy in Turkey. Firstly, when we mention the size of the population, with over 70 million citizens and growing, Turkey is at a quandary as to what to do with its energy demand. Because Turkey is still considered a developing nation its energy consumption is on the whole much lower than many European country. Yet with a rising population and growing middle class, Turkey is beginning to consume more energy. According to a Deloitte Report, "the large, young and increasingly urban population together with expected industrial development potential in Turkey represents a significant growth potential."[1] The current generation of youth has access to a wide variety of resources that were not available in the past. With the advent of the Internet, the present youth population can see what standard of living "developed" nations have and attempt to strive for this same lifestyle. Yet the problem is that unlike developed nations, Turkey does not have the fossil fuel resources to power its growth nor does it have the capital to acquire these resources.

Now that we have discussed demand it would be appropriate to examine the total primary energy supply for Turkey as well as the sources of its energy. As we can note from Figure 2 there is a finite amount of energy in the demand and supply cycle. One of the most distressing aspects of the Turkish demand and supply relationship is that it is heavily depended on oil and natural gas, 33.9% and 32.7% respectively; neither of which Turkey has in great supply. This vicious cycle of energy dependence for economic growth creates a nightmare for certain government agencies because the country is essentially held hostage to its consumption and growth patterns. Without energy it cannot grow but without growth it will remain a developing nation, needing the energy imported from abroad. Yet imported energy means a larger trade balance, lower parity for the Turkish lira and more imported energy to stimulate more growth.

[1] (Deloitte Aug 2010, p.3)

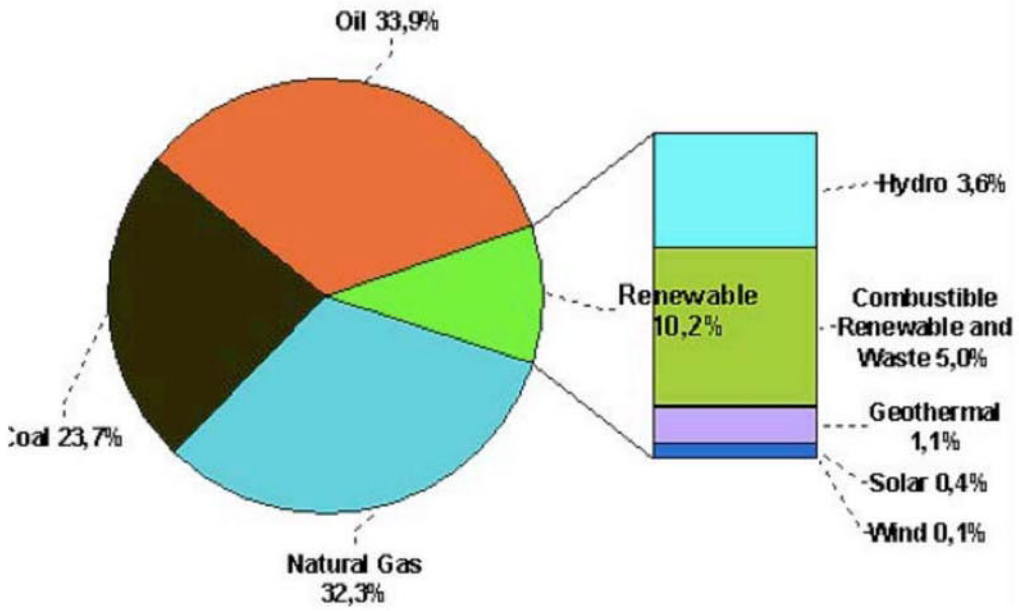



**Figure 2: Total Primary Energy Supply in MTOE: Turkey, 2007 (106.3 MTOE)**

**Source: www.enercee.net**

The primary energy supply is not actually the major issues for Turkey. Its overall energy use per capita, to be discussed later, is actually at a manageable level. Since it is a developing nation, many of its citizens do not have the same standard of living as developed nations. Yet the problem for Turkey is that of the energy sources that it relies on, most are imported from abroad. There are two main reasons for the dire condition of Turkey's energy issues; the first of which obviously is that the domestic supplies are quite low so even if the country wanted to supply its own energy it would be unable to. Secondly, demand has reached unprecedented levels. Turkey's lightening economic growth as well as surging population has made it a larger and larger net importer of energy. The figure for 2008 stood at nearly 80%, which makes the country subject to the whims of the international energy market.

Should an energy crisis happen, as has in the past, Turkey ends up paying more and more for energy. While there are some energy contracts in place, in general the country is at the mercy of fluctuating energy supplies and prices. If we consider that a

lot of its oil and natural gas comes from Russia and Iran respectively, Turkey also has to be careful with its political associations. If we consider these two countries, both are capable of just "shutting of supplies" as Russia did a few years ago in its conflict with the Ukraine. Because it is heavily reliant on its neighbors that have resources, Turkey is limited in many political and economic ways. Always having to rely on others can also become a problem when energy is in short supply. If the resources in either of these countries do become exhausted one day, this event could leave Turkey in a very unpredictable situation and unable to meets its citizen's residential and commercial energy needs.

As we can see, energy supply, demand, acquisition and consumption are all serious issues for Turkey. Because the country does not have any known traditional energy sources, it needs to look elsewhere for energy independence. Yet knowledge of renewables as well as understanding how they can fit into the energy sector in Turkey needs to be given priority status by the Turkish government. Without proper recognition of these alternatives fuel's abundance as well as relevance to the country, the government is just perpetuating the traditional cycle of energy dependence that has existed in Turkey for the last 50 years. This paper, which will be an analysis of the importance of solar energy to the overall energy sector in Turkey will be an attempt to see if it is possible for solar to help Turkey to one day become independent of its energy importation and use cycle.

## 1.4 Structure of this work

This paper with its nine chapters will outline the present situation of solar energy in the Turkish energy sector and demonstrate how solar energy products are vital to the construction industry and Turkish economy. Chapter 1, the introduction, will state the background, objective, primary literature as well as the overall structure. Chapter 2 will describe the methods used in the research of this paper. Chapter 3, will explain background and will outline the present energy situation in Turkey including information on domestic resources including primary and final energy figures as well as imported energy. Chapter 4 has in-depth information about electricity and its role in Turkey. Chapter 5 revolves around both legal and economic aspects of RES in Turkey with a

specific focus on solar technology. Chapter 6 is an explanation of current solar projects in Turkey and discusses specific relevant case studies. Chapter 7 takes a broader approach and compares Turkey and its energy statistics to other countries. Chapter 8 looks at the future of RES in Turkey and Chapter 9 makes some conclusions and recommendations based on the overall research.

# CHAPTER 2: EXPLAINATION OF METHODS USED IN RESEARCH

This research was conduct in a variety of ways and the following section will outline the methods of research, which include both data collection, research as well as individual interviews.

## 2.1 Description

The primary purpose of this research is to use contemporary sources to analyze the significance that solar energy has to the Turkish energy supply and demand situation. The secondary purpose is to use this background information to understand how solar energy products are becoming increasing a part of the Turkish construction industry. I will use primary resources to perform an analysis of past, present and future trends in the renewables market in Turkey with special focus on how they relate to energetic, economic and environmental concerns. Although there are other types of renewables in Turkey such as hydro and biomass, the former already has a mature established market, meaning the potential contributions are already known, and the latter is relatively insignificant making it difficult to find significant research on the field. Due to the growing profiles that solar technologies have received in recent years, it is assumed that they were the most appropriate fit for the research.

## 2.2 Materials

There were a variety of sources consulted for the topic's research. The paper's content and analysis includes the use of the following: books, academic journals, statistics provided by Turkish national as well as international databases, interviews with experts in the field, as well as company information provided by various leading solar energy producers. A complete list of the materials can be found in the bibliography.

## 2.3 Procedure and Methods

The procedure for this paper consisted of three steps. Prior to the actual research, the first step was to perform a general data collection. In order to familiarize myself with the material, I consulted experts in the field as well as read current research about the solar energy development in Turkey.

Secondly, I devised a research question for my paper. After examining all of the material collected and given Turkey's inability to support its own energy needs, it seemed most efficient to analyze the importance of an abundant yet unutilized energy source: solar. By seeing how solar can perhaps close certain energy gaps, I was able to investigate Turkey's overall energy policy, the politics of renewable energy as well as make recommendations for the future. The final step that was undertaken was targeted research related to the question. This step included collecting information on recent solar developments in Turkey as well as its relevance to the energy sector in Turkey so as to be able to write the thesis.

## 2.4 Calculations, equipment and procedure

As this paper is more of a qualitative than a quantitative paper, the research was chiefly concerned with sampling data from both primary and secondly resources that had previously performed calculations. While there were a few calculations that needed to be performed, most of the statistical information can be understood from the previously performed research studies. In addition to this no software was implemented in order to conduct research. Since most of the hard data has been compiled from large research centers and think tanks, this work was primarily concerned with the synthesis of information and used it for the connections between the construction industry and solar energy products in Turkey.

## 2.5 Theory

The theory behind this research paper is that it presents a body of information that if subsequently collected by another investigator would reach similar or identical results and conclusions. There is one caveat to this idea, primarily the sources that were consulted. While there are many organizations collecting data on solar energy in Turkey, such as the IEA or the Turkish Ministry of Energy, there were at times conflicts in the numerical values collected from these sources. This paper attempted to use all of this information so as to ensure that all areas of the research study were covered. In the case there was conflicting information from two sources, a third source or fourth

was consulted and deductions were made based on the most widely accepted information.

A thorough research was undertaken so as to ensure the information available in the field was exhausted. By using the latest research, most sources are less than five years old, this research posits that its data is the most up-to-date and void of technical errors.

# CHAPTER 3: HISTORICAL DEVELOPMENTS IN PRIMARY AND FINAL ENERGY CONSUMPTION IN TURKEY TILL 2010

This chapter will primarily deal with energy issues such as production and consumption in Turkey. Additionally, it will show the change in use over time of traditional and renewable sources.

## 3.1 Primary energy development by energy carrier

Prior to analyzing the energy development by carrier we can also use the data gathered in table 1 to understand how the primary and final energy has changed over time.

Table 1: Primary Energy Supply by source and Final Energy Demand by Source

Source, IEA, 2011

| Energy resources | Year | | | | | |
|---|---|---|---|---|---|---|
| | 1980 | 1990 | 1995 | 2000 | 2010 | 2020 |
| Coal | 21.0 | 31.1 | 27.2 | 26.6 | 30.6 | 39.5 |
| Oil | 51.5 | 45.6 | 46.5 | 42.0 | 28.9 | 24.3 |
| Natural gas | 0.1 | 5.9 | 10.1 | 18.8 | 27.2 | 22.8 |
| Nuclear | — | — | — | — | 2.9 | 5.8 |
| Hydro | 3.0 | 3.7 | 4.8 | 4.1 | 4.2 | 2.8 |
| Other | 24.4 | 13.7 | 11.4 | 8.5 | 6.2 | 4.8 |

Table 22 Final energy demand by source (%) [21]

| Energy resources | Year | | | | | |
|---|---|---|---|---|---|---|
| | 1980 | 1990 | 1995 | 2000 | 2010 | 2020 |
| Coal | 18.4 | 22.7 | 17.6 | 19.0 | 20.5 | 36.0 |
| Oil | 47.1 | 48.3 | 50.4 | 46.5 | 35.7 | 27.6 |
| Natural gas | 0.1 | 1.9 | 6.1 | 9.7 | 16.4 | 10.9 |
| Electricity | 6.3 | 9.5 | 11.4 | 13.9 | 17.7 | 18.9 |
| Other | 28.1 | 17.6 | 14.5 | 10.9 | 9.7 | 6.6 |

As we can note in 1980 the only significant amount from a RES source was hydro at 3% of the total primary energy supply. This increased in the 1990s and 2000s but is scheduled to decrease in 2020 as more RES and nuclear power will come on line and provide a greater percentage of the total. If we further examine the table and look to the final energy demand by source we can see that once again since the 1980s

electricity has climbed from 6.3% to over 18% of the final energy totals. Natural gas also had an incredible increase from a 1980s figure of 0.1% to a 2020 figure of 16.4%. Coal saw a doubling as well from 18.4% to 36%. The only sources that has decreased is oil and that is simply because the Turkish supply was exhausted over the last two decades.

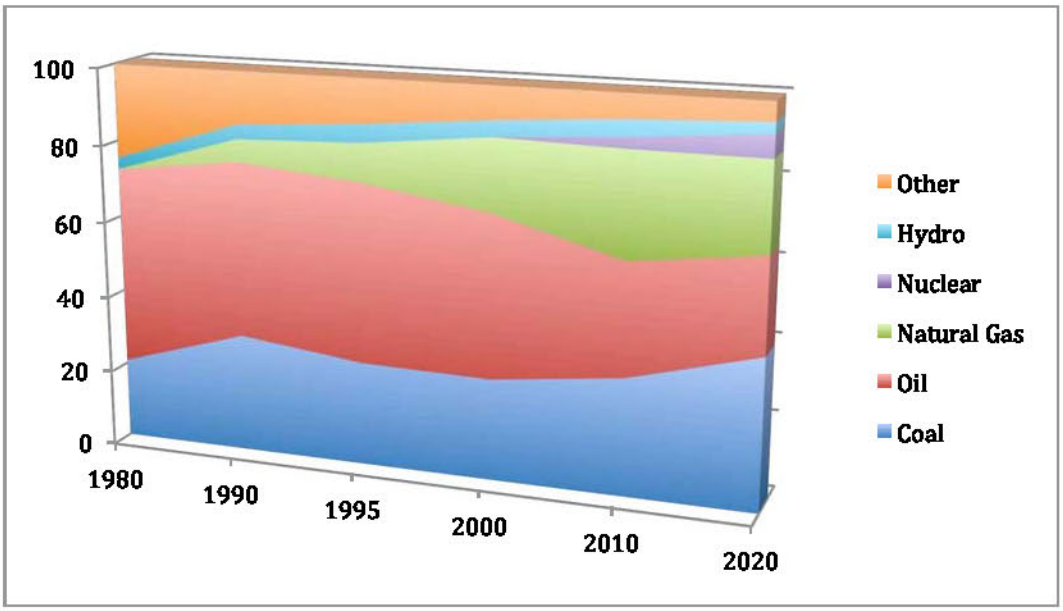



**Figure 3: Primary Energy Supply by Source (Graph Version)**

**Source, IEA, 2011**

Observing figure 3, we can note the importance of certain energy carriers to the Turkish Energy equation. There are five primary sources for this energy: natural gas, coal and lignite, oil and hydro which all assist Turkey in meeting its energy needs. The only true renewable that is presently contributing to energy needs in Turkey on a significant scale is hydro energy. Other RES such as solar, biomass or wind are quite insignificant in the overall energy totals. It is possible with greater investment in RES projects these percentages will change. We can see also from figure 3 that more than half of the primary energy supply comes from two very unclean and non-renewable sources: oil and coal. Natural gas has also made significant contributions to this sector as well.

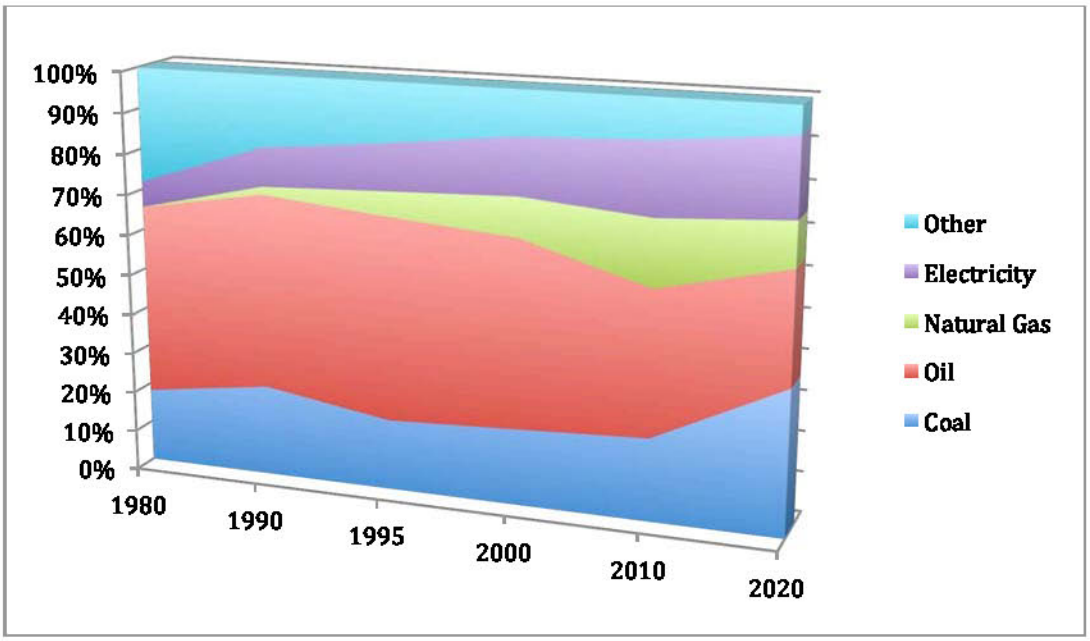



**Figure 4: % Final Energy Demand by Source (Graph Version)**

**Source, IEA, 2011**

Figure 4 also shows us that in terms of final energy demand by source, Turkey is still highly reliant on coal and oil. Although natural gas and electricity are making some increases, they still represent a minimal amount to the overall final energy demand. We can see that the decreased reliance on oil has meant increases in electricity and natural gas. If Turkey can use more of its RES to cover the electricity demand, it will be in a better position to start covering more of these needs.

## 3.2 Energy use by sector (Households, Transport, Industry, Services)

When we examine the Final Energy Consumption of Turkey as seen in figure 5, we can note that there are three major sectors to which the energy goes. Most logically 42.1% of the energy goes to sustain households. In the past decade this has been one of the areas that has seen the largest growth because of the steady rise in population and the increased rate of consumerism. As the country has begun to get rich, citizens have become more and more diligent in their demand for energy for vehicles as well as for household appliances.

The next two sectors at 29.5% and 23.3%, both industry and transport respectively are quite logical. As the country is still considered "developing", it is still heavily involved in manufacturing. The major industries include textiles, car parts manufacturing and agriculture. As a result many European countries look to setting up factories in Turkey. The geographic proximity is appealing, meaning less turn around time for products, and the wages, at nearly one third of EU worker salaries', are significantly lower than those of the EU. The transport industry is one of the fastest growing sectors in Turkey. Because there is a major reliance on industry, logically Turkey exports a lot of the products produced domestically as well as internationally. A way to get the products to the market is via ground transportation. Since there are very few fossil fuel resources in Turkey, the final energy consumption is primarily based on non-domestic supplies. In order to power its ground vehicles and the thousands of transportation companies, oil and natural gas must be acquired.

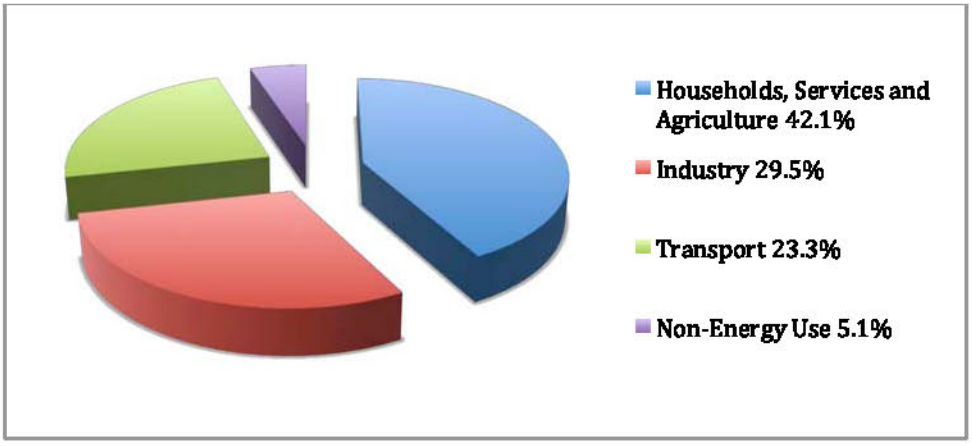



**Figure 5: Final Energy Consumption in Turkey, 2008**

**Source: www.enercee.net**

Since it is not likely that any of these sectors will reduce their demand for energy, Turkey must come up with creative ways to meet its domestic needs.

## 3.3 The import balance of primary energy production

If we consider figure 6 below we can see that the country has begun to request more and more energy from non-domestic sources. When the graph begins Turkey was just below 20% in terms of imports but as demand has increased, domestic supply has not

been able to keep pace and the country looked to its neighbors for energy resources. In 2008, the end of this data, the rate was nearly 80%. This quadrupling of energy imports over the last 40 years has had serious impacts on the Turkish economy because it has to pay significantly to run its economy.

Certain resources such as natural gas and oil come mostly from the surrounding nations to Turkey like Russia and Iran. According to the ICC, "in 2007, approximately 40% of crude oil, 60% of fuel oil and 60% of natural gas came from the Russian Federation". This over reliance on one country can cause a problem for Turkey should that country decide it wants to raise its prices or should it no longer want to sell products to Turkey. In financial terms these figures are important too because while Turkey's volume of energy exports was $5.4 billion USD, its net import of energy totaled $28.6 billion USD – a significant difference" (ICC, 2008). Once again this means that Turkish lira is being spent outside the country to acquire resources rather than being spent on improving the energy structures in the country creating a larger trade balance for Turkey. Turkish citizens are paying a great deal more for energy resources because their country does not have very many traditional fossil fuels and because the internal infrastructure in the country is not being invested in.

An expert in the Turkish renewable energy field, Murat Ozakat, highlighted the importance of energy security and independence. As managing partner in Mitra, a wind and real estate investment, Ozakat stated in a recent interview that, "Turkey pays $50 billion a year to other countries for oil, gas, coal and electricity, and by 2023 it will be $100 billion if we don't act now."[2] Obviously the price of energy is not consistent and will logically increase over time. Additionally, as demand increases and supplies dwindle, it is logical that resources will go to the country with the ability to pay more. Turkey as a developing country will most likely not have this ability. Another point that Ozakat made with respect to the Turkish government's policy on renewables and one that has serious long-term impacts on the country is, "But to develop these sectors, we need longer-term credit and incentives from the government. This is a national security

[2] (Wind Tech Istanbul 2011)

issue."[3] His statement underscores the need for a comprehensive and progressive energy policy that includes renewable energies such as solar as real alternatives to fossil fuels.

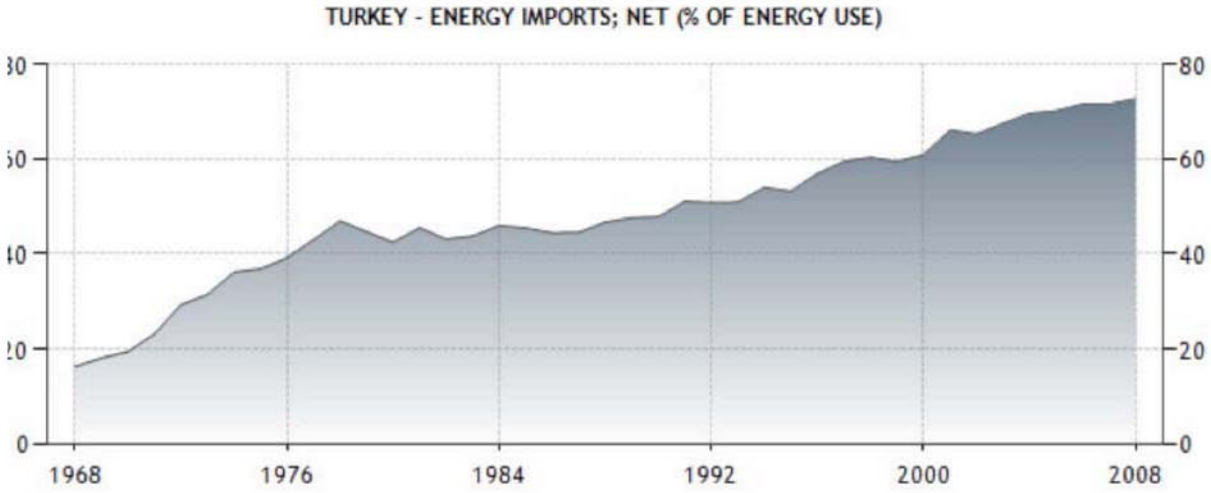



**Figure 6: Turkish Energy Imports: (Net % of Energy Use 1968-2008)**

**Source: www.tradingeconomics.com**

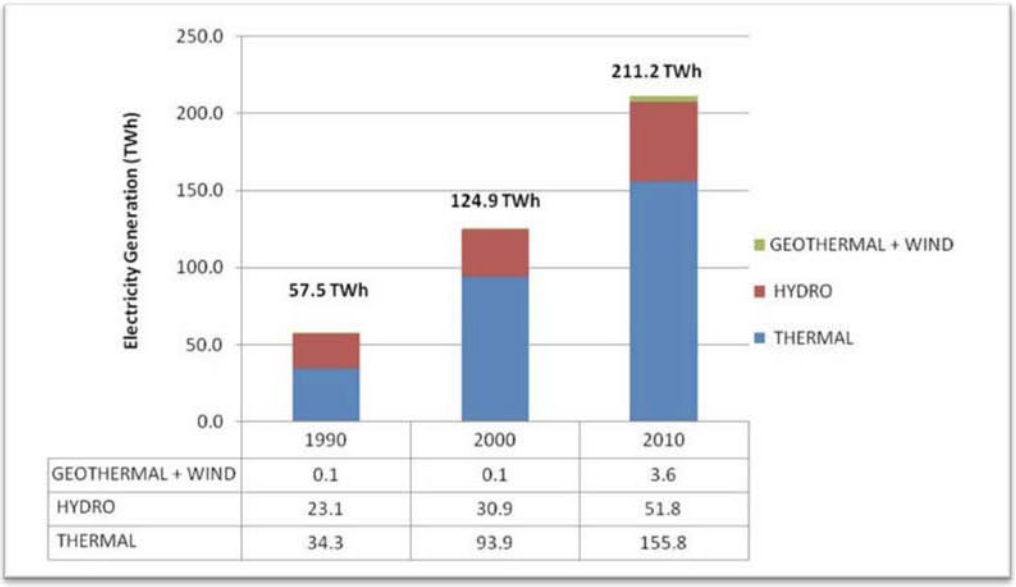
## 3.4 The historical and current relevance of renewables to Turkish electricity

Renewables has not historically been a significant part of the energy program of Turkey. While they have always existed on a small scale, they did not have a great impact on the country until recently. It was very difficult to obtain information on the historical relevance of renewables to the overall Turkish energy program because these types of statistics were not recorded but values for electricity were available. It is assumed that these values reflect nearly the situation of the entire energy industry.

The most recent figure that I found reflected 1990's values; which means Turkey has been collecting data on renewables for approximately the last 20 years. Figure 7 shows what the last 2 decades have meant for RES in Turkey. As we can see in 1990, geothermal and wind energy were not even calculated. The major RES sources that were tracked were hydro and thermal. Yet each year RES has become more and more important to the overall electricity program in Turkey. Current figures show that 211.2

[3] (Wind Tech Istanbul 2011)

TWh of electricity is produced in Turkey yearly from RES sources. While this represents a little less than 20% of total energy consumption in Turkey, it demonstrates the high profile being given to RES.




| | 1990 | 2000 | 2010 |
|---|---|---|---|
| GEOTHERMAL + WIND | 0.1 | 0.1 | 3.6 |
| HYDRO | 23.1 | 30.9 | 51.8 |
| THERMAL | 34.3 | 93.9 | 155.8 |

**Figure 7: The Relevance of Renewables to Turkish Energy Supply 1990-2010, Source, Fitchner, 2012**

Figure 8 shows what percentage of the overall RES in Turkey each of the different technologies occupies. RES sources such as geothermal and wind are very insignificant at 2%; but this chart demonstrates that the sector has grown since 1990. But the growth has not been very significant considering that 2 decades have passed. While hydro is significant at 24%, the real focus should be on thermals such as solar thermal because it represents nearly ¾'s of the RES produced electricity in Turkey.

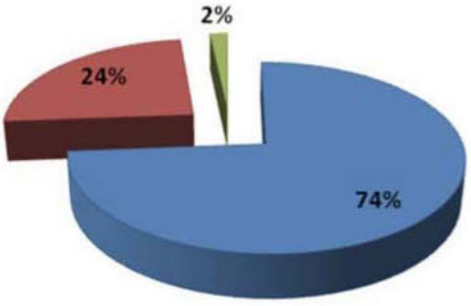



**Figure 8: % of RES to total RES contribution in Turkey, 2010Source, Fitchner, 2012**

## CHAPTER 4: THE SPECIFIC ROLE OF ELECTRICITY IN TURKEY

This section will look at electricity specifically in Turkey and show how this demand is related to RES sources.

### 4.1 The historical mix and changes over time

As we can see the sources to generate electricity have changed over the last 30 years in Turkey. In the 1970s natural gas was insignificant to electricity generation and hydro had a much smaller role. If we fast forward to 2006 figures, we can see that in fact meeting electricity generation demand would be impossible with out natural gas. Oil has remained stagnant but coal and peat sources have also seen increases such as a doubling in the last 15 years.

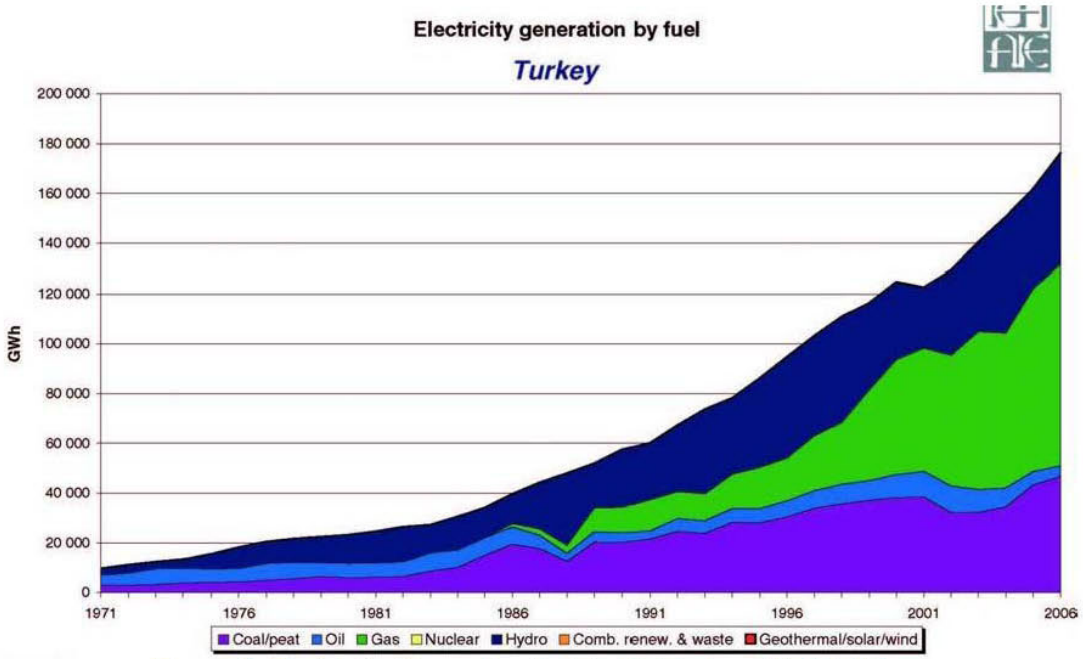



**Figure 9: Electricity Generation by Fuel in Turkey, 1970-2006**

**Source: IEA, 2008**

As demand for electricity has increased Turkey has had to include more and different types of technologies in order to keep up with demand. This has meant a greater diversification of resources.

### 4.2 The historical role of hydropower and other renewables until 2010

As there has been greater demand for electricity there are clearly changes in sources as well. Hydro energy has been a traditional powerhouse for electricity in Turkey as we can see in table 2 since the 1960s it has contributed close to half of the electricity generation in the country. As the sources have become diversified however this figure has dropped and the projections are hydro to meet just under 20% of the electricity demand by 2020. The demand will be met by other sources such as oil and nuclear. Other renewables are relatively insignificant when it comes to electricity generation. The "others" column is actually seen to have a drop in electricity generation.

Table 2: % Electricity Supply by source in Turkey 1980-2020

Source, IEA, 2011

| Energy resource | Year | | | | | |
|---|---|---|---|---|---|---|
| | 1980 | 1990 | 1995 | 2000 | 2010 | 2020 |
| Coal | 25.5 | 35.1 | 32.6 | 28.6 | 27.6 | 24.9 |
| Oil | 27.7 | 6.8 | 6.9 | 3.6 | 1.6 | 6.8 |
| Natural gas | — | 17.7 | 19.2 | 35.0 | 36.4 | 36.4 |
| Nuclear | — | — | — | — | 4.8 | 12.8 |
| Hydro | 48.8 | 40.2 | 41.1 | 32.6 | 29.5 | 19.0 |
| Other | — | 0.2 | 0.2 | 0.2 | 0.1 | 0.1 |

### 4.3 Evolution and current problems of the transmission and distribution grid

One of the greatest problems facing the construction industry and its ability to provide solar energy is the technical problems that an influx of solar energy would engender for the Turkish national grid. The national grid is out of date and was constructed in the 1960s. It is still a common occurrence today in Turkey for power shortages to occur due to a grid malfunction or overload. Despite the fact that there have been improvements, the system needs a virtual overhaul. The primary technical problem is the grid's use of the delivery of energy is too simple and has a specific capacity. Overloading that amount

causes any number of problems from repairs to complete renewal. The national grid's technical problems may be the major factor behind why the 2010 update to the RES law saw only 600 MW/h in contracts approved by the government till 2013 as only 600 WW/h. If we look at solar energy's ability to make individuals producers of energy, the grid would also have to be changed to accommodate not only millions of consumers, but also millions of producers.[4]

We can also look at figure 10 and see that even those electricity transmission and loss rates are declining in Turkey, Enerdata states that, "the rate of T&D losses in the Turkish Power Grid is 14.5% of the volume distributed. The world stands at 9%" (2011). Turkey clearly needs to improve upon these figures in order to keep its power grid competitive.

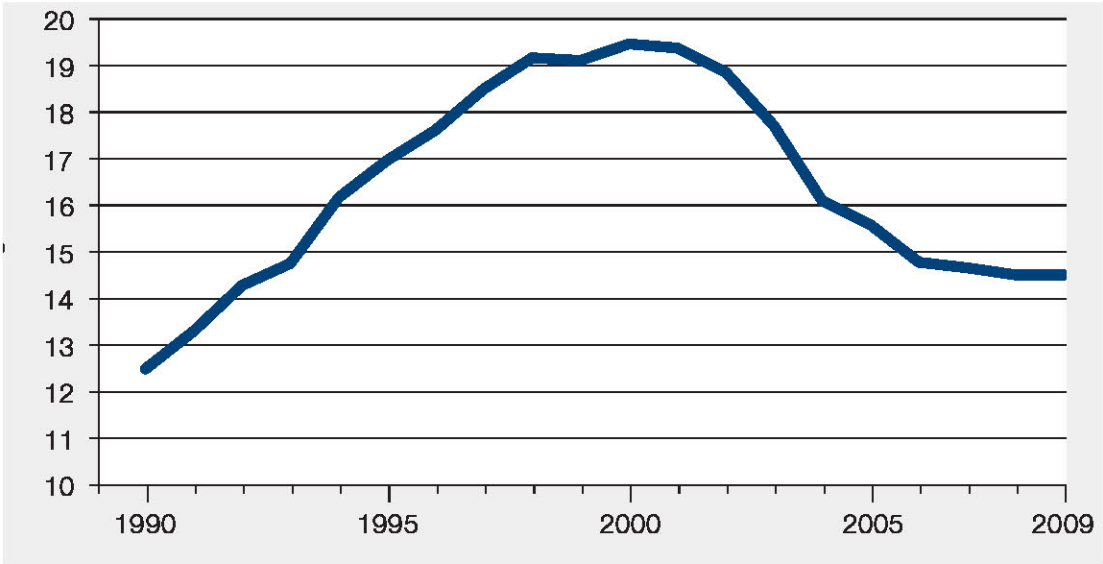



**Figure 10: Electricity Transmission and Distribution Loss in Turkey, Source, Enerdata, 2011**

## 4.4 Import and Export Issues

As was previously mention Turkey has some major issues with the import of its total energy supply but with respect to electricity the situation is a bit more positive. As we can see form Table 3 below, which demonstrated 2007 figures, the country actually

[4] (Harte 2011)

exports a significant amount more of electricity than it imports. With an import of 864 GWh and an export of 2422 GWh, Turkey is clearly an exporter of electricity. This could have something to do with the increasing number of wind farms that have been set up in the country over the past decade. With its geographic proximity to nations such as Greece and Bulgaria, it is often easier to sell this electricity to neighbouring countries than try and transfer it to a distant part of Turkey. At any rate it makes the importation of electricity situation in Turkey to meet the need quite positive when compared to the overall energy matrix in the country. Being able to meet these needs perhaps Turkey can design a more electricity-based energy program or it has the option to increase these electricity generating plants so as to be able to sell more and more of its energy abroad. The export of electricity will actually help Turkey with its trade balance as well.

**Table 3: Annual Generation Program and Realization for 2007 (GWh)**
**Source: Ecomode, 2011**

| UTILITIES | 2007 ANNUAL PROGRAM | 2007 ANNUAL PROGRAM (REVISED) | 2007 REALIZATION |
|---|---|---|---|
| TOTAL GENERATION OF TURKEY | 187733 | 193068 | 191558 |
| IMPORT | 540 | 743 | 864 |
| TURKEY'S GENERATION + IMPORT | 188273 | 193811 | 192422 |
| EXPORT | 3093 | 2873 | 2422 |
| TOTAL CONSUMPTION OF TURKEY | 185180 | 190938 | |

## CHAPTER 5: LEGAL AND ECONOMIC ASPECTS

This chapter will deal with many important issues surrounding the legal as well as the economical aspects of RES in Turkey.

### 5.1 Major indicators (energy vs electricity intensity: eg MJ/GDP)

When we examine some major indicators for Turkey we can see that both energy and electricity intensity highlight interesting aspects of the Turkish energy market. According to the IEA, "signifies the relationship between energy consumption and gross domestic product" (2011). Therefore a high intensity means it costs more to covert energy into GDP. Sometimes developing nations can have lower figures that developed ones because of

> the replacement of new, more energy efficient capital stock and appliances, which takes place more often in the industrialized world than in the developing world, resulting in a weaker link between energy consumption and GDP growth in the industrialized world" (2011).

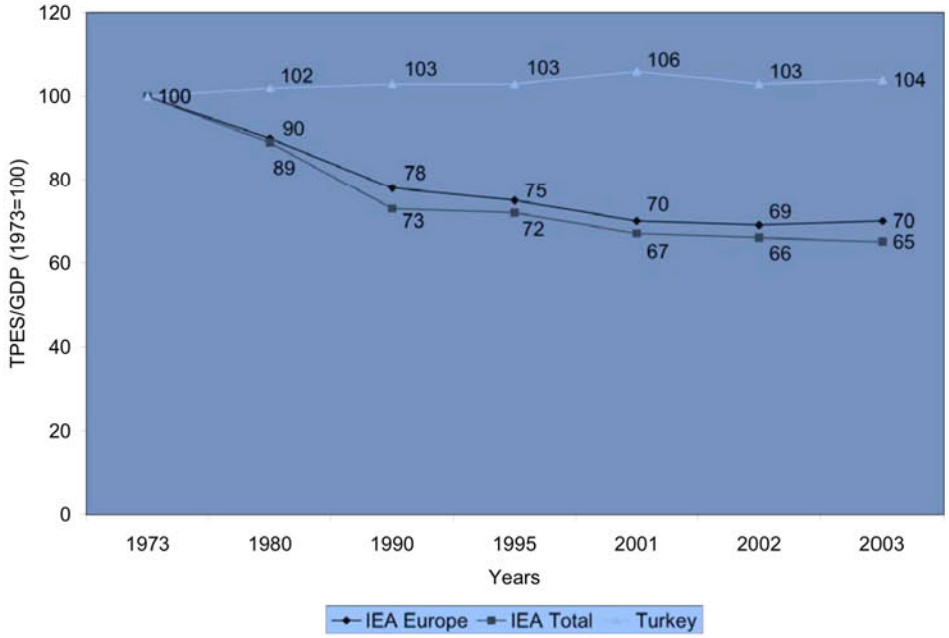



**Figure 11: Dev. of Energy Intensity of Turkey & Other IEA Countries, 1973-2003**

**Source: IEA, 2004**

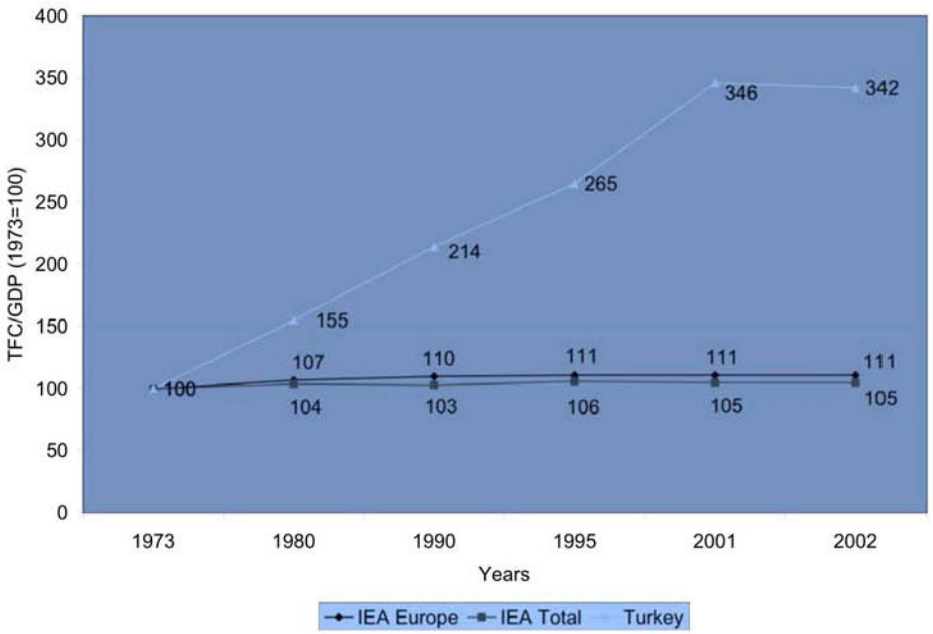



**Figure 12: Dev. of Elec. Intensity of Turkey & Other IEA Countries, 1973-2002**

**Source: IEA, 2004**

Energy intensity in Turkey has been pretty stagnant over the last 20 years as we saw in figure 11. Whereas the opposite is true with electricity intensity, which has increased rapidly in Turkey as can be seen in figure 12. This statistic is surprising and quite positive for Turkey even though IEA countries' are lower.

Unlike figure 11, figure 12 shows us that Turkey's electricity intensity is nearly three times that of other IEA countries and has been on an upward trend since the 1970s. According to the IEA, "as industrialized IEA member countries become more energy efficient they also, on average, become more electricity intensive, to varying degrees (2005). Turkey does need to find a way to reduce this rate and help the country to become more energy efficient and competitive with other IEA nations.

## 5.2 Development of energy prices by energy carrier

There are a variety of energy carriers in Turkey but for this study we will compare just two major one. In tables 4 and 5 we can see the comparison between electricity and natural gas in USD/kWh. Although there are differences between day and night rates,

commercial and residential as well as interruptible and uninterruptible prices, on the whole natural gas is still cheaper than electricity in Turkey. Perhaps this could explain the increasing importance than natural gas is playing in helping Turkey to meet its energy needs as well as the overall energy program.

**Table 4: Cost of Electricity in Turkey 2011**

| Cost of Electricity | | |
|---|---|---|
| | Active Energy | |
| | Day | Night |
| | USD/kWh | USD/kWh |
| **Double Term Tariff** | | |
| Industry mid voltage | 0.115 | 0.062 |
| Direct connection to the local power grid with private line (industry) | 0.100 | 0.052 |
| **Single Term Tariff** | | |
| Industry mid voltage | 0.120 | 0.066 |
| Direct connection to the local power grid with private line (industry) | 0.105 | 0.055 |
| **Source:** Turkish Electricity Distribution Company (TEDAS), as of July 1, 2012<br>USD 1 = TRY 1.8 as of July 2012 | | |

**Table 5: Cost of Natural Gas in Turkey, 2011**

| Cost of Natural Gas* | | | | | |
|---|---|---|---|---|---|
| **Gas Sales Tariff for Eligible Industrial Customers which have Signed Gas Sales Agreement with BOTAS** | | | | | |
| Uninterruptible Prices | | OIZ Prices | | Interruptible Prices | |
| USD/kWh | USD/Sm³ | USD/kWh | USD/Sm³ | USD/kWh | USD/Sm³ |
| 0.034 | 0.359 | 0.034 | 0.358 | 0.034 | 0.358 |
| **Gas Sales Tariff for Distribution Companies** | | | | | |
| Household Consumption | | Eligible Industrial Consumption | | | |
| USD/Sm³ | | USD/Sm³ | | | |
| 0.386 | | 0.359 | | | |
| **Source:** Petroleum Pipeline Corporation (BOTAS)<br>* Excluding SCT and VAT<br>USD 1 = TRY 1.8 as of July 2012 | | | | | |

## 5.3 Development of costs of solar over time

Figure 13 demonstrates that eventually around 2015 solar energy cost will be equal with more traditional sources. This is for two reasons, the rising cost of the traditional sources as well as the decreasing cost to solar energy production. With energy prices increasing due to more and more demand, the cost of solar has begun to look more

and more attractive in Turkey. After the initial investment, which is substantial, there is essentially free energy. But the lack of information on the part of the average consumer prevents many individuals from taking advantage of this technology. One hopeful aspect of rising energy costs is that the production of solar energy materials in Turkey has become a reality. More small Turkish entrepreneurs are beginning to get into the PV panel producing industry and thus have significantly lowered the cost of these materials in Turkey. Currently there are 27 companies in Turkey that produce either PV or Solar Thermal materials but there is no known CSP technology producer.

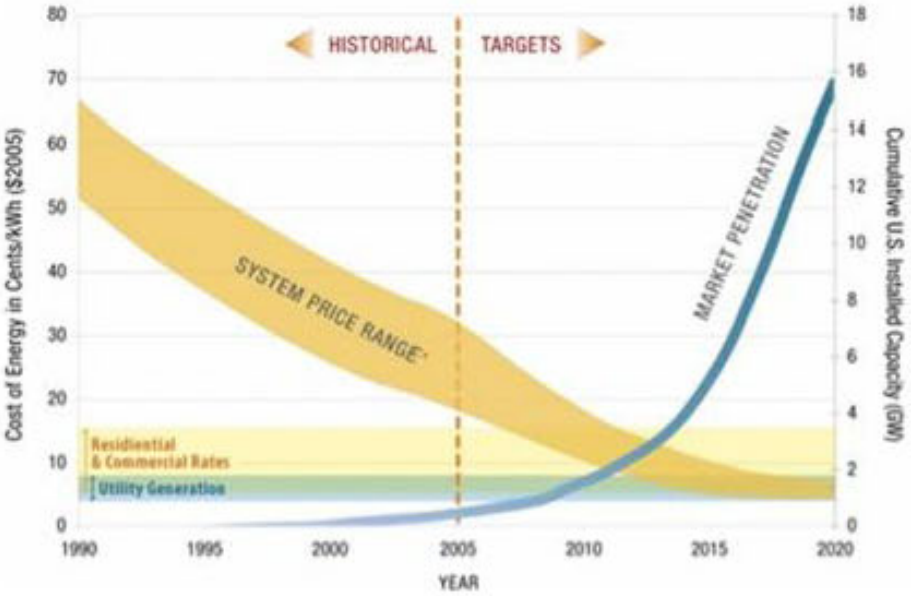



Figure 13: Decreasing Price of Solar Energy in cents/ kWh 1990-2020

Source: Solarcellsale.com

## 5.4 Comparison of costs of renewables for electricity generation with costs of coal, natural gas and nuclear in 2010

If we step back a bit and take a look at the cost per MW/h we can see that as of 2010, solar was still one of the most expensive type of energy to produce in terms of initial investment, capital costs and energy generation. Table 6 below demonstrates to us that most developing nations regardless of their solar irradiation potential have a preference and a need for "cheap power". Looking at table 6 in terms of a business,

and the cost per MW/h we can clearly see why there is a preference for dirtier energies such as oil and coal. Solar simply is not at the competition level yet and this figure is even more heightened in a developing country such as Turkey.

**Table 6: Capital (Investment) Costs Per MW/h for Alternative Technologies in Electricity Generation Technology**

**Source: Goncu**

| Technology | Capital Costs (€/MWh) |
|---|---|
| Natural Gas Combined Cycle Power Plants | 6.14 |
| Coal Power Combined Heat Plants | 16.24 |
| Wind Onshore Power Plants | 28.89 |
| Small Hydro (Run of River ) Power Plants | 24.43 |
| Nuclear Power Plants | 17.09 |
| Solar PV Power Plants | 223.03 |

But according to European Commission, the rising costs of fossil fuel electricity is helping the solar market because "between the first half of 2008 and the first half of 2010, electricity prices climbed roughly 30 percent for Turkish households and industry."5 This means the overall costs associated with solar may actually begin to decrease when we compare them to the production costs of traditional fossil fuels.

## 5.5 Subsidies for renewables in an international context

As we can note from table 7 below, there are some countries that do not have a subsidy because it simply does not makes sense due to the low solar irradiation quotient. Therefore these countries have decided to invest in other RES technologies. Yet Turkey's closest neighbors in the EU, Greece and Italy have recognized their own solar energy potential and offered $0.55 and between $0.36-0.44 respectively for

[5] (Stancich 2011)

companies attempting to make this energy mainstream. Ironically enough, the Netherlands, which has nowhere near the solar irradiation of Turkey has between a $0.459-0.583 amount of a subsidy. All of this investment on the part of its neighbor should be both a warning and incentive to Turkey to improve its solar energy policy.

**Table 7: Subsidization per Euro Cent in EU Countries**

**Source: www.energy.eu/#feedin**

| Member state | Wind power 'On-shore' | Wind power 'Off-shore' | Solar PV | Biomass | Hydro |
|---|---|---|---|---|---|
| Austria | 0.073 | 0.073 | 0.29 – 0.46 | 0.06 -0.16 | n/a |
| Belgium | n/a | n/a | n/a | n/a | n/a |
| Bulgaria | 0.07 – 0.09 | 0.07 - 0.09 | 0.34 – 0.38 | 0.08 - 0.10 | 0.045 |
| Cyprus | 0.166 | 0.166 | 0.34 | 0.135 | n/a |
| Czech Republic | 0.108 | 0.108 | 0.455 | 0.077 - 0.103 | 0.081 |
| Denmark | 0.078 | 0.078 | n/a | 0.039 | n/a |
| Estonia | 0.051 | 0.051 | 0.051 | 0.051 | 0.051 |
| Finland | n/a | n/a | n/a | n/a | n/a |
| France | 0.082 | 0.31 - 0.58 | n/a | 0.125 | 0.06 |
| Germany | 0.05 – 0.09 | 0.13 - 0.15 | 0.29 – 0.55 | 0.08 - 0.12 | 0.04 - 0.13 |
| Greece | 0.07 – 0.09 | 0.07 - 0.09 | 0.55 | 0.07 - 0.08 | 0.07 - 0.08 |
| Hungary | n/a | n/a | 0.097 | n/a | 0.029 - 0.052 |
| Ireland | 0.059 | 0.059 | n/a | 0.072 | 0.072 |
| Italy | 0.3 | 0.3 | 0.36 – 0.44 | 0.2 – 0.3 | 0.22 |
| Latvia | 0.11 | 0.11 | n/a | n/a | n/a |
| Lithuania | 0.10 | 0.10 | n/a | 0.08 | 0.07 |
| Luxembourg | 0.08 – 0.10 | 0.08 - 0.10 | 0.28 – 0.56 | 0.103 - 0.128 | 0.079 - 0.103 |
| Malta | n/a | n/a | n/a | n/a | n/a |

| | | | | | |
|---|---|---|---|---|---|
| Netherlands | 0.118 | 0.186 | 0.459 – 0.583 | 0.115 - 0.177 | 0.073 - 0.125 |
| Poland | n/a | n/a | n/a | 0.038 | n/a |
| Portugal | 0.074 | 0.074 | 0.31 – 0.45 | 0.1 – 0.11 | 0.075 |
| Romania | n/a | n/a | n/a | n/a | n/a |
| Slovakia | 0.05-0.09 | 0.05-0.09 | 0.27 | 0.072 - 0.10 | 0.066 - 0.10 |
| Slovenia | 0.087 - 0.094 | 0.087 - 0.095 | 0.267 – 0.414 | 0.074 - 0.224 | 0.077 - 0.105 |
| Spain | 0.073 | 0.073 | 0.32 – 0.34 | 0.107 - 0.158 | 0.077 |
| Sweden | n/a | n/a | n/a | n/a | n/a |
| United Kingdom | 0.31 | n/a | 0.42 | 0.12 | 0.23 |

## 5.6 The 2005 Renewables Energy Law and 2010 update

One of the major reasons that solar energy and renewable energy in general has seen marked growth in the last five years is the introduction of the 2005 Renewables Energy Law. One feature of the law is the date that it was introduced; while many European countries such as Germany have had decades old policies concerning RES technology, Turkey introduced this concept less than seven years ago. As before mentioned the RES market in the country is really in the beginning stages and lacks the maturity or comprehensive nature of those of other countries. Its goal,

> 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.[6]

With this idea in mind, the Turkish government has realized that its dependency on foreign sources is a great burden to the country both economically and politically. Unfortunately as Ergun states, "the Law did not provide any tax advantage to entities generating electrical energy from renewable energy resources."[7] So regardless of the government's desire to reduce reliance on foreign resources there was no real serious policy that would make RES a viable option for consumers or businesses. Without proper investment and government subsidization it is impossible to think that such a new sector would be able to develop on its own in a developing country such as Turkey.

One promising aspect to the RES market in Turkey is the addendum that was included in the 2010 version of the law. Since the RES market was just beginning to develop in 2005 there was not much support on the side of government or on the side of business. But five years on, ideas have begun to change about the significance and relevance of these energy sources to the country. Perhaps this sea change was motivated by the increasing price of oil or even the recent global crisis. At any rate, there were certain updates to this law that were helpful and that were harmful to the RES market; solar energy in particular. As mentioned, in 2005 there was a feed-in-tariff

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[6] (EIE 2005)
[7] (Ergun 2005)

aimed at offsetting the price of these technologies in Turkey but this was not very comprehensive. In 2010 there was a revision of this law that at first proved to be promising for the RES sector,

> The legislative framework adjusts the prices for the sale of electricity to the state according to their generation method. According to the law, renewable energy plants will be subject to prices of between ¢7.3 and ¢13.3 per kW/h. A hydroelectric power plant will be able to sell electricity at a cost of ¢7.3, the same as the amount for a wind farm, while geothermal energy suppliers can sell at a higher price of ¢10.5. Companies that use biomass and solar power are subsidized the most at a rate of ¢13.3 per kW/h.[8]

If we look to the changes that have been made since 2005 we can see that many of the RES technologies have been given a boost in terms of investment but they are still more expensive than other fossil fuels such as coal and natural gas. The subsidy is significant at 13.3 cents per kW/h but if the initial cost is nearly 25 cents per kW/h then it still is nearly double the price of other fuels. The fact that RES energy is more expensive is particularly important to Turkey's consumers and business community. As a developing country, paying more for energy has a large impact on a bottom line or a household's expenses. Turkey therefore needs a way to get the costs associated with these RES sources down so that they are actually affordable to the average consumer and business.

Finally, there is another major problem with the update of the 2005 law, the restrictions if places on solar energy generation. "The new amendment restricts the amount of solar power that can be added to the grid over the next two years. Only 600 megawatts of solar power can be connected by December 31, 2013."[9] One can only wonder as to why this decision was made because there was no explanation for it. Perhaps the declaration was made so as not to overload the outdated Turkish power grid. Excess supply might cause transmission as well as maintenance problems for the country. But as was previously stated with such potential, Turkey should be encouraging solar energy development programs rather than limiting them.

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[8] (Invest Turkey 2010)
[9] (Harte 2011)

One very obvious aspect of the 2005 law and its 2010 update is that it in no way is forward thinking enough to be of any consequence and in fact is quite behind that of many of its European counterparts. The amount of subsidization given to the RES markets in many EU countries is quite significant especially with respect to solar energy. Turkey with all its solar resources has not been able to make this technology more accessible simply because of the costs associated with it.

## 5.7 Financing Solar Energy Products and Projects

While the 2005 Renewables Law and its 2010 update helped to introduce and develop the concept of solar energy as a possible energy source, in general there are major difficulties that face anyone or any company interested in creating a significant solar industry in Turkey despite all of its potential. In addition to the government's lack of attention, the major barrier for solar energy in Turkey is the price. The cost of energy produced by solar is just too expensive at this point for the "average" Turkish citizen. The government, which only gave a 5 Euro cent FIT in 2005, is seriously overlooking the industry. Levent Bas of cleantechies.com mentions "the tariff which is merely to offset the cost of purchasing the material does not make the technology feasible or attractive to foreign or domestic investors."[10] Even the 13.3-cent update does not make the technology cheaper than other RES and is clearly more expensive than traditional sources. If the Turkish government were really serious about solar energy, it would have created policies like those of its EU neighbors, bringing the cost of solar energy down to an affordable range. The concept that the government has been unable to grasp is that by enacting an initial subsidy, it can generate interest in the market and then over time the cost of this energy will come down. Without the assistance, solar energy and other RES will remain out of reach for Turkey's energy market. This last fact is the most unfortunate of all because the country is so blessed with a variety of different RES. Figure 14 again highlights the priority given to different RES. Greater subsidies mean the government is serious about growing the industry; solar is not among this plan.

[10] (Bas 2009)

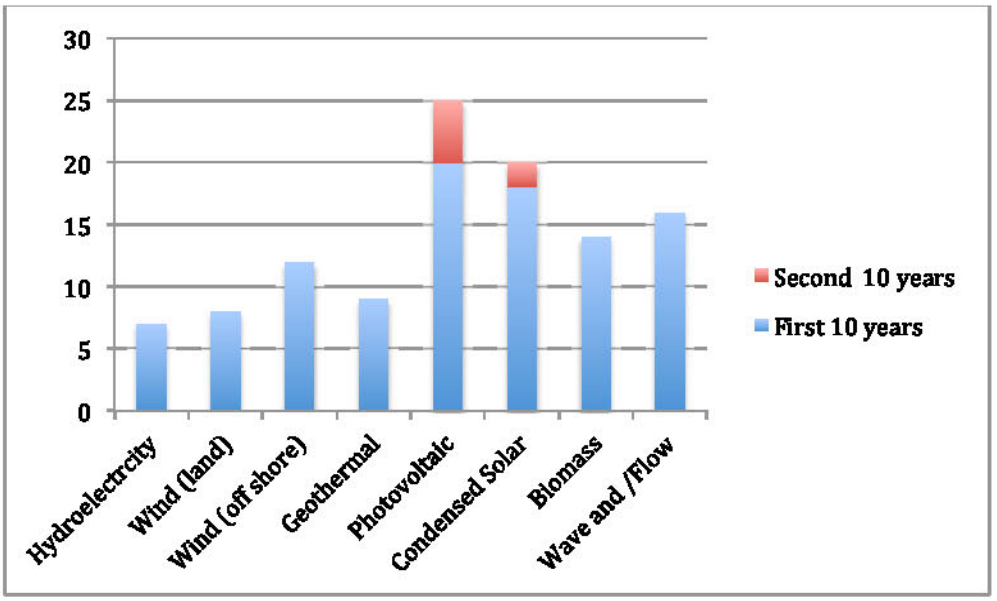


Figure 14: Renewables Purchase Price by Public Sector in Turkey

Source: www. cleantechies.com

### 5.7.1 Feed-In Tariff

As a result of the Renewables Laws update of 2010 there was a new Feed-In Tariff established. While there were many reasons for this, one of the main ones is the closer and closer connection that the country has been making with the EU. As we can note in table 8, solar energy receives the most amount of a subsidy but it is not nearly enough to make it appealing enough to investors. The companies that are investing in solar energy in Turkey therefore must think long term. The initial feed-in-tariff was only 5 Euro cent per kW/h in less than five years this amount has doubled to 10.2 euro cents per kW/h. There is therefore quite a bit of hope on the side of investors that Turkey will go further and provide more and more funding for RES technologies. Perhaps once a true realization on the part of the government occurs; investors will be able to attain the cost per kW/h that makes the technology financially sustainable.

**Table 8: Feed-in Tariffs by RES in Turkey, 2011**

**Source: Ministry of Energy and Natural Resources, Republic of Turkey**

| | Years | €/kWh | CAD/kWh | USD/kWh |
|---|---|---|---|---|
| Wind | 10 | 0.056 | 0.075 | 0.073 |
| Hydro | 10 | 0.056 | 0.075 | 0.073 |
| Geothermal | 10 | 0.080 | 0.107 | 0.105 |
| Solar | 10 | 0.102 | 0.136 | 0.133 |
| Biomass & landfill gas | 10 | 0.102 | 0.136 | 0.133 |
| | | | | |
| Program Cap: 600 MW/yr through 2013. | | | | |
| Payment made in US cents, not Euro cents. | | | | |

### 5.7.2 Financial Incentives for Solar Products

Another aspect of this 2010 update that must be analyzed is the investment by particular technology. If we examine table 9 below we can see another one of the Turkish government's priorities. Just as there is a feed-in-tariff for many of the RES, solar energy is receiving subsidies depending on what type of solar technology is being employed.

**Table 9: Feed-in Tariffs by RES in Closer Detail by Individual Technology**

**Source: Ministry of Energy and Natural Resources, Republic of Turkey**

| | Years | €/kWh | CAD/kWh | USD/kWh |
|---|---|---|---|---|
| **Solar PV** | | | | |
| PV panel integration | | 0.006 | 0.008 | 0.008 |
| Modules | | 0.010 | 0.013 | 0.013 |
| Cells which constitute modules | | 0.027 | 0.036 | 0.035 |
| Inverter | | 0.005 | 0.006 | 0.006 |
| Tracking system | | 0.004 | 0.005 | 0.005 |
| | | | | |
| **Concentrating Solar** | | | | |
| Heat tube | | 0.018 | 0.025 | 0.024 |
| Mirrors | | 0.005 | 0.006 | 0.006 |
| Tracking system | | 0.005 | 0.006 | 0.006 |
| Mechanical components of heat storage | | 0.010 | 0.013 | 0.013 |
| Mechanical components of heat collection | | 0.018 | 0.025 | 0.024 |
| Stirling Engine | | 0.010 | 0.013 | 0.013 |
| Panel integration and mechanical construction | | 0.046 | 0.061 | 0.060 |

As we can note solar energy is being subsidizes but there is a preference within this technology for concentrating solar; particularly panel integration and mechanical

construction. This technology, which basically places panels onto various devices as the sole energy source has been given a priority in Turkey. In fact in Turkey these devices are clearly visible on stoplights and road signs in many parts of the country. The idea is to reduce the strain on the energy market by providing a small energy source for the essential device; therefore it does not have to be hooked up to the electrical grid because it can function independently. Because of the size of cities such as Istanbul and Ankara there is clearly an opportunity to lessen the strain on energy supplies by using these devices with solar energy.

The next preferable technology is Solar PV cells that constitute modules; this technology is the most common one conjures when thinking of solar energy; essentially the flat panels that are placed on roof tops. This table also helps us to understand that once again solar energy is not a priority for Turkey. If the government was truly serious about its own solar energy and RES market it would mean that there was more financial investment in euro cents per kW/h in terms of subsidies. Additionally, it would mean that the government would be branching out into other "forms" of solar such as mirrors or heat tubes. While Turkey is "investing" in RES such as solar, it really needs to widen its exposure to this field. With more and more investment in different "types" of solar there is a higher likelihood that this technology will be able to make a real impact on the Turkish energy sector.

## 5.8 TURSEFF: Turkey Sustainable Energy Financing Facility

There are some key reasons as to why the solar energy market has experienced a marked growth over the past five years. While there have been government sponsored feed-in tariff programs that have enticed investors, a new mandate to create an agency that specifically deals with the promotion of solar energy in Turkey has been established with the assistance of the EU and the EBRD. As the agency claims on its own promotional material, "TURSEFF is a credit line, dedicated to investments in energy efficiency and renewable energy projects. TURSEFF has tailor-made financing

solutions for clearly defined customer needs."[11] What this agency does essentially is make funds available for individuals who want to purchase materials that create energy from renewable resources. The program is available to residential, small-scale commercial and large-scale commercial applicants. Loans range in value from $US 75,000 to $US 5 million. While these funds are loans, they may be used to finance 100% of the actual project. In fact since four of the major banks in Turkey are involved, the applicant can decide which bank s/he would like to work with.

In real terms what this means is that investors who would like to create a RES based enterprise or even consumers that are interested but did not have the financial resources now have the means available to fund their projects. Because there is no constraint on who is eligible, the company or individual merely has to complete an application and select a supplier of RES material, such as wind turbines or solar panels. The agency even assists with the initial contact between the supplier and the applicant. Furthermore, this program is not just "free money" for individuals or companies that tack a solar panel onto to their roofs, in fact according to the TURSEFF website,

> Projects financed under TURSEFF should meet certain performance criteria. Projects relating to energy efficiency measures in industrial and commercial processes should save more than 20% of energy. Projects relating to energy efficiency in the building sector should save more than 30% energy.[12]

By requiring a certain performance, the agency is actually increasing the profile of solar energy in the public eye. Enforcing energy saving it is not investing in RES for investments sake, it seems to be the beginning of a real change on the part of the government in terms of "how" it evaluates RES.

Finally, TURSEFF does a lot of promotion and advertisements can regularly be seen on television as well as billboards around the country. In the past year alone there have been two high profile conferences in Istanbul conducted by the agency so as to

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[11] (Turkey Sustainable Energy Financing Facility 2010)
[12] (Turkey Sustainable Energy Financing Facility 2010)

increase awareness for the program. Perhaps with continued promotion, RES capabilities will be recognized and available to all individuals in Turkey.

# CHAPTER 6: RENEWABLE ENERGY CASE STUDIES IN TURKEY

This section will deal specifically with the possibilities of solar technologies in Turkey and how they are or should be implemented.

## 6.1 Solar energy for construction

Solar energy has long been a part of people's lives in Turkey. Due to its geographic location, the importance of the sun to agricultural growth cycles as well as its known potential to provide energy, solar energy is not a new concept. Yet never before has there been such interest in how the sun can assist the country. Because of Turkey's status as a developing country, historically resources for the development of any energy project, renewables aside, have been difficult to come by. If we take a look at one example, the GAP, the southeast Anatolian Project, a hydroelectric power generating center, we can see that the initial surveys were performed in the 1920s with the creation of the Turkish Republic but it was not until the 1980s that the project was realized. The country is still undertaking many actions to be able to fully implement a policy that was researched nearly 100 years ago.

With the opening of the Turkish market in the 1980s and the concept that Turkey has become a politically as well as economically stable country, the investment potential as well as FDI to the country become a reality. In recent years, the idea that the energy from the sun can be harvested on a grand scale in order to help the country meets is severe energy deficiencies is becoming more and more acceptable. In fact Turkey, which imports nearly 70% of the resources to assist it in meeting its energy needs, is desperate to find a way to lower these costs. While Turkey has many potential renewables, such as geothermal, hydroelectric, this paper will primarily discuss the relevance of solar energy to the overall energy sector and the construction industry in the country.

## 6.2 Recent Developments

Since it is a relatively new sector in Turkey we can therefore see that solar energy is in the very beginnings of its development. Because there has not been a real capitalization in the solar industry as opposed to other renewables such as hydroelectric or wind energy, there still exists a great potential for development; if the

significance solar can be realized, then this RES will surely have a higher profile. Having a high potential for solar energy due to its geographical position, Turkey has an average annual total sunshine duration of 2.640 hours (daily total is 7,2 hours), and average total radiation pressure as 1.311 kWh/m²-year (daily total is 3,6 kWh/m²).[13] Solar energy potential is calculated as 380 billion kWh/year. If we consider Turkey's geography, we can note that given its location, the total amount of sunlight it receives per day, if captured, could provide all of the energy needs for the country. While there is a difference between potential and practical energy acquisition, it is clear that solar should be much higher up on the Ministry of Energy's priority list.

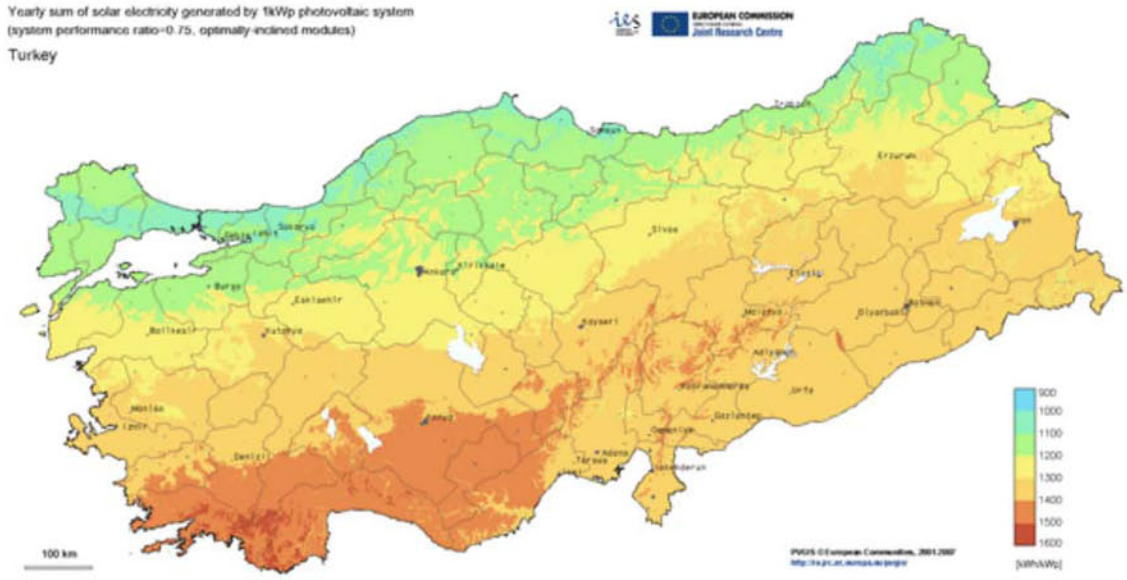


**Figure 15: Global Horizontal Irradiation: Turkey**
**Source: Solargis.com**

Looking at figure 15 above we can see that more than half of the country has a Global Horizontal Irradiation of between 1700 and 2000 k/Whm.[2] While some regions in southern Turkey have seriously begun to consider their solar options, there is no comprehensive solar policy in Turkey and solar energy's potential remains in the speculative realm.

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[13] (Geo Model Solar 2011)

While varying considerably in terms of methodology, materials and level of technology used, solar energy technologies may be divided into two main groups: PV Solar and CSP Solar. The Turkish government in fact also divides projects and subsidies along these lines. There is a fundamental difference in the way the energy is captured which will be discussed below.

### 6.3 PV Solar In Turkey

If we consider the most common production of solar energy globally and one that has the greatest potential in Turkey, we can recognize that it involves PV (photovoltaic) panels. What these cells do essentially is convert light from the sun into electricity. The purpose of these solar cells presently is "to supply small amount of power as well as help conduct research and as of 2010, the installed solar cell capacity was 5 MW."[14] While this level is very low considering the potential, we can posit that despite that the lack of private and public investment in this RES, it does contribute to the energy sector in Turkey; albeit on a very small level. At present, PV systems account for just 5 megawatts of installed capacity. But in fact according to Julia Harte of Reuters, "Theoretically, installing PV arrays across some 770 square miles — one half of one percent of Turkey's landmass — could supply the nation's current electrical capacity."[15] Of course this would be a monumental initial investment but at the vey least it would help Turkey to minimize its reliance on foreign energy resources.

While solar PV technology is growing in popularity, it is still very expensive. The average Turkish citizen who has a average yearly income of $US 6,000 would find it impossible to personally access this type of technology; furthermore power produced from this type of energy would also be more expensive since the government subsidies do not offset the cost of solar energy to make it competitive. Yet according to the Turkish Ministry of Energy and Natural Resources, "With the decrease in the cost of using solar cells and increase in their efficiency, solar cell dependent energy

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[14] ( Republic of Turkey: Ministry of Energy and Natural Resources 2010)
[15] (Harte 2011)

generation is expected to increase in Turkey."[16] One of the ways that Turkey could help to reduce the costs of these panels would be to produce them locally. Certain regions have begun to offer tax breaks and attractive relocation packages to solar energy material production companies. By producing the materials in Turkey, importation and transportation fees would be eliminated and it would add to the local economy. Since the cost of labor in Turkey is relatively inexpensive as compared to Europe, the company would benefit. The major issues it the lack of qualified individuals in this sector; this topic will also be addressed in greater detail in Chapter 4 and its relationship to the construction industry.

## 6.4 CSP Solar In Turkey

Another significant type of solar energy project that is beginning to gain attention in Turkey is CSP solar. CSP is essentially a process in which, "solar energy is used to generate heat; heat can be used either directly or for generating electricity."[17] Yet there is once again a disconnection between the potential and the implementation in Turkey. Using the Solar Energy Potential Atlas the annual calculated CSP for Turkey is 380 billion kWh. Now this number is theoretically possible. But according to the Ministry of Energy,

> the amount of solar collectors installed in Turkey is roughly 12 million m² with a technical solar energy potential of 76 TEP, and annual generation volume is 750.000 m², part of which is exported. Such amount indicates that 0,15 m² of solar collectors are used per capita.[18]

Yet once again the potential versus the currently captured amount of solar energy shows a huge discrepancy. The likelihood of success with this technology may be one of the reasons that the government has increased its subsides for this specific technology as we saw in table 9.

While subsidies for this technology have increased there is really only one major project on the CSP horizon in Turkey. GE has created a CSP project that is currently in

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[16] ( Republic of Turkey: Ministry of Energy and Natural Resources 2010)
[17] ( Republic of Turkey: Ministry of Energy and Natural Resources 2010)
[18] ( Republic of Turkey: Ministry of Energy and Natural Resources 2010)

its developmental stage. It is "a hybrid gas, wind and CSP project, using e-Solar's CSP technology."[19] Furthermore in the past year CSP seems to have gained a higher profile in terms of business investment because the U.S. Department of Commerce is attempting to stimulate interest in RES in Turkey by bringing a "renewable energy trade mission (including 15 -20 US companies) to Turkey on December 5-9 of last year."[20] Turkey has been identified as a focus of US trade and project finance resources. Perhaps this mission will demonstrate to the Turkish government that investors are willing to take a chance on the Turkish solar market and they should as well.

## 6.5 Solar Heating and Cooling Projects

The majority of the solar systems in Turkey consist of solar water heating systems. In most southern regions of Turkey is quite commonplace to see a water tank and a solar flat-plate collector to heat the water on the roofs of most houses and businesses. It is estimated that the currently total installed collector capacity of Turkey is 8.2-million $m^2$ collector area.[21] This is a significant amount of energy that Turkey is generating passively. We also know that the "annual amount of solar-based heat generation is around 420.000 TEP. This data suggests that Turkey is a significant manufacturer and user of solar collectors among the countries of the world."[22] If we examine figure 16 below, we can note that Turkey has nearly 6% of the global solar hot water as of 2007.

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[19] (Stancich 2011)
[20] (Stancich 2011)
[21] (Argun 2011)
[22] (Republic of Turkey: Ministry of Energy and Natural Resources 2010)

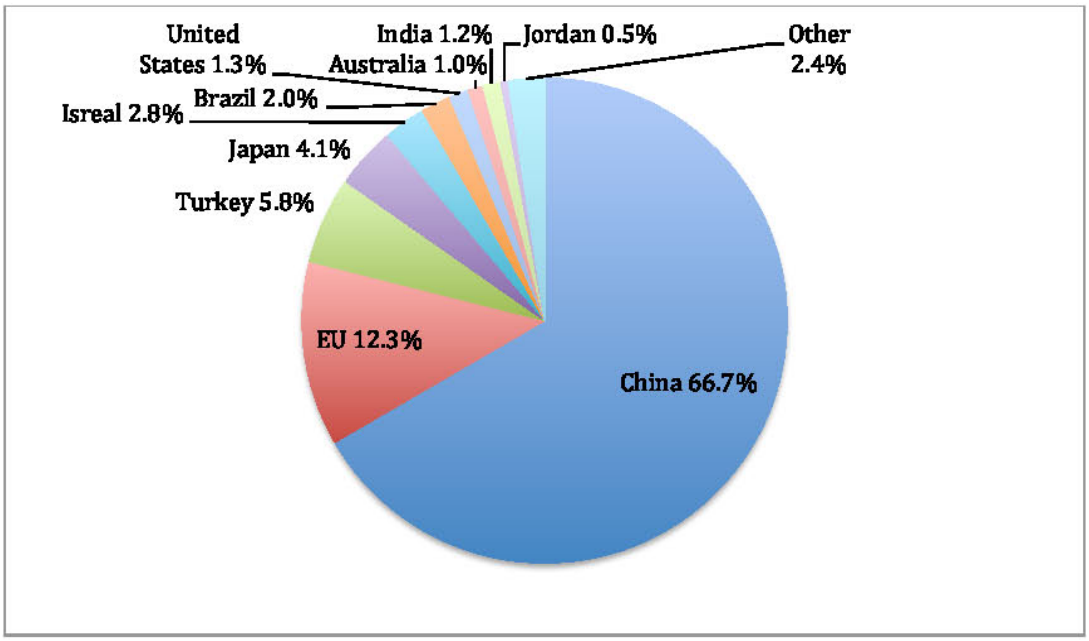


**Figure 16: Global Share of Solar Hot Water/Heating Capacity, 2007**

**Source: GS Report**

Yet the problem with these systems is that they are so widespread but they are the only ones known of in Turkey. Knowledge of PV technology as well as CSP is virtually non-existent. According to Bengü Uluengin, an ecological architect and professor at Bahçeşehir University in Istanbul "at trade fairs, we have people coming up to us pointing at PV panels and asking, 'Where is the water storage tank for this thing?' In Turkey, people know solar thermal. They don't know PV."[23] Because of this lack of knowledge, individuals are actually missing out on the potential to generate more of their own energy. Once again we can see the need for a more comprehensive solar energy plan in Turkey as well as a component of this plan that needs to include public education about this RES.

## 6.6 Turkey's "Solar City: Antalya"

While it is true that the solar energy has few political allies in Turkey, there is one region of the country which is try to change this, the southern city of Antalya has taken

[23] (Harte 2011)

major strides to transform itself into a "Solar City". In fact the very forward-thinking and RES-oriented mayor, Mustafa Akaydin, is attempting to change his city into a solar leader such as Barcelona, Spain or Malmo, Sweden. The city recognizes that solar alone will not be able to provide all of the city's needs and is working on other RES such as biomass and wind energy to supplement the abundant solar sources it has.

The city is generating a great deal of energy because there is presently between 1 and 2 megawatts of solar power located on the roofs of local residences. Yet Akaydin's plan is quite comprehensive and he plans to go much further than having only residents on board with his solar city. Akaydin wants to get business on his side too and plans to mandate improvements to the solar energy capacity of Antalya's hotels. Since the city is a prime tourist location, Antalya could offset the high-energy demands at peak tourism times by increasing the solar capacity of this industry. Furthermore, such a move might also gain it the reputation as an eco-city. Eco-tourism is a niche market and has begun to appeal to more and more tourist looking to combine a holiday with a certain ideology. According to Akaydin, "the municipality intends to construct a solar farm and nurture a homegrown PV production industry. Plans are already underway for a 100-kilowatt solar "forest" near Antalya, with "trees" composed of PV arrays."[24] The ability to access this amount of energy will help the city on its way to be essentially self-sufficient when it comes to energy needs and production.

Yet despite its goal to be a Solar City, Antalya is not without its obstacles in trying to ensure that its solar future is bright. One of the major issues facing Antalya and one which is true of many Mediterranean cities, is that Antalya has already maximized its rooftop usage. Antalya is a tourist destination in which the population swells to nearly 5 million in the summer but year round there are approximately 1 million residents. As is the case in many cities in Turkey space is a premium and so most residents live in high-rise apartment buildings. The rooftop, a clear place to take advantage of PV technology is already crowded with many thermal heaters as this solar energy is the most popular in Turkey.

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[24] (Harte 2011)

Additionally, cost is an issue for solar energy in Turkey. As Harte states, "the average Turkish house requires 3 kilowatts of electrical capacity. That amount of solar power costs approximately $10,000 to install."[25] This cost is often more than the yearly salary for individuals, making its cost effectiveness virtually zero.

[25] (Harte 2011)

## CHAPTER 7: ENERGY IN TURKEY IN AN INTERNATIONAL CONTEXT

This section will deal with comparing Turkey and other countries in terms of its electricity per capital, per GDP as well as its share of renewables.

### 7.1 Comparison of energy and electricity per capita with other countries

After having examined the supply as well as demand for energy in Turkey the next logical aspect would be to investigate how the patterns of consumption are changing as per important variables such as population and economic growth. The EIU states that, "the energy consumption in Turkey has reached a level of 102 million tons of oil equivalent, or 1,420 kg of oil equivalent per head in 2008."[26] It should be mentioned once again that this is still significantly below the usage of developed nations.

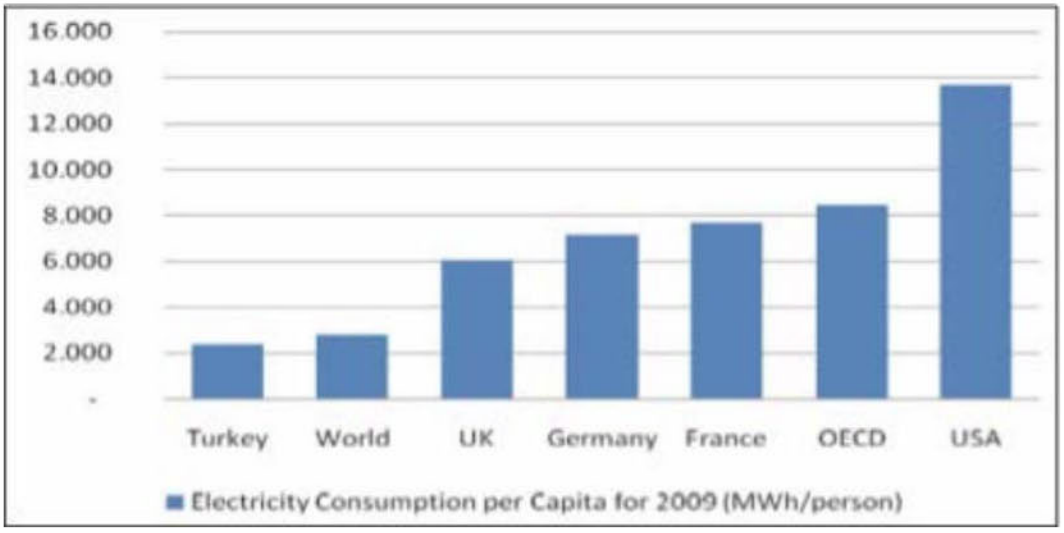


**Figure 17: Electricity Consumption per Capital for 2009 M/Wh/person, Source, IEA, 2011**

If we look at figure 17 we can see how Turkey compares to other countries in electricity usage per person. It is remarkably lower than the US and is even below the world and OECD average. Yet this trend is on the rise and according to the Ministry of Energy, Turkey is, "Undergoing rapid population growth and industrialization, and the country

has been creating a pressure on natural resources."[27] Once again despite the desire of the Turkish population for commercial products as well as more energy for residential or commercial use, there is simply a limit on what the country will be able to do if it continues to rely on traditional energy resources.

## 7.2 Comparison of energy and electricity per GDP with other countries

Additionally we can note the connection between GDP growth and energy use. As is known energy is a prerequisite to GDP growth because the latter requires input to generate a product that will affect the country's GDP. As we can note Turkey's GDP is growing at an extraordinary rate.

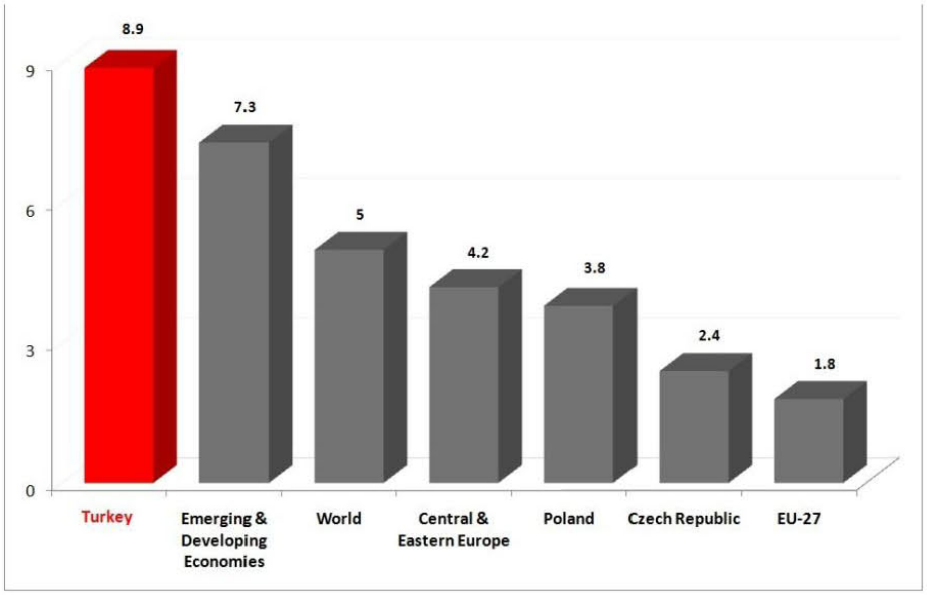


**Figure 18: GDP Growth Rates Worldwide,**
**Source, Fitchner, 2012**

As figure 18 demonstrates in 2010 the Turkish economy grew at 8.9%. Now if we compare this rate to the energy per GDP or energy intensity of other countries in figure 19, we can see that Turkey is actually quite competitive. The graph in Figure 19 shows how much energy it takes to produce a USD; certain countries such as Norway need quite a bit of energy to generate this as does the US. But other countries such as India require less energy than developed or industrialized nations to produce a dollar.

[27] (Republic of Turkey Ministry of Energy and Natural Resources 2010)

Turkey's figure which is between India and the UK at 5.8 MJ/$ shows the country to be quite competitive.

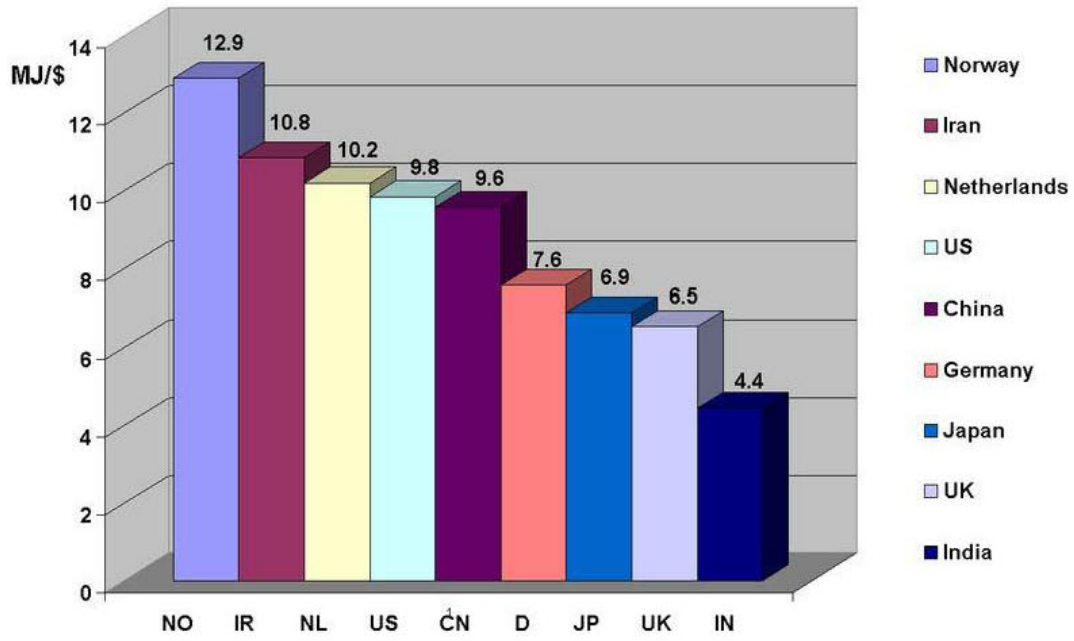


Figure 19: Energy Intensity in Certain Nations as a Comparison to Turkey, Source EIA, 2006

## 7.3 Comparison of shares of renewables in energy and electricity with other countries

We can also look at how Turkey measures up to other countries with respect to its RES program. It is certainly not in the top 10 in terms of producers. IEA 2010 figures show that only 69.6 TWh were produced from RES in the country. Now this may seem like quite a lot for Turkey which is why its necessary to put it in perspective and we can also examine which percent of the total production comes from RES. In Turkey the is only 3% of total energy production comes from RES. This is a long way off from other powerhouses such as the US at 17% and the EU at 22%.

**Table 10: Ranking RES programs by production of TWh,**

**Source, IEA, 2011**

| Rank | Country | Year | Total |
|---|---|---|---|
| | European Union | 2009 | 834.5 |
| 1 | China | 2010 | 764.5 |
| 2 | United States | 2010 | 436.4 |
| 3 | Brazil | 2010 | 429.6 |
| 4 | Canada | 2010 | 360.2 |
| 5 | Russia | 2010 | 167.4 |
| 6 | India | 2010 | 132.3 |
| 7 | Norway | 2009 | 117.7 |
| 8 | Germany | 2011] | 121.9 |
| 9 | Japan | 2010 | 102.8 |
| 10 | Spain | 2010 | 90.42 |
| ------- | Turkey | 2010 | 69.6 |

## CHAPTER 8: FUTURE PERSPECTIVES OF SOLAR IN TURKEY

This section will take a look at Turkey's resources and potentials RES to make estimates about how they will be used in the future.

### 8.1 Which scenarios exist for Turkey (primary energy, final energy, electricity)

When we consider the scenarios that exist for Turkey we need to consider table 11 because it demonstrates to us the primary energy demand by source as well as the final energy demand by source. We can note once again that the only RES that is significant among this table of technologies is hydro and it only provides less than 3% of the primary energy supply. Furthermore we can see that the demand is rising at a rapid rate and these needs must be met in order for Turkey to continue to prosper. Electricity also will see a 7% increase over the next 10 years and this cannot be met by hydro alone. New RES technologies must come online in order to meet these needs.

**Table 11: Primary Energy Supply by source and Final Energy Demand by Source, Source: IEA, 2011**

| Energy resources | Year | | | | | |
|---|---|---|---|---|---|---|
| | 1980 | 1990 | 1995 | 2000 | 2010 | 2020 |
| Coal | 21.0 | 31.1 | 27.2 | 26.6 | 30.6 | 39.5 |
| Oil | 51.5 | 45.6 | 46.5 | 42.0 | 28.9 | 24.3 |
| Natural gas | 0.1 | 5.9 | 10.1 | 18.8 | 27.2 | 22.8 |
| Nuclear | — | — | — | — | 2.9 | 5.8 |
| Hydro | 3.0 | 3.7 | 4.8 | 4.1 | 4.2 | 2.8 |
| Other | 24.4 | 13.7 | 11.4 | 8.5 | 6.2 | 4.8 |

**Table 22 Final energy demand by source (%) [21]**

| Energy resources | Year | | | | | |
|---|---|---|---|---|---|---|
| | 1980 | 1990 | 1995 | 2000 | 2010 | 2020 |
| Coal | 18.4 | 22.7 | 17.6 | 19.0 | 20.5 | 36.0 |
| Oil | 47.1 | 48.3 | 50.4 | 46.5 | 35.7 | 27.6 |
| Natural gas | 0.1 | 1.9 | 6.1 | 9.7 | 16.4 | 10.9 |
| Electricity | 6.3 | 9.5 | 11.4 | 13.9 | 17.7 | 18.9 |
| Other | 28.1 | 17.6 | 14.5 | 10.9 | 9.7 | 6.6 |

We can also examine table 12 to look closely at the electricity generation by source. As we can unfortunately note there only RES in this combination is hydro and this

percentage of contribution will drop significantly over the next decade. The new technologies that will replace it have only been posed as nuclear and oil. But in fact if RES were better explored then some of this electricity generation need could be met.

Table 12: Electricity by Source % 1980-2020,

Source, IEA, 2011

| Energy resource | Year | | | | | |
|---|---|---|---|---|---|---|
| | 1980 | 1990 | 1995 | 2000 | 2010 | 2020 |
| Coal | 25.5 | 35.1 | 32.6 | 28.6 | 27.6 | 24.9 |
| Oil | 27.7 | 6.8 | 6.9 | 3.6 | 1.6 | 6.8 |
| Natural gas | — | 17.7 | 19.2 | 35.0 | 36.4 | 36.4 |
| Nuclear | — | — | — | — | 4.8 | 12.8 |
| Hydro | 48.8 | 40.2 | 41.1 | 32.6 | 29.5 | 19.0 |
| Other | — | 0.2 | 0.2 | 0.2 | 0.1 | 0.1 |

Therefore we can say that the scenario is quite dire for Turkey in both total energy and electricity. Because previous plans beside a nuclear plant were not put in place, meeting energy and electricity needs is going to be difficult from domestic sources.

## 8.2 What potential exist for solar in major Turkish sector, construction, industrial applications, and consumers

This section will outline the significance that solar energy products, projects and programs can have for the construction industry in Turkey. The key question in this study is why solar? And the follow question is why solar for the construction industry? In order to aptly address the connection between the two industries we should understand for the purposes of this paper, the Construction Industry refers to the domestic industry that involves the construction of both commercial and residential edifices.

### 8.2.1 Why Solar for Construction?

When we attempt to answer the question why solar for the construction industry, one does not have to look much farther than the house or the building that they work in.

Since nearly every activity, especially related to business, takes place indoors in some form, it is clear that buildings provide a key opportunity for solar power. Since every house and office has a roof, adding PV panels to these locations really requires foresight and investment. With the cost of these products decreasing at a nominal rate, more and more businesses as well as individuals can afford to have panels on their home; thus utilizing the energy that come directly from the sun.

### 8.2.2 Solar for Industrial Installations

As was previously mentioned, the economy of Turkey is heavily reliant on both the manufacturing and transportation industries. While this normally would mean great rewards for a developing country, the energy needed to develop these industries has to continually be imported since traditional fossil fuels are relatively non-existent in Turkey. Therefore if we look at the ability that solar energy provides for commercial enterprises, we can see that it has the potential to offer limitless energy after the initial investment costs are paid for.

### 8.2.3 Solar Energy for Consumer Installations

There are many reasons why consumers should look towards solar energy for the future. One of the most convincing, especially for most individuals is cost. As the price of traditional fossil fuels begins to rise, it is logical that consumers will look for less expensive ways of providing energy for their daily lives. One of the most startling statistics is, "Between the first half of 2008 and the first half of 2010, electricity prices climbed roughly 30 percent for Turkish households and industry."[28] If we consider the wage per capita is $US 6,000 annually we can see how a significant rise such as this one will encourage people to turn to other technologies for energy. Also we can see that unlike a few years ago, the price of PV has come down drastically. Ecology expert and professor Mehmet Uluengin believes that, "in a couple of years he expects solar power to reach grid parity, the point at which its price will rival that of conventional grid power."[29]

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[28] (Harte 2011)
[29] (Harte 2011)

The other reason that solar should be something that consumers push for is space. Of the 77 million people who live in Turkey, nearly 20 million live in Istanbul in apartments. Since these apartments are essentially individuals stacked on top of one another that limits the amount of surface area that can take advantage of solar energy devices. This limited space and high demand makes the need to encourage or mandate solar devices even more pressing. While roof tops can be small, it is still possible to equip them with some form of PV technology that would help offset the increasing demand that a growing population and economy has had on the energy supplies.

## 8.3 What are the prospects for renewables in primary energy?

Despite the seemingly dire status of energy in Turkey there are prospects for Turkey. While they may not be as bright as those in the EU or US, the country is changing and moving toward RES, albeit slowly. By examining table 13 we can see this in a bit more detail. The technical and economic potentials are listed for each of the RES technologies in Turkey. When we compare these to the amounts under construction and the even minimal amount currently in operation its clear that there is great room for improvement. One area that really needs to be addressed by the Turkish RES market is solar energy. There are no major projects in operation or even planned for construction for reasons previously mentioned. Turkey needs to find a way to reduce costs enough to make this technology financially viable because it is so abundant in the country. Also table 13 shows us that wind energy and even Geothermal are grat resources that have been traditionally neglected by the energy market. Should Turkey one day be able to capitalize on these sources it may end up being a net exporter rather than importer of energy.

**Table 13: RES Potentials by source in Turkey, Source, Fitchner, 2012**

| | Technical potential | Economic Potential | Under Construction | In Operation |
|---|---|---|---|---|
| Hydro (MW) | 54000 | 45000 | 14150 | 16926 |
| Wind (MW) | 80000 | 48000 | 3293 | 1587 |

| | | | | |
|---|---|---|---|---|
| Solar (Mtoe) | 56 | 32.6 | | |
| Geothermal (MW) | 1500 | 600 | 148 | 94 |

## 8.4 What are the prospects for renewables in electricity generation?

As was mentioned in the previous section, electricity potential from RES like primary energy has great potential that has remained untapped. Since 2005, with the development of the first RES law, Turkey has steadily been increasing the amount of electricity generated from RES but it is nowhere near the potential that it has. Table 13 once again gives us an idea about electricity potentials in terms of RES. We can see that by 2020 there is a planned installed capacity of 30 MW for Renewables in terms of electricity generation. While this is a great goal to have it nowhere matches the estimated potential of the wind economic potential of 48 MW or even the Geothermal economic potential of 600 MW. RES is going to be part of the electricity generation make-up but it is up to Turkey to determine the pace. Based on table 14 we can see that it does not plan to take a very aggressive stance on this issue.

**Table 14: Electric Power Capacity Development in Turkey**

**Source, IEA, 2011**

| Fuel type | 2005 | | 2010 | | 2020 | |
|---|---|---|---|---|---|---|
| | Installed capacity ($MW_e$) | Generation (GWh) | Installed capacity ($MW_e$) | Generation (GWh) | Installed capacity ($MW_e$) | Generation (GWh) |
| Coal | 14,465 | 48,386 | 16,106 | 104,040 | 26,906 | 174,235 |
| Natural gas | 10,756 | 66,417 | 18,923 | 125,549 | 34,256 | 225,648 |
| Fuel oil | 2124 | 10,531 | 3246 | 18,213 | 8025 | 49,842 |
| Renewables[a] | 14,112 | 50,900 | 25,102 | 86,120 | 30,040 | 104,110 |
| Nuclear | 0.0 | 0.0 | 2000 | 14,000 | 10,000 | 70,000 |
| Total | 41,457 | 176,234 | 65,377 | 347,922 | 109,227 | 623,835 |

[a]Renewables includes hydropower, biomass, solar and geothermal energy.

## 8.5 Major Barriers to Solar Energy and Construction Sector in Turkey

While Turkey undoubtedly has a great deal of potential when it comes to solar energy there are still some major barriers that the country will have to overcome in order to make it a feasible part of the energy equation.

### 8.5.1 Problematic construction sector

The construction sector in Turkey is one of the fastest growing of the entire economy. In fact while other sectors have suffered in wake of the global economic crisis, the construction sector has done surprisingly well. As we have seen in a previous section, this sector much like the housing sector in the US is often what fuels other sectors in the economy. Yet the Turkish construction industry is plagued by certain problems that continue to make it a difficult sector in which to introduce new technology. In a study organized by ITU there were many surprising critiques of the industry. One of the major problems was, "organizational cultures in Turkish firms are characterized by both unequal (or hierarchical) and harmonious, family-like (clan) relationships."[30] A problem arises in a business, which is conducted like a family relationship because the issues of power, responsibility and control can be unclear. The discrepancy over these issues is problematic because this clan-like strategy does not match or allow companies to deal with the demand and pressures of such a competitive environment. Furthermore this same study states that the Turkish Construction Industry is also plagued with other problems,

> the relations with government authorities, rather than the market, determine the strategic decisions in Turkish organizations. Even the large company owners manage the company as a family-enterprise, rather than involving the professionals in the major decisions.[31]

### 8.5.2 Solar Energy is not a Government Priority

The present administration has been unable to realize or implement programs that take advantage of its RES abundance. In December of 2010, there was an additional RES law passed in Turkey but it in a way seems counterintuitive to encouraging renewables production. According to Hurriyet Daily News, "The new law limits the volume of energy that the state is allowed to buy and determines the long-term prices for electricity

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[30] (Ela Oney-Yazici 2007, pp. 525)
[31] (Ela Oney-Yazici 2007, pp. 525)

purchases."[32] Apparently in an attempt to encourage competition among electricity companies, they state is steadily moving toward privatization of the energy sector. The logic is that companies will become more and more competitive so as to provide better and cheaper services for consumers. "The law limits the total production of licensed solar energy companies to 600 MW annually until Dec. 31, 2013, and authorizes the Cabinet to determine the limits afterwards."[33] Therefore we can see the Turkish government does not look at RES as a priority. What this means for the industry is that it will have to find the funds from outside the country in the way of FDI from investors. Yet this subject can also be problematic for individuals wishing to invest in the Turkish energy sector.

When we consider the implementation of the feed-in tariff we can say that the 2005 RES law for solar was essentially a disaster due to the low priority that the technology was given. The 2005 law only provided a 5,5Euro Cent/kWh feed-in tariff. Given the cost of producing one kWh of PV energy it was simply unprofitable and did little to encourage investment in the sector; other RES such as wind were assisted by this program. This would explain the overall increase in wind energy in the past 5 years. Yet even the recent 2010 feed-in-tariff program that was introduced has done little to stimulate interest in the market. The new tariff for solar power of $0.133 per kilowatt-hour is an attempt but still not close enough to provide for the development of the industry. According to Harte, "that's just under 10 euro cents per kilowatt, far less than the 45.7 and 33 euro cents that Germany and Spain, respectively, offer their solar producers".[34]

Two other barriers that face investors to the Turkish Energy Sector is the snail-paced bureaucracy that the country is famous for as well as its antiquated and at time illogical legal structure. Because the implementation and creation of laws is an incredibly slow process in Turkey, many investors have been reluctant to bring their money to Turkey.

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[32] (Hurriyet Daily News 2010)
[33] (Hurriyet Daily News 2010)
[34] (Harte 2011)

As was previously mentioned, the RES law was passed in 2005. When we compare it to the US, which passed its first RES law in the late 1970s, we can see the country is severely lacking in its ability to have the legal system keep up with technology. In a recent case, we can see that Senas Group, a Turkish Green Energy company which also invests in the construction sector as well as civil aviation invested 2 million euros in a solar energy project in Germany simply because it was unable to develop a promising investment in Turkey due to RES regulations. An interview with the Senas Group chairman Fahrettin Tanınmış, highlights the incredibly frustrating situation that many RES companies in Turkey find themselves in

> We all know that Turkey has 1.5 times more solar potential than Germany. But the time between us starting the company and us starting to distribute energy is two months and 10 days in Germany, whereas we have been waiting for a wind power license in Turkey since 2007.[35]

There is an established and comprehensive infrastructure in Germany that does not exist in Turkey. It is clear that by being behind the technology, Turkey is loosing out on investments from domestic investors as well as foreign ones. Policies such as this one will continue to keep Turkey marginalized and subject to the fluctuation in the unstable world energy market.

### 8.5.3 Lack of knowledge and professionals

Another major issue for the Solar Energy Sector in Turkey is the lack of trained professionals in the Turkish market. This has a two-fold impact. The first issues is that without individuals with professional knowledge of the Solar Energy Industry there is less likelihood that the industry will ever gain a strong presence in the country. Solar Energy experts can help to advise governments, the business as well as consumers on the best methods for solar energy products. Because of the extreme lack of highly skilled individuals, developing legislation as well as solar energy based projects is negligible in Turkey. Which emphasizes the second impact. This lack of trained individuals means that companies that wish to develop the solar energy industry in Turkey will have to pay a premium for the training and skills from abroad. The training is already expensive but given the state of the Turkish Lira, this has an even more dire

[35] (Hurriyet Daily News 2010)

impact on the price associated with investing in solar energy. Not surprisingly, there is not one Turkish university that has a dedicated RES advanced degree program. Since the practical and professional knowledge does not exist in Turkey, it will have to be developed in order to the RES sector to true become significant to the Turkish energy equation. Until this point, exorbitant fees for training as well as professional installations will continue to be the standard.

### 8.5.4 Solar Panel Installation Training lack of training

Another major problem that faces the Turkish construction industry in terms of being able to take advantage of solar energy is the lack of a truly trained work force when it comes to solar panel installation. While there are nearly 30 companies that provide solar PV and solar thermal installations this is quite a low number compares to the 75 million-strong population. Since the solar industry in Turkey is essentially in its beginning stages it is easy to see how this field lacks the appropriate number of qualified individuals for installations. Furthermore as there are no CSP energy projects in Turkey as of yet, there are very few individuals knowledgeable of this technology. The true circumstances of this lack of knowledge actually have an impact on Turkey's trade balance. By not investing in its own personnel and providing training and professional development opportunities, Turkey will have to continue to pay for non-domestic companies to come in and train individuals as well as provide all types of technical support.

# CHAPTER 9: CONCLUSIONS

This sector will provide an overview of the entire paper as well as some recommendations for the future of the two industries in Turkey. Additionally, concluding remarks about the entire research will be made.

## 9.1 Turkey and its Solar Future: Recommendations

When we look at Turkey overall it is obvious that there is serious potential with the solar energy projects that are being enacted as well as the ones that are scheduled. With an estimated 380 billion kWh/year of potential solar energy just waiting to be harvested, the country could theoretically be energy independent. Not having to import any of its energy resources would be a monumental achievement for the country, especially since it has for more than 100 years been a net importer of energy. Energy independence would have a drastic impact on the trade balance as well as the economy, allowing the country to truly 'fuel' the potential industrial giant that is limited solely by lack of energy. While Turkey is presently a regional power in terms of political might, complete energy independence would mean that the country would have even more leeway to act as a leader of regional opinion rather than a follower. Being dependent on imported petroleum and natural gas from its questionable neighbors has long made Turkey a pawn in regional disputes and balance of power.

While there are many projects and programs at work in the country, Turkey is a relative newcomer to the field of solar energy; this is a bit ironic considering the large potential. If we consider a European counterpart, Germany, which does not have nearly the same solar energy potential as Turkey, seems "light years" ahead of the sleeping Mediterranean giant. With the new RES law's introduction in 2005, we saw the first organized attempt to make renewables part of the Turkish domestic energy equation. Yet the lack of a comprehensive solar energy plan truly did not assist with investment of this technology. Without proper incentives for investors for R&D it is not likely that a sizeable solar energy industry will develop in Turkey.

The lack of an established solar industry has serious consequence for the construction sector. While many countries are moving towards reliance on more renewable energy-

based buildings and infrastructures, Turkey has not been able to see how an initial investment will mean greater energy independence in the long run. Since most commercial as well as residential activity takes place indoors, the construction of dwelling as well as buildings with solar energy is the logical move for Turkey. Yet the construction industry also has faced some serious challenges in recent years. While regulations for major construction projects have been put in place for both consumer and society protection, there is still a great deal of "de facto" versus "de jury" issues in the Turkish construction industry. Widespread corruption means a lack of transparency for consumers and potential health hazards. While focusing on how solar energy can help to alleviate the energy problems for Turkey, the country also needs to focus on a streamlining of the construction sector itself.

There are many potential solutions for Turkey and how it may improve both industries. But there needs to be a general recognition on the part of the government as well as an established long-term energy plan that would involve RES and one that focuses on improving solar energy projects. Should the Turkish government move towards a mandate and require at least a percentage of the new construction projects to be solar energy compatible, the country would be better equipped to deal with increasing energy demands which are clearly just around the corner. The fact that the government is unable or unwilling to provide real economic motivation for the implementation of this technology, whether in a commercial or residential setting, shows its priority for solar energy. Unfortunately according to this author, this plentiful and renewable energy source is being greatly overlooked. While the solar energy industry will continue to develop, it is doubtful that within the next 10 years that there will be any significant addition to the Turkish energy equation via solar energy.

## 9.2 Concluding Remarks

In order to gain an accurate assessment of the situation in Turkey, we must look at the situation long term. Turkey will become a leader in solar energy generation in the future. It is not a matter of if but rather when. Once the government realizes the solar potential of the country, my prediction is that it will reach a critical mass and citizens will begin petitioning the government for real changes. The promising developments in

the solar energy sector have made it an interesting place for investors from a variety of countries. The hope of this author is that Turkish investors and the government itself can take advantage of this RES source before outside investors do. Finally, we can point to the city of Antalya as Turkey's beacon in its solar awakening. The city is being looked at as a test case. While it has proposed many RES projects that do not involve solar, the most important aspect is that all eyes are looking south for the next phenomena in energy in Turkey. Should the Antalya case prove to be successful then the lessons learned in this southern solar city perhaps can be applied to other areas of Turkey and assist the country with its energy independence.

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## CHAPTER 10: APPENDIX

Turkish Energy Statistics

| | | |
|---|---|---|
| **Coal > Production** | 2,170,000 ton | [26th of 65] |
| **Coal consumption** | 81,100,000 | [11th of 41] |
| **Coal Proved Reserves > Total** | 34,153 | [4th of 32] |
| **Commercial energy use** | 1,180.89 | [65th of 119] |
| **Electric power consumption > kWh** | 126,774,000,000 kWh | [22nd of 132] |
| **Electricity > Production by source > Fossil fuel** | 79.3% | [109th of 223] |
| **Electricity > Production by source > Hydro** | 20.4% | [87th of 223] |
| **Electricity > Production by source > Nuclear** | 0% | [54th of 223] |
| **Gasoline prices** | 1.44 | [22nd of 141] |
| **Geothermal power use** | 4,377 | [4th of 53] |
| **Nuclear waste generated** | -0.36 | [44th of 45] |
| **Oil Consumption > Thousand barrels daily** | 688 | [23rd of 63] |
| **Oil imports > Net** | 584,326 barrels per day | [9th of 21] |
| **Oil refining ability** | 719,275 barrels per day | [19th of 51] |
| **Oil reserves** | 288,400,000 barrels | [54th of 97] |
| **Primary Energy Consumption > Million tonnes oil equivalent** | 85.3 | [24th of 63] |
| **Traditional fuel consumption** | 3.1% | [91st of 130] |
| **Wall plugs > Plug type** | | |
| Europe | | |
| **Wall plugs > Voltage** | 230 V | [43rd of 209] |
| **Wind energy installation** | 20.6 MW | [33rd of 53] |