MSc Program
Renewable Energy in Central and Eastern Europe

Photovoltaics in Turkey: Current Status and Future Prospects

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"Master of Science"

supervised by

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Affidavit

I, **Mehmet Altug Zaimoglu,** hereby declare

1. that I am the sole author of the present Master Thesis, "Photovoltaics in Turkey: Current Status and Future Prospects",
   98 pages, bound, and that I have not used any source or tool other than those referenced or any other illicit aid or tool, and
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Abstract

Turkey is one of the most promising candidates of future photovoltaic market worldwide regarding meteorological conditions, availability of land and the targets set for securing energy supply and reducing Greenhouse gas emissions.

The country, which had set targets for utilization of solar power for electricity generation just a year ago, will have the very first application for eligibility of generation via renewable energy sources license in mid June, 2013. Since there have not been any PV plants built formally and generated electricity, investors are a little bit confused about the stages of project planning, implementation and generation.

First of all SWOT analysis is structured for the future PV market in Turkey. Within the results raised from SWOT analysis, this paper firstly studies on economical aspects of rooftop and utility scale PV plants, which will bring some useful information about profitability of designed plants as proposals. Moreover Turkey, doubling greenhouse gas (GHG) emissions with excess impact of energy sector in last two decades, has a big opportunity of taking control of emissions and reducing it. In addition to that, market integration of PV systems will bring much more job opportunities, which will be an important contributor for reducing higher unemployment rate like in Turkey.

Despite the fact that Turkey needs to improve the administrative framework, contribute to public awareness and put much more emphasis on PV systems, there is no doubt that Turkey would serve well as a sort of role model for developing countries and emerging economies that aim to utilize renewable energy sources (RES) and generate electricity domestically.

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Acronyms

BAPV: Building Applied Photovoltaics

BIPV: Building Integrated Photovoltaics

DCF: Discounted Cash Flow

EMRA: Electricity Market Regulation Authority

EPIA: European Photovoltaic Industry Association

EU: European Union

FIT: Feed-in-tariff

GDP: Gross Domestic Product

GDRE: General Directorate of Renewable Energy

GHG: Greenhouse Gasses

GPW: Geothermal power plant

HPP: Hydropower plant

IAF: International Accreditation Forum

IEA: International Energy Agency

IMF: International Monetary Fund

MEF: Ministry of Environment and Forestry

MENR: Ministry of Energy and Natural Resources

NPV: Net-Present Value

PPP: Purchasing Power Parity

PV: Photovoltaics

PVPS Programme: Photovoltaic Power System Programme

RES: Renewable Energy Sources

SEPA: Solar Energy Potential Atlas

TETC: Turkish Electricity Transmission Company

TETCC: Turkish Electricity Trading and Contracting Company

TSMS: Turkish State Meteorological Service

TurkStat – TSI: Turkish Statistical Institute

WPP: Wind power plant

1 Introduction

Republic of Turkey, located between Europe and Asia (between latitudes 35° and 43° N, and longitudes 25° and 45° E), has substantial increase in energy demand, which is about 8% per annum in recent years [1]. Turkey's growing economy and urbanization leads the country to generate more energy, increases demand and also dependence to foreign energy resources. Although the country is located near petroleum and natural gas rich countries, none of these conventional resources are found on this peninsula. Gross electricity generated is composed of 75.2% by means of conventional resources – mainly coal, petroleum and natural gas, while the amount of electricity generated by hydropower plants (HPP), wind power plants (WPP) and geothermal power plants (GPW) is only 24.8%, in which HPPs' are commonly utilized. [2]. According to International Monetary Fund (IMF), Turkey is the 16th biggest economy in the world and in number five in Europe respectively by gross domestic product at purchasing power parity (GDP (PPP)) in 2011 [3]. In line with continuous strong growth of economy and industry production, the Turkish Electricity Transmission Company (TETC) forecasted that the country's electricity demand is expected to grow in a high demand scenario by 7.9% per year between the years 2009 and 2020 [4]. Concerning these points and statistics, Turkey will have to use more local energy sources in order to handle the energy supply security, reduce GHG emissions, water pollutants and dependence on foreign energy resources.

On the other hand, although Turkey has signed the Kyoto Protocol in 2009, Turkish government has not introduced a carbon market or any precautions for avoiding continuous strong increase of emissions. In the past, GHG emissions have increased year by year with the increase in industrialization and urbanization [5, 6].

Although Turkey has adequate meteorological, geographical conditions and rich in RES, country utilized RES for electricity generation in lower amounts till last decade compared to most European countries. Starting from the last decade, the interest towards renewable energy projects has increased with the government's Electricity Market and Security of Supply Strategy act introduced in 2010 with new and more efficient feed-in-tariffs, incentives and regulations compared to predecessor law. Besides the investments and attention towards wind and hydropower, photovoltaic seems to playing contribute positively to Turkey's future, regarding economics, social status and security of supply. According to the measurements made by

Turkish State Meteorological Service (TSMS) between 1966-1982, average insolation duration is 7.2 hours per day, where average annual solar radiation is 1311 kWh/m^2 per year [7]. On the other hand, the Bavarian city of Germany – Munich, which has average insolation duration of 4.68 hours per day and average annual solar radiation of 1142 kWh/m^2, utilizes PV amply, although the city has relatively lower numbers with respect to Turkish averages. According to the forecasts done by TETC, Turkey's electricity demand will be approximately 390 TWh by 2019, which means the demand will double compare to 2009[8]. Indeed, PV appears as an important contributor for reaching the target set by the government (2010-2014 Strategic Plan) to achieve that at least 30% of electricity shall stern from RES by 2023.

1.1 Motivation

Republic of Turkey, located in sunny belt has many advantages, especially over European PV market leaders – i.e. Germany, Italy, Spain and other EU member states regarding meteorological and geographical conditions. In 2009 Turkish government introduced the 2nd Turkish Renewable Energy Act on Electricity Generation in 2010, which the FIT for photovoltaic is set to 0,133$/kWh. If domestic products are used for generating electricity this price can be up to 0,200$/kWh. Although, the incentives and conditions introduced by Turkish government seems weaker than these market leaders, the sunshine duration, average annual radiation rates, and suitability of the land increase the eagerness to get deeper into future prospects for Turkish PV market. In addition this, Ministry of Energy and Natural Resources will receive the applications for licensed generation of electricity from PV for the first time on 10-14 June, 2013, which seems to be the most important milestone of utilization of PV and booming effect is expected for Turkey. The main purpose of this study is to analyze current status of Turkish PV market and electricity generation and show that; this country can be a promising market player in the future regarding economical and ecological aspects, since the country needs to decrease it's dependence to conventional imported resources and to reduce GHG emissions.

1.2 Core objective

This paper analyzes current status of photovoltaic market, framework and opportunities in Turkey and outlines possible future prospects regarding social,

economic and legislation aspects with recommendations, which aims to show how effective and efficient incentive schemes can be introduced and how to attract citizens' and investors' attention towards clean and sustainable energy use.
This study contains two complementary assessments of the Turkish PV market.

I. An analysis of the PV market status and related framework conditions for Turkey is conducted within the thesis. This involves a comparison of the Turkish market with successful international examples, e.g. the German PV market, in order to undertake a comparative evaluation of the effectiveness and efficiency of the framework and the renewable energy act introduced by the Turkish government.
II. Another assessment is done to see if Turkey can become an important contributor in the future of global PV market with sufficient improvements on regulatory framework, R&D studies and laws.

1.3 Citation of main literature

The main literature used for this study comprises documents, journals, books and publications that can be found on associations' websites, which are related to PV, governmental websites of Turkey those open to public. The most important references used within this stern are from:

- Documents from Ministry of Energy and Natural Resources (MENR)
- Documents from Energy Market Regulatory Authority (EMRA)
- Databases from Turkish Statistical Institute (TSI)
- Databases from EuroStat
- Databases from Turkish Electricity Transmission Company (TETC)
- Databases and Publications from General Directorate of Renewable Energy (GDRE)
- Publications of International Energy Agency (IEA)
- Turkish and foreign journals on Turkish Renewables and PV market
- Reports and databases from European Photovoltaic Industry Association (EPIA)
- Documents for General Directorate of Renewable Energy (GDRE)
- Statistics from German Federal Ministry for the Environment, Nature Conservation and Nuclear Safety

1.4 Structure of work

The principle structure of work for this thesis is summarized in the schema below:

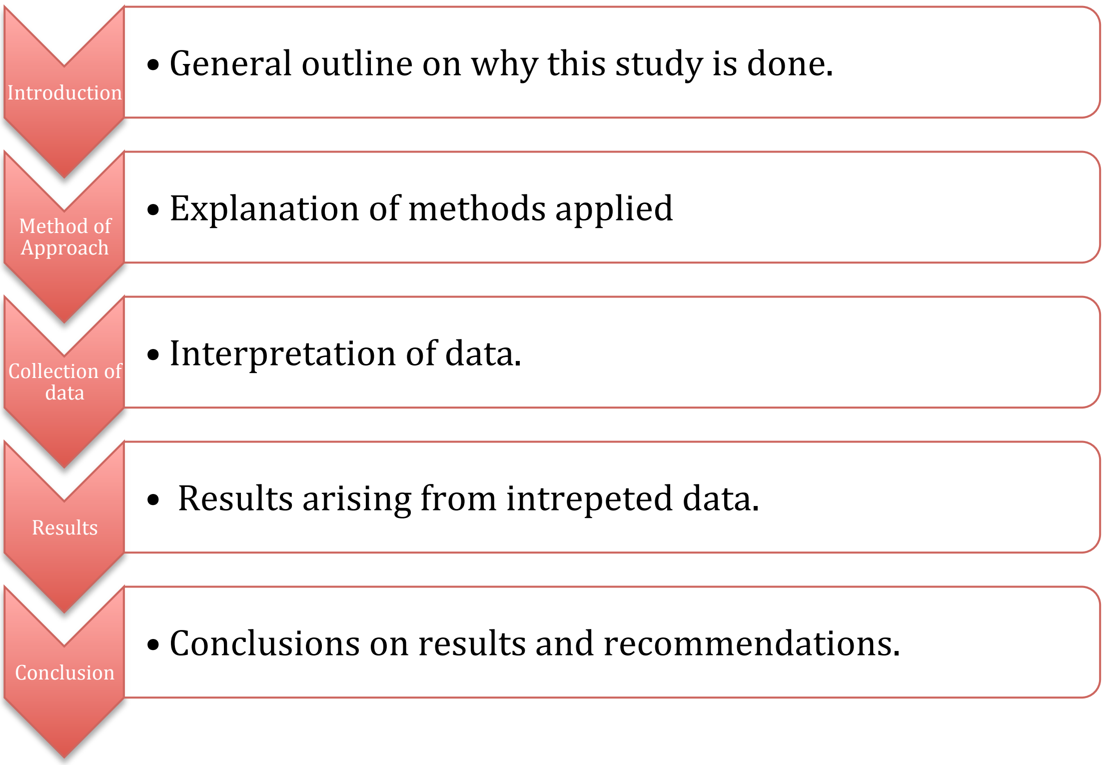


Figure 1: Structure of work (schematic)

The overall work and representation in this paper follows the schematic structure as illustrated above. A detailed explanation of the individual parts is given next.

1) **Introduction:** In this part of the study, general information about current status of the Turkish electricity market. Moreover a brief explanation on potentials of solar power is mentioned. The sections of the chapter explain the core objective of this study referenced with motivations mentions the literature utilized for this study and outlines the structure of the study. This chapter is subdivided into 4 parts: Motivation, core objective and citation of main literature and structure of work.
2) **Method of Approach:** In this section, the methods conducted in this paper is explained in detail, where 3 different methods are used:
    a. **SWOT Analysis:** An analysis that is done for outlining strengths, weaknesses, opportunities and threats of the Turkish PV market. This assessment outlines the current status of Turkish PV market, and shows some indications on what needs to be done in future.

b. **Questionnaire:** A questionnaire is conducted on participants with the sample of 200, to gain information about their ideas on investing in PV systems and knowledge on RES and PV systems.
c. **An economic assessment on BIPV/Roof-top PV systems**
d. **An economic assessment on utility scale PV systems**
e. **An ecological assessment on the utilization of PV systems**
f. **A brief indication of employment impacts of the PV sector**

3) **Documentation of Data:** In this section collected and derived data will be illustrated. Firstly, the data on Turkish and German electricity market data will be given in order have an opinion on different markets. Then the potentials, legislations and current status of both countries' PV market will be analyzed and compared.
4) **Assessment of the Turkish PV market**

   SWOT Analysis' interpretation draws a roadmap for Turkey's future PV market, while awareness and eagerness to utilize PV systems are analyzed through the results arouse from questionnaire.

   Economic assessments of a sample BIPV/Roof-top system and a sample utility scale PV power plant is done and discussed using discounted cash flow method.

   The opportunity to avoid GHG emissions via PV plants, when the systems start to operate is assessed.

   Employment impacts will be analyzed through some conversion and substitution methods, when the systems are installed.
5) **Results**

   The data rose from this study is analyzed an interpreted.
6) **Conclusions**

   Recommendations are made and conclusions are derived.
7) **Acknowledgements**
8) **References**
9) **Annex**

2 Method of Approach

In this part of the study, the research method applied is overviewed and explained. While building the methodology, secondary and then primary research is done and regarding the data coming from these, relevant methods that are going to be used are explained. As secondary research, local and foreign studies done till today on Turkish Renewable Energy Act, potential utilization, employment impacts, databases and reports given on PV market for both Turkey and Germany are interpreted and utilized. After the data collected and documented, results arising from these studies are explained and interpreted in “results” section.
Primary research is done in six sections:

1. SWOT Analysis on Turkish PV Market
2. A questionnaire is applied to citizens of Turkey to gain information on PV-knowledge and to evaluate citizens’ eagerness in investing in BIPV/Roof-top systems.
3. An economic assessment on a BIPV/Roof-top for the regions having global annual irradiation greater than 1620 kWh/m^2 year is done.
4. An economic assessment on a typical utility scale PV system for the regions having global annual irradiation greater than 1620 kWh/m^2 year is done.
5. Ecological assessment on the utilization of PV systems.
6. Brief indication of employment impacts of the PV sector.

2.1 SWOT Analysis

The SWOT analysis is an important element of this study. It contains to analyse strengths, weaknesses, opportunities and threats of the Turkish PV market regarding economic, social, geographical and governmental aspects. *Strengths* part stands for the advantageous conditions of Turkey over other countries. *Weaknesses* part stands for the conditions that are relatively inefficiency or absence of strengths compared to other countries. *Opportunities* stand for the external conditions in which implementation of the new project or market entry will boost other entities in economical and sociological ways. *Threats* stand for external conditions that can be a barrier or a threat in front of new business entry.

Firstly, strengths and weaknesses are defined, which are based on internal structure of the market and then, possible threats and opportunities waiting for the current Turkish PV market are examined. This method basically gives information about the market and outlines strengths, opportunities, weaknesses and threats of the market. With the outcomes of this study, some proposals are given accordingly to improve the Turkish PV market, which can hasten the process of investments and project start-ups.

2.2 Questionnaire

A questionnaire is prepared in order to gain information about the general knowledge on renewable energy, electricity generation from RES and to test the eagerness of people to use PV systems in their households – i.e. BIPV/Roof-top (see questionnaire in Annex H).

150 citizens participated in this questionnaire and some of them did the questionnaire online, while the others handed manually. The reason why the questionnaire is applied in two different ways is to reach adequate number of participants, who have or do not have opportunities to do the survey online. The data collected from participants is analysed and mined using IBM SPSS Statistics software. Cross tabulation and chi-square tests are applied to gain information about what is researched. Participants are segmented according to their ages, monthly wages and educational backgrounds.

2.2.1 Age

The participants are segmented according to their age with following age groups:

- Under 18
- 18-25
- 26-39
- Above 40

This segmentation allows us to test whether knowledge and consciousness on newly driven technologies on renewables – especially wind, PV and geothermal is about age or keeping abreast of the new world.

2.2.2 Monthly Wages

The participants are segmented according to their monthly wages with following wage groups:

- Not Working / Student
- Below 1,000 TL
- 1,000 TL – 2,500 TL
- 2,501 TL – 5,000 TL
- 5,001 TL – 10,000 TL
- Above 10,000 TL

Segmenting participants according to the monthly wages is quite important, since it will give information about the eagerness towards implementing BIPV/Roof-top systems to their households or not, connecting with their affordability to implement these systems.

2.2.3 Educational Backgrounds

Although this variable seems to be dependent on age or vice versa, Turkey's educational background statistics done by TurkStat in 2010 show that, 57% of the population aged 22-39 years old were graduated from primary school [9]. Doubtlessly, education plays an important role on individual's vision and consciousness on global trends and threats, which can also be a hypothetical question for "Is education affiliated with Turkish citizens knowledge on RES and PV?"

In addition to these personal questions, 4 other questions are asked to gain information about general knowledge of citizens on RES and PV.

2.2.4 Questions

4 questions asked to the participants to collect data on RES and PV generation knowledge:

1) Do you know that electricity can be generated from RES (Hydro, Biomass, Solar, and Geothermal)?

This question was asked to participants in order to test whether they have brief information on RES. Taking 3 segment questions into account following question could be answered:

- Is there a connection between age and knowledge on RES?
- Is there a connection between education level and knowledge on RES?

2) Do you know that electricity can be generated from solar energy using PV?

This question was asked to participants in order to test whether they have brief information on solar electricity generation. Following questions can be asked:

- Do people know that solar sources are RES?
- Is there a connection between knowledge on solar electricity generation and age?
- Is there a connection between knowledge on solar electricity generation and education?

3) Do you know that PV systems can be used in your households? (Namely BIPV or roof-mounted)

This question was asked to the participants in order gain information about whether they know that they can use solar systems for electricity generation in their households or not. Another question to be answered is that, is there an affiliation between solar electricity knowledge on BIPV/Roof-top systems?

4) Do you prefer to install BIPV/Roof-top system to your household knowing that the system can compensate its cost in approximately 10 years?

This question was asked to the participants in order to gain information whether they want to install a BIPV/Roof-top system to their households or not. Since, many of the people are not aware of even renewable energy systems, PV, support scheme and unfortunately global warming. The question was asked to participants indicating the payback time of a BIPV/Roof-top system. Following questions can be asked:

- Are eagerness to invest in BIPV/Roof-top systems and monthly wages affiliated?
- Are eagerness to invest in BIPV/Roof-top systems and knowledge on BIPV/Roof-top systems affiliated?
- Is education level affiliated to eagerness to invest in BIPV/Roof-top systems?

To test the dependence of the variables and groups defined below, Pearson Chi-square tests are applied and cross tabulations are prepared via **IBM SPSS 20 Statistics** software. SPSS (originally Statistical Package for Social Sciences) is a computer program used for data mining, text analytics and statistical analysis releasing results to be interpreted.

Cross tabulations are prepared to see the distribution of participants' responds to each question divided to subgroups according to age, education and income levels.

Pearson Chi-square test tests a null hypothesis stating that the frequency distribution of certain events observed in a sample is consistent with a particular theoretical distribution. Chi-square test does not test if the variables show different attributes within the groups, but indicates groups and variables are significantly dependent. In other word, the changes in attributes of the groups do somehow change in results. The value of the test statistic is:

$$X^2 = \sum_{i=1}^{n} \frac{(O_i - E_i)^2}{E_i}$$

Equation 1: The value of Pearson Chi-square test statistic

Where;

X^2: Pearson's cumulative test statistic, which asymptotically approaches a χ^2 distribution
n: Number of sample – the number of cells in the table
O_i: an observed frequency
E_i: an expected (theoretical) frequency asserted by the null hypothesis

Expected Count: is the count asserted by the null hypothesis. The formula to find expected count is:

$$\frac{Row\ Total\ x\ Column\ Total}{N}$$

Equation 2: Expected count

For instance expected count for the for the group of people aged between 18-25 who do not know electricity generation from solar power among the respondents is: (62x33)/132 = 15.5.

			SolarKnowledge		
			Yes	No	Total
Age	Under 18	Count	7	1	8
		Expected Count	6.0	2.0	8.0
	18 - 25	Count	43	19	62
		Expected Count	46.5	15.5	62.0
	26 - 39	Count	40	8	48
		Expected Count	36.0	12.0	48.0
	Above 40	Count	9	5	14
		Expected Count	10.5	3.5	14.0
Total		Count	99	33	132
		Expected Count	99.0	33.0	132.0

Expected counts, given as output via SPSS descriptive statistics are important, since the variance between expected counts and observed counts indicate the dependency on null hypothesis.

ρ-value: is the probability, if the test statistic really were distributed as it would be under the null hypothesis, of observing a test statistic is more extreme or extreme as the one that actually observed. In our Pearson chi-square tests ρ value is going to be analyzed in $\alpha=0.05$ significance level.

Significance level (α): the significance level is the criterion used for rejecting the null hypothesis. The significance level is used in hypothesis testing as follows: First, the difference between the results of the experiment and the null hypothesis is determined. Then, assuming the null hypothesis is true, the probability of a difference that large or larger is computed. Finally, this probability is compared to the significance level. If the probability is less than or equal to the significance level, then the null hypothesis is rejected and the outcome is said to be statistically significant.

Data clearance: The data obtained from 18 participants are cleared somehow trying to get rid of unbiased responds, since the responds given to questions "Do you know electricity generation from hydro, wind, biomass and solar?" and "Do you know that electricity can be generated from solar power?" are paradoxical. 8 participants from the 18 claimed that they do not know electricity generation from RES but they do know electricity generation from solar power while remaining 10 claimed that they know electricity generation from RES but they do not know electricity generation from solar power, although the types of RES including solar was indicated in the first question.

2.3 Economic assessment on BIPV/Roof-top systems

In this part of the study a rooftop PV system is proposed in order to cover all electricity needs by a family household with 4 members in Antalya. Antalya is chosen as a proposed city, since having much more global irradiation and sunshine duration with respect to average numbers of Turkey (1650.3 kWh/m^2/year and 3013 hours/year). First of all, based on the daily consumption of a 4-membered family, total capacity of PV system needed to cover whole consumption is estimated by using PVGIS, which is a PV potential production estimator released by Joint Research Centre of European Commission. As a reference point the month July is taken, since the peak demand in Antalya is encountered mostly in summer due to excessive usage of air conditioners.

After then, system components that are going to be used are specified. While choosing the components, systems capacity, modules' efficiency, inverter's efficiency and adaptability to the system and warranty periods took into account.

Moreover, yearly consumption and generation quantity is calculated in order to find out how much kWh of electricity will be fed to grid to sell it to Distribution Company. In addition to this, the generator with this system installed, get rid of the electricity bills, which contribute as savings for the generator.

In decision period, **Discounted Cash Flow (DCF) Analysis** is used in order to see if the project is profitable or not. Discounted cash flow analysis a valuation method used to estimate the attractiveness of an investment opportunity. Discounted cash flow (DCF) analysis uses future free cash flow projections and discounts them on specific discount rates or weighted average cost of capital rate to arrive at a present value, which is used to evaluate the potential for investment. The formula to calculate DCF namely Net Present Value (NPV) is:

$$DCF = \sum_{t=0}^{n} \frac{CF_n}{(1+r)^t}$$

Equation 3 Discounted Cash Flow

Where;

DCF: discounted cash flow
CF_n: cash flow in period n
r: discount rate
t: number of periods to be applied

In order to calculate DCF, Microsoft Office 2011 Excel is used. The final result arouse from the calculations will show if it is worth to invest in or not following the rule:

If DCF < 0, it is risky to do invest,

If DCF >= 0, it is worth to do investment.

The NPV of the investment is firstly calculated on discount rate of 16%, which is Turkish Republic's Central Bank Rate at the end of 2011 and then discount rate of 5% is assumed, which many banks in Europe adopt this rate.

On the other hand two different cases will be used based on assumptions on FIT rates applied:

I. What happens if the system's components are all manufactured in Turkey and warrant certifications?

II. What happens if the FIT rate to be applied is 39.14€¢/kWh (=50.63$¢/kWh) as applied in 2010 in Germany?

These assumptions and related questions will give some useful information on if the FIT applied for PV systems in Turkey is efficient or not.

2.4 Economic assessment on Utility Scale PV Systems

In this part of the study, PV power plant with a capacity of 3 MW_p built with thin-film – i.e. Cadmium Telluride (CdTe) solar panels, located in Antalya, where the city has 8.25 hours of sunshine duration per day and having average daily global radiation of 4.51 kWh/m^2, is examined.

Likewise the previous study on roof-mounted PV systems, while implementing the project, some calculations and assumptions are obtained from the PVGIS like possible system, module, inverter, wiring losses and losses due to dust and optimized slope angle.

In this part, calculations on project finance are done with same methodology as the previous study, which is DCF method. Discount rates applied on the calculations are chosen as the most desirable rates of the companies' worldwide.

2.5 Environmental Assessment on Utilization of PV Systems

The analysis briefly calculates and illustrates the amount of avoided GHG emissions assuming:

- Capacities of 600 MW PV power plants are installed in 2013 and 2014.
- Cadmium Telluride (CdTe) solar panels are used in each installation.
- Annual yields of the proposed systems are taken from PVGIS – PV estimation software, with different areas and slopes.

To calculate possible avoided GHG emissions a heuristic with to steps is applied.

1. Substitution factors are used in order to find out how much electricity are generated using conventional resources instead of utilizing PV.
2. LCA emission factors for each type of conventional resources are taken into account to calculate total amount.

Total avoided GHG emissions then can be calculated via simple equation:

$$\text{Avoided GHG emission} = \text{Electricity Generated (MWh)} \times \text{Substitution Factor} \times \text{LCA emission factor } (mtCO_2e/MWh)$$

Equation 4: Amount of GHG emissions avoided

On the other hand, using LCA emission factors by PV systems, which are harmonized in various studies, are used to find the life-cycle emissions of proposed system.

2.6 Brief indication on employment impacts of the PV Sector

While the method that is going to be applied to find out some useful information and numbers, some assumptions made and facts gained about the companies in PV Sector are used which was reported by Greenpeace and EPIA's collaborative work, described in Chapter 4 – Section 6. Mainly, this paper studies the gross employment impacts of employment, while mentions about net impacts to show the whole picture of employment impacts in overall economy.

3 Documentation of Data

In this section, the necessary data is documented, which is gained within primary research, and some statistical and economical indicators are illustrated to build up the core objectives stated in Section 1.3.

3.1 Electricity market outline of Turkey and Germany

In this section, a comparative study on Turkish and German electricity and PV market is done, in order to have general idea and approach results for Turkey's future PV market via deriving existing data.

3.1.1 Turkey

Turkey generates electricity mainly from thermal conversion plants. Conventional resources used for electricity generation accounted for nearly 74% of total of 209.3 TWh in 2010. Since Turkish energy sector is import dependant by 71%, these thermal conversion plants create economic burden to public finances, which also increases foreign trade deficit.

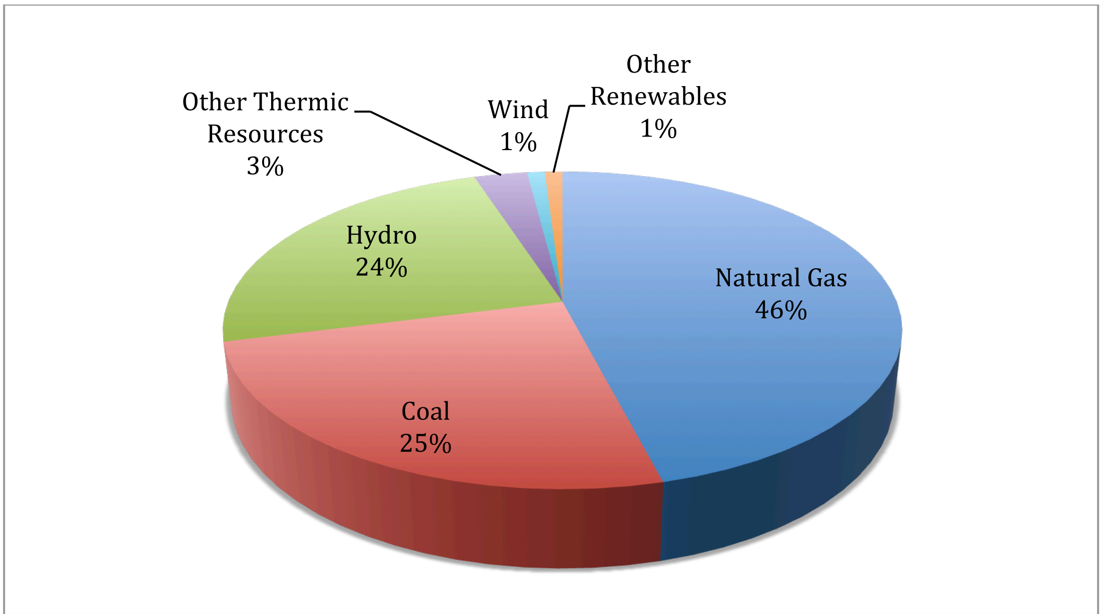


Figure 2 Electricity generation from different resources in Turkey 2010 (TWh)

As it is seen from the figure, electricity generation is mainly composed of thermic conversion processes. Hydropower also plays an important on electricity production contributing by 50.23 TWh [10]. However hydropower is now called *traditional renewable energy* in today's world standards.

Another statistics show that, thermal conversion power plants contribute 65% of whole electricity generation capacity with 32,317 MW. You can find total installed capacity, gross generation and net consumption of electricity between 2001 and 2010 in Table 1 [11].

Year	Total Installed Capacity (MW)	Gross Generation (GWh)	Net Consumption (GWh)
2001	28,332.4	122,724.7	97,070.0
2002	31,845.8	129,399.5	102,948.0
2003	35,587.0	140,580.5	111,766.0
2004	36,824.0	150,698.3	121,141.9
2005	38,843.5	161,956.2	130,262.9
2006	40,564.8	176,299.8	143,070.5
2007	40,835.7	191,558.1	155,135.2
2008	41,817.2	198,418.0	161,947.6
2009	44,761.2	194,812.9	156,894.1
2010	49,562.1	209,307.7	172,050.6

Table 1: Capacity, Gross Generation, Net Consumption 2001-2010

In 2010, electricity market reform done by the government, made private companies eligible to generate, retail and wholesale operations and distribute electricity generated [12]. This reform also played an important role in additional capacities, where the burden of electricity market to public funds decreased and stronger competitive market is established.

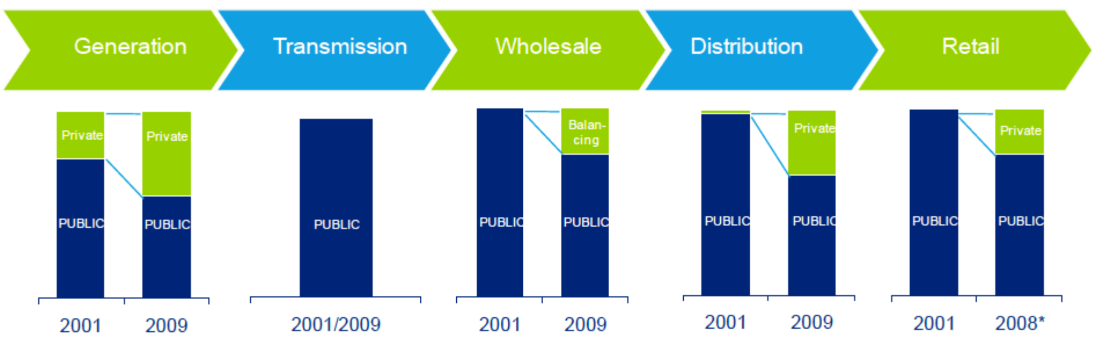


Figure 3: Private companies share in Turkish electricity market

Table 1 above shows that, the average annual growth rate of net consumption between 2001 and 2010 is 7.7%, which is larger than other European countries' growth rate. Average annual rate of increase in electricity consumption between 1990 and 2008 is shown in Figure 4 [13]. The reason behind this substantial increase is due to economic growth, industrialization and urbanization. So Turkey needs more electrical energy than the last decade to keep growing process. Although the capacity was increased in year 2009 with respect to 2008, gross generation and net consumption decreased, since global crisis affected production in many sectors, especially automotive and textile in Turkey.

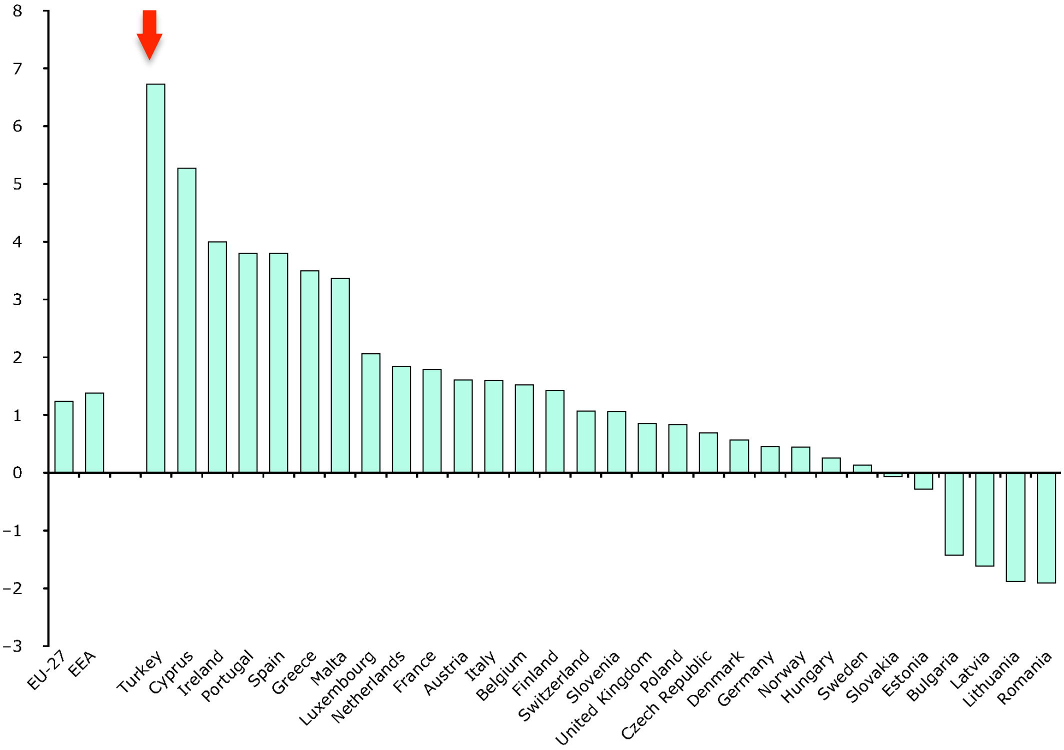


Figure 4: Average annual percentage change of electricity consumption (1990-2008)

Turkey's population was 73,722,998 verified by TurkStat in 2010. So the net electricity consumption per capita in 2010 was 2,333.7 kWh, which was lower when compared to world and Europe (see in figure 5) [14].

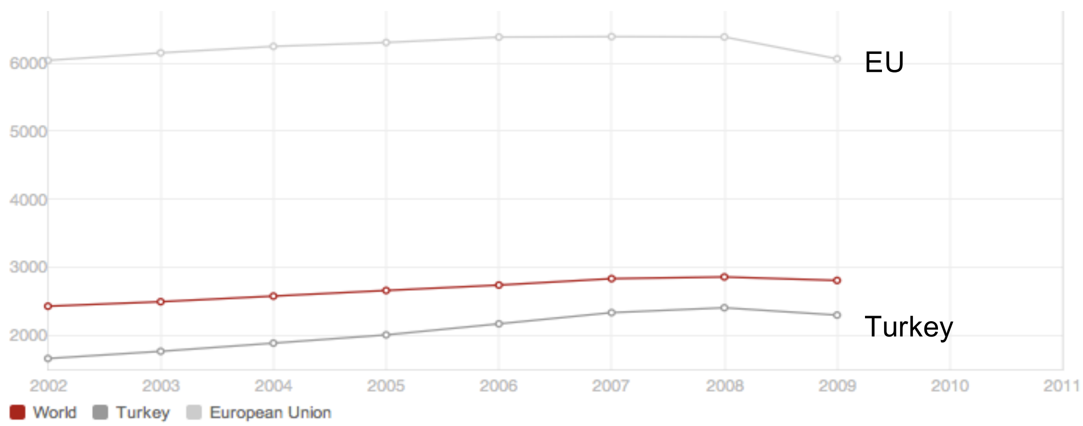


Figure 5: Evolution of Electricity Consumption per Capita 2002-2009

These statistics indicate that, electricity consumption in Turkey is likely to increase in upcoming years. Peak and electricity demand projections were done by MENR in 2011 for two different scenarios, which are *minimum* and *maximum* demand cases. The numbers are as follows shown in Table 2 and Table 3.

Year	Peak Demand		Electricity Demand	
	MW	Increase	GWh	Increase
2011	36,000	7.8%	227,000	7.9%
2012	38,400	6.7%	243,340	7.2%
2013	41,000	6.8%	262,010	7.6%
2014	43,800	6.8%	281,850	7.6%
2015	46,800	6.8%	303,140	7.6%
2016	50,210	7.3%	325,920	7.5%
2017	53,965	7.5%	350,300	7.5%
2018	57,980	7.4%	376,350	7.4%
2019	62,265	7.4%	404,160	7.4%
2020	66,845	7.4%	433,900	7.4%

Table 2: Peak and Electricity Demand (High Demand Scenario) (Source: [4])

When we have a look on high demand scenario, average increase in electricity demand will be 7.5%.

Year	Peak Demand		Electricity Demand	
	MW	Increase	GWh	Increase
2011	36,000	7.8%	227,000	7.9%
2012	38,000	5.6%	241,130	6.2%
2013	40,130	5.6%	257,060	6.6%
2014	42,360	5.6%	273,900	6.6%
2015	44,955	6.1%	291,790	6.5%
2016	47,870	6.5%	310,730	6.5%
2017	50,965	6.5%	330,800	6.5%
2018	54,230	6.4%	352,010	6.4%
2019	57,685	6.4%	374,330	6.4%
2020	61,340	6.3%	398,160	6.3%

Table 3: Peak and Electricity Demand (Low Demand Scenario) (Source: [4]

On the other hand, when we take the low demand scenario into account, annual average grow rate increase in electricity demand will be 6.6%. When we compare world's electricity demand with an annual average growth, which is 2.4% [15], Turkey has to increase its electricity production. "Turkish economy grows drastically and in parallel with that, energy demand increases," said Turkish deputy prime minister while doing newspaper interview with Japanese Nikkei (Babacan, 2012). However Turkish government set targets for electricity generation from RES as minimum 30% by 2023 focusing:

- Full utilization of hydropower economically useable potential
- Installed wind capacity of 20 GW (10 GW by 2015)
- Installed geothermal capacity of 600 MW (300 MW by 2015)
- Installed PV capacity of 3 GW

Besides these targets, Turkish government considers to build three nuclear power plants (NPP) across the country, which the target of decreasing energy based foreign trade deficit (Babacan, 2012) lies behind. Building NPP's might decrease foreign deficit, but when these start to operate, three things are open to debates: **1)** Raw material will be imported and the plant is going to be built by foreign companies. **2)** Turkey lies in seismic belt, i.e. earthquake potential. **3)** Possible environmental burdens.

On the other hand Turkey also set targets for priority of electricity generation from domestic resources, to increase efficiency, decrease GHG emissions and foreign trade deficit that consists of mainly energy imports.

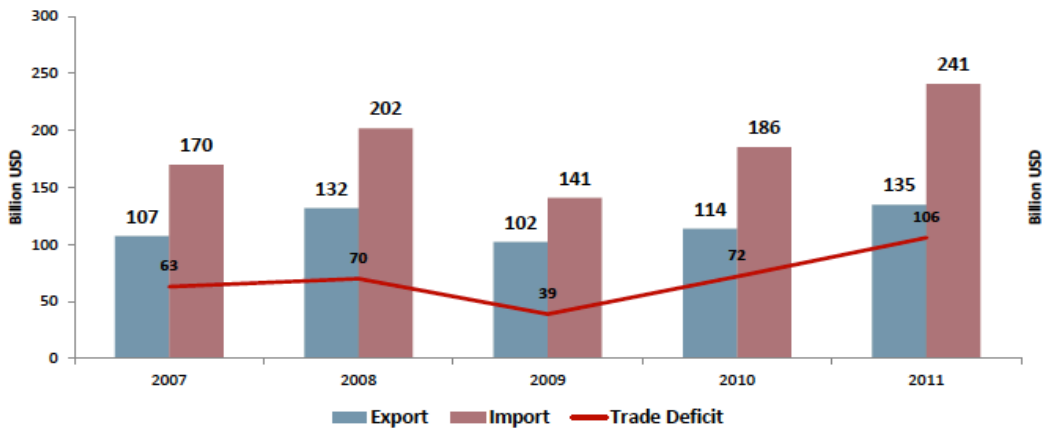


Figure 6: Trade balance of Turkey 2007-2011 (Source: [46])

In 2011, 44% of the trade deficit was caused by energy imports, which is approximately 46.6 billion USD, creating burden to public finances.

3.1.2 Germany

Germany ranked the 7th biggest consumer all over the world regarding electricity [16]. Germany generates electricity mainly from nuclear energy and thermal conversion plants. Hence, targets set by European Commission (20% energy mix from RES, reduction of GHG by 20% and 10% biofuel usage) and the nuclear disaster in Fukushima, Japan reconsidered Germany to reevaluated their energy policy and announced that by 2022 all NPPs will be phased out. Germans generated 628 TWh of electricity in 2010 [17].

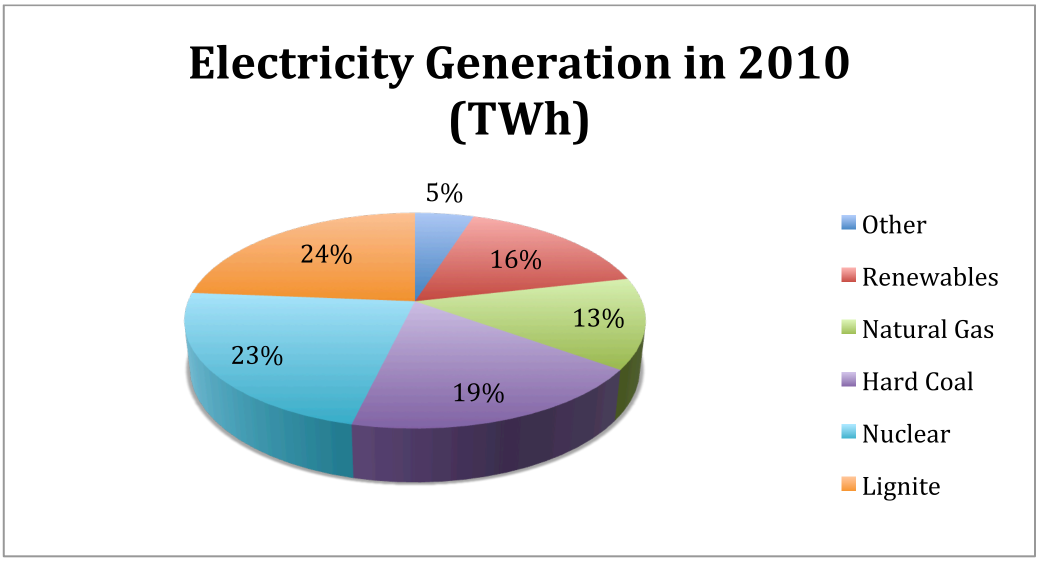


Figure 7 Electricity Generation from different resources in Germany 2010 (TWh)

In the last decade, RES has increased its significance in whole world and Germany is kept updated with trends in electricity generation via alternative resources.
The breakdown of RES for electricity production is illustrated in Figure 7. In 2010 Germany generated 16.6% of electricity from RES, which accounts for approximately 103 TWh (see Figure 8 for breakdown of generations from RES). Although the contribution of PV to German electricity market seems low, after 2010 generation of electricity via PV boomed and reached grid parity level for PV systems up to 100 kW_p [18], and Germany installed record capacities by years 2010 and 2011 consecutively.

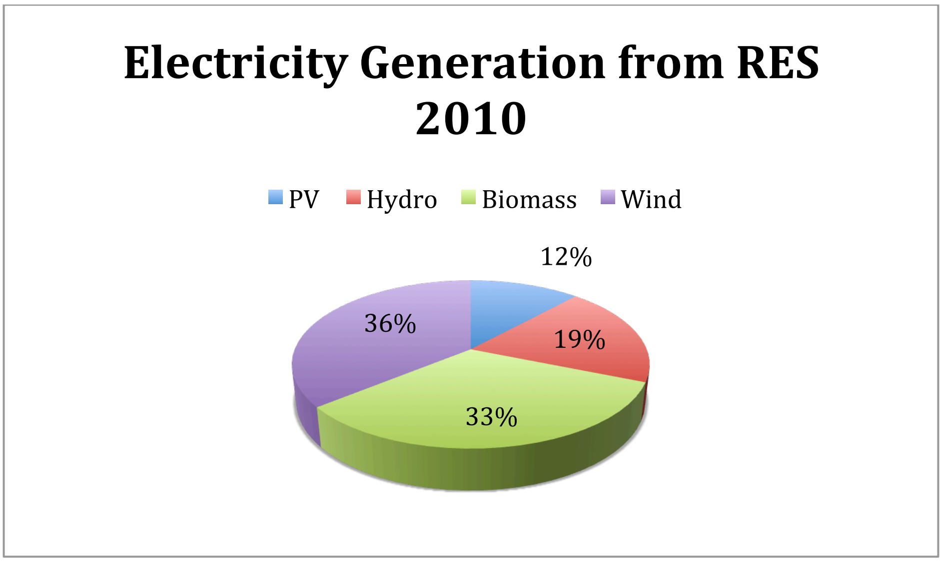


Figure 8 Breakdown of Electricity Generation from RES in Germany 2010

However 2011 statistics show that, use of electricity from RES increased to 122 TWh, which contributes to 19.8% share of total electricity generation [17]. On the other hand, German government set medium and long-term goals for share of RES for electricity, heat and transport sector. Targets set for share of RES for electricity production is illustrated in Figure 9 [19].

	RE share in electricity
At the latest	[%]
2020	at least 35
2030	at least 50
2040	at least 65
2050	at least 80

Figure 9: National mid and long-term targets for Germany

In order to reach these targets, 26.6 billion EUR is invested in installation of renewable energy generation facilities in 2010, which was record level. The most remarkable investment was done in PV by 19.5 billion EUR. Concurrently with these investments, 367,400 people were employed in this sector- nearly two thirds of whole employment in 2010 [19]. You can find the actual numbers for employment per year in Figure 10.

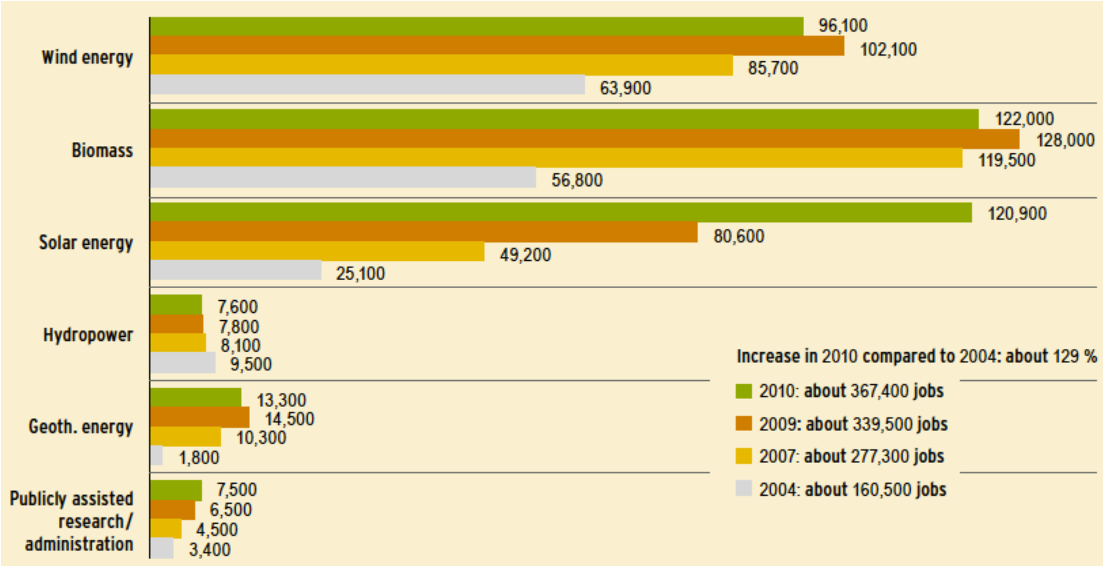


Figure 10: Employment in Germany's renewable energy sector

Figure 10 shows and clearly proves that; renewable energy sector is not only a favour for world's ecological future, but also an employer bringing welfare.

The law, which firstly promoted renewables was introduced in 1990 in Germany under the name of *Federal Electricity Law (StrEG)* and as successor of it, *Germany's Renewable Energy Law (Erneuerbaren Energien Gesetz)* came into force in 2000. After then, the interest towards RES substantially increased. Between 2000 and 2010 the shares of renewable energy almost tripled, although gross electricity consumption increased annualy by 8.2% [19].

	1990	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
Final energy consumption (FEC)	[%]	[%]												
Electricity generation (based on total gross electricity consumption)	3.1	4.7	5.4	6.4	6.7	7.8	7.5	9.2	10.1	11.6	14.3	15.1	16.3	17.0

Figure 11: Renewable energy shares of electricity generation from 1998-2010

Integration of RES into German electricity sector also supplied fossil fuel savings of 234.4 TWh of primary energy, economically 2.5 billion EUR savings from import costs [19].

3.2 GHG Emissions

GHG emissions endanger world's future in terms of global warming and conservation of nature. Developed countries in the world placed emphasis on reducing and avoiding GHG emissions through industrial, automotive and energy sector.

On the other hand, Turkish economic growth based on industrialization and urbanization makes the country need more energy. Previous and today's governments replied this energy demand with thermal conversion power plants, which have considerable impact on increase in GHG emissions. However total GHG emissions increased by 115% from 1990 to 2010 [20].

Type	2010	1990
Carbondioxide	326.47	141.36
Methane	57.54	33.5
Nitrousoxide	13.03	11.57
Fluorinated GHG	4.89	0.6
Total	**401.93**	**187.03**

Table 4: GHG emissions in Turkey (1990-2010)

Mainly, GHGs arouse from energy sector, industrial processes, agricultural activities and wastes. Figure 12 shows that nearly 71% of GHGs arouse from energy sector in Turkey.

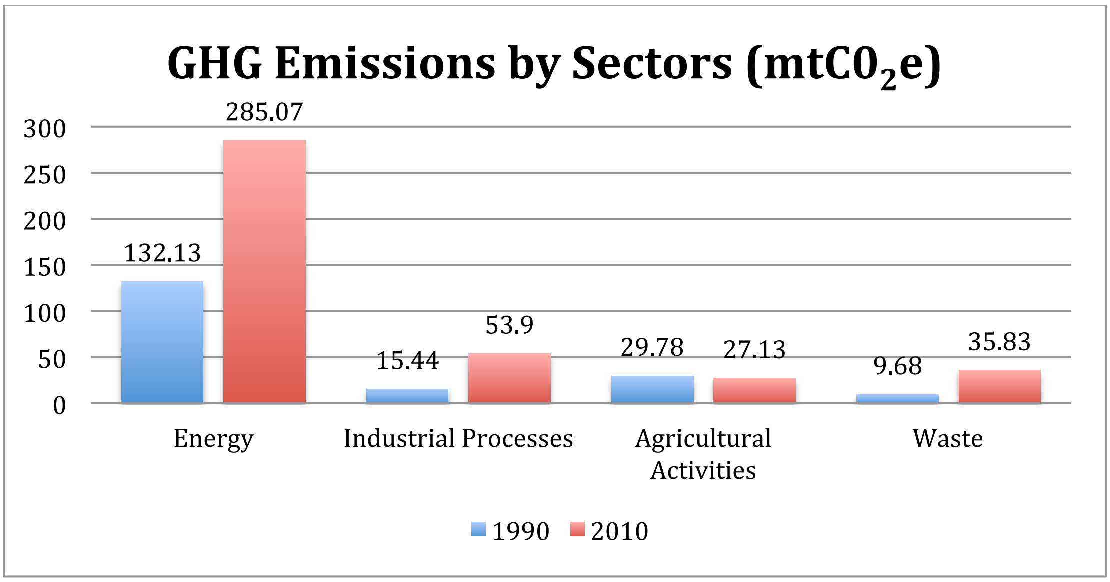


Figure 12: GHG Emissions by sectors in Turkey (mtCO$_2$e)

Figure 12 indicates that, the most important contributor of increase in GHG emissions is energy sector [20]. The numbers are not surprising since the increase in Turkey's demand towards electricity, heat and transport is unstoppable. Therefore utilizing RES for electricity generation seems to contribute in avoidance of GHG emissions. In deed, these statistics must not be ignored since projections done by European Environment Agency could be interpreted as GHG emissions will increase by nearly 50% with respect to 2010's numbers [21].

On the other hand, Germany – as a developed country, took precautions for reduction of GHG missions. In 2010, the country had 960.1-mtCO2 emissions [22]. However the country reduced its emissions by 25% from 1990 to 2010, which renewable energy and carbon market played important roles for that. Via renewable energy, Germany avoided 117.9-mtCO_2e GHG emissions in 2010 of which nearly 64% from electricity generation from RES illustrated in Figure 13 [23]. Again according to the projections done by EEA in 2011, it is expected to have lower levels of emissions in Germany – i.e. below 800 mtCO_2e [22]. These numbers show that electricity generation via renewables will be an important contributor in Turkey, also in terms of avoidance of GHG emissions.

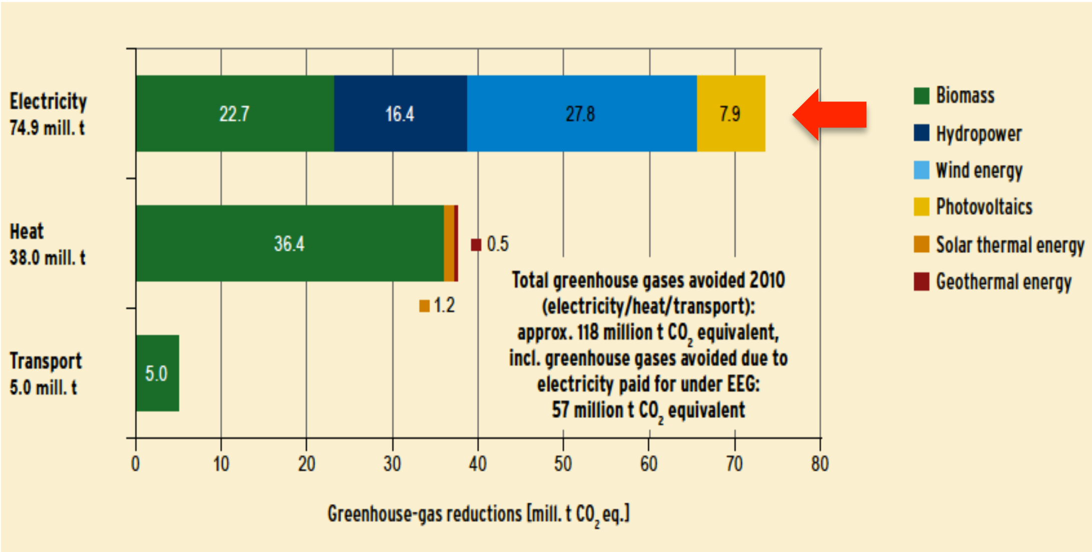


Figure 13: GHG emissions avoided via use of RES in Germany (2010)

3.3 PV Market in Turkey and Germany

In this section, current status of Turkish and German PV market will be analysed and compared in order to draw a roadmap for future Turkish PV market, deriving results from German PV market.

3.3.1 Turkey

Turkey, having average sunshine duration of 7.2h/day and average annual solar irradiation of 1,311 kWh/m^2 per year still do not have a mature PV market. Although the land has something to offer regarding impressive geographical, meteorological and geopolitical conditions, the market cannot be stimulated. The main reason behind immature PV market lies behind low interest of predecessor and today's governments towards electricity generation from PV and even in RES other than hydropower. There are several advantages of utilizing solar power for Turkey:

- Reduction in GHG emissions
- Security of energy supply
- Reuse of degraded land
- Increase in domestic energy generation / decrease in energy imports
- Deploying rural electrification more effectively

In the following subchapters, readers will be informed on current status of PV in Turkish energy sector.

3.3.1.1 Legislation

In legislative terms, Turkey still does not have a separate legislation for electricity generation from solar power. The government firstly introduced electricity generation from RES in *"The Electricity Market License Regulation"* which was enacted in and published by Official Gazette No: 24836 on Aug 4, 2002. With this law following incentives are provided for RES:

- **Reduced license fee:** facilities that are going to generate electricity via RES will pay 1% of the total license fee and exempted from paying annual license fee for the first eight years of operation.
- **Connection priority:** Turkish Electricity Transmission Company (TETC) and public/private distribution companies are obliged to give connection priority for the facilities that will utilize RES.
- **Purchase obligation:** Retail sale license holders must purchase electricity primarily from renewable based PPs, whenever the price of renewable based electricity is lower than or equal to Turkish Electricity Trading and Contracting Company (TETCC).

Three years later in 2005, *"Law on Utilization of Renewable Energy Resources for the Purpose of Electrical Energy Law No. 5346"* was enacted with date of acceptance on May 10, 2005. With this law, the renewables which can be utilized from the incentive scheme were stated as: biomass, biogas, wave, current, tidal, hydro, geothermal, solar and wind. In addition to this, the first FIT scheme was introduced for electricity generation from RES as: for each year, FIT is the **average electricity wholesale price of previous year determined by EMRA** which is valid for the applicants until the end of **2011** and certified generators that have been operating for **seven years or less**. The Council of Ministers is **authorized** to increase such price by 20% at the beginning of each year. In addition, although the law was introduced to diversify RES and aimed to make investors utilize electricity generation in economic manner, awaited interest towards RES could not be realized, since the tariff set by the law is uncompetitive, which is discouraging especially for PV. Other incentives that were introduced with this law were [18]:

- **Reduced fees for land acquisition:** 50% discount on permission, rent, right of access and land use fees, which are owned by Treasury or General Directorate of Forestry, during investment period.
- **Purchase Obligation:** Retail sale license holders are obliged to buy 8% of the electricity that they sold in previous year via RES certificated generators.
- **Other incentives:**
    - Exemption from the fees charged for the development of woodland villages, promotion of forestation and erosion mitigation.
    - Ban, when the public land has negative impact on use and efficiency of RES utilization.
    - Eligibility of investment in development and manufacturing solar cells and concentrated collectors to benefit from the incentives is determined by the Council of Ministers.

Later on, an amendment law which is called *"Energy Efficiency Law No. 5627"* was enacted as a successor of Law No. 5346 in 2007. With this law FIT for all kind of RES was defined as "for each year, FIT is the average electricity wholesale price of previous year determined by EMRA which cannot be lower than **5 €¢/kWh** and greater than **5.5 €¢/kWh** which is valid for renewable energy certified generators that are commissioned before **2013** and have been in operation for **10 years or less**. Legal entities which have license for utilization of RES for electricity generation are eligible to sell the generated electricity for greater than 5.5 €¢/kWh in spot electricity market. The **authorization** of the council is **abolished** for increasing the FIT price at the beginning of each year. Other changes in this amendment law are as follows [24]:

- **Reduced fees for land acquisition:** The discount rate is increased to 85% and also applied to land and system use fees for power lines between transportation roads and system connection points applicable for the first 10 years of investment and operation period and for generators commissioned until the end of 2011.
- **Purchase obligation:** Same as the predecessor law expect that 8% purchase obligation is abolished.

In 2010, the amendment law "*Law on Utilization of Renewable Energy Resources for the Purpose of Electrical Energy Law No. 6094"* was enacted, aiming boost in renewable energy investments. This law is the first law in renewables market that applies different FIT prices for different kinds of RES.

For electricity generation from solar power, **13,3 $¢/kWh** will be paid to the generator for a 10 years of period starting from commissioning date, which have started or will start operation between 18 May 2005 and 31 December 2015. After 2015, FIT's will be determined by the Council of Ministers. Besides FIT, additional incentives will be paid to generators for each of domestically manufactured components for a period of 5 years starting from their commissioning date and commissioned before 31 December 2015. The Council of Ministers will also determine domestic component incentives for the generators that are commissioned after 31 December 2015. As a requirement, MENR published a regulation, which license domestic manufacturers are obliged to illustrate the principles and procedures related to standards, certification and inspection of the components, which are going to be used in solar power plants. According to *"The Regulation Regarding Local Manufacture of the Components Used in the Generation of Electricity from Renewable Energy Resources"* introduced by the ministry, suppliers of mechanical or electro-mechanical components must obtain "Manufacture Status Document" which shows that the component is manufactured in Turkey and must be prepared by a certified public accountant to be certified by the Chamber of Industry and "Manufacture Certificate" which shows that the component is compatible with national and international standard and must be prepared by an international accrediting agency. After then, the buyer, i.e. license applicant has to submit these forms to Ministry. After the authorities validate these documents, the Ministry send the approval form to EMRA indicating bonus tariffs to be applied for electricity generation for each domestic component. Incentives that will be given to each component for PV are shown in Table 5.

Domestic Component	Incentive ($cent/kWh)
PV panel integration and solar structural mechanics production	0.8
PV modules	1.3
Cells forming the PV modules	3.5
Inverter	0.6
Materials focusing the solar rays on to the PV module	0.5

Table 5: Bonus premiums for domestic components of PV (Source: [24])

If we assume that the components of PV system are all domestic, the maximum FIT, which the generator is going to be paid is 20 $¢/kWh which is equal to approximately 15.6 €¢/kWh.[1] The FIT price, even if domestic components are used, seems to be not impressive as much as the FIT prices set by other EU countries. The economic study will be illustrated in following sections. The amendment law brings new some other new legislation for electricity generation from solar power. In deed, the first license applications for PVPPs will be accepted by EMRA in between June 10-14, 2013. While accepting the license applications, applicants must take into consideration some rule and principles as follows:

- The operation and payment principles regulation was introduced by EMRA under the name of *"The Regulation Regarding Certification and Supporting Renewable Energy Resources"* in 2011. You can see the support mechanism in Annex A.
- Renewable based electricity generation power plants including solar power are exempted from 1% treasury share.
- Total capacity installed cannot be greater than 600 MW by the end of 2013 and after then the Ministry of Council will determine the new capacity for upcoming years.
- The maximum capacity of a PV project should be less then 50 MW.
- The owner of the land will be given the priority for the licence, if more than 1 real person or legal entity apply for that land.
- If more than 1 applications will be made for the same land, TETC (Turkish Electricity Transmission Company) will do tender, based on underbidding of FIT which is 13.3 $cent/kWh for 10 years.
- Annual yearly sum of global radiation on horizontal surface should not be less than 1650 kWh/m^2 – year for the lands that are going to be chosen.

[1] Currency parity: 1 $ = 0.78 €, September 24, 2012

- Ministry of Natural Resources released 121 substations with connection capacities, which PV plants can be connected. Applications will be accepted within 30 km diameter around the plots shown in Figure 14.
- The land should not be a first-class farming and/or agricultural land. If the applicants propose their applications in national parks, preservation sites, and wild life promotion sites, applicants should ask for an affirmative from Ministry of Environment or regional conservatory board.
- The land should not be greater than 2 ha/MW.
- 85% reduced fee for tenancy and easement.

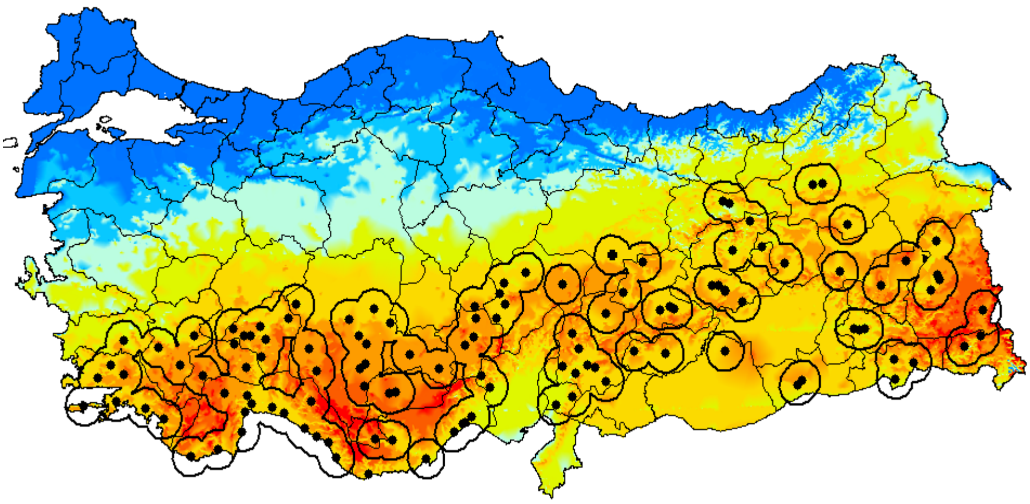


Figure 14: Eligible transformer substations for PV plants (Source: [24])

- Applicants must do measurements on the land at least for 6 months in order to be eligible for licence application and submit solar measurement station installation report. You can find a draft of the report in Annex B.
- On the other hand, real or legal entities, who consider to build micro cogeneration and renewable energy based electricity generation facilities having maximum capacity of 500 kW are exempted from license fee and founding a company. The base and bonus FITs applied for electricity generation from solar power also applies in unlicensed applications. You can see a draft of application form in Annex C.

3.3.1.2 Potential

Republic of Turkey, which is in sunny belt between latitudes 35° and 43° N, and longitudes 25° and 45° E has a huge potential of electricity generation from solar power with average sunshine duration of 7.2 h/day and average annual global solar radiation with 1,311 kWh/m^2-year. Until 2012, rather than solar power, the country has utilized hydro, biomass, wind, geo-thermal and solar thermal resources in some ways increasing the shares of renewables. Till the end of 2011, Turkey has only utilized solar power in demonstration and research projects and in some telecom stations, highway signalling, forest monitoring towers, meteorological stations and fire observation stations. The estimated total PV capacity installed in Turkey is 6 MW. Solar electricity potential of Turkey in terms of natural, technical and economical is illustrated in Table 6 [24].

Natural Potential	Technical Potential	Economic Potential[2]
977,000	6,105	305

Table 6: Solar Electricity Generation Potential of Turkey (TWh/year)

As it is seen from the table above, Turkey has a economic generation potential of 305 TWh/year, which is approximately 1.5 times higher than total electricity generation in 2010.

On the other hand, Turkey has much more average annual global solar irradiation rates than other EU countries, especially Germany. GDRE in cooperation with TSMS released Solar Energy Potential Atlas (SEPA) for Turkey releasing following statistics:

Month	Monthly total solar radiation (kWh/m2-month)	Sunshine Duration (h/month)
January	59.7	106.9
February	76.6	135.2
March	116.8	170.2
April	139.1	203.5
May	171.5	260.5
June	186.9	318.1
July	193.4	339.3
August	174.8	322.3
September	140.3	277.9
October	100.0	200.6
November	64.7	142.0
December	50.0	96.3
Total	**1473.8**	**2572.8**
Average	**4 kWh/m^2-day**	**7h/day**

Table 7: Monthly average solar energy potential of Turkey

SEPA, which is an official study done on projections released by GDRE, shows that Turkey has a technical potential power generation capacity of 380 TWh/year, which corresponds to generation done by 56 GW_p gas powered stations [25]. You can see

[2] Economic potential is the total capacity of a nation to produce goods and services. In specific terms, it is the potential of a nation to manufacture, install and operate PV systems in terms of economical structure of that nation.

monthly variation of average daily solar radiation and insolation duration in Figures 15 and 16.

On the other hand monthly total solar radiation and sunshine duration change according to 7 different regions of Turkey (see Table 8). According to these statistics, MENR published a regulation on which, the available connection capacities for regional transformer stations based on solar electricity power plants are specified in August 2011. You can see the areas, which are eligible for connection with some limited capacities, making total of 600 MW in Annex D.

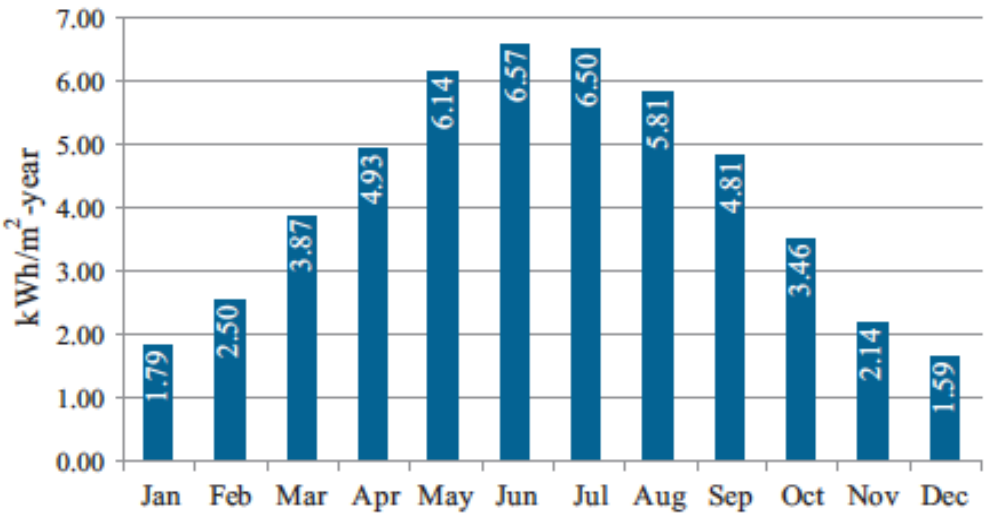


Figure 15 Monthly variation of average daily solar radiation

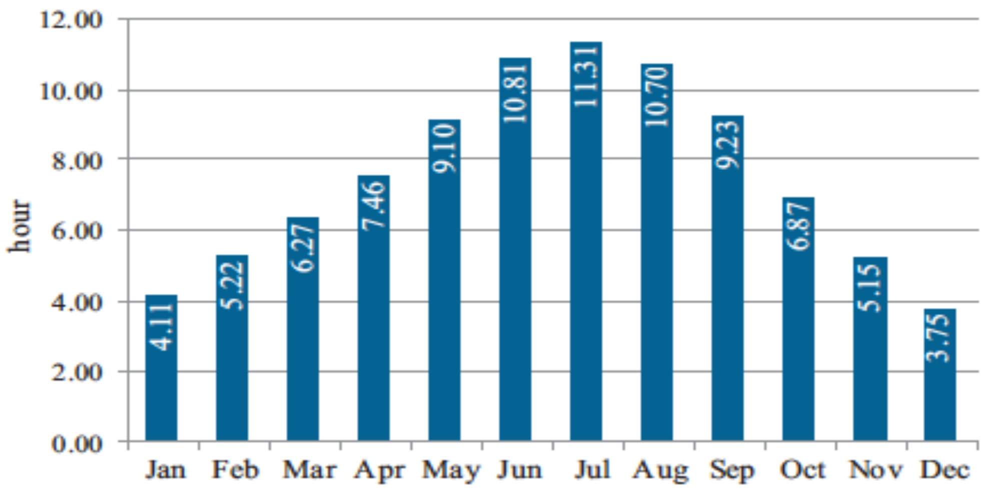


Figure 16 Monthly variation of average daily insolation duration

Region	Monthly total solar radiation (kWh/m^2month)	Sunshine Duration (h/month)
South-eastern Anatolia	1648	2845
Mediterranean	1548	2737
Aegean	1528	2615
East Anatolia	1523	2519
Central Anatolia	1481	2563
Marmara	1329	2250
Black Sea	1305	1929

Table 8: Regional solar energy potential of Turkey

3.3.1.3 R&D

"*Currently here is not any manufacturer on feedstock, ingots, wafers and cells in Turkey. There are a few PV module and PV constituents (glass, frame, inverter, battery) manufacturers*" stated in the PVPS Annual Report on Turkey published in 2011. As mentioned in Legislation section in this report, domestic components seem to be important contributor for bonus incentives. While Turkey has several indicators as being future's one of the most important players in PV market, R&D figures show that components of PV systems still are likely to be imported in upcoming years. Doubtlessly, imported components and low R&D subsidies will not attract and give courage to investors. Some PV projects continued or started in 2012 with state subsidies, which make total of 40.75 million EUR are shown in Table 9 [26].

PROJECT (OR HELD BY)	INSTITUTION	DURATION	FUND FROM STATE
Utilization of renewable energy resources and increasing energy efficiency	Regional Development Administration of South-eastern Anatolian Region (GAP)	2009-2013	4,9 mio €
Photovoltaic Test and Research Centre	TÜBİTAK-UME	2012-2013	2,6 mio €
New Generation/Dye Synthesized/ Organic PV cell production studies	EGE UNIVERSITY SOLAR ENERGY INSTITUTE	2011-2013	1 mio €
GAP Renewable Energy and Energy Efficiency R&D Centre	HARRAN UNIVERSITY	2011-2013	4 mio €
Environmental Tests Centre	TÜBİTAK-UME	2009-2012	12 mio €
Energy Feasibility Studies for 100 Public Buildings	MINISTRY OF ENVIRONMENT AND URBAN PLANNING	2012-2013	1,7 mio €
Energy Information and Technology Management Centre	MINISTRY OF ENERGY AND NATURAL RESOURCES	2010-2014	8,7 mio €
Studies on Renewable Energy Resources	MINISTRY OF ENERGY AND NATURAL RESOURCES	Through 2012	0,6 mio €
Photonics Research Centre	GAZI UNIVERSITY	2011-2013	5,25 mio €

Table 9 R&D state subsidies through 2012

Other than state subsidized researches, mainly some other universities, research groups devoted to these universities and some institutions currently do R&D studies, without receiving any fund from the state.

3.3.2 Germany

Germany in the last decade had given emphasis on PV too much that; the country has been the market leader with installations on 7,408 MW_p and 7,485 MW_p done in years 2010 and 2011 consecutively. Although meteorological conditions and land availability are disadvantageous compared to Turkey, cumulative installed capacity of PV by the end on 2011 in Germany reached 24,678 MW_p, which nearly contributes to 50% of whole European PV installed capacity (see Figure 16).

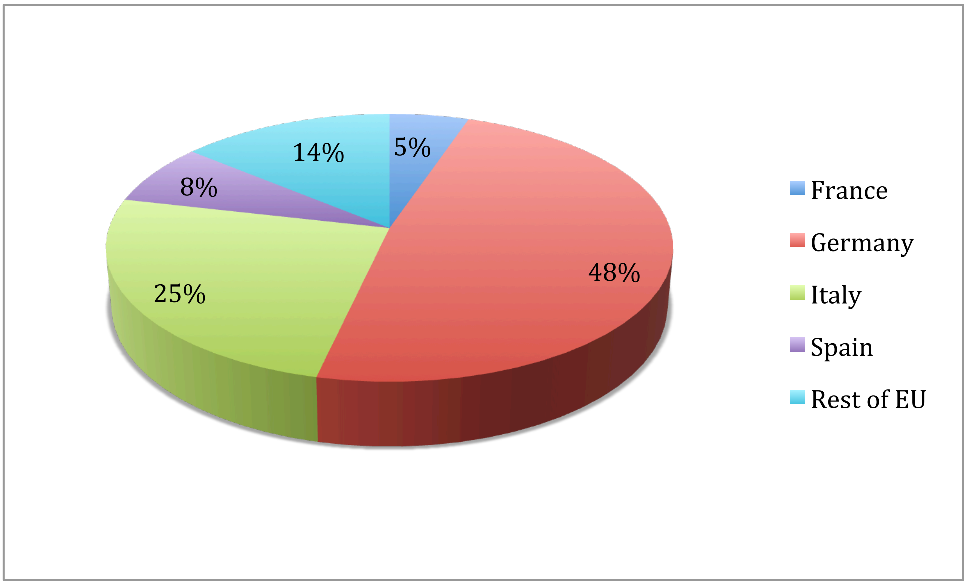


Figure 17 Total installed PV capacity in Europe by 2011

While PV contributes to 2% of whole electricity production in 2010 (11.7 TWh), this percentage was increased to 3%, which is worth of 19 TWh in 2011 [17].

When the cumulative installed capacity in Germany is segmented, BAPV and BIPV/ROOF-TOP systems, i.e. residential and commercial/industrial contributed nearly 80% of the whole capacity, which means Germany supplies electricity from solar energy mostly from small and mid-scale solar power plants with total capacity of approximately 19,700 MW_p. You can see cumulative installed PV capacity segmented in accordance to their types in Figure 18 [27].

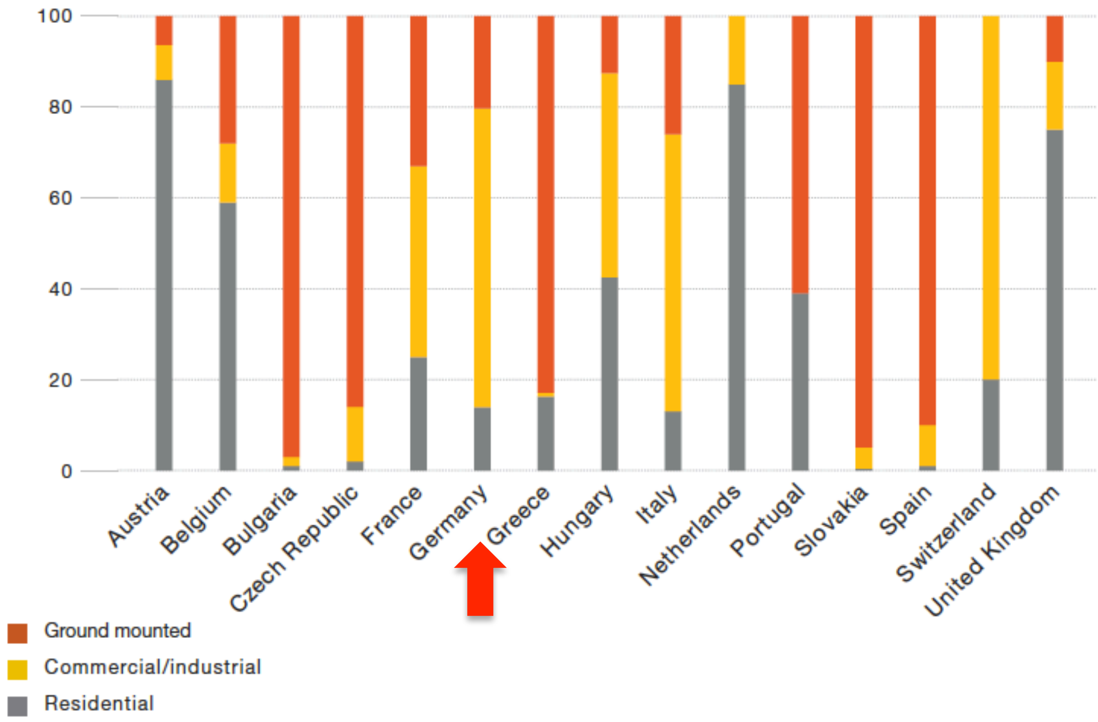


Figure 18 Segmentation of installed PV capacities in Europe till the end of 2011

This figure is absolutely important in terms of showing contribution of citizens and commercial/industrial entities that are fairly aware of advantages of PV systems in Germany.

3.3.2.1 Legislation

Although Turkey has not segmented FITs according to the type and capacity of PV systems, German renewable energy law – also known as Erneuerbare-Energien-Gesetz, separated the framework and incentive schemes according to the types of installation.

However in 2012, German parliament decided to do some reductions and cuts on FITs. The main reason of this action is interpreted as; since the prices of modules, including their constituents still in dropping trend, German government has been struggling to pay the premiums. With reductions and cuts in the premiums, the country awaits installed capacity of 2.5-3.5 GW. This strategic plan will apply till 2017, aiming 400 MW reduction of installed capacity each year, which the financial burden created by premiums paid will be decreased. In Table 10, you can find the premiums paid for each type of installation in 2011 and premiums that are valid from March 2012 in Table 11.

Type	Capacity	Capacity Installed	FIT (€/kWh)
Rooftop	< 30 kW		0.287
	< 100 kW		0.273
	< 1 MW		0.258
	> 1 MW		0.215
Ground-mounted	Conversion and sealed areas		0.221
	Commercial zones		0.211
Net metered	< 30 kW	< 30%	0.124
		> 30%	0.167
	< 100 kW	< 30%	0.11
		> 30%	0.153
	> 100 kW	< 30%	0.094
		> 30%	0.139

Table 10 German FIT rates applied in 2011 (Source: [44])

Solar Feed-in Tariffs	Installed in, at or on building or noise protection wall				Freestand Facility
Revision 2012	**≤ 10 kW**	**≤ 40 kW**	**≤ 1 MW**	**≤ 10 MW**	**≤10 MW**
Generation covered by feed-in tariff	100%	90%	90%	100%	100%
Put into service As of 01.04.2012	19.50	18.50	16.50	13.50	13.50
As of 01.05.2012	19.31	18.32	16.34	13.37	13.37
As of 01.06.2012	19.11	18.13	16.17	13.23	13.23
As of 01.07.2012	18.92	17.95	16.01	13.10	13.10
As of 01.08.2012	18.73	17.77	15.85	12.97	12.97
As of 01.09.2012	18.54	17.59	15.69	12.84	12.84
As of 01.10.2012	18.36	17.42	15.53	12.71	12.71

Table 11 German FIT rates applied in 2012 (Source: [45])

Newly regulated incentive scheme adopts 0.15 € reduction from premiums for each month per generated kWh. All the tariffs apply for 20 years starting from the operation date of the plant. The reduction on FITs to be applied in November will be announced depending on the newly installed capacities in July, August and September. When two tables are compared, reductions from 20-29.5% can be observed. In addition, net metering and also large scale solar power plants with installed capacity greater than 10 MW_p will not benefit from FIT anymore.

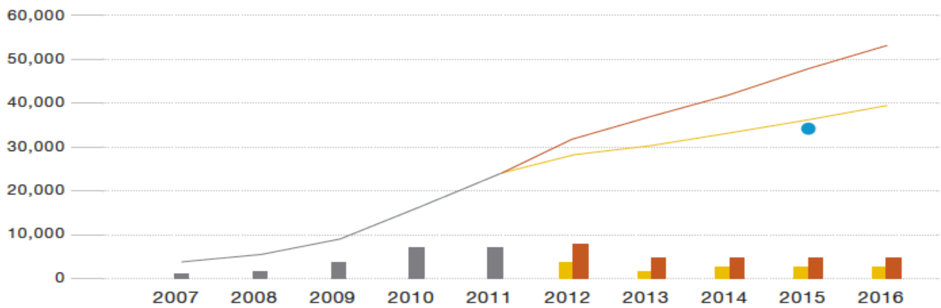
3.3.2.2 Potential

Germany's potential of electricity generation according to BMU is 150 TWh per annum, which is equal to installed alternating capacity of 150 GW composed of additional different types of plants (façades, rooftops and municipal areas) [23].

On the other hand according to the report "Global Market Outlook of PV 2016" released by EPIA in 2012, Germany can reach its national target of installed capacity of 34,279 MW by 2015 [27], which is equal to annually installed capacity of approximately 2,500 MW. Annual installed capacity between the years 2012-2017 can be lower compared to last two years, but new capacities will contribute to reach the target, although the deployment of new FITs anticipate the annual installed capacities will drop by 400 MW each year. According to expected additional capacities in years between 2012-2017 announced by the Minister of BMU, a simple calculation can be made:

(i) 24,678 + 2,500 + 2,100 + 1,700 + 1300 = 32,278 MW (Low Scenario)

(ii) 24,678 + 3,500 + 3,100 + 2,700 + 2,300 = 36,278 MW (High Scenario)



	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016
EPIA Moderate	1,271	1,809	3,806	7,408	7,485	4,000	2,000	3,000	3,000	3,000
EPIA Policy-Driven						8,000	5,000	5,000	5,000	5,000
EPIA Moderate (cumulative)	4,170	5,979	9,785	17,193	24,678	28,700	30,700	33,700	36,700	39,700
EPIA Policy-Driven (cumulative)						32,700	37,700	42,700	47,700	52,700
National target 2015									34,279	

Figure 19 Moderate and Policy-Driven Scenarios on Installed Capacity Potential in Germany

Germany created challenging market reaching near grid parity. Throughout years, Germany will fully utilize its economic potential as well as cheaper electricity generation costs than retail and wholesales even some cuts are done by government in FITs paid.

3.3.2.3 R&D

Germany, being the market leader in the whole world has shown, how they placed emphasis on electricity generation via solar power. In 2011, the federal government decided to establish the funding initiative *"Innovationsallianz Photovoltaik"* in which, 100 million EUR was allocated to PV R&D while 500 million EUR was allocated to investments in industry. Throughout this program, expansion and security of EEG is supplied in order to keep the industry alive and sustainability of international competitiveness.

Year 2011	Outflow of Funds	New Approvals
Silicon Wafer Technology	21.5	40.7
Silicon Thin film	5.3	17.6
Compound Semiconductor, predominantly CIS / CIGS thin film	5.1	7.3
Cross projects for thin film	1	-
Concentrated PV	2.5	2.7
Systems Engineering, Network Integration	1.7	3.2
Cross-technology projects, alternative concepts	1.7	1.7
TOTAL	38.8	73.2

Table 12 Distribution of funds allocated for different PV funding priorities

Table 12 indicates that a total of 112 million EUR was allocated to PV R&D including new approvals. However in 2010, projects worth of total 40 million EUR were approved, while this number was increased by 83% to 73.2 million EUR in 2011. However from 2004, Germany has been allocating funds to new approved projects worth of approximately 290 million EUR [28]. In last few years the federal government is interested in electricity storage systems for electricity generated by RES. Within the framework of the task 6th Energy Research Programme, *"Energy Storage Funding Initiative (Förderinitiative Energiespeicher)"* is going to support and handle 200 million EUR for further improvements in energy storage between 2011 and 2014, which is claimed by the professionals as the future's one the most important innovations to be brought [29].

4 Assessment on Current Turkish PV Market

As current status of both Germany's and Turkey's current electricity and PV market are analysed and illustrated in the previous section it is obvious that, Turkey has to place an emphasis in clean energy technologies and work in accordance. The "ready-to-boom" PV market has some internal strengths and weaknesses compared to other countries, while external potential opportunities and threats will play an important role in development stage of the market. To draw a roadmap for Turkey in that sector, SWOT analysis is done to outline possible actions to be taken on road to success.

Strengths

- Country's thirst for domestic energy production
- Average annual solar irradiation of 1311 kWh/m^2
- Average sunshine duration of 7,2 h/day
- Availability of land
- Located in sunny belt – higher potential than most of the European countries
- Economic growth → increase energy demand

Weaknesses

- Immature market
- Low R&D studies and subsidies
- Low FIT with respect to leading countries (13.3 $cent/kWh)
- Installation cap till 2015
- Measurement requirement
- High lead times due to measurement requirement
- Low educational levels
- Low levels of expertise on environment and PV

Opportunities

- Reducing GHG emissions
- An important contributor for national target (30% of electricity generated from RES by 2023)
- Lowering foreign-trade deficit
- Increasing energy security of supply
- Employment
- Applicable to irrigation systems

Threats

- Public awareness – acceptability
- High inflation rates
- High taxes
- Being import dependent on PV and measurement equipment
- Low interest from the government towards PV

Strengths: Turkey located in sunny belt between 35° and 43° N latitudes, and 25° and 45° E longitudes has a huge potential compared to other EU countries regarding economic growth, meteorological and geographical conditions as mentioned before. On the other side Turkey's economic growth (9.2% and 8.5% increase in years 2010 and 2011 consecutively in GDP [30]) indicates that, energy demand for commercial and industrial sectors is projected to increase.

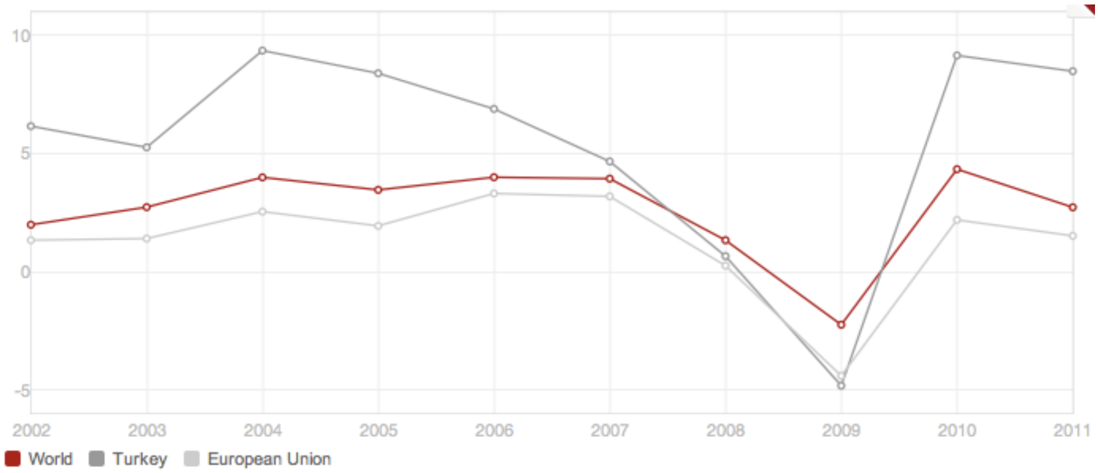


Figure 20 Average annual increase of GDP (%)

Turkey has to meet the increasing demand trend towards energy with additional capacities of which, PV can be an important contributor of electricity sector.
In addition to these, Turkey still does not have any electricity generation facility, which utilizes solar energy. With sufficient geographical conditions such that the availability of land and meteorological conditions, PV systems can supply the need for country's domestic electricity production.
Also utilization of solar power for electricity generation without getting a licence will gather much more interest towards renewables and PV by small investors and also citizens, who will have much more contribution to recognition of these systems in the whole country.
Weaknesses: Turkey enacted the latest legislation on PV utilization for electricity production lately in 2011 as an amendment law, which aims to enhance energy supply security and competitive and liberalized market. In addition, the law on utilization of solar energy for electricity generation was enacted in the beginning of 2012. In other words, Turkey does not have a mature and stabilized PV market for both large and small scale plants. Eventually the regulations are enacted, but yet the application process for renewable energy licenses has not started or there has not been any facility which is connected to the grid, so it is not still clear that the framework, bureaucracy and economics are sufficient enough for investments or

not. This blurry future market may lower the courage of investors towards PV. Besides framework, neither government nor research institutes/universities have placed an emphasis on R&D studies of domestic production of PV systems and its constituents. Government has just created funds available worth of nearly 40 million EUR in 2011.

The amendment law enacted in 2011 and law on utilization of solar energy for electricity generation has also some weaknesses, which may create conflicts in decision process of an investor. First of all the FIT introduced, which is worth of 13.3 $¢/kWh (approximately 10 €¢/kWh), is lower than the very first FITs introduced by other countries and equal to current FIT with cuts in Great Britain. Still FIT rates applied in the countries in which system costs are decreased by 50%, and cost of electricity generation from PV is near grid parity boundary are higher than the FIT applied for PV in Turkey. On the other hand, FIT rates are applicable for 10 years if any of the components of the system is not manufactured domestically, while if the system is composed totally of domestic components, an investor can benefit from the highest FIT applicable (approximately 14.7£¢/kWh) for five years and 10€¢/kWh for the remaining 2nd five years period.

Turkey, met with renewable energy technologies rather than hydropower in the last decade has low levels of expertise and knowledge in this field. There are limited numbers of institutions and departments in universities, which base their education on renewable energy technologies and related fields and offering only PhD or MSc programs. Low levels of interest towards renewable energy in education also do not bring challenges and expertise, which will decelerate the work done especially in operation and maintenance phases.

One another weakness of the market is based on Value Added Tax applied on components of PV system, which is way high 18%.

Opportunities: While enacting the amendment law No. 6094, one of the targets is set for 2023, which aims to generate 30% of whole electricity from RES. Rather than hydropower and wind power, PV will doubtlessly be an important contributor in reaching the target. On the way through the target, utilization of PV plants will create new fields of work and probably will play at least a minor role in decreasing unemployment statistics. According to the last statistics released by TurkStat, unemployment rate at the end of 2011 was 9.9%, which amounts to approximately 2.640 million citizens. When PV market is integrated in energy sector, employments in field of manufacturing, government entities, consultancy, audit, and computer sciences will increase admissions from every segment regarding education, age and sex.

While Turkey has opportunities to increase share of PV in electricity market and correspondingly employment rates, the country has to deal with GHG emissions released by energy generation. For instance in 2010, Germany avoided 7.9-mtCO2e emissions just with electricity generation of 11.7 TWh via PV. Since Turkey signed Kyoto Protocol and has to decrease the substantial growth of emissions, PV is one of the most suitable choices on the way to implement.

Turkey, 72% dependent on imported energy resources, has become face to face with cut offs many times due to instable international relations and political instability in Middle East and southeast of Turkey, which threatens the security of energy supply. Turkey - deemed as “energy corridor” between Middle East and Europe, has to secure the energy supply and generate its electricity from its natural resources. In this context, utilization of solar power will contribute to security of energy supply and prevent from possible cut offs.

Agricultural activities play an important role in countries’ especially in Turkey’s nourishment and workforce. In Turkey, 1/3 of the population live on by agricultural activities. According to the statistics released by TurkStat, Turkey’s agricultural export at the end of year 2010 had just passed 15 billion USD, which seems one of the most important sectors in Turkish economy bringing crucial source of revenue. According to projections done by Ministry of Food, Agriculture and Livestock, exports done in 2023 will reach 30 billion USD. To reach these values Turkey has to do more in agricultural reforms. One of the most important aspects regarding agricultural reforms is irrigation system. Irrigation in Turkey is done mainly with the use of diesel or electric generator powered water pumping systems, which require fuel and create higher operation and maintenance cost with respect to PV powered pumps. However “the economic analysis proves that PV powered pump is preferable in the long run” although capital costs are higher compared to diesel powered water pumps [32].

Threats: In order to be eligible to apply for getting a license, although TSMS continuously does sufficient measurements for solar radiation, wind speed and temperature, the law stipulates each applicant to do measurements at least for 6 months. Even if two different legal or real entities want to apply for license for the same area, both of them have to submit their own measurements to EMRA. Moreover, even in the period of measurement, exchange rates might change which struggles an investor to forecast net cash flows from generation of electricity. Especially when the period of applicable FIT rates (10 years) is taken into account, sudden changes in exchange rates and global financial trends might affect pay back times of installations, since FIT rates per kWh are dependent on that day's Turkish Lira – American Dollar exchange rate.

In addition, the devices that are going to be used for measurements will be supplied and installed by foreign companies. Foreign measurement consultancy and installations doubtlessly will not contribute to challenges in domestic PV market and Turkish economy. In addition to that, applicants who apply for license but cannot get the license will be only charged for just measurements. This will also create burden to entity finances, so the applicants who do not own the area that they apply for may not be encouraged.

In addition to these many citizens in Turkey have lower affordability to invest in such a system, having investment cost of nearly 11,000$. One has to take into account that, GDP per capita in Turkey is 10,498$ [31].

4.1 Public Awareness of PV Systems

The last and may be one of the most important weaknesses of potential Turkish PV market is public awareness. The questionnaire applied for this study shows that, **75%** of respondents have heard or known about electricity generation via solar resources, while just **48%** of them know that they can generate electricity in their households. Thus solar knowledge and BIPV/Roof-top mounted systems knowledge with education cross tabulations gave some notable output.

Education * SolarKnowledge Crosstabulation

			SolarKnowledge		Total
			Yes	No	
Education	Primary School	Count	1	1	2
		Expected Count	1.5	.5	2.0
	High School	Count	16	6	22
		Expected Count	16.5	5.5	22.0
	University	Count	58	25	83
		Expected Count	62.3	20.8	83.0
	MSc./PhD.	Count	24	1	25
		Expected Count	18.8	6.3	25.0
Total		Count	99	33	132
		Expected Count	99.0	33.0	132.0

Chi-Square Tests

	Value	df	Asymp. Sig. (2-sided)
Pearson Chi-Square	7.768[a]	3	.051
Likelihood Ratio	9.932	3	.019
Linear-by-Linear Association	4.385	1	.036
N of Valid Cases	132		

a. 2 cells (25.0%) have expected count less than 5. The minimum expected count is .50.

Table 13 Education and solar knowledge cross tabulation

Notable output aroused from the cross tabulation is:

- 73%, 70% and 96% of the participants consecutively holding high school, undergraduate and postgraduate degrees know that, it is possible to generate electricity via solar energy.
- Although ρ is equal to 0.051, which is greater than significance level by 0.001, we can interpret that the groups and solar knowledge are marginally significantly dependent. Through Pearson's test we cannot interpret as; as the education level increases, the knowledge on solar power increases. But statistics in the cross tabulations show that, knowledge on solar power somehow has the highest percentage in MSc/PhD segment.

On the other hand education and knowledge on electricity generation via BIPV/Roof-top system cross tabulation is as follows:

Education * BIPV Crosstabulation

			BIPV		
			Yes	No	Total
Education	Primary School	Count	0	2	2
		Expected Count	1.0	1.0	2.0
	High School	Count	7	15	22
		Expected Count	10.5	11.5	22.0
	University	Count	37	46	83
		Expected Count	39.6	43.4	83.0
	MSc./PhD.	Count	19	6	25
		Expected Count	11.9	13.1	25.0
Total		Count	63	69	132
		Expected Count	63.0	69.0	132.0

Chi-Square Tests

	Value	df	Asymp. Sig. (2-sided)
Pearson Chi-Square	12.398[a]	3	.006
Likelihood Ratio	13.558	3	.004
Linear-by-Linear Association	11.261	1	.001
N of Valid Cases	132		

a. 2 cells (25.0%) have expected count less than 5. The minimum expected count is .95.

Table 14 Education and BIPV/Roof-top knowledge cross tabulation

Findings and interpretations are as follows:

- ρ-value, which is 0.006 approached from chi-square test is much lower than the specified significance level of 0.05. So we can say that knowledge on BIPV/Roof-top mounted systems are significantly dependant.
- As mentioned above the respondents, which have idea on solar electricity generation via solar power in their households, contribute to 48% of the whole sample.
- As it is seen high variances in second and third row, it proves our significant dependence finding.
- 32%, 45% and 76% from groups consecutively high school, undergraduate and postgraduate degree holders know BIPV/Roof-top systems. Within these statistics, we can interpret that education level plays a role in roof-mounted PV systems knowledge.

According to statistics released by TurkStat in 2010, the education levels of 22-39 years aged population:

None	5%
Primary School	40%
High School	35%
University	13%
MSc/PhD	1%
Not known	6%

Table 15: Education levels of 22-39 aged populations in Turkey 2010

Since we have found marginally significant and significant dependencies on education and solar electricity, the statistic released by TurkStat leads us to do interpretation as knowledge on solar electricity in whole country is way much lower that observed statistics via SPSS.

Another cross tabulation was made to analyse if eagerness in investing such a PV system is related with income or not. Following results are obtained:

Income * Eagerness to invest Crosstabulation

			Eagerness to invest		Total
			Yes	No	
Income	None	Count	24	28	52
		Expected Count	27.6	24.4	52.0
	Below 1,000 TL	Count	9	5	14
		Expected Count	7.4	6.6	14.0
	1,000 - 2,500 TL	Count	13	11	24
		Expected Count	12.7	11.3	24.0
	2,501 - 5,000 TL	Count	13	15	28
		Expected Count	14.8	13.2	28.0
	5,001 - 10,000 TL	Count	10	2	12
		Expected Count	6.4	5.6	12.0
	Above 10,000 TL	Count	1	1	2
		Expected Count	1.1	.9	2.0
Total		Count	70	62	132
		Expected Count	70.0	62.0	132.0

Chi-Square Tests

	Value	df	Asymp. Sig. (2-sided)
Pearson Chi-Square	6.633[a]	5	.249
Likelihood Ratio	7.114	5	.212
Linear-by-Linear Association	1.615	1	.204
N of Valid Cases	132		

a. 2 cells (16.7%) have expected count less than 5. The minimum expected count is .94.

Table 16 Cross tabulation of eagerness to invest and income level

However the chi square test showed us that, income level and eagerness to invest are not significantly dependent to each other. Moreover, other remarkable result arouse from the statistics is that 53% of the respondents have willingness to invest in such a system, disregarding the system cost. Such a result might implicate weakness of the market but on the other hand it shows that the possibility to integrate small PV systems will not be so much harder, deriving us to a result for opportunity.

4.2 Economic Assessment on BIPV/Roof-Mounted System

An economic study in generation electricity via roof mounted PV system in Antalya, where has one of the biggest contributions to peak demand because of its climate, to find an answer to the question whether FIT is sufficient or not.
Ankara the capital of Turkey has average annual global radiation of 1,650 kWh/m^2 per year according to SEPA released by TSMS and GDRE, which is way greater than many global radiation rates in Europe. Typical electricity consumption of a household with 4 members of family is illustrated in Table 17 [33].

APPLIANCES	Wh
Oven	400
Lights	440
Fridge	935
TV	680
Air Conditioner	8000
Washing Machine	300
Dishwasher	300
Computer	700
Other Appliances	600
TOTAL	**12,335**

Table 17: Electricity consumption of a household in July in Antalya

A household has electricity consumption of 12,335 Wh per day in July and August, since Antalya has an average highest temperature of 34.4 and 34.3 in July and August between 1970 and 2011 [34]. June will be taken as reference month since it is the month, which air conditioner is used regarding durations between 6-8 hours.
In this approach, it is assumed that air conditioner is inverter type with cooling capacity of 12,000 BTU/h, energy label A and consumption of 0.97kW/h.
With this approach, peak demand will be wholly supplied by Roof-top mounted systems in July and August and in other months excess electricity generated via the system will be fed into grid in order to exploit from FIT. In this study, PV Potential Estimation Utility is utilized for potential electricity generation of a typical system in Antalya, which is prepared by Institute for Energy and Transport (IET) under the authority of Joint Research Centre (JRC), which is one of the programs that put into action by European Commission. Since electricity consumption in July and August are in top levels, the household needs 3 kW roof-mounted PV system in order to supply the demand of 12,335 Wh in July. Average daily and monthly electricity production of this system, is estimated by PVGIS as follows where:

1. PV panels used in system are crystalline silicon (c-Si)

2. Optimized slope of 33° and azimuth 0°.
3. Estimated losses due to temperature is 16.8%
4. Estimated losses due to angular reflectance effects is 2.6%
5. Other losses (inverter, cables etc.) contribute to 14.0%
6. Combined PV system losses: 30.3%.

	Fixed system: inclination=32 deg., orientation=0 deg.			
Month	Ed	Em	Hd	Hm
Jan	8.21	255	3.70	115
Feb	9.45	265	4.34	122
Mar	11.60	361	5.45	169
Apr	12.40	372	5.84	175
May	12.70	393	6.19	192
Jun	13.10	394	6.52	196
Jul	12.90	401	6.49	201
Aug	12.80	398	6.44	200
Sep	12.90	386	6.36	191
Oct	11.10	344	5.36	166
Nov	8.65	260	4.03	121
Dec	7.19	223	3.25	101
Year	11.10	338	5.34	162
Total for year		4050		1950

Ed: Average daily electricity production from the given system (kWh)

Em: Average monthly electricity production from the given system (kWh)

Hd: Average daily sum of global irradiation per square meter received by the modules of the given system (kWh/m2)

Hm: Average sum of global irradiation per square meter received by the modules of the given system (kWh/m2)

Table 18 Average daily and monthly electricity production from 2.8 kW system in Antalya

Components of the system:

1) PV panels: Sunrise 200 Watt 24 V Mono-crystalline Photovoltaic Solar Panel

You can find the technical specifications of the panel in Annex E:

Cost: 590$ (VAT included)

Warranty period: 10 years

2) Inverter: SMA Sunny Boy 3000 W Grid-Tied Inverter SB3000US

You can find the specifications of this inverter in Annex F.

Cost: 1750$ (VAT included)

Warranty period: 10 years

3) Cabling: Typical cables for PV having resistant to -40°C to 90°C temperature.

Cost: 0.01$/$W_p$

4) Reversible Meter Cost: 70$

On the other hand, generators who fully utilize solar power will get rid of paying electricity bills to the distributors. For this case, the monthly savings on electricity consumption bills excluding distribution fee and other fees based on latest electricity wholesale price (October 2012 – 0.283 TL/kWh = 0.1551 $/kWh) is shown in Table

15. The period of consumption is started in January with October 2012's wholesale price and 12.4% and 12% rise in prices applied in the beginning of 2nd and 4th quarters of year is assumed, since the same policy in electricity prices was applied in 2012.

	Average Daily Consumption (kWh)	Average Monthly Consumption (kWh)	Elec. Price ($)	Bill
January	4.335	134.39	0.155	20.83
February	4.335	121.38	0.155	18.81
March	4.200	130.20	0.155	20.18
April	4.100	123.00	0.174	21.35
May	4.000	124.00	0.174	21.53
June	4.400	132.00	0.174	22.92
July	12.335	382.39	0.174	66.38
August	12.100	375.10	0.174	65.12
September	4.400	132.00	0.174	22.92
October	4.200	130.20	0.194	25.32
November	4.100	123.00	0.194	23.86
December	4.335	134.39	0.194	26.07

Table 19: Monthly electricity consumption cost

According to the table based on assumptions, a consumer can have savings up to 355$/year. On the other hand total electricity generated in a year via PV system is 4050 kWh. The generator uses total of 2042 kWh electricity in a year, so remaining 2008 kWh shall be sold to distributor. When we take 13.3$¢/kWh FIT into account, the generator will be paid 267.06$ every year.

Operation and management cost (O&M cost) of PV systems, which is relatively too much lower than other types of electricity, will increase by 10%, which is also the inflation rate announced by Ministry of Economy.

Case 1: The FIT applied for PV systems is 13.3$¢/kWh and discount rate is 16%.

Year	Discounted CF	Nominal CF	Savings	Invest. Replace.	O&M	Sales	Discounted Costs
					10%		
0	(11,560)	(11,560)		(11,560)			11,560
1	501	582	355		(41)	267	271
2	495	666	444		(45)	267	297
3	495	773	555		(49)	267	324
4	501	906	693		(54)	267	353
5	512	1,074	867		(59)	267	384
6	527	1,285	1,083		(65)	267	418
7	548	1,549	1,354		(72)	267	454
8	574	1,881	1,693		(79)	267	492
9	604	2,296	2,116		(87)	267	534
10	638	2,816	2,645		(95)	267	578
NPV:	(6,165)	All Units are in. -USD					15,665
Annuity	(635)						1,613

Table 20 NPV of an investment with 16% discount rate

As seen from the Table 20, the NPV value of the investment is -6,6164.8$, which indicates that the investor must not take the risk of installing roof-mounted PV system on his household.

Case 2: The FIT applied for PV systems is 13.3$¢/kWh and discount rate is 5%.

Year	Discounted CF	Nominal CF	Savings	Invest. Replace.	O&M	Sales	Discounted Costs
					10%		
0	(11,560)	(11,560)		(11,560)			11,560
1	554	582	355		(41)	267	300
2	604	666	444		(45)	267	362
3	667	773	555		(49)	267	437
4	746	906	693		(54)	267	526
5	842	1,074	867		(59)	267	633
6	959	1,285	1,083		(65)	267	760
7	1,101	1,549	1,354		(72)	267	911
8	1,273	1,881	1,693		(79)	267	1,092
9	1,480	2,296	2,116		(87)	267	1,308
10	1,729	2,816	2,645		(95)	267	1,565
NPV:	(1,605)	**All Units are in. -USD**					19,454
Annuity	(165)						2,003

Table 21 NPV of an investment with 5% discount rate

Table 21 indicates that, even in too much lower discount rate (5% in this case), the investment will not pay back itself. The investment to this PV system will be risky enough for the investor with NPV of 1,604,5$.

Even with lower discount rates, the projects are not efficient enough in terms of economics.

Case 3: The FIT applied for PV is 20$¢/kWh for the first 5 years based on legislation, since domestic components are used in the system and 13.3$¢/kWh for the remaining period and discount rate of 16%.

Year	Discounted CF	Nominal CF	Savings	Invest. Replace.	O&M	Sales	Discounted Costs
					10%		
0	(11,560)	(11,560)		(11,560)			11,560
1	617	716	355		(41)	402	271
2	595	801	444		(45)	402	297
3	581	907	555		(49)	402	324
4	575	1,041	693		(54)	402	353
5	576	1,209	867		(59)	402	384
6	527	1,285	1,083		(65)	267	418
7	548	1,549	1,354		(72)	267	454
8	574	1,881	1,693		(79)	267	492
9	604	2,296	2,116		(87)	267	534
10	638	2,816	2,645		(95)	267	578
NPV:	(5,724)	**All Units are in. -USD**					15,665
Annuity	(589)						1,613

Table 22 NPV of an investment with domestic components and 16% discount rate

Table 22 shows us that, even if all of the components used in the system are domestically manufactured, it is not worth of doing investment on this project with high discount rate.

Case 4: The FIT applied for PV is 20$¢/kWh for the first 5 years based on legislation, since domestic components are used in the system and 13.3$¢/kWh for the remaining period and discount rate of 5%.

Year	Discounted CF	Nominal CF	Savings	Invest. Replace.	O&M	Sales	Discounted Costs
					10%		
0	(11,560)	(11,560)		(11,560)			11,560
1	682	717	355		(41)	402	300
2	727	801	444		(45)	402	362
3	784	908	555		(49)	402	437
4	857	1,041	693		(54)	402	526
5	948	1,209	867		(59)	402	633
6	959	1,285	1,083		(65)	267	760
7	1,101	1,549	1,354		(72)	267	911
8	1,273	1,881	1,693		(79)	267	1,092
9	1,480	2,296	2,116		(87)	267	1,308
10	1,729	2,816	2,645		(95)	267	1,565
NPV:	(1,020)	**All Units are in. -USD**					19,454
Annuity	(105)						2,003

Table 23 NPV of an investment with domestic components and 5% discount rate

This case shows us that; lower discount rates still do not let the investment compensate itself. The results driven from last two cases indicate that, applied discount rates still do not let the investor to take the risk of investing of a typical roof-mounted PV system.

To overcome investment risk, another choice is to see what happens if FIT applied for PV systems is increased. Doubtlessly higher FITs applied on renewables generation will increase the attention and involvement in RES generation facilities. However today's market leader – Germany and other important co-players of the market, such as Italy, Spain and France apply still too much higher FIT, although some of these countries halted the rates applied. At this point, it seems efficient and effective to enact higher FITs and halt them accordingly, since these rates may create burdens on public finances.

Rather than changing the discount rates or adding bonus tariffs when domestically manufactures are integrated, FIT applied in 2010 by the Federal Government of Germany is used for other cases in calculations.

Case 5: FIT is 50.63$¢/kWh as applied in Germany in 2010 and discount rate is 16%.

Year	Discounted CF	Nominal CF	Savings	Invest. Replace.	O&M	Sales	Discounted Costs
					10%		
0	(11,560)	(11,560)		(11,560)			11,560
1	1,148	1,331	355		(41)	1,017	271
2	1,052	1,416	444		(45)	1,017	297
3	975	1,522	555		(49)	1,017	324
4	915	1,656	693		(54)	1,017	353
5	868	1,824	867		(59)	1,017	384
6	835	2,035	1,083		(65)	1,017	418
7	813	2,299	1,354		(72)	1,017	454
8	802	2,630	1,693		(79)	1,017	492
9	801	3,046	2,116		(87)	1,017	534
10	808	3,566	2,645		(95)	1,017	578
NPV:	(2,542)	**All Units are in. -USD**					15,665
Annuity	(262)						1,613

Table 24 NPV of the investment with FIT of 50.63$¢/kWh and 16% discount rate

Table 24 indicates that, although the FIT applied is increased nearly by 300%, still the investment is risky.

Case 6: FIT is 50.63$¢/kWh as applied in Germany in 2010 and discount rate is 5%.

Year	Discounted CF	Nominal CF	Savings	Invest. Replace.	O&M	Sales	Discounted Costs
					10%		
0	(11,560)	(11,560)		(11,560)			11,560
1	1,268	1,331	355		(41)	1,017	300
2	1,284	1,416	444		(45)	1,017	362
3	1,315	1,522	555		(49)	1,017	437
4	1,363	1,656	693		(54)	1,017	526
5	1,429	1,824	867		(59)	1,017	633
6	1,518	2,035	1,083		(65)	1,017	760
7	1,634	2,299	1,354		(72)	1,017	911
8	1,780	2,631	1,693		(79)	1,017	1,092
9	1,963	3,046	2,116		(87)	1,017	1,308
10	2,189	3,566	2,645		(95)	1,017	1,565
NPV:	4,184	**All Units are in. -USD**					19,454
Annuity	431						2,003

Table 25 NPV of the investment with FIT of 50.63$¢/kWh and 5% discount rate

With discount rate of 5% and FIT of 50.63$¢/kWh, the investment seems efficient in terms of economics.

To sum up nearly all of the cases showed that, investing in roof-mounted systems in Turkey are risky. So there are more precautions to be taken and meliorations to be done in Turkish PV market, which will be expressed and interpreted later on in *Results* and *Conclusions* chapters.

4.3 Economic Assessment on Utility Scale PV Plants

Although nearly 80% of the installations in Germany is composed of residential and commercial installations as mention in the previous chapter, doubtlessly utility scale PV plants also play important role in generating green energy. On the other hand, Turkish investors and electricity market, recently preparing for license applications period seems to be one of the most promising players of the future. However with the enacted law at the end of 2010, total capacity of 600 MW is to be built till the end of 2014.

Today's one of the most important concerns in PV market is the average system price consisting of module and balance of system (BoS) costs. As the utilization of PV system in electricity generation sector increased, the system prices have been dropping down gradually year-by-year. According to International Renewable Energy Agency (IRENA), average system prices felt by 16% in 2010 with respect to prices in 2009 [35].

On the other hand, system prices in Turkey cannot be estimated since there is not any utility scale PV plant or a prototype. Doubtlessly, the system cost will be too much higher than the U.S.A. and other European countries, but in this study average prices obtained from IRENA's report are going to be used.

System cost of utility scale PV plant is mainly composed of:

1. Balance of System (BoS) cost
    a. Inverter cost
    b. Mounting/Racking
    c. Combiner box and miscellaneous electrical components
    d. Site preparation and installation
2. PV Module cost

These costs change according to system capacity, meteorological conditions and domestic manufacturing. Although the average system costs were compiled from 92 different PV plants with capacities of 10 MW each in Canada, Australia, China, Thailand, India, Japan, the Czech Republic, Belgium, Greece, Spain, France, Germany, Italy and the US, the prices can be applicable to utility scale PV power plants having lower capacities than 10 MW. In any case, "PV power plants with capacity above 2 MW do not appear to offer significant economies of scale [36].

According to the report of IRENA on cost analysis of solar PV, average system price for fixed and ground-mounted utility scale PV power plants was 4.71$/W. In detail, while the plants, which utilize mono-crystalline or poly-crystalline solar PV modules, had average system cost of 5.03$/W, generators utilizing thin-film PV modules paid 4.16$/W [36].

On the other hand, although system prices are in decreasing trend, still PV is the most expensive type in electricity generation process through all conventional and renewable resources. For instance, levelised cost of electricity generation in Germany for rooftop PV systems was 350$/MWh in 2010, which is the highest among all resources [36].

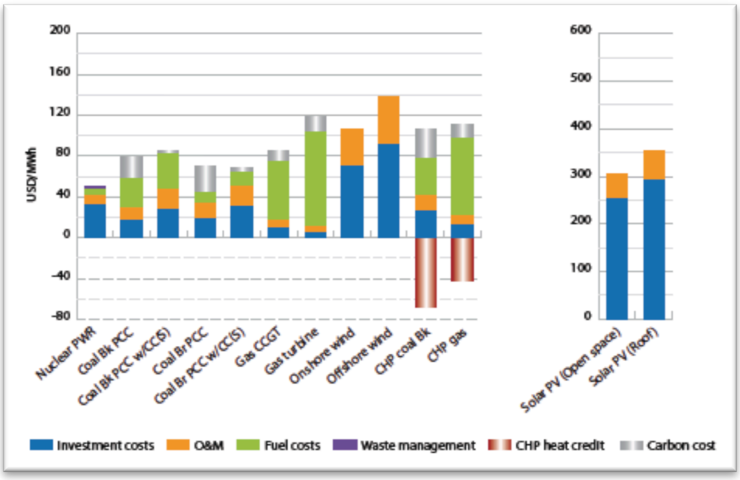


Figure 21 Levelised cost of electricity (LCOE) in Germany in 2010 at 5% discount rate

Figure 21 shows another useful information on PV system costs. Investment costs contribute nearly 85% of the whole cost, which is one of the major concerns of an investor in project planning stage.

PV Module Cost

With increasing R&D studies and improvements in mass production of the modules, module prices decrease gradually year by year. In the first quarter of 2012, the prices of PV modules are as follows [36]:

- High efficiency c-Si: 1.94$/W
- Japanese/Western c-Si: 1.22$/W
- Chinese major c-Si: 1.24$/W
- Emerging economies c-Si (Chinese, Korean and Indian): 1.02 $/W
- High efficiency thin-film: 0.93$/W

Balance of System (BoS) Cost

In 2010, the contribution of BoS cost to total installation cost and breakdown of BoS cost in the US as follows [36]:

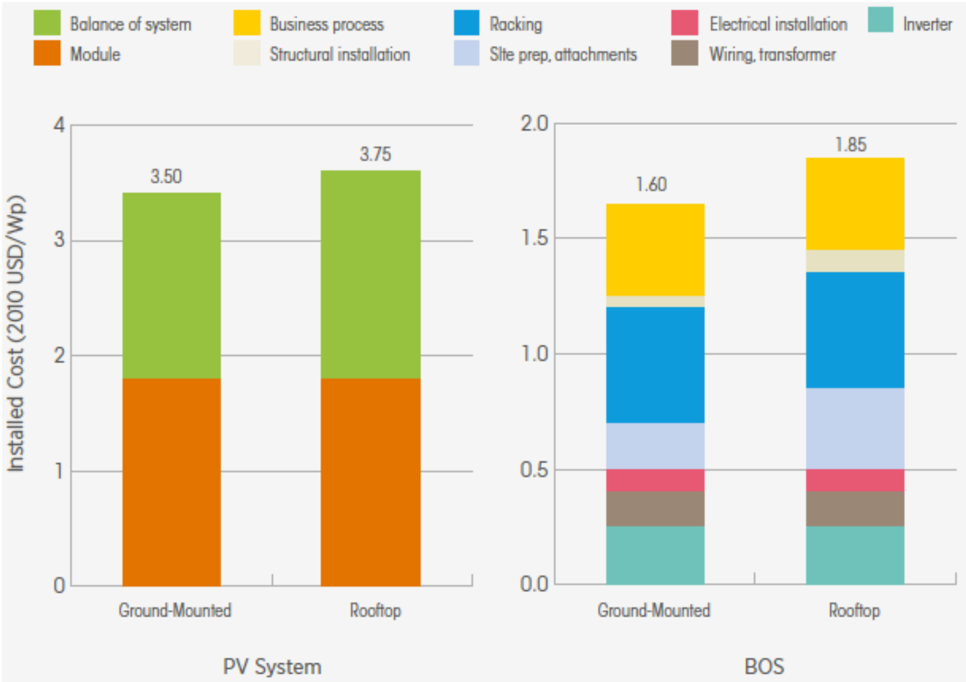


Figure 22 Breakdown of BoS cost in the US in 2010

Turkey, one of the potential strongest market candidates, will start to utilize large PV systems in 2013. To see, if investment in large scale PV systems is reasonable or not, an economic analysis is done on a system proposed with following specifications:

- Capacity of 3 MW
- In province Antalya near Aksu district
- Ground-mounted
- Fixed tilt
- Azimuth 0°
- Slope 33°
- Thin film – Cadmium Telluride (CdTe) solar PV modules are used in different cases of 3 MW PV power plant, since thin film modules work better and generate more electricity in diffuse light conditions and hot environments like Antalya having average annual maximum temperature of ca. 25° C. On the other hand as compared above, thin films have lower prices compared to silicon technology
- Module cost per W: 0.93 $
- BoS cost per W: 1.60 $
- O&M Cost per kW: 32 $/year
- Inflation rate: 9.20%.

When the area, the slope, module type are taken into account, this system will generate approximately 4.74 GWh of electricity with annual yield of 1580 kWh/kW per annum. With a typical company who wants to receive benefit, 4-6% of discount rate applied to the calculations of NPV via DCF method.

Case 1: The FIT applied is 13.3 $¢/kWh and discount rate of 6%.

Year	Discounted CF	Nominal CF	O&M	Invest Replace	Electricity Sales	Discounted Costs
			9.20%			
0	(7,590,000)	(7,590,000)		(7,590,000)		7,590,000
1	504,170	534,420	(96,000)		630,420	92,308
2	467,771	525,588	(104,832)		630,420	96,923
3	433,196	515,943	(114,477)		630,420	101,769
4	400,333	505,412	(125,008)		630,420	106,858
5	369,079	493,911	(136,509)		630,420	112,201
6	339,334	481,352	(149,068)		630,420	117,811
7	311,006	467,638	(162,782)		630,420	123,701
8	284,006	452,662	(177,758)		630,420	129,886
9	258,250	436,308	(194,112)		630,420	136,381
10	233,660	418,450	(211,970)		630,420	143,200
NPV:	(3,989,195)	**All Units are in. -USD**				8,751,036
Annuity	(542,004)					1,188,985

Table 26 NPV of an investment when FIT is 13.3 $¢/kWh at discount rate of 6%

As it is seen from the calculations, the investment is risky enough to implement.

Case 2: The FIT applied for the first 5 year period is 20 $¢/kWh (with premiums due to domestically manufactured components) and for the remaining period 13.3 $¢/kWh and discount rate of 6%.

Year	Discounted CF	Nominal CF	O&M	Invest Replace	Electricity Sales	Discounted Costs
			9.20%			
0	(7,590,000)	(7,590,000)		(7,590,000)		7,590,000
1	803,774	852,000	(96,000)		948,000	92,308
2	750,417	843,168	(104,832)		948,000	96,923
3	699,842	833,523	(114,477)		948,000	101,769
4	651,886	822,992	(125,008)		948,000	106,858
5	606,393	811,491	(136,509)		948,000	112,201
6	339,334	481,352	(149,068)		630,420	117,811
7	311,006	467,638	(162,782)		630,420	123,701
8	284,006	452,662	(177,758)		630,420	129,886
9	258,250	436,308	(194,112)		630,420	136,381
10	233,660	418,450	(211,970)		630,420	143,200
NPV:	(2,651,432)	**All Units are in .-USD**				8,751,036
Annuity	(360,245)					1,188,985

Table 27 NPV of an investment if domestically manufactured components are used at discount rate 6%

With receiving bonus tariffs for the first 5 years, the project seems better than Case 1, but still it is risky enough to invest in. Rather then being risky, current administrative framework conditions are not attractive at all.

Case 3: The FIT applied is 13.3 $¢/kWh and discount rate of 4%.

Year	Discounted CF	Nominal CF	O&M	Invest Replace	Electricity Sales	Discounted Costs
			9.20%			
0	(7,590,000)	(7,590,000)		(7,590,000)		7,590,000
1	513,865	534,420	(96,000)		630,420	92,308
2	485,936	525,588	(104,832)		630,420	96,923
3	458,672	515,943	(114,477)		630,420	101,769
4	432,028	505,412	(125,008)		630,420	106,858
5	405,959	493,911	(136,509)		630,420	112,201
6	380,419	481,352	(149,068)		630,420	117,811
7	355,366	467,638	(162,782)		630,420	123,701
8	330,756	452,662	(177,758)		630,420	129,886
9	306,544	436,308	(194,112)		630,420	136,381
10	282,690	418,450	(211,970)		630,420	143,200
NPV:	(3,637,765)	All Units are in. -USD				8,751,036
Annuity	(448,504)					1,078,924

Table 28 NPV of an investment with FIT of 13.3 $¢/kWh at discount rate 4%

As the discount rate is taken as 4%, NPV of a clearly negative value implies that, the project is not worth of considering and implementing at all.

Case 4: The FIT applied for the first 5 year period is 20 $¢/kWh and for the remaining period 13.3 $¢/kWh and discount rate of 4%.

Year	Discounted CF	Nominal CF	O&M	Invest Replace	Electricity Sales	Discounted Costs
			9.20%			
0	(7,590,000)	(7,590,000)		(7,590,000)		7,590,000
1	819,231	852,000	(96,000)		948,000	92,308
2	779,556	843,168	(104,832)		948,000	96,923
3	740,999	833,523	(114,477)		948,000	101,769
4	703,497	822,992	(125,008)		948,000	106,858
5	666,986	811,491	(136,509)		948,000	112,201
6	380,419	481,352	(149,068)		630,420	117,811
7	355,366	467,638	(162,782)		630,420	123,701
8	330,756	452,662	(177,758)		630,420	129,886
9	306,544	436,308	(194,112)		630,420	136,381
10	282,690	418,450	(211,970)		630,420	143,200
NPV:	(2,223,956)	All Units are in. -USD				8,751,036
Annuity	(274,194)					1,078,924

Table 29 NPV of an investment when domestically manufactured components are used at discount rate of 4%

Each case shows that, current incentive scheme is not attractive under the given framework conditions. It is obvious that, lower incentive periods and rates leads an investment infeasible and impels investor's interest towards PV projects. In deed, it is not valid to expect a power generating facility to compensate itself in 10 years. On the other hand, it is important to take the lifetime of a PV plant, which is approximately 20 years into account. In that sense, it is assumed for the following cases that, MENR is going to propose the same incentives for the 2nd ten-year operation period of a plant.

Case 5: The FIT applied for the whole investment horizon is 13.3 $¢/kWh and discount rate of 4% for 20 years.

Year	Discounted CF	Nominal CF	O&M	Invest Replace	Electricity Sales	Discounted Costs
			9.20%			
0	(7,590,000)	(7,590,000)		(7,590,000)		7,590,000
1	513,865	534,420	(96,000)		630,420	92,308
2	485,936	525,588	(104,832)		630,420	96,923
3	458,672	515,943	(114,477)		630,420	101,769
4	432,028	505,412	(125,008)		630,420	106,858
5	405,959	493,911	(136,509)		630,420	112,201
6	380,419	481,352	(149,068)		630,420	117,811
7	355,366	467,638	(162,782)		630,420	123,701
8	330,756	452,662	(177,758)		630,420	129,886
9	306,544	436,308	(194,112)		630,420	136,381
10	282,690	418,450	(211,970)		630,420	143,200
11	259,149	398,948	(231,472)		630,420	150,360
12	235,881	377,653	(252,767)		630,420	157,877
13	212,843	354,399	(276,021)		630,420	165,771
14	189,992	329,005	(301,415)		630,420	174,060
15	167,287	301,274	(329,146)		630,420	182,763
16	144,685	270,993	(359,427)		630,420	191,901
17	122,145	237,926	(392,494)		630,420	201,496
18	99,622	201,816	(428,604)		630,420	211,571
19	77,075	162,385	(468,035)		630,420	222,149
20	54,459	119,325	(511,095)		630,420	233,257
NPV:	(2,074,628)	**All Units are in. -USD**				10,642,242
Annuity	(152,655)					783,075

Table 30 NPV of an investment with investment horizon of 20 years, FIT of 13.3 $¢/kWh and discount rate of 4%

When the support scheme period for utilization of PV systems for electricity generation is assumed as 20 years, it is obvious that the project is not profitable. Within this result, it will not be wrong to interpret that FIT rates applied for solar power projects are low.

Case 6: The support scheme for PV systems is extended to 20 years. Each kWh produced earns the generator 20 $¢ for the first 10 years and 13.3$¢ for the remaining period.

Year	Discounted CF	Nominal CF	O&M	Invest Replace	Electricity Sales	Discounted Costs
			9.20%			
0	(7,590,000)	(7,590,000)		(7,590,000)		7,590,000
1	819,231	852,000	(96,000)		948,000	92,308
2	779,556	843,168	(104,832)		948,000	96,923
3	740,999	833,523	(114,477)		948,000	101,769
4	703,497	822,992	(125,008)		948,000	106,858
5	666,986	811,491	(136,509)		948,000	112,201
6	631,408	798,932	(149,068)		948,000	117,811
7	596,701	785,218	(162,782)		948,000	123,701
8	562,808	770,242	(177,758)		948,000	129,886
9	529,672	753,888	(194,112)		948,000	136,381
10	497,235	736,030	(211,970)		948,000	143,200
11	259,149	398,948	(231,472)		630,420	150,360
12	235,881	377,653	(252,767)		630,420	157,877
13	212,843	354,399	(276,021)		630,420	165,771
14	189,992	329,005	(301,415)		630,420	174,060
15	167,287	301,274	(329,146)		630,420	182,763
16	144,685	270,993	(359,427)		630,420	191,901
17	122,145	237,926	(392,494)		630,420	201,496
18	99,622	201,816	(428,604)		630,420	211,571
19	77,075	162,385	(468,035)		630,420	222,149
20	54,459	119,325	(511,095)		630,420	233,257
NPV:	501,230	**All Units are in. -USD**				10,642,242
Annuity	36,881					783,075

Table 31 NPV of an investment at discount rate of 4% with bonus premiums paid in the first ten years of operation

The numbers from the last case shows that increasing the support period to twenty years will let the investment be economically viable when domestically manufactured components are fully utilized. This case shows that, increasing the support period to 20 years is one of the best improvements to attract investors, who are concerning project finance. However the cash flow turns into positive value at the end 15th operation year, meaning that the investment compensates itself between the 14th and 15th years of operation illustrated in the table on the next page.

Year	Discounted CF	Nominal CF	O&M	Invest Replace	Electricity Sales	Discounted Costs
			9.20%			
0	(7,590,000)	(7,590,000)		(7,590,000)		7,590,000
1	819,231	852,000	(96,000)		948,000	92,308
2	779,556	843,168	(104,832)		948,000	96,923
3	740,999	833,523	(114,477)		948,000	101,769
4	703,497	822,992	(125,008)		948,000	106,858
5	666,986	811,491	(136,509)		948,000	112,201
6	631,408	798,932	(149,068)		948,000	117,811
7	596,701	785,218	(162,782)		948,000	123,701
8	562,808	770,242	(177,758)		948,000	129,886
9	529,672	753,888	(194,112)		948,000	136,381
10	497,235	736,030	(211,970)		948,000	143,200
11	259,149	398,948	(231,472)		630,420	150,360
12	235,881	377,653	(252,767)		630,420	157,877
13	212,843	354,399	(276,021)		630,420	165,771
14	189,992	329,005	(301,415)		630,420	174,060
15	167,287	301,274	(329,146)		630,420	182,763
NPV:	3,245	**All Units are in. -USD**				9,581,867
Annuity	239					705,051

Table 32 NPV of an investment brings a positive value at the end of 15th year

Case 7: The FIT applied for 20 years of operation for ground mounted PV systems with capacities lower than 10 MW is 23.3 $¢/kWh at discount rate of 4%

Year	Discounted CF	Nominal CF	O&M	Invest Replace	Electricity Sales	Discounted Costs
			9.20%			
0	(7,590,000)	(7,590,000)		(7,590,000)		7,590,000
1	969,635	1,008,420	(96,000)		1,104,420	92,308
2	924,175	999,588	(104,832)		1,104,420	96,923
3	880,056	989,943	(114,477)		1,104,420	101,769
4	837,205	979,412	(125,008)		1,104,420	106,858
5	795,552	967,911	(136,509)		1,104,420	112,201
6	755,029	955,352	(149,068)		1,104,420	117,811
7	715,567	941,638	(162,782)		1,104,420	123,701
8	677,103	926,662	(177,758)		1,104,420	129,886
9	639,570	910,308	(194,112)		1,104,420	136,381
10	602,907	892,450	(211,970)		1,104,420	143,200
11	567,051	872,948	(231,472)		1,104,420	150,360
12	531,940	851,653	(252,767)		1,104,420	157,877
13	497,515	828,399	(276,021)		1,104,420	165,771
14	463,715	803,005	(301,415)		1,104,420	174,060
15	430,482	775,274	(329,146)		1,104,420	182,763
16	397,758	744,993	(359,427)		1,104,420	191,901
17	365,484	711,926	(392,494)		1,104,420	201,496
18	333,602	675,816	(428,604)		1,104,420	211,571
19	302,055	636,385	(468,035)		1,104,420	222,149
20	270,786	593,325	(511,095)		1,104,420	233,257
NPV:	4,367,186	**All Units are in. -USD**				10,642,242
Annuity	321,345					783,075

Table 33 NPV of an investment in German case[3]

The evaluation of these cases is done and interpreted in *Results* section.

[3] German Case: FIT rate that is applied for ground-mounted systems, which have capacities lower 10 MW_p in the beginning of 2012 was 17.94 €¢/kWh in Germany.

4.4 Environmental Assessment on Utilization of PV Systems

In today's world, one of the most important challenging problems is GHG released by facilities in energy sector. In Europe, precautions are taken in national and EU level. Countries today are challenging to decrease emissions and trying to regulate carbon-trade market in order to take control of excessive GHG emission and decrease it. Turkey, doubling its emissions in last two decades, has still not taken concrete steps in order to decrease emissions – at least slowing down the growth rate of the amounts of emissions. In this sense, one of the best solutions to decrease emissions is to utilize RES. As mentioned above in *Documentation of Data chapter*, Germany avoided 7.9 mtCO_2 emissions in 2010 via utilizing PV systems for electricity generation. One must take into account that Turkey had suffered a total of 402 mtCO_2, of which 285 mtCO_2 emitted by energy sector. The benefit supplied by electricity generation via PV systems to GHG emissions can be analysed with following method for a 3 MW utility scale PV plant.

Substitution factors for PV based electricity generation:

Substitution factor will allow us to find out the equivalent electricity generated via conventional resources.

	Nuclear energy [2]	Lignite	Hard coal	Natural gas	Mineral oils
	[%]				
Hydropower	0	6	63	31	0
Wind energy	0	6	64	30	0
Photovoltaics	0	5	65	31	0
Solid biomass	0	6	63	31	0
Liquid biomass	0	6	64	31	0
Biogas	0	6	64	31	0
Landfill gas	0	6	64	31	0
Sewage gas	0	6	64	31	0
Biog. fraction of waste [3]	0	6	63	31	0
Geothermal energy	0	6	63	31	0

Table 34 Substitution factors for renewable based electricity generation (Source: [37])

Table 34 indicates that for instance, 1 kWh electricity generated from PV can be replaced typically by a mixture of electricity generation stemming from different fossil resources. According to [37] this would comprise 5% lignite, 65% hard coal and 31%

natural gas. Obviously this interpretation can be used vice versa – meaning that PV electricity with its typical load profile is replacing electricity from these fossil sources to the given extent.

CO_2-equivalent emission factors:

Moreover, each type of conventional resources has different CO_2 emission factors. Total GHG emissions avoided by a PV system will be calculated based on these characteristics. The life cycle assessment (LCA) emission factors of fossil sources are listed below.

Fuel Type	LCA emission factor (tCO_2e/MWh)
Hard Coal	0.393
Lignite	0.375
Natural Gas	0.237

Table 35: LCA emission factors for selected fuel types (Source: [38])

To illustrate the calculation of GHG avoidance, 3 MW utility-scale PV power plant will be taken as a reference. As mentioned above the annual yield of the facility is 1450 kWh/kW per annum. So total electricity generated via this PP will be 4,740,000 kWh/year. When 10 years of operation period is taken into account, total electricity generation in this period will be 47,400,000 kWh or 47,400 MWh. 47,400 MWh of electricity can be generated roughly by:

- 2,370 MWh by lignite
- 30,810 MWh by hard coal
- 14,694 MWh by natural gas

So the total GHG avoided by the system is: approximately **16,479 tCO_2e**. The amount of GHG avoided seems to be

On the other hand, with the law on utilization of solar power for electricity generation, the transformer stations that are eligible for connection of PV power plants are specified. In this respect, total eligible capacity to be built and connected to these transformer stations is 600 MW. When the caps for each transformation and global irradiations in 30 m diameter within the station is taken into account (see Annex G), total electricity generated via all systems will be **933,130 MWh/y**. So total electricity generated in 10 years of operation is 9.331 GWh. With this generation, Turkey will avoid approximately **3.24 $mtCO_2e$,** which is still much lower than Germany's avoidance in single year 2010 (7,9 $mtCO_2e$ within 11,683 GWh generation of electricity via PV).

Rather than GHG avoidance, each PV system has its own GHG emissions embedded in its LCA. Typically ground mounted CdTe thin film modules having performance ratio (PR) of 0.8 with 10.9% efficiencies, which are built on an area having global irradiation of 1800 kWh/m^2 per year, emits ca. 19 gCO_2e/kWh GHGs through its life cycle [39]. In this respect a 3 MW_p PV plant emits GHGs as total of ca. **1,800 tCO_2e** within its lifetime of 20 years

4.5 Brief Indication on employment impacts of the PV Sector

It is clear that PV sector plays noteworthy role in a nation's economical and ecological status. On the other hand, newly integrated sectors in a nation create new job occasions in that country. Likewise other sectors, the market integration of PV sector will enable new fields for employment. As shown in previous chapter in Figure 10, 367,400 people were employed in renewables sector in Germany, while 120,900 of them were in solar energy sector, in which PV plays a crucial role in 2010. However the employment impacts of PV can be studied under two different types of employment, which are direct and indirect employment effects, i.e. gross impact study.[4]

Direct employment includes the job opportunities created in the fields of manufacturing, delivery, construction/installation, project management and O&M of the different components of the technology. Indirect employment effect includes jobs the employment in upstream and downstream industries that supply and support the RE activities. [40].

According to a report released by EPIA and Greenpeace, with the feedback from the industry, it is assumed that:

- 10 direct jobs/MW_p in production
- 33 direct jobs/MW_p during installation
- 3-4 direct jobs/MW_p in wholesaling of the systems and indirect supply
- 1-2 direct jobs/MW_p in R&D

are created [41].

As mentioned in previous chapters, Cabinet has set 600 MW_p cap in total eligible capacity to be connected in 2013 and 2014. When the assumptions made by EPIA and Greenpeace are taken into account, in short term **28,200 to 29,400** of people

[4] Gross employment studies focus on the economic relevance of the RE industry in terms of employment, thus on the number of jobs provided in the RE industry and the structural analysis of employment in the RE industry.

will be directly employed. Based on the projections done by EMRA, total capacity of PV plants installed will be minimum 3,000 MW by 2023. With this base value up to **147,000** people will have opportunity to be directly employed in the sector, if it is assumed that the projects are implemented at the same time with different employees. Rather than direct employment, indirect employment must be also taken into account. I.e. PV sector will have multiplier effect, which will create indirect employment.

Since, any company has not implemented a solar power project and receive revenue yet, the multiplier effect[5] of PV sector into the economy still cannot be calculated for the Turkish PV market.

When the latest statistics, announced by TurkStat are examined, unemployment rate was 8.4% (2,226,000 unemployed) in July 2012 in Turkey [42]. Within this percentage, 10.8% of undergraduate degree holders, 10.9% high school graduates, and 9.2% vocational high school graduates are unemployed [43]. So the job opportunities created by the PV sector are open to every segment of citizens who have different educational backgrounds.

Up to now in this study, the gross employment impacts are illustrated. The employment impacts within the establishment of a new market can be designed as gross impact study and net impact study. The net impact study defines and illustrates both negative and positive effects on overall economy taking induced employment impacts of two types namely primary effect of Type 1 and secondary effect of Type 2 into account. Type 2 induced effect sets a negative impact in motion since it is initiated by higher prices for energy leading to additional costs for electricity use in industry and households. This entails changes in consumption or in production leading to lower demand either for consumption goods and services or for investment and intermediate goods and services. This in turn affects production, income and again consumption [40]. It is important to take price and cost impulses into account to consider secondary effect of Type 2. In this point of view, it would be more accurate to draw net employment impact over the whole economy. To sum up, the changes in consumption behavior, the challenges of different electricity generation sectors, downtrend of fuel exports and imports may have negative impact on employment in other sectors concerning the whole economy.

[5] Multiplier effect is an effect in economics in which an increase in spending produces an increase in national income and consumption greater than the initial amount spent.

5 Results

Turkey, with following economical and meteorological conditions mentioned in *Chapter 3,* is one of the most promising market players of the future. However till 2012, neither the government nor the NGOs have put an effort or considered to formally utilize world's most reliable power – solar power. Till now, Turkey has solar power capacity of approximately 5 MW_p, which is composed of just small applications or prototypes. In 2013 Turkey will meet the very first licence applications for solar power and start to utilize them in 2014. In *Chapter 4*, economic assessment of small and large-scale PV systems is done in order to see and analyse the profitability of the projects and their possible contributions to other aspects regarding ecology and employment impacts. It is obvious that utilization of PV systems for electricity generation adds value to the economics in other sectors like manufacturing; infrastructure and construction with *multiplier effect* and creates some good opportunities to avoid from higher unemployment rates and GHG emissions when gross impacts are studied. Regarding the numeric values and statistics maintained in *Chapter 4*, following results and key figures are obtained and interpreted:

1. **Public Awareness:** The statistics obtained via questionnaire showed us that, citizens are not made conscious of renewable energy. Although the statistics aroused from the sample shows that nearly **75%** of the respondents are aware of solar power, it will not give the same result when the same study is done over the whole country when education is taken into account **(49% of the citizens hold high school or upper degrees)**. Although the standard of literacy and numeracy is in increasing trend in the whole country, it is not enough to make the public aware of renewables and solar power.
   On the other hand, more than half of the respondents, who segmented according to their education levels, have not heard or informed about that they can use small scale – namely BIPV or Roof-mounted PV systems as residential or commercial systems. When this statistics is broadened to whole population, it is obvious that utilization of small-scale PV systems will not be country-spread. One must not forget that, these types of systems contributed nearly 80% of the whole installed PV capacity in Germany in 2009.

2. **Economic assessment on BIPV/roof-mounted PV systems:** The calculations done via DCF method showed us that, building a small-scale system is not profitable within different ranges of FITs and discount rates. Moreover, it is obvious that incentive period and applicable FIT rates are not challenging ones when compared to other country's market integration prices illustrated in the table above.

	Case 1	Case 2	Case 3	Case 4	Case 5	Case 6
Investment ($)	11,560	11,560	11,560	11,560	11,560	11,560
Investment Horizon	10	10	10	10	10	20
FIT ($c/kWh)	13.3	13.3	20	20	50.63	50.63
Discount Rate	16%	5%	16%	5%	16%	5%
NPV ($)	(6,165)	(1,605)	(5,724)	(1,020)	(2,542)	4,184
Annuity ($)	(635)	(165)	(589)	(105)	(262)	431

Table 36 Summary of cases for 2.8 kW roof-mounted PV system

Unlicensed utilization of a PV system may contribute in saving electricity consumption fees, but cannot be a source of income within this framework conditions. A householder can utilize this small system up to 20 years, which is the lifetime of a PV system and compensate the investment relatively between the 10^{th} and 20^{th} years of operation period. Yet, it is tough to assure a householder to invest in such a system just to get rid of electricity bills within longer payback periods when the income level of the whole country is taken into account.

3. **Economic assessment on utility scale PV systems:** From the beginning of 2014, utility scale solar power plants will start to generate electricity inside the territories of the country. One of the drawbacks of the whole process is measurement obligation for license applicants. The law on utilization of electricity generation from PV systems set up a condition that the potential applicants must do measurements on the field for 6 months before applying for license which is going to create an additional cost to cash flow the project. Rather than obligatory paperwork and applications, the calculations done via DCF method on possible 3 MW_p PV power plant showed us that, FITs and bonus premiums are not adequate to turn the capital cost into profit in 10 years. On the other hand, it is not adequate to expect a power

generation facility to compensate its investment cost and turn in to profit in 20 years. Yet when the best case (20 years of support scheme with bonus premiums paid for the first ten years of operation at discount rate of 4%) is taken into account and calculations are done in this respect, the investment hardly compensates itself between the 14^{th} and 15^{th} years of operation.

On the other hand, another case is applied on NPV calculations of a 3 MW_p system with higher tariff with respect to the current tariff set by the government. This case - namely German case assures a tariff of 23.3$¢/kWh, which is referenced from the price specified in the beginning of 2012 for twenty years of operation in Germany. The results rose from these cases are summarized in the table below.

	Case 1	Case 2	Case 3	Case 4	Case 5	Case 6	Case 7
Investment ($)	7,590,000	7,590,000	7,590,000	7,590,000	7,590,000	7,590,000	7,590,000
Investment Horizon	10	10	10	10	20	20	20
FIT ($c/kWh)	13.3	20	13.3	20	13.3	20	23.3
Discount Rate	6%	6%	4%	4%	4%	4%	4%
NPV ($)	(3,989,195)	(2,651,432)	(3,637,765)	(2,223,956)	(2,074,628)	501,230	4,367,186
Annuity ($)	(542,004)	(360,245)	(448,504)	(274,194)	(152,655)	36,881	321,345

Table 37 Summary of cases for 3 MW utility-scale PV power plant

When the investment horizon and FIT are taken into account, it is obvious that, current support scheme for utilization of PV systems for electricity generation is not currently attractive within the given framework conditions.

4. **Environmental assessment on utilization of PV Systems:** Today, one of the most important topics is the GHG emission from energy sector and it's environmental influences on global warming. Solar energy, which is a sub-type of renewable energy – namely green energy, will doubtlessly play an important role in that country's and world's future. When the avoidance numbers arisen from a typical 3 MW_p plant and the total contribution of possible 600 MW_p capacity are taken into account, it is obvious that, solar energy shall be one of the most important contributors of GHG emissions, where imported conventional sources are the mainstream for energy production in Turkey. Based on calculations, Turkey has the opportunity to avoid **3.24 $mtCO_2e$** GHG emissions in a short period like ten years. When it is assumed that the economical potential **(305 TWh/year)** of solar power is

fully utilized, it is possible to avoid approximately **106 $mtCO_2e$/year** of GHG emissions.

5. **Brief Indications on employment impact of the PV sector:** Turkey, having one of the most significant numbers of unemployed, is one of the most promising candidates in renewable sector. As mentioned above in *Chapter 4*, if the target set for PV is satisfied till 2023, approximately **147,000** jobs will be occupied directly. On the other hand, PV sector will let other sectors to be stirred, which will lower the unemployment rate, adding economic and sociological benefits to the public finances and the state. One must not forget that in Germany 120,900 jobs in solar energy were offered in 2010, which is approximately 4 times higher with respect to jobs offered in that area in 2004. The increase in total installed capacity is another indicator in employment in PV sector. When the net impacts of employment through PV deployment are taken into account, it is obvious that some negative symptoms may arise regarding the overall economy.

6 Conclusion

According to the numbers raised from various methods in this study shows that, Turkey is still in infantry stage of PV sector. The amendment law and other laws related to utilization of solar power for electricity generation are some milestones for Turkey, but the calculations show that there is too much things and meliorations to do and to be worked on. It is obvious that Turkey is one of the most promising potential players for the future market in terms of economical, sociological and environmental impacts. Rather than these, when Turkey adopts and give much more importance to renewable energy – especially to PV, the state can handle the security of energy supply since PV systems do not require fuel to generate electricity, importing from foreign countries. Derived conclusions with recommendations to each of them will be discussed in separated articles.

1) **Legislation**
    a. **FIT and bonus premiums:** FIT, which is introduced with the law enacted in 2010 is too much lower with respect to other countries. The calculations with DCF method showed us that, possible investments are not worth of implementing, since the investment does not compensate itself in 10 years. Two major reasons can be interfered with the case raised: Low FIT rates and the validity of support incentives. As mentioned above, Turkish FIT rates, which are applicable for PV systems are way much lower cannot compete with the ones in European countries even bonus premiums are added. Moreover the period of support is too short to implement a profitable project even these plants are built on areas, which receive higher global irradiation rates. In Europe, nearly all of the real or legal entities receive FITs for twenty years with some periodical cuts in the prices starting from some time later than the date of first generation. Higher FIT prices and validity periods may lead us to concern about public finances, but when these prices are reflected in electricity bills, higher numbers of installation will not create burden in public finances as similarly happened in Spain in previous years, where the FITs were paid from public treasury.

       Moreover, when we have a look on other mature PV markets in Europe, applicable FIT rates are subdivided according to the capacities installed. Rooftop PV and BIPV systems receive different and absolutely much more FIT rates with respect to the utility scale PV plants. As mentioned before in this study, Germany's built capacity is mainly composed of residential and commercial applications. The idea behind this is that, Federal Government of Germany has given importance to even small consumption units, in order to avoid GHG emissions and to foster the use of renewables. With this way, every small electricity consumption unit benefits from green energy and also receive income via selling excessively generated electricity via PV system to the system with higher FIT prices. When Turkey enacts another law dividing the FIT rates according to the capacities installed, it is obvious that citizens will be more likely to install these systems to compensate their investment in lower periods and receive income Rather than just doing savings on electricity bills.

b. **Taxes:** License holders, which are eligible to generate electricity from PV, are exempted of paying 1% treasury share. Moreover generators are obliged to pay just 15% of tenancy and easement prices for the first 5 years of operation, which are two advantages for making the investors courageous. On the other hand, 18% of VAT is applied from the beginning of installation to generation period, which is too high for making the investors drive attention towards PV systems. In many cases, Turkish government lowered VAT in manufacturing and sales in order to integrate a sector briskly or to keep these sectors alive during the global crisis in 2002 and 2009. One of the best ways to "make" PV sector alive is doing some tax exemption to serve investors lower investment costs.

c. **Measurement Obligation:** It is obvious that, first applications of PV systems are going to be composed of imported components. It will be a delusion to expect mass production of cells, wafers, modules, inverters and other components in short run in Turkey, which absolutely makes investors to import components of a PV system. On the other hand, with the law on utilization of solar power for electricity generation, project planners and investors are obliged to do necessary measurements in the proposed field for 6 months. In that manner, if one of two or more applicants do not own the land and apply to EMRA for that land, all of them has to necessary measurements on that land although TSMS has the measurements since 1970. Since there are a few numbers of components and consultancy services in Turkey, an investor must hire a consultant and the measurement components from foreign entities, which will be another unelectable expense for cash flows of a company. Each of the real or legal entities has to pay for measurement to foreign companies, which will have absolutely zero condition to state's wealth. In fact, the measurements are important during installation and generation processes, but it can be recommended that, TSMS can build up a measurement station in the areas which are eligible to be connected to transformer stations specified. After then, the entity that earned that license can pay the charges to TSMS or to a firm, which is in consortium with TSMS for installed measurement station and consultancy services.

d. **Stability:** Although a period lower that one year was left for license application, there is still some uncertainty in the administrative framework. For instance, in the last quarter of the year 2012, the Ministry of Forestry had announced that, applicants were not allowed to build PV plants in forests or forestry areas, although it is specified in the law on utilization of solar power for electricity generation that, licence applicant are allowed to build their plants in these areas. The complexity and instable framework definitely leads a company run out of time and doubtlessly disables the avoidance of additional costs, when the period of measurement and the application period are taken into account. Doubtlessly, instable administrative procedures and market lead an unequal challenge between generators or potential generators. Resolving instability leads the market more trustworthy and prospers the rapid growth.

2) **R&D:** R&D is one of the most important periods of studies before and during market integration of different sectors. It is obvious that research and development studies are one of the most important aspects of science and workfare, which enables continuous development of a nation. Recently, most of the R&D studies in Turkey are done on modules and glasses for PV systems but not cells, wafers and inverters as mentioned above. Having mature market, the market leader Federal Government allocated **112 million €** to the components and studies related to PV systems. In contrast, Turkish government allocated just **40.75 million €,** although having immature market

and having too much way to do. Treasury and public finances differs substantially in both cases, but allocated amount for R&D studies on PV systems show that, neither the government nor the institutions put mandatory emphasis on PV systems. BAPV systems, which have capacities lower than 10 kW, reached the grid parity in third quarter of the year 2011 in Germany. It is evitable that, R&D studies led the country to gain experience about every aspect about the industry, the experience led Germany to pass through mass production stage and mass production led the LCOE of PV systems to reach grid parity – i.e. reached electricity prices for households [27]. This induction shows that it is vital to put emphasis on R&D studies that are subsidized by public finances in order to integrate this sector into energy market and decrease the cost of generation. To sum up, the Cabinet must reconsider of allocating more subsidies for R&D studies in field from public finances and treasury.

3) **Education:** One of the most challenging cases, which threaten the future of PV market in Turkey, is the low expertise level in this field. Recently, there are a few numbers of courses to be enrolled in some departments of universities, which is relevant with solar power. In postgraduate level, it seems approximately ten programs are provided from different universities. In this point of view, white-collar workers can be employed without any struggle, but when a manufacturer or installer considers of hiring low qualified but highly experienced blue-collar workers, it is almost impossible to find that kind, since production levels of components of PV systems are extremely low, which also lead the market to struggle to develop. To avoid low expertise and time loss, the government and MENR can consider of integrating new vocational schools based on energy/renewable energy in Turkish educational system, to get rid of though times through development stages of the market and grow rapidly. With this approach possible delays in each stage of instalment can be avoided, then companies do not need to allocate cost for possible errors and delays.

4) **Public awareness:** One of the most important aspects to utilize solar power lies behind public awareness of these systems. Statistics raised from questionnaire showed us that, people are not aware of small scale PV systems, which can be integrated or mounted to their households to generate electricity as mentioned above. Low levels of awareness will doubtlessly not enable PV sector to be fostered. Nowadays, Turkish government releases public advertorials on television and radio channels

collaborating with related ministries or institutions in order to make people aware of what they aim. One of these advertorials is about the importance of energy efficiency and how to get rid of excess amount of electricity consumption. In that manner, similar advertorials can be prepared and fed to the channels to inform citizens about this green technology to get rid of paying high electricity bills and to avoid GHG emissions raised from the primary energy source consumed that they use for electricity. Another way to increase citizens' awareness towards PV systems via showing simple numbers and facts on GHG emissions avoided if these systems are chosen via social network websites. It is proven that, people are more likely to gain information and knowledge through the web than many other ways.

5) **Carbon market:** Although Turkey has signed the Kyoto Protocol in 2009, within political strategy; the state has not benefit from low carbon economy and trade market yet, which the protocol offers. There is only voluntary carbon market, which cannot be considered as a government fostered and managed. Nowadays Ministry of Environment and Forestry is working on some issues related to carbon market for taking control and decrease GHG emissions, introducing green technologies and increasing their capacities on the whole land. Within these studies, a national carbon market will be established and the country will become an international trader. In that manner, electricity generators holding conventional thermal power plants will have some limitations in excessive emissions, the trades will become another successful submarket of energy generation and many investors will take into account of building PV plants to get rid of limitations stated in national and also international carbon markets.
6) **Domestic manufacturing:** As mention in R&D article, subsidies from government plays an important role in development of the sector. If the R&D funds allocated for PV systems and system components, domestic manufacturing will start and develop accordingly. The government and also private entities must place an emphasis on domestic manufacturing and technology. Within this cyclic relationship, both of the manufacturers and electricity generators who use domestic components in their plants having an opportunity receive bonus premiums will add more income to their income statements. The role of government in this process must be allocating more R&D funds to PV technologies and courage manufacturers to do mass production of components of the system with some tax exemptions and creditable loans. In deed, within the economic assessment of utility scale PV

system, it is obvious that domestic components create a value in terms of project finance and direct/indirect employment impacts on related area.

To sum up, Turkey, who has not utilized solar power yet, will doubtlessly become face to face with some administrative and legislative obstacles and difficulties during the periods of licence application, installation and electricity generation. But it is obvious that if sufficient and attractive improvements are done within legislative framework and public finances mentioned as recommendations above, the country is going to be one of the most promising players of the future PV market.

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9 Annexes

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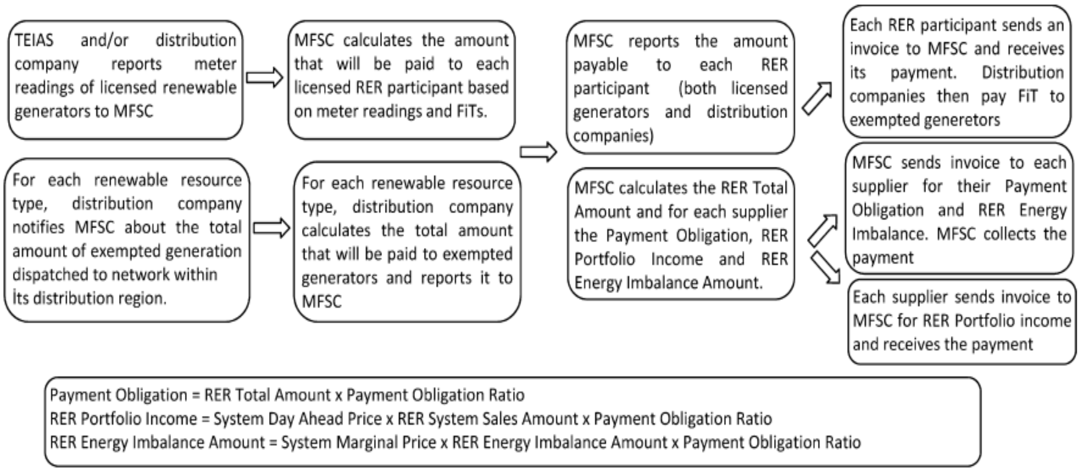
A. MONTHLY OPERATION OF RER SUPPORT MECHANISCM



B. SOLAR MEASUREMENT STATION INSTALLATION REPORT

<table>
<tr><td colspan="2">Name of the Applicant/Legal Entity</td><td colspan="3"></td></tr>
<tr><td rowspan="3">Place of Station</td><td>City</td><td colspan="3"></td></tr>
<tr><td>District</td><td colspan="3"></td></tr>
<tr><td>Locus</td><td colspan="3"></td></tr>
<tr><td colspan="2">UTM Coordinate (6 degree –ED 50 Datum)</td><td colspan="3">E N</td></tr>
<tr><td colspan="2">Name of the plot</td><td colspan="3"></td></tr>
<tr><td colspan="2">Date of Installation</td><td colspan="3"></td></tr>
<tr><td colspan="5">Devices used</td></tr>
<tr><td colspan="2">Device</td><td>Manufacturer</td><td>Type</td><td>Serial No</td></tr>
<tr><td colspan="2">Pyrometer</td><td></td><td></td><td></td></tr>
<tr><td colspan="2">Sunshine Duration Censor</td><td></td><td></td><td></td></tr>
<tr><td colspan="2">Anemometer</td><td></td><td></td><td></td></tr>
<tr><td colspan="2">Relative Humidity Censor</td><td></td><td></td><td></td></tr>
<tr><td colspan="2">Temperature Censor</td><td></td><td></td><td></td></tr>
<tr><td colspan="2">Measurement Data Logger</td><td></td><td></td><td></td></tr>
</table>

* Censors that are going to be used satisfy the measurement criterion set by World Meteorology Organization (WMO/CIMO No.8) and have at least the same quality with the ones used in measurements done by General Directorate of Meteorology.
** This report is valid only if on-site inspection done and endorsed.

SUPPLEMENT:

1) Documents related with the devices that are used on site. (Technical data)
2) An original on-site measurement permission document or duplicate of on-site measurement document for whom owns the land.
3) Photos of the station after installation
4) A report and invoice on station's installation
5) Installation report soft copy (A CD including related documents and technical data)

Prepared By (Applicant/Legal Entity)	Approval (General Directorate of Meteorology)
Signature	Signature
Cachet	Cachet
Date	Date

C. ELECTRICITY GENERATION WITHOUT LICENSE CONNECTION APPLICATION FORM

<table>
<tr><th colspan="4">Information of Applicant</th></tr>
<tr><td>Name Surname</td><td colspan="3"></td></tr>
<tr><td>Address</td><td colspan="3"></td></tr>
<tr><td>Phone Number</td><td colspan="3"></td></tr>
<tr><td>Fax Number</td><td colspan="3"></td></tr>
<tr><td>E-Mail</td><td colspan="3"></td></tr>
<tr><td>T.R. ID Number</td><td colspan="3"></td></tr>
<tr><td>Bank Account No</td><td colspan="3"></td></tr>
<tr><th colspan="4">Information of Generation Facility</th></tr>
<tr><td>Address</td><td colspan="3"></td></tr>
<tr><td>Coordinates</td><td colspan="3"></td></tr>
<tr><td>Installed Power</td><td colspan="3"></td></tr>
<tr><td>Date of Requisition for Connection</td><td colspan="3"></td></tr>
<tr><td>Projected Start-up Date of Generation</td><td colspan="3"></td></tr>
<tr><td>Type of Renewable</td><td colspan="3"></td></tr>
<tr><td>Type of Connection</td><td>☐ LV Single Phase</td><td>☐ LV Tri-phase</td><td>☐ HV</td></tr>
<tr><td>Information on Connection Transformer</td><td colspan="3"></td></tr>
<tr><td colspan="4">Other Related Information:</td></tr>
<tr><td colspan="4">Information given in this form filled in righteous by myself. If my application is accepted, I accept and commit that; I am going to install the generation facility based on information given on this form, during installation period, I will not constitute anything without obtaining necessary permissions from distribution company. If anything contrary is identified, I accept and commit that; the distribution company will cancel my application in any period.</td></tr>
</table>

Name Surname	Signature	Date

D. CAPACITIES OF CONNECTIBLE ELECTRICITY GENERATION PLANTS UTILIZING SOLAR ENERGY BASED ON REGION AND TRANSFORMER STATIONS

BÖLGE VE TRAFO MERKEZİ BAZINDA GÜNEŞ ENERJİSİNE DAYALI ELEKTRİK ÜRETİM TESİSİ BAĞLANABİLİR KAPASİTELERİ					
BÖLGE NO	UTM 6 DERECE KOORDİNATLAR				KAPASİTE (MW)
	TRAFO MERKEZLERİ	SAĞA DEĞER	YUKARI DEĞER	DİLİM	
1 KONYA	AKŞEHİR	363003,68	4244202,67	36	46
	ALİBEYHÖYÜĞÜ	468914,86	4152368,07	36	
	BEYŞEHİR	385119,41	4178209,90	36	
	ÇUMRA	477976,38	4158640,94	36	
	KONYA-3	465965,76	4201426,91	36	
	KONYA-4	478084,91	4188168,14	36	
	LADİK	448984,86	4225276,45	36	
	SEYDİŞEHİR	399320,23	4146404,44	36	
2 KONYA	ALTINEKİN	489600,00	4241126,00	36	46
	EREĞLİ	596063,21	4155309,15	36	
	GÜNEYSINIR	476806,00	4125254,00	36	
	KARAPINAR	548582,72	4176118,36	36	
	KIZÖREN	515451,42	4221725,76	36	
3 VAN AĞRI	BAŞKALE 380	422375,00	4214015,00	38	77
	ENGİL	341774,89	4250656,88	38	
	ERCİŞ	356470,71	4323712,78	38	
	VAN	356151,46	4266051,89	38	
	VAN 380	353339,00	4272418,00	38	
4 ANTALYA	AKORSAN	288284,98	4105398,68	36	29
	FİNİKE	243601,68	4022992,66	36	
	KAŞ	739819,93	4009356,82	35	
	KEMER	280848,33	4051178,88	36	
	KORKUTELİ	251423,04	4107777,90	36	
	SERBEST BÖLGE	285295,90	4080899,59	36	
5 ANTALYA	AKSEKİ	392152,86	4099905,78	36	29
	ALANYA 1	403101,84	4047677,75	36	
	ALANYA 2	421598,00	4039770,45	36	
	ALARA	382006,76	4058900,64	36	
	GAZİPAŞA	434882,94	4018240,64	36	
	GÜNDOĞDU	348585,41	4080207,22	36	
	SERİK	329845,31	4088658,25	36	
	VARSAK	295883,34	4092710,06	36	
6 KARAMAN	ERMENEK	497480,00	4046971,00	36	38
	KARAMAN	517251,94	4115608,13	36	
	KARAMAN OSB	528638,87	4118954,31	36	
7 MERSİN	AKBELEN	642238,91	4076734,87	36	35
	ANAMUR	488029,38	3994216,37	36	
	ERDEMLİ	623476,36	4061385,66	36	
	GEZENDE HES	524430,00	4046223,00	36	
	MERSİN 2	638211,30	4074606,00	36	

	MERSİN 380	651630,00	4086526,00	36	
	TAŞUCU	580282,55	4021214,33	36	
8 KAHRAMAN MARAŞ ADIYAMAN	ADIYAMAN GÖLBAŞI	382167,26	4182023,49	37	27
	ANDIRIN	267050,97	4164486,69	37	
	ÇAĞLAYAN HAVZA	294250,00	4188600,00	37	
	DOĞANKÖY	339816,60	4240831,15	37	
	GÖKSUN	284506,67	4211959,56	37	
	KAHRAMANMARAŞ	318325,74	4159659,26	37	
	KILAVUZLU	306924,48	4163770,22	37	
	NARLI	335040,33	4138942,78	37	
	SIR	287662,45	4153122,35	37	
9 BURDUR	BUCAK	285301,82	4147289,58	36	26
	BURDUR	265275,00	4182062,81	36	
	TEFENNİ	746616,45	4131937,67	35	
10 NİĞDE NEVŞEHİR AKSARAY	BOR	637055,13	4192947,76	36	26
	DERİNKUYU	650664,00	4249967,00	36	
	MİSLİOVA	653310,23	4233043,98	36	
	NİĞDE 2	651096,87	4205497,32	36	
11 KAYSERİ	ÇİNKUR	697185,53	4287853,18	36	25
	KAYSERİ KAPASİTÖR	731652,26	4304550,88	36	
	PINARBAŞI	270748,38	4286429,53	37	
	SENDİREMEKE	700765,87	4254903,75	36	
	TAKSAN	690510,44	4270232,83	36	
	YEŞİLHİSAR	686546,07	4234913,69	36	
12 MALATYA ADIYAMAN	ADIYAMAN	433191,92	4178413,97	37	22
	DARENDE	368064,67	4270579,87	37	
	HASANÇELEBİ	401548,23	4315745,32	37	
	MALATYA 1	443003,20	4246805,79	37	
	MALATYA 2	449991,34	4243417,47	37	
	MALORSA	426761,63	4243431,44	37	
13 HAKKARİ	BAĞIŞLI	415269,78	4175325,53	38	21
	HAKKARİ	386391,66	4161760,65	38	
14 MUĞLA AYDIN	BOZDOĞAN	615860,48	4171161,21	35	20
	DALAMAN	660740,42	4074513,71	35	
	DATÇA	560837,75	4068096,54	35	
	FETHİYE	690567,05	4060459,75	35	
	MARMARİS	611173,42	4080002,94	35	
	MUĞLA	619632,23	4119791,11	35	
	YATAĞAN	597369,44	4132070,13	35	
	YENİKÖY	578150,67	4111153,27	35	
15 ISPARTA AFYON	BARLA	306218,17	4209359,44	36	18
	EĞİRDİR	315216,01	4190934,79	36	
	ISPARTA	280865,05	4195296,87	36	
	KEÇİBORLU	262583,91	4204507,41	36	
	KOVADA 2	308496,76	4163690,43	36	
	KULEÖNÜ	291080,79	4194079,55	36	

	ŞARKİKARAAĞAÇ	351391,79	4222500,43	36	
16 DENİZLİ	ACIPAYAM	709190,00	4143300,00	35	18
	BOZKURT	728452,31	4188557,29	35	
	TAVAS	672121,45	4165984,43	35	
17 BİTLİS	ADİLCEVAZ	305568,10	4297936,75	38	16
	TATVAN	262382,99	4266494,75	38	
18 BİNGÖL TUNCELİ	BİNGÖL	630576,45	4306512,98	37	11
	ÖZLÜCE HES	593746,48	4331589,46	37	
	PÜLÜMÜR	576928,37	4371470,93	37	
	TUNCELİ	546358,62	4327825,75	37	
19 ŞIRNAK	PS-3	270648,69	4124983,21	38	11
	ŞIRNAK	272110,39	4154418,63	38	
	ULUDERE	302013,36	4146165,11	38	
20 ADANA OSMANİYE	BAHÇE	280856,49	4118420,88	37	9
	KARAİSALI	679557,37	4130446,16	36	
	OSMANİYE	253829,02	4105880,92	37	
	TOROSLAR	665263,14	4147840,78	36	
21 MUŞ	MUŞ	719277,11	4291321,29	37	9
22 SİİRT BATMAN MARDİN	KIZILTEPE	645487,90	4122895,43	37	9
	MARDİN	652907,89	4130656,93	37	
	SİİRT 380	747334,00	4202795,00	37	
	SİİRT ÇİM	738406,26	4204605,85	37	
	SİİRT TM	756573,14	4203396,88	37	
23 SİVAS	KANGAL	352696,65	432708,20	37	9
24 ELAZIĞ	ELAZIĞ 2	523072,47	4276260,06	37	8
	HANKENDİ	512221,90	4276806,08	37	
	HAZAR 1	531935,16	4266441,38	37	
	HAZAR 2	532376,57	4269567,27	37	
	MADEN	559742,66	4250141,68	37	
25 ŞANLIURFA DİYARBAKIR	SİVEREK	530460,27	4177950,47	37	7
26 ERZURUM	ERZURUM-1	694608,98	4422984,84	37	5
	ERZURUM-2	680208,79	4422056,56	37	
	HINIS	733851,45	4360097,29	37	
27 ERZİNCAN	ERZİNCAN	544811,57	4398734,39	37	3
	ERZİNCAN-OSB	532729,67	4402383,58	37	

NOT 1: HER BİR BÖLGEDE YER ALAN TRAFO MERKEZLERİNİN GÜNEŞ ENERJİSİNE DAYALI ELEKTRİK ÜRETİM TESİSİ BAĞLANABİLİR KAPASİTELERİNİN TOPLAMI;
O BÖLGENİN YUKARIDAKİ TABLODA YER ALAN KAPASİTESİNDEN FAZLA OLAMAZ.

LEGEND:

BÖLGE NO = AREA NO

UTM 6 DERECE KOORDINATLARI = UTM 6 DEGREE COORDINATES

TRAFO MERKEZLERI	**DOGU KUZEY**	**DİLİM**
TRANSFORMER STATIONS	EAST NORTH	ZONE NO.

KAPASITE (MW) = CAPACITY MW

NOTE 1: TOTAL CAPACITIES OF EACH CONNECTION POINTS CANNOT BE GREATER THAT REGION'S TOTAL ELIGIBLE CONNECTION CAPACITY

E. Technical Specifications of Sunrise 200 Watt 24 V Photovoltaic Panel

Encapsulation:	Glass / EVA / Cells / EVA / TPT
Cell Size & Quantity:	125*125mm, 91pcs
Max Power:	200 Watts
Tolerance:	+-3%
Voltage at Max Power (Vmp):	44.8
Current at Max Power (Imp):	4.47
Open Circuit Voltage (Voc):	50.3
Short Circuit Current (Isc):	5.2A
Max System Open Voltage:	1000V
Diodes:	2 x bypass
Physical Dimensions:	170cm x 94.5cm x 4.5cm
Weight:	19.0kg
Operating Temp Scope:	-40 to +85°C
Relative Humidity:	0 to 100%
Certificate:	CE
Warranty:	20 years

F. Technical Specifications of SMA Sunny Boy 3000 W Grid-Tied Inverter

	SB 3000US
Max. Recommended Array Input Power (DC @ STC)	3750 W
Max. DC Voltage	500 V
Peak Power Tracking Voltage	180 – 400 V @ 208 V 200 – 400 V @ 240 V
DC Max. Input Current	17 A
DC Voltage Ripple	< 5%
Number of Fused String Inputs	4
PV Start Voltage	228 V
AC Nominal Power	3000 W
AC Maximum Output Power	3000 W
AC Maximum Output Current	15 A @ 208 V, 12.5 A @ 240 V
AC Nominal Voltage / Range	183 – 229 V @ 208 V 211 – 264 V @ 240 V
AC Frequency / Range	60 Hz / 59.3 Hz – 60.5 Hz
Power Factor	1
Peak Inverter Efficiency	96.6 %
CEC weighted Efficiency	95.0 % @ 208 V 95.5 % @ 240 V
Dimensions W x H x D in inches	17.8 x 13.8 x 9.3
Weight / Shipping Weight	88 lbs / 94 lbs
Ambient temperature range	– 13 to +113 °F
Power Consumption: standby / nighttime	< 7 W / 0.1 W
Topology	PWM, true sinewave, current source
Cooling Concept	Convection, regulated fan cooling
Mounting Location Indoor / Outdoor (NEMA 3R)	●/●
LCD Display	●
Lid Color: aluminum / red / blue / yellow	●/❍/❍/❍
Communication: RS485 / Wireless	❍/❍
Warranty: 10-year	●
Compliance: IEEE-929, IEEE-1547, UL 1741, UL 1998, FCC Part 15 A & B	●

G. Yearly Electricity Generation Potential

Transformer Stations	Capacity (kW)	Annual Yield[6] (kW/kWh)	Total (kWh/y)
Konya	92000	1560	143520000
Van-Ağrı	77000	1500	115500000
Antalya	58000	1580	91640000
Karaman	38000	1600	60800000
Mersin	35000	1490	52150000
Maraş-Adıyaman	27000	1590	42930000
Burdur	26000	1530	39780000
Niğde-Nevşehir-Aksaray	26000	1600	41600000
Kayseri	25000	1670	41750000
Malatya-Adıyaman	22000	1530	33660000
Hakkari	21000	1760	36960000
Muğla-Aydın	20000	1550	31000000
Isparta-Afyon	18000	1530	27540000
Denizli	18000	1510	27180000
Bitlis	16000	1510	24160000
Bingöl-Tunceli	11000	1480	16280000
Şırnak	11000	1500	16500000
Adana-Osmaniye	9000	1480	13320000
Muş	9000	1490	13410000
Siirt-Batman-Mardin	9000	1480	13320000
Sivas	9000	1610	14490000
Elazığ	8000	1530	12240000
Şanlıurfa-Diyarbakır	7000	1540	10780000
Erzurum	5000	1540	7700000
Erzincan	3000	1640	4920000
TOTAL	**600000**		**933130000**

[6] Source: http://re.jrc.ec.europa.eu/pvgis/apps4/pvest.php

H. Questionnaire

Güneş Enerjisinden Elektrik Üretimi Üzerine Anket

1- Yaşınız?

☐ 18’den küçük ☐ 18-25 ☐ 26-39 ☐ 40’tan büyük

2 – Eğitim durumunuz?

☐ İlk Öğretim (İlk Okul/ Orta Okul)

☐ Orta Öğretim (Lise/Meslek Lisesi)

☐ Yüksek Okul/Üniversite

☐ Yüksek Lisans/Doktora

3 – Aylık geliriniz?

☐ Çalışmıyor/Öğrenci

☐ 1,000 TL’nin altında

☐ 1,000 – 2,500 TL

☐ 2,500 – 5,000 TL

☐ 5,000 – 10,000 TL

☐ 10,000 TL’dan fazla

4 – Yenilenebilir enerji kaynaklarından (hidro, rüzgar, güneş, jeotermal, biyokütle) elektrik üretimi hakkında bilginiz var mı?

☐ Evet ☐ Hayır

5 – Güneş enerjisinden (bir diğer adıyla Güneş pillerinden – fotovoltaikler) elektrik üretimi hakkında bilginiz var mı?

☐ Evet ☐ Hayır

6 – Güneş enerjisinden elektrik üretimi yapan sistemleri evlerinizde kullanabileceğinizi biliyor muydunuz?

☐ Evet ☐ Hayır

7- Ortalama olarak 10 yılda kendi maliyetini çıkaracak bu sistemi evinizde kullanmayı tercih eder miydiniz?

☐ Evet ☐ Hayır