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Solar Photovoltaic Market in Turkey:

Prospects and Challenges

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EXECUTIVE SUMMARY

There are several challenges that the Turkish energy market faces. The high level of dependence on imported energy sources and the negative externalities caused by the utilization of fossil fuels stand as the main problems the policy makers will strive to solve for the immediate future. In the effort to alleviate these problems, renewable energy sources in the country can potentially play a central role. Several policy mechanisms have recently been put into motion to support the growth of the renewable sources in the country. Among the renewable energy sources, solar energy is one which has a substantial potential in the country although the photovoltaic market is only in its initial stages.

This report aims to provide a holistic view of the current market situation and come up with several policy suggestions which can spur the development of the market. Firstly, an overview of the electricity generation market in the country is given and the main policies surrounding solar energy are summarized. After that, several obstacles are identified which have been instrumental in limiting the market growth in the past years. Finally, a discussion of several policy suggestions is made which can help in removing these obstacles and spurring the growth of the market. The regulatory processes, infrastructure problems, land availability, high upfront costs and financing needs, electricity market inefficiencies and the lack of expertise in the sector are pinpointed as the main challenges ahead of the market and the suggestions are made with a consideration to overcome these problems. Changes in the bureaucratic processes and in the regulatory environment, alternative financing mechanisms, introduction of additional subsidy schemes, improvements in the electricity infrastructure and several other measure are discussed which can help in forming a sustainable and steadily growing photovoltaic market in the country for the near future.

INTRODUCTION

Turkey has experienced considerable changes in its electricity market in the past decades. Rapid growth in the electricity demand has led to considerable transformation in the electricity sector with large increases in the generation capacity to accompany it. Between the years 2000 and 2013, the electricity demand of the country almost doubled[1]. According to the official projections, it is expected that the high growth in power demand will persist in the near future with an average annual growth rate of around %5.5 between 2015 and 2023[2]. Meeting the rising levels of electricity demand will be a challenge for Turkey in a number of ways. Firstly, Turkey is heavily reliant on imports for much of its energy consumption. A main focus of the policy makers is to decrease the levels of dependence on energy imports. Secondly, the policies will have to be devised in a way to keep the electricity prices at reasonable levels to avoid impeding economic growth. Lastly, the increasing carbon emissions of the country will have be kept in check. For the year 2013, around %56 of the primary energy sources used for electricity generation had to be imported, while around %71 of the electricity supply was fueled by fossil fuel sources[3]. Turkey will have to limit the growth of its fossil fuel based capacity because of the negative externalities created by the utilization of these sources. The carbon emissions caused by the combustion of fossil fuels contribute to the global phenomenon of climate change and have significant adverse health effects on the population. As the electricity demand keeps on increasing with rising levels of economic prosperity, the focus of the policy makers will be to find appropriate ways to fuel the rising demand in a cost competitive manner without exacerbating the dependence on imported sources and fossil fuels.

The energy challenge that Turkey faces also has an international dimension. Besides the domestic concerns, external pressures will also have considerable influence on the future of the Turkish energy policy. 2015 will be a defining year for the UNFCCC climate change negotiations as the Paris Conference will determine the new global agreement to succeed the Kyoto Protocol. The ultimate aim of the conference is to limit the global level of increase in temperatures to under 2° Celsius. Turkey is obliged to present its own plan for reducing its GHG emissions to help achieve that target. The intended national determined contribution of the country has to be submitted before the conference will take place on December, 2015. On the other hand, 2015 is also significant for Turkey as the G20 summit will be hosted by the country for the first time. The G20 agenda on 2015 will

[1]Turkish Electricity Transmission Company, Retrieved from http://www.teias.gov.tr/istatistikler.aspx , accessed on 28.3.2015

[2]Turkish Electricity Transmission Company(2014), “Turkey 5-Year Electrical Energy Generation Capacity Projection(2014-2018)”, p. 14

[3]Energy Market Regulatory Authority(2014), “2013 Electricity Market Development Report”, p. 12

largely be determined by the Turkey and the responsibility of incorporating climate change policy in the G20 agenda will lie on the Turkish leadership. An additional actor that will continue to influence the Turkish energy policy is the European Union. Turkey has been a candidate to become an EU member for an extended amount of time. Even though it has lost most of its initial appeal and priority for both of the parties, the ongoing process is still a factor that continues to pressure Turkish policy making. As the negotiations advance, Turkey will be required to harmonize its regulations and policies on energy and climate policy with those of the European Union. These factors will add to the pressure that Turkey is facing to build a sustainable energy plan, reducing its reliance on fossil fuels.

In addressing the energy problems that Turkey faces, renewable energy sources can potentially play an important role. Turkey does not have significant fossil fuel reserves other than the cheap quality lignite reserves which have relatively low heating values. While Turkey lacks sizeable amounts of conventional fuel sources, there is considerable domestic potential for many types of renewable energy sources. Among these, hydro, wind, solar, biomass and geothermal sources can be listed. Solar energy technologies stand out as one of the renewable options with the most potential for Turkey. These can be divided into two broad categories which are solar photovoltaic and solar thermal power generation. Solar thermal technology entails the conversion of solar radiation first into heat energy and then into electricity while photovoltaic panels convert solar radiation directly into electrical power. Although solar thermal power also has distinct advantages and potential for development, in the current market picture photovoltaic power shows the most promise. It is the most widely used solar electricity technology in the world and the one that is the most proven in terms of economic feasibility. Solar photovoltaic power can potentially play a significant role in the energy future of the country and help reduce the double reliance on fossil fuels and imports. Currently, the photovoltaic market in Turkey is still emerging and there are several obstacles in its way that have hindered its development. Applying the correct policy measures to overcome these problems would help the photovoltaic market to take off. With the correct policies in place, photovoltaic energy would be able to offset a portion of the fossil fuel fired generation and assist in increasing the energy security of the country.

SOLAR POWER POTENTIAL IN TURKEY

Turkey is gifted with a suitable geographical location for solar energy generation. A study was made by the General Directorate of Renewable Energy to investigate the solar energy potential of the country using the data compiled by the Turkish State Meteorological Service spanning between the years 1966 and 1982. According to the study, the total annual hours of sunshine is reported to be 2640 in Turkey, while the average global radiation is reported as 1,311 kWh/m^2. The average radiation levels show great variability across different regions of the country. The regions with the most favorable conditions are the Southeast and the Mediterranean regions with 2993 and 2956 hours of average sunshine duration and 1,460 kWh/m^2 and 1,390 kWh/m2 of average irradiation received respectively. On the other hand, the Marmara and the Black Sea regions are the least suitable for solar energy with 2409 and 1971 hours of average sunshine duration and 1,168 kWh/m^2 and 1,120 kWh/m2 of average irradiation levels[4]. In a later study, the Turkish State Meteorological Service measured Turkey's average solar radiation as 1,474 kWh/m2 and the average annual sunshine hours as 2573 using the data available between the years 1971 and 2000[5]. On 2010, the Solar Energy Potential Atlas was published by the General Directorate of Renewable Energy, which measured the average solar radiation as 1527 kWh/m2 based on data between 1986 and 2005[6].

This level of solar radiation positions Turkey in an advantageous place for solar energy generation in the global context and especially among the other European countries. The average irradiation level across Europe is reportedly 1096 kWh/m2 per year[7], significantly lower compared to the Turkish average. The average solar radiation that Turkey receives is reported as the fifth among European countries, after Spain, Portugal, Malta and Cyprus. Given the significantly lower available land area in the other countries, Turkey can be regarded to have the highest solar energy potential in Europe along with Spain. However, in terms of utilizing the potential, there is much way to go. Germany, Italy and Spain are the countries with the highest installed solar energy capacity in Europe. Spain has an approximate photovoltaic system performance of 1600 kWh/kW per year while Italy has around 1326 kWh/kW and Germany has only around 936 kWh/kW, while Turkey has around 1420 kWh/kW[8]. The cumulative installed capacity in Spain, Italy and Germany were 5.6 GW, 18 GW and 35.5 GW respectively on 2013[9], while the capacity in Turkey only amounted to 54 MW by 2014[10]. Germany's

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[4] General Directorate of Renewable Energy , http://www.eie.gov.tr/eie-web/turkce/YEK/gunes/tgunes.html , accessed on 3.30.2015

[5] Sensoy S, Ulupınar Y, Demircan M, Alan I˙, Akyurek Z, Bostan P. A.(2010), 'Modeling solar energy potential in Turkey', Turkish State Meteorological Service, Ankara, Turkey

[6] 'Solar Energy Potential of Turkey', Power Point Presentation, General Directorate of Energy Affairs, Ministry of Energy and Natural Resources, Retrieved from http://www.estelasolar.eu/fileadmin/ESTELAdocs/documents/members_only/Workshops_and_Meetings/25.06.2012_ESTELA_WorkShop_BXL/Presentations/ESTELA_SWS_4_MA_Solar_Energy_Turkey_25.06.2012.pdf accessed on 01.04.2015

[7] Šúri M., Huld T.A., Dunlop E.D. Ossenbrink H.A., 2007. 'Potential of solar electricity generation in the European Union member states and candidate countries'

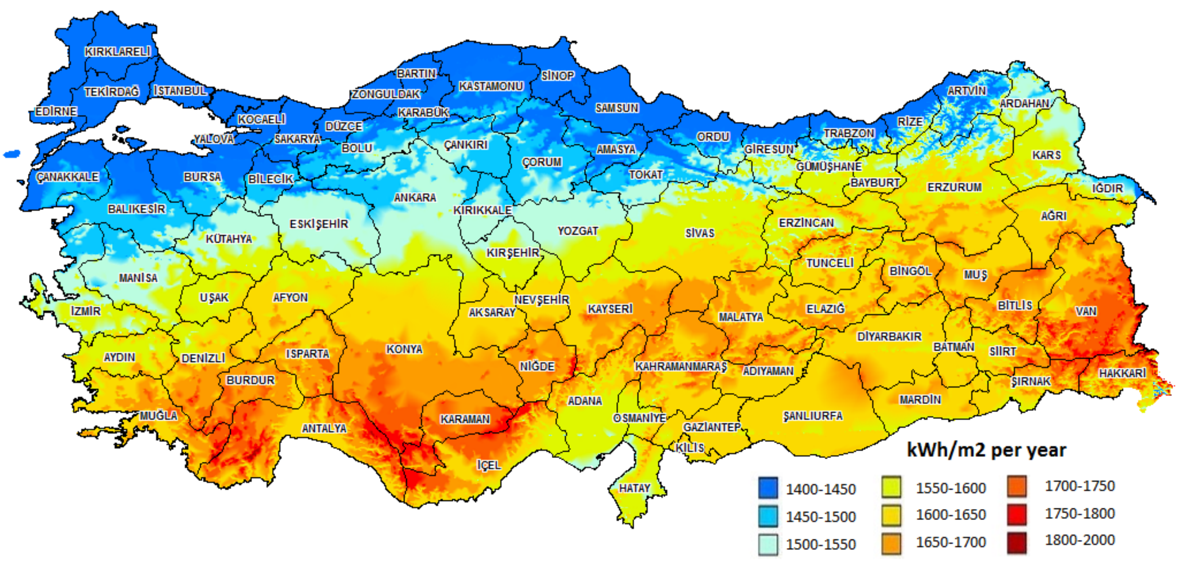
[8] International Energy Agency(2015), 'Trends 2014 in Photovoltaic Applications', pp. 26-28

[9] International Energy Agency(2014), 'PVPS Report Snapshot of Global PV 1992-2013', p. 11

[10] Turkish Electricity Transmission Company, Retrieved from http://www.teias.gov.tr/istatistikler.aspx , accessed on 28.3.2015

achievement is particularly impressive given the lower levels of solar radiation it receives. Turkey's relatively favorable position can be further demonstrated by looking at the conditions from some other countries across the globe. Even though the average performance from a photovoltaic module is only around 1050 kWh/kW per year in Japan, the country has succeeded reaching a cumulative installed capacity of 13.6 GW by the end of 2013, of which around 7 GW was installed on 2013 alone[11]. Even though Turkey's solar potential falls short compared to several countries closer to the Equator, a comparison with the achievements of other countries with much less potential demonstrates that there is significant cause to be optimistic about the future of the solar energy in the country.

Figure 1: Levels of Global Radiation Across Turkey



Source: The General Directorate of Renewable Energy (http://www.eie.gov.tr/MyCalculator/Default.aspx)

Solar energy investments have been steadily increasing in many parts of the world. Several developed countries have already established large solar capacities and are still aiming at ambitious new targets. Several developing countries, among which China and India are the chief, have also begun to pursue ambitious targets for solar energy utilization. Global installed photovoltaic capacity expanded rapidly to reach 140 GW's on 2013 up from only 1 GW on 2002[12]. As a result of the growing concerns for climate change and energy sustainability, the world is heading towards an energy system in which solar energy and renewable sources in general will play an increasingly important role. As a result of the increasing research and booming investments in the sector, the

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[11] International Energy Agency(2014), 'PVPS Report Snapshot of Global PV 1992-2013', p. 7

[12] International Energy Agency(2014), "Trends 2014 in Photovoltaic Applications" p. 9-10

costs of solar systems have significantly fallen and the average panel efficiency has significantly increased in the recent past.

CURRENT ELECTRICITY MARKET AND FUTURE TARGETS

In the recent decades, the Turkish electricity market underwent a substantial reform process. Historically, the market was dominated by a vertically integrated state monopoly. As the liberalization process of the economy began, efforts to reform the electricity market were attempted by the early 1980's but significant change could occur only after the necessary constitutional changes were made on 2001. The radical reform package that passed on that year enabled privatization and price reform in the market. The package also allowed the state monopoly to be separated into different parts each operating in the different segments of the market. Currently, of the four state owned entities, EÜAŞ (Electricity Generation Company) operates in the generation sector, TEIAŞ (Turkish Electricity Transmission Company) operates in the transmission sector, TEDAŞ (Turkish Electricity Distribution Company) operates in the distribution sector and TETAŞ (Turkish Electricity Trade and Contracting Company) operates in the wholesale trading sector[13]. The share of the public in the overall generation capacity has been on a declining trend but the state still has a prominent role in the generation sector. Capacity under the public control accounted for around %60 of the total on 2013. %34 of the total capacity is owned directly by EÜAŞ and its subsidiaries while a further %26 is accounted for by the ongoing public contracts[14]. It is expected that the role of the state in the generation sector will get further reduced in the near future. The transmission sector is still completely controlled by the state via TEIAŞ. At the end of a long process, by 2013, the privatization of the distribution sector was completed. TEDAŞ still retains its entity mainly as a coordinator but the distribution segment is in fact completely owned by private companies. The country is divided into 21 different distribution regions which were then privatized based on a competitive process[15]. 21 different private utility companies are currently operating in the market.

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[13] Cetin, Tamer and Oğuz, Fuat(2007), 'The politics of regulation in the Turkish electricity market', Energy Policy 35 pp. 1763-64

[14]Energy Market Regulatory Authority(2014), "2013 Electricity Market Development Report", pp. 13-14

[15] Camadan, Ercüment and Kölmek, Fatih(2013), 'A Critical evaluation of Turkish Electricity Reform', The Electricity Journal, Volume 26, Issue 1, pp. 60-61

Figure 2: 21 Electricity distribution regions and utility companies

Source: TEDAŞ (http://www.tedas.gov.tr/Sirketler/Sayfalar/Anasayfa.aspx)

One of the main provisions that was introduced by the reform on 2001 was the establishment of EMRA, the Energy Market Regulatory Authority. EMRA was envisioned as an independent and fiscally autonomous entity, to be governed by an appointed board. The responsibilities of EMRA include the "preparing and implementing of secondary legislation, authorization of market participants, composing and publishing tariffs, monitoring and supervising the market actors, conducting technical, legal and financial audits, settling disputes, approving, amending and enforcing performance standards, and, where necessary, applying sanctions"[16]. EMRA still acts as the main authority responsible of overseeing the electricity market.

Even though important steps have been taken in the privatization process, electricity pricing is still controlled by the state. The retail electricity prices are set by EMRA periodically for every three months. A national pricing mechanism is used which involves reflecting the costs of electricity generation, transmission and distribution in the electricity bills. However, the differing costs across the 21 distribution regions are not reflected. This creates imbalances between the different regions especially since some of the regions have chronic problems of high transmission and distribution losses. The average loss and theft ratio in the country was around %14 on the year 2012. When three regions are omitted, this average falls to around %9 which is around the world average but still higher than most of the developed countries. The three regions that have problematic loss and theft ratios are the Dicle, Vangölü and Aras regions in the Southeastern part of the country. Among these, the Dicle Region had a loss and theft ratio of %75.4, the Vangölü region had around %65.8, and the

[16] Evrim Ergün, Çağdaş and Gökmen, Nigar, 'Electricity regulation in Turkey:overview', Energy and Natural Resources multi-jurisdictional guide 2013, pp. 1-2

Aras region had around %27.6 for the year 2013[17]. This imbalanced picture enabled the customers in these regions to pay less than the actual costs for their electricity while the losses were reflected to customers in the rest of the country who had to share the burden of the high loss ratios. The national pricing system coupled with the high loss and theft ratios in some of the regions are preventing the costs of electricity generation to be reflected in the customer prices and creating market inefficiencies. A transition to a regional cost based mechanism has been on the agenda for some time. A methodology for computing regional price levels is already made up. The shift was planned to take place at the end of 2012 but was then postponed. It is currently set to be enforced by the end of 2015 but whether an additional postponement will take place will be decided by the Council of the Ministers[18].

As of the end of 2014, the Turkish installed generation capacity amounted to a total of 69.5 GW. This figure consisted of %34 hydroelectricity, %36.8 natural gas, %12.3 domestic coal, %8.7 imported coal, %5.2 wind energy, %0.6 geothermal energy and only around %0.1 of solar energy. For the year 2014, it is estimated that a total of 250.4 tWh's of electricity was generated. %48 of this amount was fueled by natural gas, %29 by coal, %16 by hydro, %3 by wind, %1 by fuel oil and a further % 1 was fueled by geothermal energy[19]. The high level of energy dependence becomes apparent when we consider that the fuel used for nearly all of the generation from the natural gas sources and around %40 of the generation from coal sources had to be imported from abroad on 2014. The overall share of imported sources in the electricity mix of the country have historically been high. The share of imported sources in total generation was higher than %50 between the years 2002 and 2011[20]. The rapid expansion of natural gas capacity in the last decade was the main source of energy dependence. Now it seems that the increasing need for coal imports have also begun adding to the problem.

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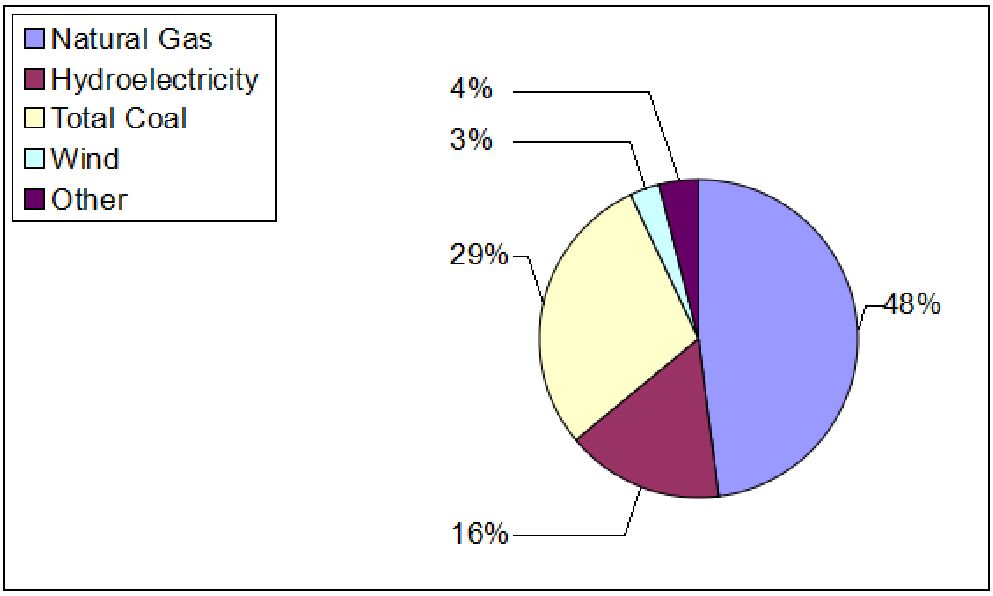
[17] Energy Market Regulatory Authority(2014), "2013 Electricity Market Development Report", p.59

[18] Official Gazette No: 26948 Date: 26.07.2008

[19] Turkish Electricity Transmission Company, Retrieved from http://www.teias.gov.tr/istatistikler.aspx , accessed on 28.3.2015

[20] General Directorate of Renewable Energy http://www.eie.gov.tr/document/uretilen_enerjinin_birincil_kaynaklara_dagilimi.png ,accessed on 3.31.2015

Figure 3: Electricity Generation by Source on 2014



Source: TEİAŞ

The energy targets declared by the government reflect this concern for increasing import dependence for electricity generation. Solid energy targets are envisioned for the year 2023 which will mark the hundredth of the Turkish Republic. The targets involves increasing the power generation capacity to around 121 GW for the year 2023, a sizeable increase of 50 GW compared to 2014. An important portion of this projected increase will be provided by an expansion of coal-fired generation capacity. According to the official targets, the government plans to increase the total coal fired generation capacity to 25 GW, hydroelectricity capacity to 36 GW, wind capacity to 20 GW and solar capacity to 3 GW by 2023. In this time frame, the capacity of natural gas plants is planned to be kept constant at around 25 GW. Nuclear power will also be introduced to the electricity mix by 2023 with a projected contribution of 9.6 GW[21]. Later, these targets were amended in the National Renewable Energy Action Plan published on 2014 which decreased the limited the planned hydroelectricity contribution to 34 GW and increased the target for solar power to 5 GW[22]. The targets aim at achieving a %30 share of the renewable energy sources in the generation mix by 2023[23]. The government also has an outlook towards 2030, by which it envisions that a total generation capacity of 165 GW will be required for the needs of the country. By 2030, the state

[21]Bloomberg New Energy Finance(2014), 'Turkey's changing power markets', p. 18
[22]Ministry of Energy and Natural Resources(2014), 'Turkey National Renewable Energy Action Plan', p. 22
[23]State Planning Agency(2009), 'Electrical Energy and Supply Security Strategy Document'

foresees a further increase in total coal capacity to 35 GW and more ambitious additions in wind and solar to achieve capacities of 38 GW and 16 GW respectively[24].

Table 1: The capacity targets set out by the government (GW)

	2014	2023	2030
Total	69.5	121	165
Coal	15	25	35
Natural Gas	25	25	25
Hydro	23.6	34	34
Wind	3.6	20	38
Solar	0.04	5	16
Nuclear	0	9.6	12
Other	2	2.5	5

Source: TEİAŞ and General Directorate of Energy Affairs (http://www.ewea.org/events/workshops/wp-content/uploads/2013/03/EWEA-TUREB-Workshop-27-3-2013-Zafer-Demircan.pdf)

The main policy goals apparent in these targets are diversifying the generation mix and boosting energy security. However, the extent to which the planned expansions will be sufficient to solve the energy problems is debatable. According to the estimations of a study conducted by the researchers from Bloomberg New Energy Finance, an important share of the additional coal capacity in the 2023 vision will have to be contributed by imports of hard coal. In the business as usual scenario presented in the study, nearly %60 of the coal-fired electricity is supplied by sources of hard coal on 2030. Even though Turkey has a respectable amount of proven lignite reserves of 13.4 billion tons, it only has around 0.4 billion tons of proven hard coal reserves. Thus, the study concludes that Turkey's reserves will not be enough to accommodate for such a large expansion in capacity. That is basically due to

[24] 'What Energy Mix for Turkey in 2030?'. Power Point Presentation, General Directorate of Energy Affairs, Ministry of Energy and Natural Resources, Retrieved from http://www.ewea.org/events/workshops/wp-content/uploads/2013/03/EWEA-TUREB-Workshop-27-3-2013-Zafer-Demircan.pdf , accessed on 25.03.2015

the dearth of domestic hard coal reserves and the low quality of the lignite sources[25]. Recent statistical figures seem to be backing up the projections of the study. Between the end of 2013 and the beginning of 2015, generation capacity fueled by imported coal sharply rose from 3.9 GW to 6 GW[26]. If the estimations are correct and this recent trend continues, it doesn't seem likely that, even if they can be achieved, the current energy targets will result in a decisive solution to the energy dependence problem of the country. The subsidies given to the coal industry have also increased substantially in the recent years. The amount of the quantifiable subsidies given to the coal industry on 2013 had reached around 730 million US dollars[27]. Even though the government has been pushing towards increased utilization of coal, it seems that the introduction of nuclear energy and the increasing capacity of the renewable sources may in fact play a larger role in addressing energy dependence compared to the role of coal. Additionally, there are several other costs of developing coal capacity on the society and on the environment. Such an expansion of coal capacity would inevitably cause the GHG emissions of the country to increase rapidly. That would make it harder for Turkey to demonstrate to the world that it is committed to do its part in the effort against climate change, more so since Turkey has experienced high growth in its GHG emissions in the recent past[28]. Coal combustion is also causing several local problems related with environmental pollution and human health. Increasing coal capacity would only exacerbate these problems.

Therefore, it is important to re-examine the central role assigned to coal in the energy future of the country. Many argue that a drastic expansion of coal-fired generation is not truly necessary to meet the future energy needs. Instead, priority can be given to other policy options, such as pursuing a more ambitious solar energy policy. The current solar energy target of 5 GW for 2023 can't be considered ambitious given the countries high potential. With the right policies, the target can be surpassed. However, it is doubtful that even this modest target will be realized with the current trajectory. A careful examination of the current solar energy policies and making changes wherever needed are necessary for the current target to be reached and exceeded.

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[25]Bloomberg New Energy Finance(2014), 'Turkey's changing power markets', pp. 1-45

[26] Turkish Electricity Transmission Company, Retrieved from http://www.teias.gov.tr/istatistikler.aspx , accessed on 28.3.2015

[27] Acar, Sevil, Kitson, Lucy and Bridle, Richard(2015), 'Subsidies to Coal and Renewable Energy in Turkey', p. 10

[28]United Nations Climate Change Secretariat, 'Summary of GHG Emissions for Turkey, Retrieved from https://unfccc.int/files/ghg_emissions_data/application/pdf/tur_ghg_profile.pdf , accessed on 1.04.2015

SOLAR ENERGY POLICIES AND REGULATORY FRAMEWORK

A feed-in tariff scheme is currently the principal type of subsidy that is being utilized for promoting photovoltaic power generation. The government provides a 13.3 $ cents per kWh feed-in tariff for a period of 10 years. According to the legislation, the amount of the tariff can be increased up to 20 $ cents per kWh for a period of five years by using domestically manufactured components in the panel installation. The five year bonus tariff for using domestic manufacturing consists of the following components: PV cells for an additional 3.5 $ cents per kWh, PV panel integration and manufacture of solar structural mechanics for 0.8 $ cents per kWh, PV modules for 1.3 $ cents per kWh, inverter for 0.6 $ cents per kWh and PV solar concentrator for 0.5 $ cents per kWh[29]. Unlicensed power providers with less than 1 MW of capacity can benefit from this tariff when selling to the grid as well as the larger scale licensed generators. Net metering is allowed for such installations, excess electricity can be sold to the grid at the end of each month. Any investments made before 31st of December, 2020 can benefit from the tariff[30].

Table 2: The current photovoltaic feed-in tariff

	Amount(US $ cents per kWh)	Duration(years)
Standard Feed-in Tariff	**13.3**	**10**
Total Possible Local Content Bonus	**6.7**	**5**
-Panel Integration	0.8	5
-PV Module	1.3	5
-Solar Cells	3.5	5
-Inverter	0.6	5
-Concentrater Material	0.5	5

Source: Official Gazette No:27809 Date: 29/12/2010

[29]Ministry of Energy and Natural Resources(2014), 'Turkey National Renewable Energy Action Plan', pp. 53-54
[30]Ministry of Energy and Natural Resources(2014), 'Turkey National Renewable Energy Action Plan', p. 22

The General Directorate of Renewable Energy is the main branch of the government responsible for promoting renewable energy technologies. Its main duties include making measurements, projections, feasibility studies and research and development studies in the area of renewable energy as well as designing appropriate policies and carrying on community outreach projects[31]. On the other hand, the Electricity Market Regulatory Authority acts as the main regulator in the electricity market. It is responsible for setting secondary legislation for the market and setting the licensing rules. The Renewable Energy Resource Support Mechanism is also applied through EMRA. Both licensed and unlicensed generators have to apply to the mechanism on an annual basis to benefit from the feed-in tariff[32]. The Turkish Electricity Transmission Company is charged with interconnection issues, it receives bids for licensed generation and distributes the licenses to the winners. Other government bodies also play a part in the licensing process such as the Ministry of Environment and Urbanization and the provincial agriculture directorates. The permitting procedure is generally regarded as a long and difficult bureaucratic undertaking.

EMRA issued a bylaw on 2011 allowing for grid-connected facilities with a maximum of 500 kW of installed power to be exempt from licensing rules and the company establishment obligation. Later, this limit has been expanded with an amendment and currently facilities up to 1 MW of installed capacity are allowed to operate in the market without the need for licensing. For large installments with a capacity greater than 1 MW, only licensed generation is allowed. A total of 600 MW of licensed capacity was allowed on 2013, with certain set quotas for different locations[33]. License applications are made through competitive bidding for the permitted amounts of licensed generation for each different region. The amount of applications made was significantly above the permitted capacity on 2013. The process of bidding and obtaining licenses is still not completed, although the bidding process has been completed for some of the regions[34]. As for off-grid installations, there is currently no set size limit and no regulation.

There are a few other incentives used to promote solar energy. The legislation allows for reduced cost of land acquisition for the purpose of renewable energy generation. Currently, getting a %85 discount on permission, rent and land use fees is possible whenever the land owned by the General

[31]General Directorate on Renewable Energy, Retrieved from http://www.eie.gov.tr/eie-web/english/summary/summary.html accessed on 02.04.2015

[32] Official Gazette No: 28782 Date: 01.10.2013

[33]Oğuz Topkaya, Şermin(2012), 'A discussion on recent developments in Turkey's emerging solar power market', Renewable and Sustainable Energy Reviews 16, pp. 3754– 3765

[34]Turkish Electricity Transmission Company, Retrieved from http://www.teias.gov.tr/Duyurular.aspx

Directorate of Forestry or the Treasury is used. The discount is applicable for the first 10 years of operation. During the license application, renewable power plants are only required to pay %1 of total license fees and are exempted from license fee payments for the first 8 years of operation. According to the regulations by EMRA, all the distribution companies are obliged to give priority to renewable generation facilities for network connection. Additionally, the retail sector is obliged to purchase electricity from renewable power plants whenever the price of renewable electricity is lower than or equal to the wholesale price set by the Turkish Electricity Trade and Contracting Corporation and whenever there is no cheaper supply available in the market[35].

Solar investments can also benefit from the general investment incentive scheme employed in the country. The recently adopted incentive system has four distinct components. These are the General Investment Incentive Plan, Regional Investment Incentive Plan, Large Scale Investments Incentive Plan and the Strategic Investments Incentive Plan. The possible incentives under these categories include different levels of value added tax breaks, customs duty exemptions, interest support and social security premium support for business owners. Within the regional incentive framework, the country is divided into six regions based on the level of development and the amounts of incentives are provided accordingly. Large scale investments have set minimum investment amounts for different sectors and strategic investments are classified as those that would help reduce the current account deficit of the country[36].

In terms of research and development, the countries capacity has been increasing in the recent years. In addition to the General Directorate on Renewable Energy, the Marmara Research Center of the Technological and Scientific Research Center of Turkey also carries on solar energy related research projects along with a number of universities. Ege University, Muğla University, Middle East Technical University, İstanbul Technical University, Kocaeli University, Harran University and Fırat University can be counted among the chief academic institutions in the country that are involved with solar energy research. Most of these universities house research centers dedicated to renewable energy technologies and to photovoltaic energy in particular including practical applications of these systems. Solar photovoltaic science and engineering is also gaining ground in the curriculum of related undergraduate and graduate programs in such institutions. Surely the proliferation of such programs and research will help in meeting the countries need for expertise in the area.

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[35]Ministry of Energy and Natural Resources(2014), 'Turkey National Renewable Energy Action Plan', p.28
[36]KPMG, Turkey(2012), "The New Investment Incentives in Turkey", pp. 5-8

Technical and Economic Aspects of Photovoltaic Power

There are two main types of photovoltaic panels currently used in the world market. These are the crystalline silicon cells and thin-film solar cells. Crystalline silicon can also be divided into the two most widespread sub-categories of mono-crystalline and poly crystalline solar cells. These have slightly different characteristics. Crystalline solar cells currently occupy a large portion of the market. On 2013, their share within the global panel production was around %90. Meanwhile, thin-film technologies had made up nearly all of the remaining %10 of the global manufacturing on the same year[37]. While, there are also efforts to develop several other types of solar cells, these currently have very small market shares. However, they may become increasingly relevant in the future. Organic solar cells and concentrating photovoltaic technologies can be provided as such examples[38]. The main difference between crystalline silicon cells and thin film cells is that while the crystalline silicon cells have significantly higher levels of efficiency, thin film cells are cheaper to install on a per watt basis. Different types of solar cells have certain advantages over others and it is important to have an understanding of the different characteristics to select the most suitable choices for each setting.

Aside from the levels of solar radiation, there are several other factors to consider when evaluating the expected output from photovoltaic installations. Temperature levels, the angle tilt of the modules and various system losses are all factors that influence the productivity of a photovoltaic module. Counter-intuitively, the generation levels of the panels tend to be reduced in high temperatures and amplified in lower temperatures. System losses include a wide array of components such as AC and DC wiring losses, inverter losses, mismatch losses, soiling and shading. Some of these are related to the technical aspects of converting direct current into alternative current while others like soiling and shading losses are related to the physical blockage of sunshine from reaching the module. Additionally, the output of the modules tends to degrade by a ratio of around %0.8 every year on average[39]. It is generally assumed that a typical photovoltaic module has an economic lifetime of around 25 years[40], although many modules currently exist that have successfully been in operation for longer times. The quality of the panel and the other components is crucial to ensuring the durability and the performance of a system. Therefore, the different options should be carefully considered when choosing the components of a system.

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[37] Fraunhofer Institute for Solar Energy Systems (2014), "Photovoltaics Report", p. 4, Retrieved from http://www.ise.fraunhofer.de/de/downloads/pdf-files/aktuelles/photovoltaics-report-in-englischer-sprache.pdf , accessed on 3.4.2015

[38] International Energy Agency(2010), 'Technology Roadmap: Solar Photovoltaic Energy', p. 7

[39] Jordan, Dirk C. And Kurtz, Sarah R.(2012), 'Photovoltaic Degradation Rates — An Analytical Review', National Renewable Eenergy Laboratory, pp. 13-16

[40] Fraunhofer-Gesellschaft. (2013). 'Predicting the life expectancy of solar modules'. ScienceDaily. Retrieved from www.sciencedaily.com/releases/2013/10/131022091622.htm accessed on 02.04.2015

Tilt angles by which the solar panels are placed can drastically alter the levels of output from a module. An ideally placed panel in Turkey would be facing south towards to Equator and have a tilt angle of around 36° to 42° for maximizing output, which would be around the geographical latitude of Turkey. This can create limitations in the rooftop photovoltaic market in the country since the roofs of the buildings were not constructed with these considerations in mind. In terms of the ground-mounted systems these limitations wouldn't pose a problem, as the installation can be easily adjusted according to the needs of the system. Solar tracking mechanisms can also be used for the ground-mounted systems. Tracking systems work on the premise of rotating the panel during the day to track the movements of the sun in order to maximize output. Tracking can be performed both on the north-south axis and the east-west axis. However, the tracking systems are more costly and they are only economically viable in certain locations with very high levels of solar radiation. There probably wouldn't be widespread applicability for these systems in the Turkish context.

A typical characteristic of photovoltaic power is the variability of output across the months of the year and the hours of day. The maximum output can be expected on the months of May, June, July and August while the minimum output from the modules would be observed on the months of November, December, January and February for Turkey[41]. However these also show variability across different regions due to different climactic conditions. The maximum levels of output during the day would be achieved around noon, while the solar panels naturally would not be functioning in the night. Additionally, the panel outputs can be expected to fluctuate under certain weather conditions like cloudiness and snow. This great variability in output can potentially create disturbances and imbalance in the power grid. The intermittency factor has to be accounted for when planning policies related to photovoltaic power. As a result of the various system losses and the variability in output, the average capacity factors of photovoltaic modules were around %20 on 2010, showing high variability based on location[42].

The capital costs associated with the systems mainly consist of the system costs and the bureaucratic costs. The system costs include the costs of the panel and the various other components required for generation such as the inverters, wiring and the mounting system. These costs have been rapidly falling in the last decade on a global scale. The average price of a solar panel have dropped to around 0.7 dollars per watt on 2013 from around 4 dollars on 2007, and it is estimated that the downward

[41] Oğuz Topkaya, Şermin(2012), 'A discussion on recent developments in Turkey's emerging solar power market', Renewable and Sustainable Energy Reviews 16, pp. 3756-57

[42] Tidball,Rick, Bluestein,Joel,Rodriguez,Nick and Knoke,Stu(2010)'Cost and Performance Assumptions for Modeling Electricity Generation Technologies', National Renewable Energy Laboratory, p.10

trend in costs will persist in the near future[43]. Ongoing costs associated with photovoltaic systems are the operation and maintenance costs. If the financing of a project is made through the use of debt, financing costs should also be kept in consideration. The bureaucratic costs consist mainly of the costs of the various procedures required to begin the operation. Along with the labor costs, these are generally referred to as the soft costs. With so many factors to consider, it is hard to estimate average rates of return on photovoltaic investments in the country. Considerations would vary greatly across the different regions of the country and various types of installations.

POSSIBLE APPLICATIONS IN THE MARKET

In the Turkish market, there currently are two main types of investments that can be made on-grid. These are the licensed and unlicensed generation options. Systems up to a capacity of 1 MW can operate unlicensed whereas those with greater generation capacities require licensing to operate. Systems aimed solely aimed at self-consumption can also operate without a license regardless of the capacity size. Given the differences in the regulation of the two kinds of generation, it is proper to investigate these under two different categories. Apart from on-grid applications, off-grid investments are also possible. Some applications of this kind can be economically viable in locations that are remote to the grid, especially for the purpose of powering agricultural irrigation systems.

Unlicensed Generation

Unlicensed generators have the option of consuming some of their generation for their own use and sell the excess into the grid at the feed-in tariff price of 13.3 dollar cents per kWh for 10 years. Net metering is possible and the electricity used is calculated on a daily basis to determine if and how much excess electricity was fed to the grid. If the consumption exceeds generation at the end of a month, the difference is paid on the electricity bill by the regular electricity tariff. If the opposite happens, the amount is paid to the generator on the feed-in tariff amount. Alternatively, the generators can simply opt to sell all their generation to the grid. A consideration of the electricity prices vis-a-vis the feed-in tariff levels would be the main factor in making the decision (thus also a consideration of the Us dollar/TL parity, since the feed-in tariff if based on dollars and the electricity prices are based on Turkish Liras).

Unlicensed systems can be divided into two groups in terms of the type of installation. Photovoltaic panels that are placed on top of the roofs of buildings in the residential, commercial and public

[43]Feldman,David,Barbose,Galen, Margolis,Robert James, Ted, Weaver,Samantha, Darghouth,Naïm, Fu,Ran, Davidson,Carolyn, Booth,Sam and Wiser,Ryan(2014), “Photovoltaic System Pricing Trends: Historical, Recent and Near Term Projections”

sectors can be referred to as roof-top installations. Those that are placed on the ground in available areas can be referred to as ground-mounted installations. Although they share the same basic traits, these two types if installations also have their distinct problems and applicability. There are some different factors to consider for the roof-top installations and for the ground-mounted installations. For the rooftop installations, the availability and the condition of the roof spaces in the buildings are important whereas for the ground-mounted installations land costs would be a central consideration.

There were around 8.6 million buildings in total in the country on 2010. About 7.4 million of these were used for residential purposes[44]. A comprehensive study of the residential buildings and dwellings across Turkey was undertaken by the Turkish Statistical Institute for the year 2011. According to the study, 20% of the population resided in buildings which have one floor, 19.5% of the population resided in buildings which have 2 floors, 11.9% of the population resided in buildings which have 3 floors and 23.1% of the population resided in the dwellings located in buildings which have 6 or more floors on 2011. The average number of floors a building had was 4[45]. Although these numbers can't paint a clear picture of the rooftop capacity in the country, they can reveal some indications. The existence of more than 8 million buildings in the country signal the theoretical extent of the potential rooftop photovoltaic market. The prevalence of multi-story apartment buildings may be problematic for photovoltaic investments as the utilization of the roof space would raise legal ownership issues. Also in cities with many high buildings, shading is going to be a substantial problem. In the study, the available roof area in the buildings and the suitability of the roofs are not examined. Further studies need to be conducted on the state of the buildings and rooftops in order to be able to make estimations of the potential rooftop photovoltaic market size.

Several different sectors can benefit from unlicensed generation. Residential units with the appropriate roof or land areas can benefit from small scaled installations aimed mainly at self-consumption to cut back on their electricity costs. Many commercial and industrial enterprises can also benefit from such installations. These include buildings like factories, hospitals, schools, various business and government buildings. Substantial savings can be achieved especially in larger installations where the unit costs of generation would be relatively lower. Organized Industrial Zones can especially benefit from such installations to supply a portion of their own electricity needs. Unlicensed self-consumption installations with a capacity larger than 1 MW offer fitting opportunities to cut back on the costly electricity bills of the organized industrial zones. For example, a large solar

[44] Keskin, Tülin (2010) 'The Buildings Sector Current Situation Evaluation Report', p. 8
[45] Turkish Statistical Institute(2013), 'Population and Housing Census, 2011', pp. 242-243

installation has recently begun operation in the Kayseri Organized Industrial Zone with a capacity of 7 MW[46].

Alternatively, systems up to 1 MW can be installed on the ground with the sole purpose of selling the generated electricity to the grid. Such installations can be attractive for investors who want to invest in the solar energy sector but don't want to deal with the extensive bidding processes associated with licensed generation. However, there is some uncertainty with the unlicensed generators as to what will happen to the installations after the 10 year period ends. Unlike the licensed generators, the unlicensed generators are not allowed to sell their electricity in the market. Additional regulations will need to be made before the 10 year period ends.

Unlicensed generators need to go through an extensive bureaucratic process to start operations which takes a lot of time. However, contrary to the licensed generators, forming a company is not required. Although the environmental impact assessment is not required, documentation still has to be taken from the Ministry of Environment and Urbanization. Documentation regarding the sites agricultural status also needs to be received from the local agricultural directorate. Several additional legal documents that are needed include documentation to right to use the property and a technical analysis report done by the Renewable Energy Directorate among others. The application is made to TEDAŞ and the interconnection is made through distribution lines. With a recent change, the applications for the plants up to 100 kW of capacity can be made through regional TEDAŞ agencies. Also, detailed specification instructions have been published by TEDAŞ for systems with less than 30 kW of capacity to guide the prospective investors. These are steps in the right direction that can help in curtailing the permitting process. Currently, the period before the interconnection agreement is made can last up to 270 days.[47] It is reported that it can take up to a year in total to finish the bureaucratic processes and start the construction phase whether it is a rooftop installation or a ground-mounted installation. Even though the process is extensive, it can still be regarded more efficient compared with the process for licensed generation. For investors who don't want to deal with the licensing process and the additional losses in revenues due to competitive bidding, investing in 1 MW capacity plants with the purpose of selling to the grid looks appealing. Self-consumption facilities in the Organized İndustrial Zones and in other commercial and industrial buildings also offer

[46] http://www.hurriyet.com.tr/yerel-haberler/Kayseri-Haberleri/kayseri-osb-turkiye-nin-en-buyuk-gunes-enerjisi_93444 accessed on 18.05.2015

[47] Powerpoint presentation, 'Elektrik Piyasasında Lisanssız Elektrik Üretimine İlişkin Mevzuat ve Projelendirme'. Turkish Electricity Distribution Company, 23 January 2015

ample opportunities. Thus, around 3 GW of applications were made for unlicensed generation on 2014[48].

Licensed Generation

Licensed generators are going to be decided based on the competitive bidding process on the 600 MW of designated capacity across the country. Licensed generation will be restricted to those regions that receive over 1650 kWh/m2 of annual solar radiation with varying capacity limits set for each region. After the process begun on 2013, around 9 GW of applications were filed. These installations will actually sell their electricity at the same feed-in tariff price of 13.3 dollar cents per kWh. However, they are also required to submit a financial contribution proposal of a certain amount per MW to the Turkish Electricity Transmission Company. They are required to pay the proposed amount in the first three years after they have begun operations. Those applicants that have offered the most amounts will be given licenses. Therefore, it can be expected that their ultimate income per kWh of electricity generated will be significantly lower compared to unlicensed generators. On the other hand, since the licensed installations will be on a substantially larger scale, their system costs would be less than unlicensed installations due to the economy of scales.

Figure 4: Map showing the suitable areas for licensed generation

Source:TEIAŞ

(http://www.teias.gov.tr/ebulten/haberler/2012/G%C3%9CNE%C5%9E%20ENERJ%C4%B0S%C4%B0%20HABER/sayfam1.html)

48Retrieved from http://www.aljazeera.com.tr/al-jazeera-ozel/burokrasi-gunesi-kaciriyor accessed on 03.04.2015

The process of distributing licenses have been begun on mid-2013. The ultimate prices to be paid for all locations are still not decided. However, the winning bid have been determined for a number of regions. As of yet, pre-licenses for a total of around 240 MW of capacity have been distributed. The distributed locations include many localities like Erzurum, Elazığ, Konya, Antalya, Denizli, Burdur and Diyarbakır. The winning bids for these included a wide range of values from 2.5 million Turkish Lira's to less than 0.1 million Turkish Lira's per MW highly dependent on the location and the level of competition. Three parts of the bidding process have been completed and it is announced that the 4th, 5th and the 6th parts for a total of 302 MW will be opened for bidding on by the end of April, 2015[49]. The licensed generators have not yet begun operations and there are still some processes to be completed before the generation can begin.

The bureaucratic process entails interaction with a multitude of governmental bodies. The applicants must first apply for a pre-license. Several legal documents must be filed including a letter of indemnity and a document from the local directorate of agriculture showing the land is not suitable for agricultural purposes[50]. Additionally, the pre-licensing fees have to be paid. The pre-license period can normally last as long as 24 months but it can be extended to 36 months. The application is made to the EMRA and after the documents are verified by the EMRA the files are passed on to the Renewable Energy Directorate for a technical analysis. After the technical analysis, the file is sent to the TEIAS for the bidding process when there are several applicants for the same designated location. TEIAS declares the bidding process a month in advance. In the month following the bidding process, the results are announced. The files are then sent to the EMRA again for the distribution of the pre-licenses to the companies who have made the winning bids. After the pre-licensing period begins the applicants have to carry out a number of duties to apply for generation licenses. A number of the obligations include acquiring the property rights of the site, approval of development plans, acquiring an environmental impact assessment from the Ministry of Environment and Urbanization, getting reports on the militarily forbidden zones and applying for an interconnection agreement among others. The interconnection is made through the transmission lines. A measurement process of the solar capacity of the proposed site lasting at least a year is also required. Six months of this measurement has to be performed on-site[51]. After all these obligations are met, the construction can begin followed by generation of the plant. All these processes take a very long time and as a

[49] Turkish Electricity Transmission Company, Retrieved from http://www.teias.gov.tr/Duyurular.aspx accessed on 20.04.2015

[50] Power Point Presentation, 'Güneş Enerjisi Santrali (GES) Yatırım Süreci ve Mevzuat' , Güneş Enerjisi Sanayicileri ve Endüstrisi Derneği, 23.01.2015

[51] Power Point Presentation, 'Güneş enerjisine dayalı lisans başvuruları(Mevzuat ve uygulama)' , Mustafa Gözen, Energy Market Regulatory Authority, Solarex İstanbul 2014

result hinder the attractiveness of such investments. Correspondence with around two dozen different government bodies is required to finish the process which is very costly in terms of both time and money.

THE CASE FOR PHOTOVOLTAIC POWER

An increased share of solar electricity in the Turkish generation mix would be beneficial for the country for a number of reasons. Increases in solar electricity generation capacity can help promote energy security in the country by reducing the reliance on imported sources and by diversifying the local generation mix. The current account deficit has been a central problem for the Turkish economy in the last decades and it is largely caused by the high import needs of the energy sector. Utilizing an increased share of the local energy sources would help alleviate the problem especially if a significant share of the solar systems can be manufactured locally. Solar energy can potentially be one of the main instruments for Turkey in forming a more independent and sustainable energy system. Photovoltaic power can also help reduce the dependence on fossil fuel combustion and help reduce the negative externalities associated with the fossil fuels. The two main negative externalities can be listed as the GHG emissions that are speeding up climate change and the significant health costs caused by air pollution[52]. Coal consumption in the country is one of the chief sources of these external costs inflicted on the society.

The problems with coal also extend beyond the electricity generation phase in the value chain. There are serious problems in Turkey regarding the safety standards in its coal mines. The tragedies in the coal mines in Soma and Ermenek on 2014 demonstrate the lack of restraint in the mining industry and the horrifying price it can exact on society. The death toll from the two mining accidents amounted to 319. The figures of worker deaths per tons of coal extracted demonstrate how far behind Turkey is in terms of occupational safety. Between the years 2007 and 2012, 0.46 miners have lost their lives in Turkey per million tons of coal extracted whereas the same figure was 0.02 in the US, 0.13 in India and 0.74 in China [53]. It needs also to be kept in mind that this figure doesn't include numbers from 2014 which was a disastrous year for Turkey in terms of occupational safety. The coal mining methods employed in Turkey are outdated and the safety conditions of the workers are not given sufficient consideration. The poor working conditions are a factor in keeping coal energy cheaper in the country.

Developing solar energy can also help create additional employment and development opportunities. One frequent argument that is brought up against renewable energy sources is that such

[52] Health and Environmental Alliance(2013), "The unpaid power bill, How coal plants make us sick" p.35
[53] Kaymaz, Timur and Kizilca, Irem (2014), "Efficiency and Occupational Safety in Coal Mine Facilities", p.10

investments can't replace the conventional generation sources in terms of their contribution to the economic development and job creation. However, several studies demonstrate that this is not the case. According to a study made by the World Bank, a dollar of investment to photovoltaic energy can create almost twice more job opportunities compared to a dollar of investment to coal energy[54]. These figures exclude the value chains of the two technologies. If the modules are domestically manufactured, the contribution of solar energy in the economy would be greater. Currently, all components of photovoltaic panels can be manufactured domestically except for the solar cells. Furthermore, there are some indications that these also may be domestically manufactured in the near future given the right conditions. Solar cells are the key components of a solar panel so their manufacturing is key. If a consistently growing solar energy market can be created, a local panel manufacturing industry can also emerge and contribute to the economy in a substantial manner.

Solar photovoltaic power is also ideal for distributed generation. The concept of distributed generation is one that is gaining increased interest across the world. It refers to consumption of electricity at the point of its generation. Many proponents of distributed generation argue that as opposed to centrally controlled systems distributed generation can help empower local communities and reduce the need of electricity to be transmitted across long distances often with significant transmission losses. With increased on-site generation of electricity, the consumers would gain more control and latitude against the large utility companies. These additional benefits should also be kept in mind when devising solar energy policies.

CHALLENGES AHEAD

Given the general state of the photovoltaic market and the regulatory environment surrounding it, several factors can be listed that have so far held the market back. Bureaucratic and regulatory problems, problems related with infrastructure, high capital costs, problems with land, insufficiency of expert knowledge and the inefficiencies in the electricity market will continue to be the main impediments to the growth of the market in Turkey. These issues should be addressed to ensure a viable and healthy solar energy market in the country in the near future.

Bureaucratic and Regulatory Problems

The current regulatory processes take a very long time and are quite costly for the investors. The fact stands true both for large scale installers and small scale investments. Similar processes can be completed in much shorter periods of time in many of the countries experienced in the solar energy

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[54]Bacon, Robert and Kojima, Masami,(2011) 'Issues in estimating the employment generated by energy sector activities', Sustainable Energy Department, World Bank, p. 38

market. These processes will have to be curtailed to make solar energy investments more attractive for the prospective investors. The current regulatory framework functions as an obstacle against solar investments as much as it supports them.

Infrastructure Problems

The adequacy of the transmission and distribution infrastructure places limitations on the amount of solar capacity that can be added in the generation mix. The 600 MW limit that was set for licensed regulation was a result of the limitations of the infrastructure network. Continued investments to the transmission and distribution sector will be required in order to set increased limits for solar energy utilization. As the unlicensed installations pick up pace, the newly added capacity will cast additional burdens on the grid network. The monitoring of the situation and a regular maintenance of the grid will be required. The current levels of intermittent sources in the mix are still relatively low and thus the problems with integration of intermittent sources have not yet emerged[55]. As the share of intermittent sources like solar and wind will increase in the electricity mix, several adjustments and investments will have to be made to the grid infrastructure.

Although there hasn't been adequate experience in integrating solar power sources into the electricity grid, some experience have been gained on intermittent resources by the integration of wind energy sources in the recent years. The insights gained from that experience as well as the experiences of other countries can serve as guidelines on how best to integrate more renewable sources into the electricity mix.

Problems related to Area and Land Availability

For rooftop installations, the availability and the state of the current roof stock is a limitation. There aren't adequate studies that have examined these. Many cities are composed of large apartment building with inadequate rooftops and with the problems of shading. Nearly none of the current building stock was constructed with solar installations in consideration. An additional problem in the southern regions of the country may be the widespread use of solar water heaters on rooftops. They may pose a competition to rooftop photovoltaic applications.

For the ground-mounted installations, other problems related to land use exist. Critics have pointed out that the extensive use of land for solar installations may undermine the use of land in the agricultural sector. The country has a fairly mountainous geography which limits the available area that can be used for agricultural production as well as photovoltaic installations. Currently, photovoltaic installations are not allowed to be built on agricultural lands, While there are still

[55] Ministry of Energy and Natural Resources(2014), 'Turkey National Renewable Energy Action Plan', p. 43

sufficient vacant areas for solar installations in the country, the competition with the agricultural sector for lands should be monitored as the photovoltaic installations will eventually pick up pace.

High Capital Cost and Financing Problems

The relatively high capital costs of photovoltaic installments impede the proliferation of photovoltaic investments. The operations and maintenance costs of photovoltaic investments are relatively minor and there is no fuel costs but the installation costs are quite high. These investments are relatively long term investments which makes it hard for individuals or firms to pursue without sufficient financial guarantees. This characteristic of solar energy coupled with the bureaucratic barriers and the deficiency of know-how in the market makes photovoltaic power less attractive. Several financing schemes are used elsewhere in the world which can mitigate the negative effects of the high upfront costs of photovoltaic generation. Financing mechanisms such as third party financing and solar leases should be adopted to help spur investments in the market.

Some international finance institutions are currently providing funds in the Turkish market for renewable energy and energy efficiency investments. Turseff (Turkey Sustainable Energy Financing Facility) and Midseff (The Turkish Mid-size Sustainable Energy Financing Facility) are two main financing institutions that distribute such funds with the help of the European Bank for Reconstruction and Development,through several local banks. AFD (French Agency for Development) also has a program to provide loans in Turkey for clean energy investments[56]. Such opportunities will remain important for financing clean energy investments in general.

The subsidies that are being provided for conventional sources of electricity like coal also make it harder for solar energy to compete. The current policy system is geared towards an expansion of conventional means of electricity generation which has so far hindered the growth of the photovoltaic market. However, since the photovoltaic system prices have been steadily declining in the recent years, photovoltaic generation is set to become more competitive. Nuclear energy is one of the main energy sources that is planned to be utilized in the future. One of the main arguments brought up in favor of nuclear energy is that it is a relatively cheap source of power. A comparison between the price of nuclear energy and solar energy demonstrates that the cost gap between the two sources is not that substantial. There are currently two planned nuclear plant powers in the country whose power purchase contracts have been signed. The electricity from the nuclear power plant at Akkuyu is set to be purchased with a fixed price of 12,35 USD cents per kWh while the

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[56] http://www.afd.fr/lang/en/home/pays/mediterranee-et-moyen-orient/geo/turquie/tr-axes-strategiques-strategie-Turquie-strateji-turkiye accessed on 12.05.2015

electricity from the plant at Sinop will be purchased with a price of 11,8 USD cents[57]. It can be observed that these prices which can keep the nuclear energy plants profitable are not substantially cheaper compared to the 13.3 USD cents of feed-in tariffs provided for solar plants especially when it is considered that the duration of the feed-in tariff is 10 years whereas the deal with the Akkuyu plant involves a 15 year period. After these periods of time electricity generated by the nuclear plant will be sold freely in the market whereas the same is not currently possible for the unlicensed segment of the solar market. The licensed generators would be able to sell their generation after the 10 year period but they in turn would incur more costs caused by the required contributions decided by the bidding process, so their net gain per kWh of generation would actually be less than the standard 13.3 USD cents.

Inefficiencies in the Electricity Market

The lingering inefficiencies in the electricity market will be another factor that will continue to hinder the development of the photovoltaic market. High loss and theft ratios in some regions of the country decrease the attractiveness of investing in solar energy. In the current system of national pricing, the accurate costs of electricity generation can't be reflected on the electricity bills. The electricity tariffs need to be decided separately for each private utility company for the costs of electricity to be accurately reflected in the electricity bills.

Lack of Expertise in the Market

The human factor plays an important role in boosting photovoltaic power investments as it does in all the other industries. Currently, the public awareness in the country on the matter is still fairly low despite an increased interest in the recent years. There is a lack of expertise on the side of the industry, the government and the prospective customers of photovoltaic power. This needs to be addressed to enable a better market environment. Businesses, academic institutions as well as the state and civil society organizations can play an important role in addressing this challenge.

[57] http://www.bloomberght.com/haberler/haber/1350913-yildiz-nukleer-ile-72-milyar-dolar-daha-az-dogalgaz-ithal-edecegiz accessed on 12.05.2015

POLICY RECOMMENDATIONS

Several steps can be taken to deal with the obstacles that have so far impeded the growth of the market. With the right policies in place, there is no reason why solar energy shouldn't be able to play a substantial role in the energy future of the country. Following are some of the policy measures that can be utilized to promote the solar energy market.

Streamlining the bureaucratic processes

Eliminating the bureaucratic obstacles should be one of the priorities of the policy-makers moving forward. The existence of multiple governmental bodies that are responsible necessitates long processes of correspondence with each that is costly for investors. Alternatively, a single coordinating institution can be established that would be responsible for distributing permits to solar installations. This institution can work in cooperation with the other bodies as an intermediary between them and the investors. This would make the process much easier and faster for the investors. With such a one-stop shop approach, the responsibilities of the investors would be much less and they would be able to track the progress of their applications from a single center. Additionally, simplified and standardized manuals should be made available for anyone that wishes to make investments in the sector. Changes in the regulations should be constantly updated and the latest developments should be communicated in a clear manner. A database of all the regulations and subsidies should be easily accessed by the prospective investors and the information to complete each step must be clearly and completely communicated.

One problem with the regulations is that many different types of investments are being subjected to the same processes. The small scale residential customers who want to install solar panels on their rooftops are legally under the same status as the investors that want to install 1 MW capacity solar farms for selling to the grid. The processes can be made much easier for the small scale rooftop investments. The regulation of the small scale rooftop investors should be differentiated from the larger scale investors. It takes around a year for the unlicensed investors to get permits regardless of the size of investment. While in Germany for example, the permits for small rooftop installers can be acquired in a matter of weeks. In sum, the regulation for different types and sizes of installations should be differentiated. Rooftop regulations should be differentiated from other unlicensed regulations and large scale unlicensed applications should be differentiated from small scale unlicensed applications. The current divide of unlicensed versus licensed generation does not reflect the needs of a much more diverse market. Administrative lead times should be reduced to reasonable periods of time for all types of investments, especially for the smaller scale investments.

One important principle that is stressed by the European Photovoltaic Industry Association is to avoid linearity. This means that an approval from each different institution should not depend on the approval of the following one, each approval track should be independent to save time[58]. Clear deadlines should be set to ensure a smoother process and the regulatory institutions should be held responsible whenever the deadlines are not met. One provision to shorten the bureaucratic processes could be devise a system wherein the applications get automatically permitted after a set amount of time passes without required decisions given by the institutions concerned.

The solar capacity measurement obligation is an important factor that hurts the prospective licensed generators. The measurement takes a very long time and is not a really necessary process. It can be abolished or alternatively the requirements can be downscaled. One possible solution would be to enable those sites which are close in proximity to each other to fulfill their measurement responsibilities in a shared single measurement. In its current state, the measurement process takes around a year. This is mostly a redundant cost of time since the approximate values for average radiation are already available from previous measurements from satellites and meteorological stations. Likewise some procedures are redundant for smaller scale systems. For example, the environmental impact assessment shouldn't be required for very small scale solar systems and rooftop applications.

Adjusting the building codes and land allocation

For rooftop installations the state of the rooftops in the buildings is very important. There currently are no regulations that order the rooftops standards for solar installations. Such provisions should be included in the building codes to enable more available space for solar installations. The buildings right to sunshine should also be included in city planning. There isn't much that can be done for the state of the old buildings. However, the ongoing process of urban transformation that is happening in many cities across Turkey poses an important opportunity in this regard. If the necessary provisions and building codes can be applied on the new building stock, the potential of the rooftop solar market can be greatly extended.

For the ground-mounted installations, the current incentives for the use of land should be sustained. The competition for lands with the agricultural sector should be monitored. Permits should not be given for agriculturally productive sites as the agricultural sector in the country has been on decline. On the other hand, the allocation of sufficient land space should be ensured for solar installations through the use of state lands or through other measures. A balance should be established between

[58] European Photovoltaic Industry Association(2011), Photovoltaic Observatory, Policy Recommendation, p. 6

the needs of the agricultural and solar energy sectors. Especially at this early stage of the solar market development there is sufficient amount of available land area that can be used of solar generation not fit for agricultural production. These types of lands should be utilized instead of agricultural lands that are in use.

Adjustments in the feed-in tariff scheme

The current feed-in tariff amount of 13.3 cents per kWh can be considered adequate but the duration of 10 years falls a little short compared to many of the European countries which generally employ a 20 year tariff period. Currently, the unlicensed generators are not allowed to sell their generation in the market. That creates significant uncertainty for the unlicensed generators. That should be addressed by either making up an extended feed-in tariff amount or allowing the unlicensed generators to sell their generation in the market at least after the 10 year period ends either through PMUM or through bilateral agreements with customers.

One adjustment that can be made is making a differentiation between different scales of investments. Since the smaller scale investments are more costly per unit, increased amounts of feed-in tariffs can be made available for them. Similarly, since the larger scale investments are cheaper to operate, a lesser feed-in tariff can be applied to them. For example, in Germany a multi-tiered feed-in tariff mechanism has been in place for some time and it has proven to be successful. Under the German system, the tariffs applied to ground mounted and rooftop applications are differentiated. Furthermore, the tariff applied to rooftop installations is differentiated between the systems up to 30 kW, systems between 30 kW and 100 kW, systems between 100 kW and 1 MW and systems larger than 1 MW[59]. A similar mechanism can be established in Turkey that differentiates between different scales and types of solar installations and makes adjustments according to the evolving needs of the sector[60]. Eventually, such as system can take the place of the licensed/unlicensed divide in the market.

The current feed-in tariff bonus for using local components runs counter to the norms established within the World Trade Organization. Article III of the General Agreement on Tariffs and Trade prohibits the use of internal taxation and regulation to favor local production at the expense of imports[61]. Local manufacturing should be supported through means that would not violate the rules

[59] Capalino, Reid and Fulto, Mark(2012), 'The German Feed-in Tariff: Recent Policy Changes', pp. 17-18
[60] Kaya, Durmus and Canka Kilic, Fatma(2012), 'Renewable Energies and Their Subsidies in Turkey and some EU countries-Germany as a Special Example' , *J. Int. Environmental Application & Science*, Vol. 7 (1), p. 124
[61] Kuntze, Jan Christoph and Moerenhout, Tom (2013), 'Local Content Requirements And The Renewable Energy Industry - A Good Match?', p. 34

of the WTO agreement. Abolishing the local content bonus and adjusting the tariff accordingly should be considered.

One important area that is not addressed by the current law regulating renewable energy is the issue of monitoring the performance of the feed-in tariffs[62]. An accurate and efficient monitoring system should be set up for reviewing the effectiveness of the feed-in tariff. As the market develops, solar energy will become more competitive and the need for incentives will be reduced. A monitoring system will enable the adjustment of subsidies as the market develops. The profitability of the feed-in tariff should be regularly monitored and adjusted accordingly. It can be evaluated based on the internal rate of return of the investments. Eventually, the tariff should be gradually decreased over the years as the market expands, similar to the process that has taken place in many European countries. As the costs of the installations drop it could be better to try to fix the internal rate of return of the investments rather than the feed-in tariff itself. This would require a close monitoring of the market to assess the effects of many different factors in the profitability of the installations.

An additional risk with the current feed-in tariff scheme is the potential fluctuations in the exchange rate between US dollar and Turkish Lira. A depreciation of the Turkish Lira would make the feed-in tariff more appealing compared to self-consumption of the generated electricity due to the fact that the feed-in tariff is calculated on a USD basis while the electricity rate are based on TL. On the contrary, an over appreciation of TL against US would make self-consumption relatively more profitable. Such dynamics that could be influenced by the exchange rates should be monitored and adjustments should be made wherever necessary.

Addressing the financing needs

Large financing needs continues to be an obstacle in front of the solar photovoltaic market. New financing schemes would help boost investments into the sector. Financial institutions can work in collaboration with the state in order to come up with innovative financing schemes. Because of the high upfront capital requirements of photovoltaic power, different financing options are often used in the world to fund photovoltaic investments. Currently these mechanisms are new to the Turkish market and they will need to be developed and the necessary legislative changes should be made to benefit from these.

One such financing mechanism is the third party financing model. Under this model an owner can use a power purchase agreement to finance an on-site PV system. The third party developer builds and

[62] Gözen, Mustafa(2014), Renewable Energy Support Mechanism in Turkey: Financial Analysis and Recommendations to Policymakers, International Journal of Energy Economics and Policy Vol. 4, No. 2, p.284

owns the photovoltaic module on the customer's property and sells the generated electricity on a per kWh basis to the customer with an agreed price based on a power purchase agreement between the customer and the installer[63]. This model allows the customers to install and utilize solar panels in their properties while avoiding nearly all the initial costs of the installation and the responsibilities for operations and maintenance of the system. The customer buys the electricity at a lower cost than the market price and thus makes significant energy savings. The excess electricity can ideally be sold to the grid. These kinds of agreements are generally long term and can last to around 20 years.

An alternative to utilizing a power purchase agreement is the solar lease method. The main difference of this method from a power purchase agreement is that instead of a power purchase agreement, lease payments are used to pay the installer. In this model the solar equipment is leased by the customer and thus the electricity generated by the installation is used by the customer. This method also eliminates the high upfront capital costs of buying a solar module.

Another financing model for solar installations would be community shared solar. Under this model several customers can come together and cooperatively own a solar system which would enable them easier access to financing and provide them with the economy of scales benefits. Such a system can also help in overcoming the high initial cost of the photovoltaic installations.

There are problems with the utilization of these financing schemes under the current legislation. Several changes will need to be made to allow the operation of these mechanisms. Currently, the unlicensed segment of the solar industry is not allowed to get involved with electricity trading. Thus the third-party financing model is not possible and legislation needs to be set up to regulate the leasing of rooftops for utilizing the solar lease model. Allowing free trade of electricity for the licensed and unlicensed segments and making the necessary legislative changes can allow for third party ownership mechanisms to be utilized.

There has been recent discussion on whether to allow unlicensed generators to perform in the electricity market after the 10 year feed-in tariff period ends. Critics of the change point out that such a change would be unfair to the licensed generators in the market[64]. As things stand, the main advantage of the licensed generators have been that they are allowed electricity trading after the 10 year period. If the unlicensed segment of the market gets the same right, it seems that the extra fees paid by the licensed generators and the extra time they spent to get the generation license would

[63] Kollins, Katharine, Speer, Bethany and Cory, Karlynn(2010)'Solar PV Project Financing: Regulatory and Legislative Challenges for Third-Party PPA System Owners', p. 3-4

[64] http://enerjigunlugu.net/lisanssiz-elektrigin-civisini-cikardik_13539.html#.VVNV9vmqqkp , accessed on 12.05.2015

not amount to much advantage in return. On the other hand, with the current regulation the unlicensed solar applications which are not aimed at self-consumption will remain idle at the end of the 10 years period if the current legislation does not change. To benefit from the generation of these sources, market trading has to be allowed. However, the licensed generators also need to be somewhat compensated for the loss of their privileges.

The divide between the licensed and unlicensed generation does not make much sense especially if the unlicensed segment also gets the trading rights after the end of the government support. Eventually abolishing the divide and instead employing different levels of feed-in tariffs based on scale could be a better solution. The support amounts and the required processes would differ for different sizes of installations in such a model. In that way, the license cap would also be abolished. Having such installation caps carry the risk of creating a stop-and-go' situation which could hinder the sustainable growth of the market in the long run[65], so the absence of a cap could work for the benefit of the market. Under the current circumstances the bidding process takes extra time and money than would otherwise be required and high levels of competition lowers profitability considerably. Also, in the current system there is always the risk of being outbid for the potential investors in which case the time and money they have put into the process get wasted. However, the limits of the transmission infrastructure would still need to be monitored in such a system. Thus, the support amounts would need to be changed regularly to avoid the installations to overreach the capacity of the transmission system.

Insurance mechanisms also play an important part in photovoltaic investments. There currently are not enough institutions in Turkey that are willing to insure solar investments. The issue has to be addressed in order to minimize the risks involved with solar energy generation. Multiple risks exist for the investors of photovoltaic power like faulty designs, natural disasters, extreme weather events and the risk of theft. Eliminating the risk factors will be an important component going forward. A security net can be established with contributions given by the investors in the market and with the help of the government which would provide some degree of guarantee for the solar system owners at this early stage in the market development when there aren't sufficient private sector opportunities for insuring solar installations.

Additional incentive adjustments

In addition to the current subsidies, there are several policy options that can be utilized to promote photovoltaic energy. In the new investment incentive scheme, coal based energy investments can

[65] PV Policy Group(2007), 'Designing Photovoltaic Policies in Europe: Summary and Conclusions', p. 14

benefit from the 5th development region subsidies regardless of the region they are built on[66]. The regional incentive scheme had divided Turkey into 6 different regions based on level of development. 5th region is considered as the second less developed region and thus the investments in that region benefit from extensive incentives. Coal extraction, exploration and investments can be regarded as 5th region investments even when they are made on the 1st, 2nd, 3rd and 4th regions. Various incentives include breaks from several taxes, social security premiums and support on interest payments. This gives an important advantage for coal investments against other types of energy investments. This special position of coal investments need to be abolished. Alternatively, all domestic energy investments can be regarded as 5th region investments so as to allow solar investments to enjoy the same level of support.

There are also several other provisions that can be considered to further incentivize the solar energy sector. Reduced value added tax for solar components, tax rebates and low interest loan programs can be considered to cope with the high capital cost of solar installations. In this regard potential subsidies that can be provided to the prospective end users of solar energy are important as in the current framework the users of solar energy are not sufficiently incentivized. A green certificate scheme is currently under consideration by the policy makers in Turkey[67]. If applied, such a scheme can help subsidize the user of clean energy and reflect some of the external costs of fossil fuel based power generation. Auto-producers could also benefit from such a subsidy mechanism.

Demand-side management measures

The electricity rate structures can also play an important role on making on-site photovoltaic generation more profitable. Currently, there is no demand charge that is being applied on the electricity bills. Including a charge for peak demand for the commercial electricity customers can be included in the electricity tariffs. The commercial buildings usually have their peak demand near noon. Since solar panels also yield higher outputs in those hours, having a demand charge to consider would provide them an incentive to make additional savings on their electricity bills by cutting their peak demand charges by the installation of photovoltaic panels where available. Time-dependent charges can also be instrumental in providing incentives for businesses for self-generation. Currently, electricity customers in Turkey are free to choose a time of use tariff but the preference of this rate structure is relatively rare. Many customers don't have the electronic electricity meters that are necessary for the transition to a time of use tariff. Additional incentives can be put into place to increase the share of customers who prefer that rate structure. A time based rate structure would

[66] Acar, Sevil, Kitson, Lucy and Bridle, Richard(2015), 'Subsidies to Coal and Renewable Energy in Turkey', p. 9
[67] Ministry of Energy and Natural Resources(2014), 'Turkey National Renewable Energy Action Plan', p. 29

reward solar panel installers buy cutting their electricity costs at the peak hours when the electricity price would be highest which would also coincide with the time when the photovoltaic output would be at peak. Different kinds of residential and commercial customers could benefit from such measures as well as large industrial customers such as those in the organized industrial zones.

Supporting installations in the agricultural sector

The conflict for land area between the solar energy sector and the agricultural sector is often discussed. However, solar energy installations can also play a complementary role for the agricultural sector. Some of the farmlands that are away from the electricity grid can benefit from off-grid solar installations for their irrigation needs. Solar power sources can energize the water pumps needed in agricultural production[68]. Currently several regional development agencies are providing support for the utilization of renewable energy sources for the irrigation needs of the agricultural sector. These can be extended and low interest and long term loans can be designed by the government to help with financing such installations specifically for use in the agricultural sector. Technical expertise and guidance can also be provided by the government since the proper sizing of such systems would be crucial in determining their economic feasibility. As these would be off-grid installations, they would not create a strain on the transmission and distribution infrastructure.

Improving the transmission and distribution infrastructure and accounting for intermittency

The transmission network plays a crucial role in guaranteeing reliable grid access to the solar applications. The transmission and distribution network of the country should be strengthened. The investments in this sector should continue to allow for increased capacities of solar electricity to be included in the grid. The grid code requirements for the solar generators should be comprehensively and transparently communicated to the investors to make the interconnection process faster and easier. Interconnection processes should be made faster especially for the low-voltage connections.

The utilization of smart grid systems can play an important role in this regard by making it easier to gather immediate information and manage the load requirements of the system in a swift manner. Larger-scale renewable power stations will also need to be closely monitored to avoid disruptions in the system caused by sudden changes in output. Setting up these systems will require significant investments. Solar generators are already charged with a system usage fee and additionally the licensed generators are required to make financial contributions to the system. These fees should be

[68] Öztürk, Hüseyin, Yaşar, Baran and Eren, Ömer (2010), 'Tarımda Enerji Kullanımı Ve Yenilenebilir Enerji Kaynakları', pp. 13-15

sustained and the solar energy generators thus should contribute in the sustaining and expansion of the electricity infrastructure.

Solar energy generation is inherently intermittent by nature. That fact will not change in the near future barring a substantial breakthrough in the electricity storage technology. However, the effects of intermittency can be mitigated by careful policy planning. As the share of intermittent sources in the electricity mix increases, the base-load requirements of the system should be calculated to ensure uninterrupted supply to the market. Further diversifying the electricity mix, along with the appropriate demand side management measures like employing smart grid systems would help alleviate the negative effects that an increased capacity of intermittent sources are eventually bound to cause to the grid system. Strengthening the international grid interconnections can also play an important role in better accommodating intermittent sources in the electricity mix by providing more reserve electricity for the grid. In this regard the established connection with the European ENTSO-E(European Network of Transmission System Operators for Electricity) network is important and additional interconnections with other neighboring countries can also help in reducing reserve requirements in the future.

Supporting domestic manufacturing and establishing a certification mechanism

Improving the domestic manufacturing of solar equipment should be made a priority. Support should be provided for research and development efforts aimed at manufacturing local solar cells. One important factor that impedes the growth of the domestic manufacturing sector is the lack of sufficient standards on imported solar equipment. There currently are no standard requirements on the imported solar systems. Clear standards should be implemented to protect the market from cheap and low quality solar systems by the Turkish Standards Institution and the necessary infrastructure should be established to enforce the established standards. A specialized custom authority should be set up to inspect whether the incoming solar equipment is up to the standards that will be set up. Otherwise, there is the risk that the market can be flooded by cheap but low quality solar components which would dissuade many investors and hinder the development of the domestic solar panel industry. Low quality equipment usually has problems of lower lifetime and output than their apparent specifications.

The same certification process that would be applied on imported products should also be applied on the local products to ensure that the manufactured systems are of sufficient quality. Currently, there are around 20 photovoltaic manufacturers active in Turkey with a capacity of around 1000 MW. The certification of these facilities products according to the international standards can’t currently be done in Turkey. Thus they have to send their modules abroad to European certification bodies for testing. This causes the costs of the manufacturers to increase and also problems can arise in the transportation which can disrupt the results of the performance tests. Setting up a domestic center capable of performing output tests and certification can help reduce the costs of domestic production and contribute to the domestic research and development efforts[69].

Pursuing the market liberalization process

Reducing the levels of loss and theft on the distribution network and making the transition to regional electricity pricing would enable the electricity market to function more efficiently. The full costs of electricity generation and transmission should be reflected on the electricity tariff. Turkey is already aiming for these goals and their completion would also help the solar energy market. Solar energy would become more competitive in a free market environment where the electricity prices are not suppressed by the state.

The large amount of subsidies that are being provided for coal energy is also an impediment for different types of renewable energy like solar power. The phase-out from fossil fuel subsidies is already on the G20 agenda and thus an international commitment for Turkey. This process should be accelerated for enabling a better environment for solar power investments. One of the major reasons why large firms are not much willing to invest in the solar market is simply that coal investments are more profitable. A gradual phase-out of the coal subsidies could remove an important obstacle in front of solar energy generation by increasing its competitiveness against the conventional energy sources.

Improving the levels of expertise and public awareness

There are several policies that can be employed to increase the level of technical expertise in the market. If the solar market is set to grow, increased levels of expertise and know-how are required. Simple guides describing the regulatory processes and the technical characteristics of photovoltaic power should be disseminated to the public to increase the levels of public awareness. The basics of renewable energy can be incorporated into the curriculum in secondary and tertiary schools. Training activities should be set up for employees in a variety of related sectors. Awareness raising and promotion activities should be prioritized.

Increasing the involvement of the public sector

[69] Arınç, Ümit Doğay, Keleşer, Serkan, Tem, Ali and Öztürk, Muhammet'Photovoltaic Modules Performance Tests,Inspection and Product Certification', pp. 1-5

The public sector investment can potentially play a pivotal role in expanding the market. An extensive amount of publicly owned buildings like hospitals, schools and other official buildings have available roof spaces for solar installations. Increased public investments would help boost the growing market and the emerging manufacturing industry.

CONCLUSION

Solar energy as a source of electricity has been on the rise in the global generation mix in the past decade. This was largely fueled by technological improvements on the efficiency of solar modules which led to a sharp decrease in the solar module prices. Turkey is ideally placed geographically to exploit this recent trend. Utilization of solar energy could help Turkey decrease its dependence on imported energy sources and build an economically and environmentally sustainable energy system. In the midst of the looming problem of climate change, decreasing the carbon emissions of the country also stands out as an international and inter-generational responsibility. With the current trajectory, planned increases in the coal capacity will be the major cause of the additional greenhouse gas emissions of the country in the near future. Further stressing the utilization of solar energy could obviate the need to increase the coal-fired electricity capacity of the country at the high proportions currently anticipated. As a clean and domestic energy source, solar power is set to play a substantial role in the energy future of the country. With the correct policy measures, this process can be accelerated.