

CAN ENVIRONMENTAL MARKETS SUPPORT  
SOLAR ENERGY DEVELOPMENT IN TURKEY?

by

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## **ABSTRACT**

### **CAN ENVIRONMENTAL MARKETS SUPPORT SOLAR ENERGY DEVELOPMENT IN TURKEY?**

As stated in Intended Nationally Determined Contribution (INDC) that has been communicated regards to the Climate Action Plan, Turkey aims to increase production capacity of electricity from solar power to 10 GW and production capacity of electricity from wind power to 16 GW while tapping the full hydroelectric potential until 2030. Among the alternative clean energy resources in Turkey, solar energy is the most important one considering the advantageous position in the Middle East and Southeast Europe. Solar capacity has soared up in recent years due to both technological improvements which leads to cost reductions and government policies that support renewable energy progress. Law on the Use of Renewable Energy Resources for the Purpose of Generating Electrical Energy was accomplished on May 18, 2005 has brought the Renewable Energy Support Mechanism which provides a fixed and secure purchase price for the generated electricity from renewable energy. The government is planning to end the current mechanism by 2020 and it is still uncertain what will happen after its termination. The uncertainty brings to mind the question, “Could environmental markets such as carbon markets, consumer-based power purchase agreements (PPAs) and green certificates support maintaining and increasing electricity supplies from solar energy?” This study will analyze the role of support mechanisms and innovative market-based applications for solar energy development and thus promotion of carbon emission reduction targets of Turkey.

## ÖZET

### ÇEVRESEL PİYASALAR TÜRKİYE’DE GÜNEŞ ENERJİSİNİN GELİŞMESİNİ DESTEKLEYEBİLİR Mİ?

Türkiye, Birleşmiş Milletler İklim Değişikliği Çerçeve Sözleşmesi Sekreteryası’na sunduğu Niyet Edilen Ulusal Olarak Belirlenmiş Katkı (INDC) beyanında belirtildiği gibi, güneş enerjisinden elektrik üretim kapasitesini güneş 2030 yılına kadar 10 GW’a çıkarmayı hedeflemektedir. Türkiye’nin Orta Doğu ve Güneydoğu Avrupa’da avantajlı konumu göz önünde bulundurulduğunda güneş enerjisi temiz enerji kaynakları arasında en önemli olanıdır. Güneş enerjisi üretim kapasitesi, son yıllarda hem maliyet düşüşüne yol açan teknolojik gelişmeler hem de yenilenebilir enerjinin ilerlemesini destekleyen politikalar nedeniyle artış göstermiştir. Türkiye’de güneş enerjisi kurulu gücü 2017 sonu 3,421 MW’a ulaşarak toplam kurulu güç içindeki payını %4’e yükseltmiştir. Bu gelişimde hem kurulum maliyetlerindeki düşüş hem de lisanssız elektrik üretim kurulu güç sınırının 500 kW’dan 1 MW’a çıkartılması etkili olmuştur. Yenilenebilir Enerji Kaynaklarının Elektrik Enerjisi Üretimi Amaçlı Kullanımına İlişkin Kanun 18 Mayıs 2005 tarihinde Resmî Gazetede yayınlanarak Yenilenebilir Enerji Kaynakları (YEK) Destekleme Mekanizmasını getirmiştir. YEK Destekleme Mekanizmasının 31 Aralık 2020 tarihine kadar devreye girecek yenilenebilir enerji kaynaklarına dayalı üretim tesisleri için geçerli olması, bu tarihten sonra devreye girecek tesisler için belirsizlik teşkil ediyor. Bu durumda akıllara Karbon Piyasaları, tüketici odaklı Elektrik Alım Sözleşmeleri ve Yeşil Sertifikagibi Çevresel Piyasaların güneş enerjisinin desteklenmesi ve güneş enerjisi kaynaklı elektrik üretiminin artışının devamı için alternatif olup olamayacağı sorusu gelmektedir. Bu çalışma, güneş enerjisi gelişimi için destek mekanizmalarının ve yenilikçi piyasaya dayalı uygulamaların rolünü ve dolayısıyla Türkiye’nin karbon salımı azaltım hedeflerine ulaşmasındaki katkısını analiz etmektedir.

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## LIST OF SYMBOLS/ABBREVIATIONS

<b>Symbol</b>	<b>Explanation</b>	<b>Unit</b>
CO <sub>2</sub> e	Carbon dioxide equivalent	tonne
<b>Abbreviation</b>	<b>Explanation</b>	
CDM	Clean Development Mechanism	
DAM	Day Ahead Market	
EEA	European Environment Agency	
EEG	Renewable Energy Sources Act	
EIGM	General Directorate of Energy Affairs	
EMRA	Energy Market Regulatory Authority	
EPIAS	Elektrik Piyasaları İşletme A.Ş.	
EU	European Union	
FIT	Feed-in Tariff	
GHG	Greenhouse Gas	
GW	Gigawatt	
GWh	Gigawatt Hours	
IEA	International Energy Agency	
INDC	Intended Nationally Determined Contribution	
IPCC	Intergovernmental Panel on Climate Change	
IRENA	International Renewable Energy Agency	
ITC	Investment Tax Credit	
KP	Kyoto Protocol	
Kw	Kilowatt	
kWh	Kilowatt Hour	
LCOE	Levelized Cost of Electricity	
MENR	Republic of Turkey Ministry of Energy and Natural Resources	
MEUP	Ministry of Environment and Urban Planning	
MtCO <sub>2</sub> e	Million Metric Tonnes of Carbon Dioxide	
MW	Megawatt	
MWh	Megawatt Hour	
OECD	Organization for Economic Co-operation and Development	

PPA	Power Purchase Agreement
PV	Photovoltaic
REC	Renewable Energy Certificate
RECS	Renewable Energy Certificate System
REZ	Renewable Energy Zone
ROC	Renewable Obligation Certificate
RPS	Renewable Portfolio Standard
SEG	Electricity Feed-in Law
SEM	Solar Energy Map
SWOT	Strength, Weakness, Opportunity, Threats
Tco2	Tonne Carbon Dioxide
TEIAS	Turkish Electricity Transmission Corporation
TGC	Tradable Green Certificate
TUİK	Turkish Statistical Institute
UNFCCC	United Nations Framework Convention on Climate Change
VER	Verified Emission Reductions
YEGM	Renewable Energy General Directorate
YEKDEM	Yenilenebilir Enerji Kaynakları Destekleme Mekanizması
WEC	World Energy Council

## 1. INTRODUCTION

With remarkable cost reduction, power generation from renewables increased dramatically within the global power between the years 2007-2017. And total global solar power capacity has reached over 400 GW in 2017, after exceeding the 300 GW in 2016 and the 200 GW level in 2015 (Solar Power Europe, 2018). As a consequence of both cost decrease and the increase of the installed capacity cap for unlicensed electricity generation from 500 Kw to 1 MW, the share of solar installed capacity has reached to 4% in Turkey by the end of 2017 (TEIAS, 2018). Among the alternative clean energy resources in Turkey, solar energy is the most important one considering the favorable position in the Middle East and Southeast Europe. The Solar Energy Map (SEM) of Turkey which was prepared by the Renewable Energy General Directorate (YEGM), shows that the total annual insolation time is 2,741 hours (totaling to of 7.5 hours per day), and in total 1,527 kWh/m<sup>2</sup> of solar energy is derived annually (4.18 kWh/m<sup>2</sup>/day).

During the last decade, feed-in tariffs played a significant role in deployment of solar photovoltaics in the world. Regarding the ability of technological development, alternative energy generation technologies have been cost-competitive with conventional generation technologies. According to Global Levelised Cost of Electricity (LCOE) from Utility-Scale Renewable Power Generation Technologies, 2010 – 2017 by International Renewable Energy Agency (IRENA), LCOE for solar photovoltaic has declined from 0.360 USD/kWh to 0.100 USD/kWh. While the cost of solar energy has declined rapidly, some policymakers claim that feed-in tariffs can be reduced or removed totally, where rational investors will invest even without government incentives. Additionally, auxiliary supports and innovative mechanisms could be the new solution for the sustainability of the market.

Considering the Turkish market, a transition period is experienced. Renewable Energy Support Mechanism regulates feed-in tariff (FIT) for the renewable energy power plants for their first 10 year of operation. The tariff is applied in USD to renewable energy producers which is accepted as the major guarantee by the banks to supply project finance. Under the existing conditions, the deadline for Renewable Energy Support Mechanism is determined as December 31<sup>th</sup>, 2020 in the Renewable Energy Act of Turkey. Now debates are focused on the new scheme after 2020. Does the market need a new incentive model? Or could Turkey adopt alternative or complementary renewable energy support mechanisms? The main renewable energy support policies, other than FITs, are Renewable Portfolio Standards (RPSs) and Renewable Energy Certificates (RECs) (Ari and Sari, 2015). In the

recent years, a business model of Power Purchase Agreement (PPA) is rising to prominence. PPA entails a contract between the renewable energy producer and the consumer to sell them a specific amount of energy at a set price for a fixed duration (Solar Asset Management EUROPE, 2018). While consumer demand is growing for environmentally responsible products and services, more corporates are interested in use of green energy. At this point, Turkish consumers' readiness or willingness to invest in renewable energy by such a long-term contract is a question mark. In the meantime, citizen (community-funded) solar power plants and auction-based mechanisms are the wide-spreading models.

As part of combating climate change, renewable energy sources are crucial considering emission reductions in the electricity sectors is considered. Turkey is a party to both United Nations Framework Convention on Climate Change (UNFCCC) and Kyoto Protocol (KP), but she does not have an emission reduction target or is subject to any limitation. Turkey has a different position in the climate regime and cannot benefit from CDM due to being listed as a developed country in Annex I. In addition to this, Turkey takes part in the Voluntary Carbon Market (VCM) which differs from the compliance mechanisms under the KP. Rather than receiving national approval and UNFCCC processes, the certification of emission reduction is carried out in accordance with international standards. Emission reductions developed under this market are called Verified Emission Reductions (VERs) and commonly used by companies that want to take responsibility against climate change by offsetting their emissions deriving from business activities (Climate Corporation, 2018). Since the market works voluntarily and its future is ambiguous, it's difficult to measure its success in investment of renewable energy projects.

To conclude, policy instruments have a crucial role for progression of the renewable energy investments which would enable Turkey to reach renewable energy targets and utilize the potential she has. This would also lead to achieve GHG emission reduction targets.

## 2. BACKGROUND AND LITERATURE REVIEW

### 2.1. Development of Solar Energy in Turkey

In Turkey, the solar installed capacity experienced an extraordinary growth between the years 2014 and 2017 increasing from 40 MW to 3,421 MW. The large part of this has come from unlicensed power plants as detailed in Section 2.1.1. By the end of 2017, solar has a share of 4% in the country's installed capacity. Regarding the electricity generation, solar capacity produced 2,889.3 GWh having a share of 1% in total (TEIAS, 2018). This means a CO<sub>2</sub> emission reduction of 1.342.080 tonnes annually. To calculate the emission reduction, the electricity grid emission factor for Turkey is taken as 0,4645 tCO<sub>2</sub>/MWh from "Towards Decarbonising Transport 2018".

Specially, 2017 was an important year for solar energy in Turkey. The progress put Turkey in the top five national markets with China, India, Japan and USA have taken the lead of nearly %84 of newly installed capacity. 2017 was also a landmark in global. At least 98 GW of solar photovoltaics (PV) capacity was installed and thus increased the total capacity by nearly one-third as totaling to 400 GW, approximately (REN21, 2018). With 2.6 GW, added solar capacity in 2017 was more than three times that of 2016, making Turkey one of the largest markets for solar PV in Europe.

Regarding future development, Turkey plans to increase the electricity production capacity of solar energy to 10 GW until 2030 as submitted under its climate action plan to the UNFCCC. Intended Nationally Determined Contribution was submitted in 2015.

Additionally, under Turkish Electricity Transmission Company (TEIAS) Capacity Projection Report (2018-2022), two scenarios have been worked on the development of generation capacity for the 5-year period. The solar installed capacity is projected to be 8.921 MW in both scenarios with a share of 8.5% in total capacity by 2022. This means that 89% of the planned capacity by 2030 would already been expected to be reached by 2022. The main assumptions accepted by the Scenario 1 and 2 may be seen as below:

**Scenario 1:** Projects with a progression rate of %10 or less and progression rates the dates of entry into the operation of projects for which no proportional information is given are considered as unclear. Plants with a progression rate of over 70% could be put into operation in 2018. In addition, the capacity of projects with a progress rate of 35% to 70% could be operational as;

- Those which are under 100 MW in 2019,
- Those which are in the range of 100 MW – 1,000 MW in 2020,
- Those above 1,000 MW in 2021.

For those who have a progression rate of 10% to 35%, a year has been added to these projected completion dates.

**Scenario 2:** Using the same methodology, based on the limit values of 15% instead of 10%, 40% instead of 35% and 80% instead of 70%.

These assumptions have been used for the private sector's licensed investments under construction. Considering public investments, unlicensed investments and renewable energy zones (YEKA) model which is detailed in section 2.1.1.1, the capacity projections reach to below values:

- Scenario 1: 105,300 MW of total installed capacity with gross electricity generation of 539,073 GWh by 2022
- Scenario 2: 103,995 MW of total installed capacity gross electricity generation of 530,676 GWh by 2022

### **2.1.1. Main Renewable Energy Support Policies in Turkey**

Last ten years, Turkey is trying to redesign her energy policy as directing her endeavors more to renewable energy. In order to bring Turkey's strategy in line with the EU's 2009 Renewables Directive, Turkey's National Renewable Energy Action Plan (2013-2023) was released in 2014. According to the action plan, Turkey has a target to increase the share of renewable energy sources in electricity production and in total energy consumption to 37.6 % and 20.5%, respectively, by 2023. The 2015-2019 Strategic Plan can be defined as the second milestone for reaching national renewable energy target as generating 30% of the total electricity from renewable sources by 2030. As targeting to increase Licensed Projects in renewable energy, more importance is given to increase the usage of locally manufactured equipments by these projects (MENR, 2014; IEA, 2018).

In 2001, the enactment of the Electricity Market Law (No: 4628) paved the way for liberalization of electricity market activities, privatization of state-owned enterprises and the establishment of a competitive market. This also supported the private sector for electricity generation from renewable energy sources. In 2005, Law on Utilization of Renewable Energy Sources (No: 5346) ensured feed-

in tariff (FIT) for electricity generation from renewable energy resources that secures a fixed price level for a maximum 10 years of operation. The law set the guarantee price as the previous year's average electricity price of the wholesale market which would be determined by the Energy Market Regulatory Authority (EMRA). In addition to this, the upper and lower limits were set as 5.0 and 5.5Euro cent/kWh, respectively (TBMM, 2001; TBMM, 2005).

In 2011, the Law on Utilization of Renewable Energy Sources has been amended and the FIT mechanism has been changed as providing a fixed price level for each renewable resource for 10 years of operation (TBMM, 2011). Additionally, power plants constructed from the local equipment and machinery are awarded. According the law, the mechanism was valid for the facilities which start operation until the end of 2015. However, the deadline has been extended until the end of 2020 by the decree of the council of ministers dated on 5th December 2013 (Bakanlar Kurulu, 2013). Table 2.1 shows the FIT for electricity generation from renewables and local equipment support:

Table 2.1. Feed-in tariff as of 2011 (TBMM, 2011).

Type	Electricity Prices (USDcent/kWh)	Local Equipment Support (USDcent/kWh)
Hydroelectric Power Plant	7.3	2.3
Wind Power Plant	7.3	3.7
Geothermal Power Plant	10.5	2.7
Biomass Power Plant	13.3	5.6
Solar Energy Power Plant	13.3	6.7 (PV) 9.2 (concentrated)

With this amendment, the government targeted to increase renewable energy production using local equipment. The duration of local equipment support is five years instead of ten years. While benefitting from the mechanism is voluntary, it works on yearly basis. If the power plant wants to benefit from the mechanism, it must stay in the mechanism during the calendar year.

Demirdizen et al. (2013) studied the market development of renewable energy in Turkey and insists on the barriers on renewable energy production, although it is a beneficial mean of obtaining energy. The electricity market is one of the crucial factors of development of the renewable energy. Regarding the development of renewable energy, the incentives have been a very encouraging factors for Turkey to produce more renewable energy. With the enactment of the Law on Utilization of

Renewable Energy Sources, the installed capacity of renewable energy has increased from 12,976.5 MW to 34,582.2 MW between the years of 2005 and 2016 (TEIAS, 2018).

Regarding the solar energy generation capacity, a rapid increase has been experienced since 2014 as reaching to 3,420 MW (TEIAS, 2018). 99.48% of this amount is the unlicensed capacity. In 2017, unlicensed renewable installed capacity reached to 3,444 MW increasing from 835.5 in the previous year. 99% of this amount was obtained from solar energy (TEIAS, 2018).

**Unlicensed electricity generation** is a system which enables the electricity subscribers to produce their own electricity and to sell the surplus production under the Unlicensed Electricity Generation Regulation's provisions. Generation facilities based on renewable energy resources, that (i) have an installed capacity of maximum one (1) MW, or (ii) consume all of the generated electricity as utilizing their generation and consumption at the same location, have the right to generate electricity without getting a license (TBMM, 2018). As a matter of principle, the aim is to enable the consumption facilities to meet their own needs by renewable energy resources. In case of a surplus production, it can be sold to the relevant distribution company during ten (10) years, upon FIT under the Law on Utilization of Renewable Energy Sources (Sarıbrahimoğlu Law Office, 2018).

The enactment of the new Electricity Market Law (No: 6446) as of 14<sup>th</sup> March 2013, the total installed capacity of an unlicensed electricity generation plant based on renewable energy sources has been increased from 500 kW to 1000 kW (1 MW). This change and the new version of the Law on Utilization of Renewable Energy Sources entered into force on 2<sup>nd</sup> October 2013 had a significant impact on the increase of the unlicensed capacity from 40.4 MW in 2014 to 254.1, 835.5 and 3,444.2 MW in 2015, 2016 and 2017, respectively, according to TEIAS values. Unlicensed solar capacity constitutes 99% of the total installed capacity, in Turkey.

In Turkey, the main purpose of the promotion of the unlicensed generation is to enable consumers to meet their own electricity needs, however the regulation has been used mostly by investors to make profit upon FIT mechanism. Due to bureaucratic obstacles of licensed investment process, the investors who wish to establish a large-scale solar power plant have installed more than one PV plant with 1 MW capacity side by side and reached the higher capacities.

Gözen (2014) analyzed renewable energy promotion law and support mechanism in Turkey considering financial conditions and discussed the key issues and challenges. The study recommends amending FIT whenever needed; changing FIT for some renewables and monitoring the support

mechanism. Parallel to the country's renewable energy policy, it's highlighted that there is a strong need to monitor the performance regularly, if the mechanism is in the right direction or not. With the development of the market and experienced challenges, Turkish government went to design changes to its renewable energy support policy.

**Renewable Energy Zones (YEKA) Model:** In order to reduce Turkey's current account deficit and foreign-source dependency, the Electricity Market Law (No. 6446) was amended to introduce a more detailed legal basis for “Renewable Energy Zones” in March 2016. The concept of “Renewable Energy Zones” was introduced in Law on Utilization of Renewable Energy Sources (No: 5346). These areas are opened to large scale renewable energy investments. On the 9th October 2016, the Renewable Energy Zones (REZ) Regulation entered into force to outline the detailed rules for operation, investments and licencing in the zones. The REZ model is an auction mechanism where the winner of the auction is granted right to generate and sell at a price (a power purchase guarantee) determined as a result of the investment. The auction involves the condition of the establishment of local manufacturing and R&D facilities or using locally manufactured equipment with an aim to ensure localization (MENR, 2018).

Within the framework, two mechanisms are allowed. A REZ and the warrant for connection capacity can be offered to an eligible party under the “Allocation on the Condition of (Local Manufacturing” or “Allocation on the Condition of Using Locally-Manufactured Equipment” mechanisms.

Under the first mechanism, the eligible party must establish an equipment manufacturing factory and an R&D Center in Turkey. In the R&D Center, activities must be carried out for a specific period and in accordance with the specified conditions like employee number, budget and required qualifications for employees. Equipments and some specified components which were produced in Turkey must be used in the investment (T.C. Cumhurbaşkanlığı Yatırım Ofisi, 2018).

Under the second mechanism, the winner of the competition undertakes to purchase equipments and some components from the existing producers in Turkey. Equipment and components must comply with national or international standards and specified proportion of the components must met the the local content rule (T.C. Cumhurbaşkanlığı Yatırım Ofisi, 2018).

In 2017, two auctions were held for solar energy in Karapınar and wind energy in five different regions of Turkey; Kayseri-Niğde, Sivas, Edirne-Kırklareli-Tekirdağ, Ankara-Çankırı-Kırıkkale and

Bilecik-Kütahya-Eskişehir with 1,000 MW capacity each. The first auctions involved a power purchase guarantee for a period of 15 years. Under the auction process, the ceiling prices were set at 7\$ cent/kWh for wind and 8\$ cent/kWh for solar energy. The tenders were executed as a reduction from a specific ceiling price by the participants (bidders). The tenders resulted at 3.48 \$ cent/kWh and 6.99 \$ cent/kWh for wind and solar, respectively (MENR, 2017).

The planned solar power plant in Karapınar will operate for 30 years and the investor will perform R&D activities in Turkey for minimum 10 years employing 80% of employees locally. The plant is expected to be operational until 2020 and produce 1.6 billion MWh of electricity annually (Enerji Atlası, 2018). Local manufacturing of solar power plants is an important milestone which will alleviate foreign-dependency in energy.

**FIT Mechanism Participation:** Table 2.2. shows the development of number of participants utilized FIT mechanism. These are the participants with generation license.

Table 2.2. Number of participants utilized FIT mechanism by years (EMRA, 2018).

Type	2011	2012	2013	2014	2015	2016	2017
<b>Solar</b>	-	-	-	-	-	-	2
<b>Hydro</b>	4	44	14	40	126	388	418
<b>Wind</b>	9	22	3	21	60	106	141
<b>Biomass</b>	3	8	15	23	34	42	57
<b>Geothermal</b>	4	4	6	9	14	20	29
<b>Total</b>	<b>20</b>	<b>78</b>	<b>38</b>	<b>93</b>	<b>234</b>	<b>556</b>	<b>647</b>

The installed capacity of these participants may be seen through Table 2.3. After the amendment of the Law on Utilization of Renewable Energy Sources in 2011 both renewable energy installed capacity and participation to FIT mechanism have increased.

Table 2.3. Installed capacity of participants utilized FIT mechanism by years (EMRA, 2018).

Type	2011	2012	2013	2014	2015	2016	2017
<b>Solar</b>	-	-	-	-	-	-	13
<b>Hydro</b>	21	930	217	598	2.116	9.960	11.096
<b>Wind</b>	469	685	76	825	2.732	4.320	5.239
<b>Geothermal</b>	72	72	140	228	390	599	752
<b>Biomass</b>	45	73	101	147	185	204	300
<b>Total</b>	<b>608</b>	<b>1.760</b>	<b>534</b>	<b>1.798</b>	<b>5.424</b>	<b>15.083</b>	<b>17.400</b>
<b>Total Licensed Renewable Capacity</b>	<b>18.980</b>	<b>22.032</b>	<b>25.360</b>	<b>27.678</b>	<b>30.990</b>	<b>33.250</b>	<b>34.830</b>

In addition to the licensed capacity, by the end of 2017, all of the unlicensed installed capacity of 3.444 MW is covered by FIT mechanism (TEIAS, 2018).

Turkey’s FIT for the solar energy power plants and day ahead market (DAM) prices between the years 2011 and 2017 are compared in Figure 2.1 below. Yearly average exchange rate published by Turkish Central Bank has been used for the conversion of US\$ to TL (TCMB, 2018).

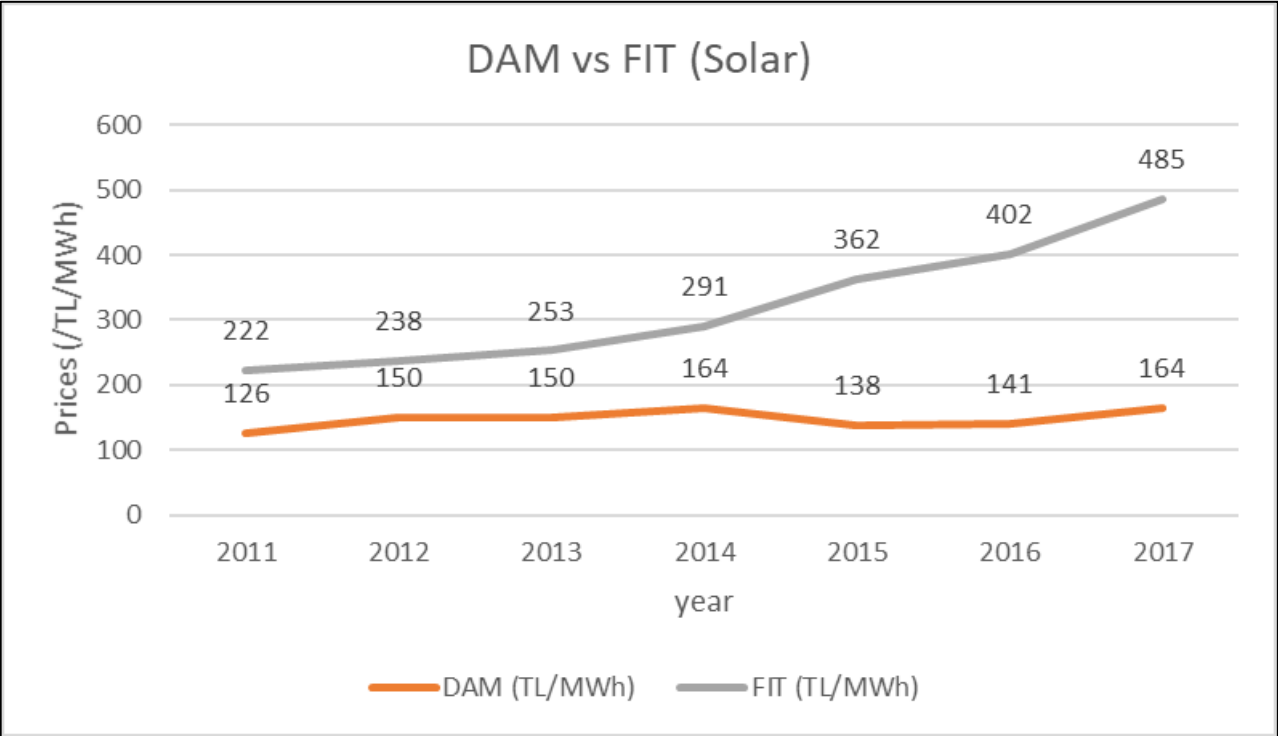


Figure 2.1. Comparison of FIT (Solar) and DAM Prices, 2011-2017 (EPIAS, 2018).

It’s obvious that FIT provided to solar power plant investors were higher than the market prices. The change of exchange rate was effective in increase of the gap. Besides, this price movement caused other renewable power producers to sell their generation to FIT mechanism rather than to the market. This had a significant impact on the increase in participation to the mechanism. It’s crucial to state that, this also increased the cost burden borne by the electricity consumers. The development of the FIT mechanism unit cost for the supplied electricity may be seen in Figure 2:

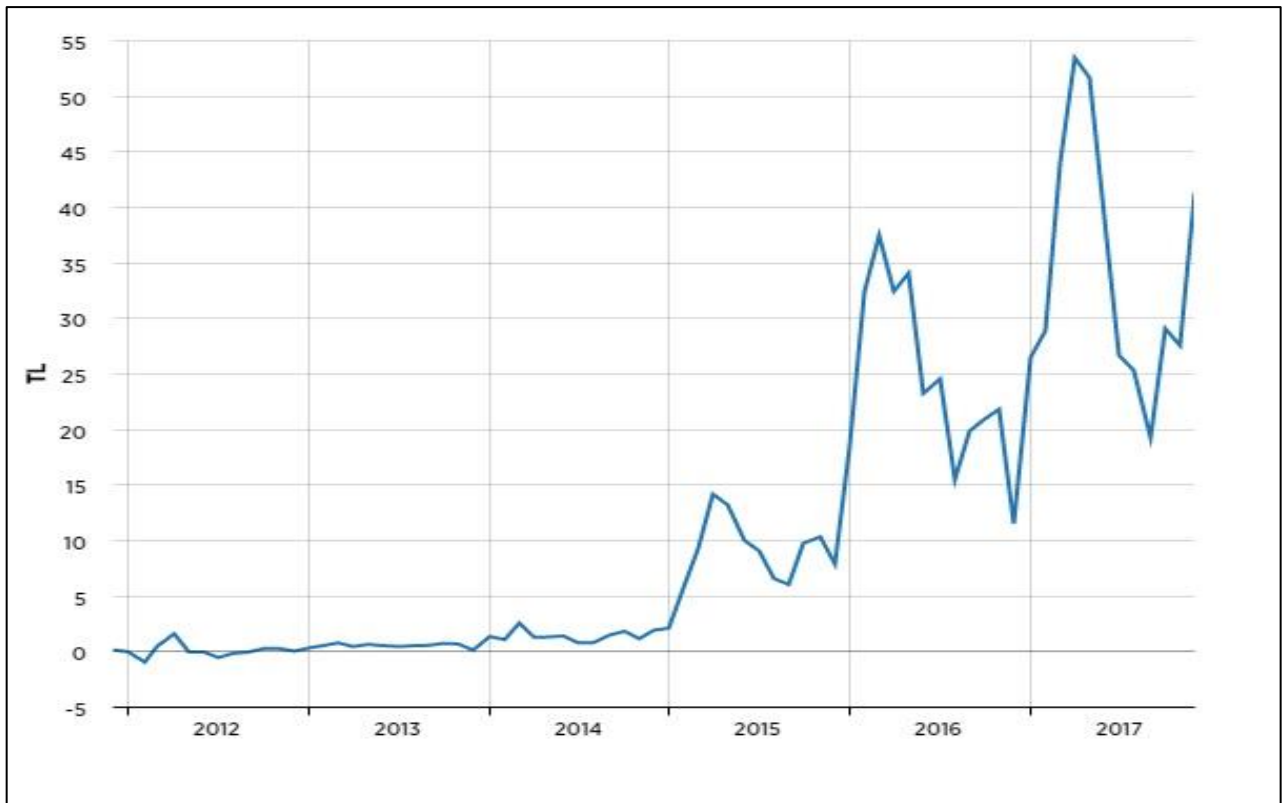


Figure 2.2. The Development of FIT Mechanism Unit Cost for the Supplied Electricity (EPIAS, 2018).

Therefore, electricity consumers have supported renewable energy and borne the cost of it whether they want it or not.

Many countries have supported solar generation through FIT which is critical to a project's ability to access financing. Particularly, the guarantee for grid connection and a secure purchasing price need to be confirmed for project finance. The length and the price of the agreement ensures bankability. At this point, consumer-based long terms power purchase agreements (PPAs) which is detailed in Section 2.3.1 can be a solution after the end of FIT mechanism.

## 2.2. Main Renewable Energy Support Mechanisms

In order to increase the deployment of renewable energy, support mechanisms have been applied by governments under renewable energy development programs. Mostly feed-in-tariffs (FIT), tax incentives, and tradable green certificates (TGC) are utilized as support mechanisms (Abolhosseini and Heshmati, 2014). The two of these policies have been applied mostly as having the major impact on renewable energy support: FIT and TGC systems.

Ringel (2006) analyzed the mostly applied support systems in the European Union (EU), including FITs and green certificates, to assess pros and cons in terms of ecological effectiveness and economic efficiency. It's concluded that both FITs and green certificates have a positive impact on enhancing the share of 'green' power production.

### **2.2.1. Feed-in Tariff**

FIT is a policy used as a support mechanism to stimulate renewable energy investments (Abolhosseini and Heshmati, 2014). Producers are paid a set price for electricity generated by renewable energy technologies (Butler and Neuhoff, 2008). It's a long-term purchase agreement which enables renewable energy investors to make long term projections for the financing of their projects. For this reason, FITs have an important role for investors to enter a market and compete for the new investments.

In EU, FIT scheme has affected the growth of primary production of renewable energy considerably which means an increase of 64% between the years 2007-2017 (Eurostat, 2019). As stated in the report "Performance and Impact of the Feed-in Tariff Scheme: Review of Evidence" by DECC, business birth rates in the UK power sector have increased significantly, since the introduction of the FIT in 2010. It's been emphasized in the same report that the private sector had invested nearly £30bn in renewable electricity, heating and transport fuels between 2010-2014, creating jobs more than 100,000 (REA, 2014). In Germany, the subsidies provided within the Electricity Feed-in Law (SEG) and Renewable Energy Sources Act (EEG) stimulated a significant growth in renewable electricity production. The renewable energy share increased from 3.1% in 1990 to 6.8% in 2000 and to 22.9% in 2012 under SEG and EEG.

According to Research Office Legislative Council Secretariat, FIT is a widely used policy which has been incentivized residential and businesses to install small-scale solar PV to generate electricity that is connected to grid. The policy has been applied around 110 locations globally. After FIT, the Australian and South Korean solar capacity increased by thirty-six and fifteen times, respectively in five years. In Japan, this has been realized as four times in three times. Zhang et al. (2014) evaluated the European FITs and Changing PV Efficiencies and Costs and they emphasized that FITs have influenced the development of PV and other renewable energy sources positively. At this point, FITs created an affordable market for independent power generators as providing a secure access to the national grid. In addition to this, they concluded that that FITs could be decreased or removed in the near future considering Levelized Cost of Energy (LCOE) values of current PV installations.

As of 2017, 113 countries (states) have adopted different types of FIT policies (REN 21, 2018). Table 2.4. shows the current situation chronologically. Text in bold indicates new/revised in 2017, and the countries with a minus indicates discontinuation.

Table 2.4. Countries which applied FIT policies (REN, 21).

Year	Cumulative	Countries/States
1978	1	United States (-)
1988	2	Portugal
1990	<b>3</b>	<b>Germany</b>
1991	4	Switzerland
1992	5	Italy
1993	7	Denmark; India
1994	10	<b>Luxembourg</b> ; Spain (-); Greece
1997	11	Sri Lanka
1998	12	Sweden (-)
1999	14	Norway (-); Slovenia
2000	14	[None identified]
2001	17	Armenia; France; Latvia
2002	23	Algeria; Austria; Brazil (-); Czech Republic; Indonesia; Lithuania
2003	29	Cyprus; Estonia; Hungary; Slovak Republic; Republic of Korea (-); Maharashtra (India)
2004	34	Israel; Nicaragua; Prince Edward Island (Canada); Andhra Pradesh and Madhya Pradesh (India)
2005	41	<b>China</b> ; Ecuador; Ireland; Turkey; <b>Karnataka</b> , Uttar Pradesh and Uttarakhand (India)
2006	46	Argentina; Pakistan; Thailand; <b>Ontario (Canada)</b> ; Kerala (India)
2007	55	Albania; Bulgaria; Croatia; Dominican Republic; Finland; Macedonia FYR; Moldova; Mongolia; South Australia (Australia)
2008	70	Iran; Kenya; Liechtenstein; Philippines; San Marino; Tanzania; Queensland (Australia); Chhattisgarh, Gujarat, Haryana, Punjab, Rajasthan, Tamil Nadu and West Bengal (India); California (United States)
2009	81	Japan; Serbia; South Africa (-); Ukraine; Australian Capital Territory, New South Wales and Victoria (Australia); Taipei (China); Hawaii, Oregon and Vermont (United States)
2010	87	Belarus; Bosnia and Herzegovina; Malaysia; Malta; Mauritius (-); <b>United Kingdom</b>
2011	94	Ghana; Montenegro; Netherlands; Syria; Vietnam; Nova Scotia (Canada); Rhode Island (United States)
2012	99	Jordan; Nigeria; State of Palestine; Rwanda; Uganda
2013	101	Kazakhstan; Pakistan
2014	104	Egypt; Vanuatu; Virgin Islands (United States)
2015	104	[None identified]
2016	104	Czech Republic (reinstated)
2017	107	<b>Zambia, Vietnam, Massachusetts (United States)</b>

Generally, FITs are flexible and can be structured according to needs of the market in which they're applied. Many countries are shifting from or revising down traditional fixed price levels. Developed countries have led emerging economies like Brazil and South Africa as adopting more competitive systems like renewable energy tenders. In Europe, a differentiated model has evolved as

result of European Commission State Aid guidelines. While large-scale projects or certain power supply systems are promoted by the way of tenders, small scale projects are still promoted through feed-in policies (REN21, 2018). Germany has started tenders for large-scale PV from 2015 by which low power purchase agreements (PPAs) have been provided. In China, the “Top Runner” program (tender with qualified PV modules using high efficiency modules) supported the installations of 5.5 GW in 2016 (IEA, 2017). In general, the cost of FIT payments made to producers are passed through the end users (electricity consumers).

### **2.2.2. Tradable Green Certificate (TGC) Systems**

While FIT is, Tradable Green Certificates are quantity-based and classified under quota systems. a price-based policy.

In these systems, a specific member - which may be a consumer, generator or supplier/retailer- of the electricity supply chain must provide a fixed minimum amount of certification annually, as determined by a public authority. These systems entitled as Renewable Electricity Standard, Renewables Obligation or Renewable Portfolio Standard. The certificates are issued per unit of electricity generated from renewable energy. The liable party may generate it by himself or buy certificates from the certificate market and then may pass through the cost of certificates to the electricity consumer (Fouquet and Johansson, 2008). The objective of these systems is that the renewable energy producer to be supported financially by selling the certificates to the liable parties in the market. And so, the target of the system is stated by the government and the certificate price is formed by the market (ECOFYS, 2007).

In UK, the renewable obligation which obliges electricity suppliers to procure a specified share of their electricity from renewable sources came into effect in 2002. Renewable Obligation Certificates (ROCs) are tradeable commodities that have no fixed price. The price is determined by a negotiation between the supplier and generator (OFGEM, 2018). On the other hand, the mechanism was closed to all new power plants from 31 March 2017. It had already closed to largescale solar PV from 1 April 2015 and to onshore wind from 12 May 2016 (Smartestenergy, 2018).

According to 2017 Annual Status Report by Berkeley Lab, approximately 50% of the renewable electricity generation and capacity growth in USA, has stemmed from Renewable Portfolio Standard (RPS) since 2000. Nationally, the role of RPS policies has reduced in due course that represents 44% of all U.S. renewable energy capacity additions in 2016. In addition to this, RPS policies still continue

to have an impact on renewable energy development, representing 70-90% of 2016 renewable energy capacity additions in the West, Mid-Atlantic, and Northeast. A joint Norwegian-Swedish certificate market for renewable electricity generation was established in 2012. The policy will be reviewed whether there is a progress every four years. In India, REC system has been started by the government to increase the share of renewable energy in total energy mix as of 2011. RECs are substantial to meet Renewable Portfolio Obligation targets for utilities and governments. Fixed RPO targets from 2010 to 2015 are as follows: In 2010, 5% of total energy generated from renewable sources, 6% in 2011, 7% in 2012, 8% in 2013, 9% in 2014 and 10% in 2015 (IEA, 2018).

In general, quota systems are considered as better than FIT mechanisms since the price is set by the market participants. For this reason, these systems are favoured in competitive power markets (Camadan, 2011).

Rather than an obligatory system, in China, green certificates have started to be issued as of July 1<sup>st</sup>, 2017. It's is a voluntary trading mechanism which is expected to make government subsidies easier for wind and solar energy. It's a pilot program in which utility-scale solar PV and onshore wind energy generators will obtain certificates for each 1 MWh to sell to private and publicly owned corporations. Renewable energy generators who prefer to receive green certificates must already be registered in the Ministry of Finance's subsidy recipients list. Electricity generators that sell certificates would not be eligible to receive subsidies (i.e. FIT). Finally, the green certificate's price is capped at the government subsidy price (IEA, 2018). Therefore, the producers are offered an option to choose between a fixed and a market price.

## **2.3. Voluntary Renewable Energy Support Mechanisms**

### **2.3.1. Corporate Power Purchase Agreements**

A power purchase agreement (PPA) is a contract in which an electricity customer or “off-taker” purchases power for a specified period and price from a renewable energy producer.

Direct and financial are two basic types of PPAs. In a “**direct**” PPA, the customer buys all the generated electricity (or the determined quantity) from the producer at the contracted rate. In general, direct PPAs are used for on-site projects where a third party owns and operates it. A **financial PPA** (may be defined as virtual PPA) is a contract in which the buyer provides a secure price to a renewable energy producer but does not directly receive the electricity generated from the plant. The buyer owns

green attributes (certificates) to verify that the electricity comes from renewable sources to support any claims about the purchase. The secure price enables the developer to guarantee his revenue and finance new projects. In a financial PPA, the producer sells the electricity production in the wholesale electricity market upon the market price. When the wholesale price is greater than the contracted price, then the producer settles the contract-for-differences by paying the difference to the buyer. When the wholesale price is less than the contracted price, then the buyer settles the difference by paying the deficit to the producer (NREL, 2017).

Miller et al. (2017) evaluated the link between LCOE and PPA structure for wind energy. It's suggested that it could make more sense to understand LCOE factors and PPA structure which would enable buyers and sellers make in point decisions for their unique project objectives and requirements. Regarding Corporate PPAs, corporates' precisions and objectives may differ. Unlike utilities, corporate buyers generally have different energy demands and may be willing to buy a specific amount of the energy generated by the power plant. A typical long term PPA could be challenging for corporations to make a commitment since economic situation, shareholder structure and management could change over that time period. In addition to this, PPAs with shorter durations may not be financially attractive and satisfy the requirements of lenders. As a solution, the project generation may be sold to various corporate buyers with multiple PPAs in order to secure financing.

2017 was another record year for renewable corporate PPAs, with over a volume of 5.4 GW globally. The US is still leading the market, by having developed more than 3.1 GW of renewable corporate PPA volumes in 2017. Sustainability attempts and the upward trend of cost-competitiveness of renewables have led the increase of corporate PPAs. Figure 3 shows the development of Global Corporate PPAs, by region (SolarPower Europe, 2018).



Figure 2.3. Global corporate PPAs, by region (BNEF, 2018).

As reported by Bloomberg New Energy Finance (BNEF), corporations entered into a record volume of PPAs for green energy in 2017. A total of 5.4 GW of PPAs were made in 10 different countries in 2017. This was 4.2 GW more than the volume realized in 2016. Approximately, half of this value represents the PPAs signed in the United States. 1 GW is coming from Europe and 95% of this volume consists of projects in the Netherlands, Norway and Sweden. Additionally, emerging markets also have interest and the first onsite corporate PPAs were signed in Burkina Faso, Eritrea, Egypt, Ghana, Namibia, Panama and Thailand.

### 2.3.2. Renewable Energy Certificates

These certificates are developed by voluntary initiatives as differently from the type explained in Section 2.2.2. Voluntary Renewable Energy Certificates (RECs) are issued not because of a requirement under national law or regulation. Therefore, it's not a product emerged for the aim of reaching a national renewable energy target. RECs are demanded by consumers who want to be a part of renewable energy support. Mostly, corporates demand these certificates as evidence of green supply which is set by their Corporate Social Responsibility programs.

Regarding EU, the REC system has been developed as a voluntary system for trade of renewable energy certificates to trigger international development of renewable energy. It provided a standard which would prove the production of renewable energy. The established methodology enabled renewable energy trade and market and thus supported the development of new renewable energy capacity in Europe. The certificates in RECS are issued for every 1 MWh of renewable energy

produced by the plant which has already been registered with the national RECS body. The certificates can be transferred between market participants located in different countries and are used to provide a proof for the renewable energy production (RECS, 2018). In 2017, the markets with the largest shares are Austria and Sweden with 100% and Norway, Switzerland, Spain and Finland all above 87%. These countries represent about 495,000 GWh of certificates into the market, 70% of the total issuing in 2017 (RECS, 2018).

In US, Voluntary Green Power Participation is the reason for unbundled renewable energy certificates demand. As a renewable energy generator produces a megawatt-hour of output, the electricity may be sold in electricity market and the REC may be separated and sold in the REC market named as “unbundled”. In general, large non-residential customers demand unbundled RECs. In average, 610 MWh of unbundled RECs were bought by REC customer in 2015. To compare, a standard home uses around 10 MWh/year. Between 2016 and 2017, the average demand volume of unbundled REC fell as more residential and small commercial clients started to buy unbundled RECs. The sale of unbundled REC went down to 420 MWh/customer in 2016 and to 270 MWh/customer 2017 (NREL, 2018).

### **2.3.3. Voluntary Carbon Offsets**

CO<sub>2</sub> emissions avoided through the production of renewable energy, represent an economic value via the carbon credit system of the market mechanisms that have been created under UNFCCC which was adopted in 1992. This arrangement allows industrialized countries which are the largest emitting ones (denoted as Annex 1 countries) to compensate their emissions by investing in cleaner technologies and projects that clearly mitigate emissions in developing countries (denoted as Non-Annex 1 countries). In this system, the renewable energy projects are susceptible to gain carbon credits due to their implicit greenhouse gases reduction in emissions and a carbon credit represents a ton of CO<sub>2</sub> avoided. Countries with emission reduction commitments under the Kyoto Protocol of UNFCCC are designated to cap or reduce greenhouse gas emissions have to achieve their targets as applying national plans or actions. Additionally, the Kyoto Protocol brought three mechanisms, that are market-based, thereby creating carbon market in which CO<sub>2</sub> emissions avoided are priced and traded to offset CO<sub>2</sub> emissions. This market is also entitled as compliance market (UNFCCC, 2018).

Carbon offsets are demanded voluntarily by mostly corporates and people that take responsibility for offsetting their own emissions and organizations that prior to emissions reductions are obliged by

regulation. Corporate social responsibility, ethics and reputation or supply chain risk are the main consideration of voluntary buyers (Ecosystem Marketplace, 2018).

Offsets can be produced including the activities; installing renewable energy infrastructure such as wind turbines or solar panels and planting trees that remove and store carbon from the atmosphere. Project types are grouped by Forest Trends' Ecosystem Marketplace into eight categories as listed below.

Table 2.5. Categories of voluntary carbon projects, 2005-2018 (Ecosystem Marketplace, 2018).

<b>Project Categories</b>	<b>Projects with Issued Offsets</b>	<b>Volume of Offsets Issued in MtCO<sub>2</sub>e (2005 - Present)</b>	<b>New Projects (Q1 2018)</b>
<b>Agriculture</b> – modifying agricultural practices to reduce emissions by switching to no-till farming, reducing chemical fertilizer use, etc.	87	6.7	1
<b>Chemical Processes and Industrial Manufacturing</b> – modifying industrial processes to emit fewer greenhouse gases.	72	63.5	0
<b>Energy Efficiency and Fuel Switching</b> – improving energy efficiency or switching to cleaner fuel sources.	633	127.9	8
<b>Forestry and Land Use</b> – managing forests, soil, grasslands, and other land types to avoid releasing carbon and/or increasing the amount of carbon the land absorbs.	170	95.3	3
<b>Household Devices</b> – distributing cleaner-burning stoves or water purification devices to reduce or eliminate the need to burn wood (or other inefficient types of energy).	161	23.4	0
<b>Renewable Energy</b> – installing solar, wind, and other forms of renewable energy production.	611	61.9	2
<b>Transportation</b> – increasing access to public and/or alternative transportation (like bicycling) and reducing emissions from private transportation like cars and trucks.	43	1.1	0
<b>Waste Disposal</b> – reducing methane emissions from landfills or wastewater, often by collecting converting it to usable fuel.	238	57.5	0

Issuances reflect the volume of emissions reductions verified under a standard. The volumes of offsets issued, transacted, and retired are important factors for determining the size of the market, but none of them are satisfying indicators of the overall carbon reductions and contributions made by voluntary carbon reduction projects aiming to combating climate change. A total of 2,015 projects have issued offsets, mainly in Asia (51%) and North America (18%). Both Europe (“Europe” here refers to all European countries, whether or not they are within the European Union (EU), as well as

Turkey) and Africa have the share of 11%. Since 2005, these projects have contributed to reduce or prevented over 437.1 MtCO<sub>2e</sub> which may be defined as voluntary markets' environmental impact (Ecosystem Marketplace, 2018).

As Turkey was seen as a developed OECD country, when the Convention was signed, it's listed in Annex I. Due to its special circumstances, Turkey has been differentiated from other countries and could not benefit from market-based mechanisms of Kyoto Protocol (MFA, 2018). Therefore, voluntary carbon market has been an attractive option for Turkish carbon reduction projects and since 2005 Turkey has been hosting voluntary carbon projects. According to the latest data published by the Ministry of Environment and Urban Planning (MEUP), 308 projects exist in the market as of 2014, April. The projects types may be seen in Table 2.6.:

Table 2.6. Voluntary Carbon Reduction Projects Developed in Turkey (MEUP, 2014).

<b>Project Type</b>	<b>Number</b>	<b>Annual Emission Reduction (tCO<sub>2</sub>/yr)</b>
Hydroelectric	159	8,747,634
Wind	106	7,951,391
Landfill/Biogas	27	3,069,273
Energy Efficiency	10	432,081
Geothermal	6	405,309
<b>Total</b>	<b>308</b>	<b>20,605,688</b>

In addition to this, according to the latest data published by Forest Trends' Ecosystem Marketplace, in 2016, carbon reductions from Asia and non-EU European countries (Georgia, the Russian Federation, and Turkey) were mostly from renewable energy projects (11.8 Mt CO<sub>2</sub> e and 1.3 MtCO<sub>2e</sub>). And voluntary projects from Turkey transacted 1.9 MtCO<sub>2e</sub> at an average price of \$1.1 per tonne. This means a revenue of \$2M for renewable energy project in addition to electricity sales. Regarding solar energy, data obtained from the Markit Registry shows that 5 solar energy projects from Turkey have been developed as a carbon project under Gold Standard. Gold Standard: A standard which was established in 2003 by WWF and other international NGOs. The aim of the standard is to provide carbon reduction projects to contribute to sustainable development while reducing carbon emissions. This corresponds to an installed capacity of 33,7 MW which benefits carbon market. In global, the share of solar energy projects in carbon market may be seen in Figure 2.4.:

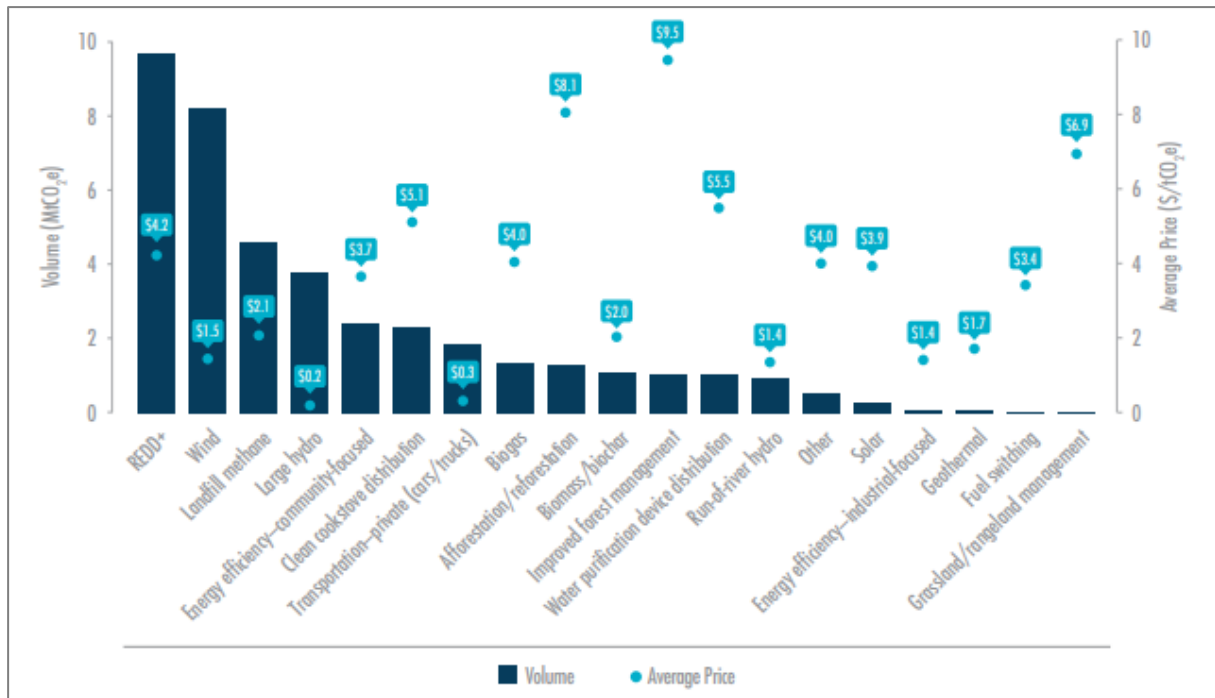


Figure 2.4. Transacted Volume, Average Price, and Price Range by Project Type, 2016 (Forest Trends' Ecosystem Marketplace, 2017).

In 2016, a volume of 256.700 tCO<sub>2e</sub> has been transacted at an average price of \$3.9/tonne and thus creating a value of \$ 1M in 2016.

Benessaiah (2012) assessed the voluntary carbon markets and insisted on the necessity for enabling and connecting organizations. The importance of the definition of carbon rights, monitoring progress and enforcement of investments in both mitigation and sustainable development goals as being responsive to changing social ecological systems depend on the cooperation and strong relationship between the related bodies. While funding which constitutes as a first step for a transparent carbon value chain, more attention should be paid to the positions of intermediates.

Wang et al. (2018) researched the potential carbon emission reductions and financial feasibility of urban rooftop photovoltaic (PV) power applications studying a case in Beijing. While the potential of rooftop PV power generation in Beijing is varying from 3,298.48 to 6,734.32 MWh/y, the annual CO<sub>2</sub> emission reduction is expected to be 3.03-6.19 Mt. Governmental subsidies are needed for the initial investment of urban rooftop PV applications and have a crucial role in its financial feasibility. The options, environmental tax and emission trading are suggested for the internalization of environmental benefits of solar energy. Where the carbon price for the three price levels is 4 to 8 times higher than the current one, it is assumed that the projects will pass the financial feasibility test.

Sahu (2014) analyzed the global renewable energy, regional renewable energy status and country specific renewable energy status. He found that these countries mainly designed their policies through tools such as FIT, RPSs, net metering, quotas with green certificates, country based national renewable energy targets, Investment Tax Credit (ITC), market incentives and auctions for the development of solar energy. The fact that most of the manufacturing companies are in China has provided more benefits for China compared to other countries.

Crago and Koeglerb examined how policy incentives impacted capacity growth of solar commercial solar market. They've concluded that factors which directly affect financials and returns on investments impacted capacity growth in the commercial solar PV market at most. Supports such as reducing cost or providing revenue such as sales tax reductions, refunds and solar renewable energy credits price are significant.

#### **2.4. Main Renewable Economics of Solar PV**

The economic returns received by a PV investment can vary according to market segments. PV price differences and revenues from each market segment could be the reasons, however the economic performance factors used to characterize PV value could result in this. A typical system payback time that is longer than 10 years (NREL, 2011).

Policymakers generally consider LCOE and “grid parity” to assess the cost competitiveness of renewable energy while evaluating national energy policies. LCOE of an energy source is calculated through dividing the lifetime generation cost by the total electricity generated and adjusting it with time preference. Grid parity is achieved when an energy is generated at prices at or below the applicable price in the market, which shows profit presence (Tao&Finenko, 2016). LCOE is used mostly when comparing electricity generation technologies or evaluating emerging technologies in the market.

This method is based on degrading financial flows to a common basis, considering the time value of money. Simply, the LCOE is the electricity price required for a project where revenue would balance costs, including a return on capital invested equal to the discount rate. An electricity price above this would bring a better return on capital, while a price below it would mean a lower return on capital, or maybe a loss (IRENA, 2012).

Over the last decade, the rate of cost reduction has been impressive. 73% decrease between 2010 and 2017, from \$0.36 to \$0.10/kWh in LCOE of utility-scale PV plants is estimated. Reduction in total installed costs has been the main reason which reached to 68% during this period (IRENA, 2018).

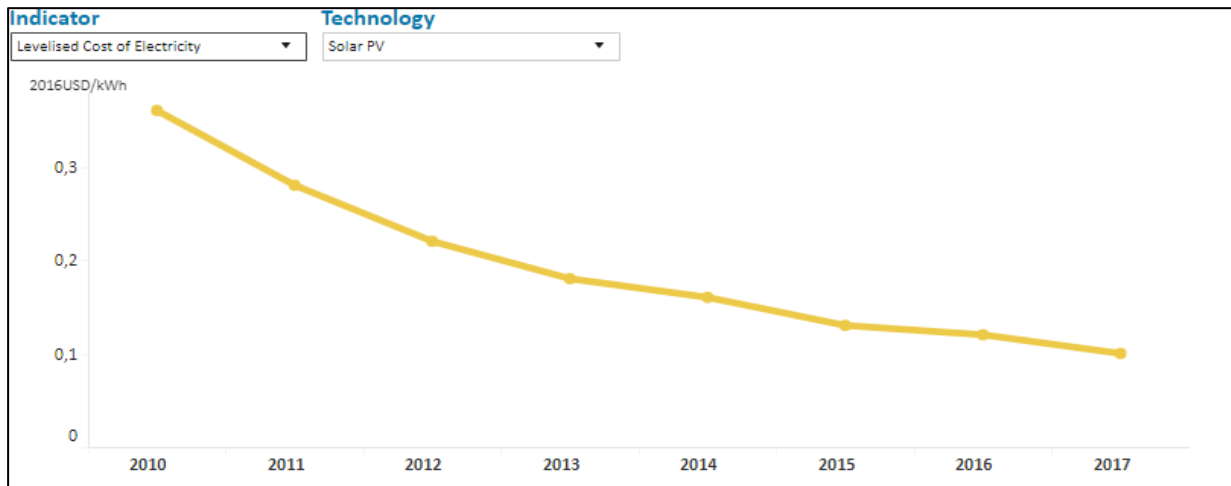


Figure 2.5. Global Levelized Cost of Electricity, 2010-2017 (IRENA, 2018).

Considering the PV module costs trends, module costs decreased by %80 between 2010-2016. While a sharp decrease has been experienced until 2013, mild cost reductions have been observed thereafter. Improvements in PV module production processes and increased efficiency as a result of latest cell designs caused cost reductions. This triggered PV module manufacturers to bring to more sustainable price level. During this period, crystalline silicon wafer based commercial module average efficiencies have increased from about 12% to 17-17.5%. 24.4% efficiency can be reached by the modules that have the highest performance in the laboratory. The factors such as cell spacing, module border, cell interconnection and cover reflection cause at least 2% efficiency loss. Though, the capacity growth and expansion of manufacturing scale have a significant role in low costs (IRENA, 2018). Figure 2.6 shows the movement of solar PV modules:

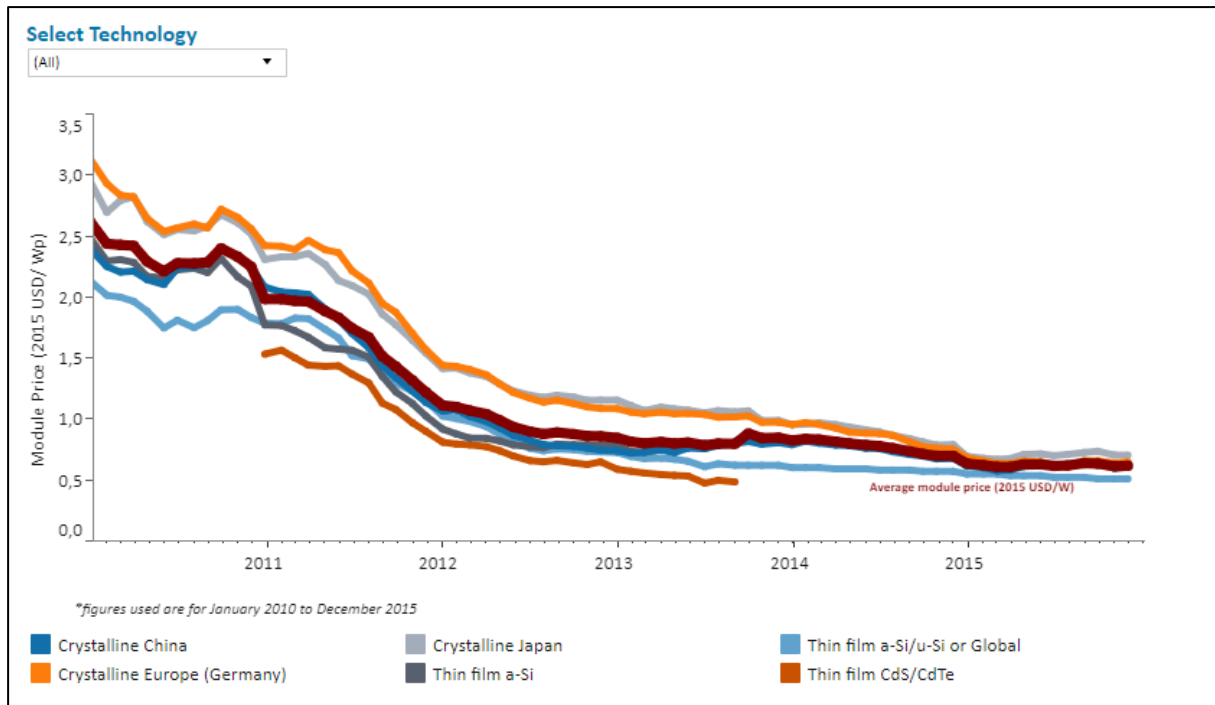


Figure 2.6. Solar PV Module Prices, 2010-2015 (IRENA, 2018).

The total costs of installing a PV system, electricity price, and the energy payback time are the most important PV economic metrics. A study conducted by Cebeci (2017) reveals that the LCOE of a PV plant in Turkey with an installed capacity of 1 MW as 0.0973 USD/kWh. 25-year lifetime was anticipated for the system. The results of financial analysis of an investment is affected by the lifetime, importantly. In the study, LCOE decreases to 0.8709 USD/kWh, as the economic lifetime of the plant increases by 5 years. And it increases to 0.9668 USD/kWh, as the economic lifetime of the plant decreases by 5 years.

The report, *The Power to Change: Solar and Wind Cost Reduction Potential to 2025*, by IRENA, identifies cost reduction potential for PV systems out to 2025 using 2015 cost reference levels. While this industry matures in more markets world-wide and increasing competition is seen, in supply chain margins and profit earned by suppliers, manufacturers, distributors and retailers decreased.

According to the report, while new and emerging markets will be staying in the high-cost category by 2025, the others will shift from high cost to mean and from mean cost to low cost structures. It is crucial to state that policy measures required to achieve this scenario have not been studied by the report. The global weighted average LCOE of solar could decline by 59% as from \$0.13/kWh in 2015 to \$0.055/kWh by 2025 based on the assumptions that installed PV system costs and operation and maintenance reduce and the global weighted average capacity factor increases from 17.9% in 2015 to 19.3% in 2025.

## 2.5. Main Germany and China as Country Samples

### 2.5.1. Germany

Germany is one of the largest solar power producers by the end of 2017. With an installed PV capacity of almost 43 GW, the country listed as 4th in the world after leaving the first place to China in 2015 depending on IRENA country rankings.

In 1990, Feed-In Law which brought FITs to promote investment in renewable energy sources entered into force. The law obliged utilities to connect renewable energy producers into the grid and to purchase the electricity at rates of 65% to 90% upon the determined tariff for final customers. A single tariff was applied to all kinds of renewable energy technologies (Morey and Kirsch, 2014).

Renewable Energy Act (EEG-Erneuerbare Energien Gesetz) in 2000 paved the way for the boom in solar power capacity. The EEG provided renewable energy investors secure returns during 20 years through FIT mechanism. (Clean Energy Wire, 2019). EEG was revised in 2004, 2009, 2012, 2014 and 2017 in accordance with the changes in renewable energy economics. The act has set a generation target 40-45% of electricity supply from renewable energy resources by 2025 and 55-60% by 2035, 80% by 2050 (BMW, 2018).

The 2012 amendment set a “floating cap” on solar power, limiting it to 2.5 to 3.5 GW annually and an overall target of 52 GW of PV power to be compensated in accordance with the FIT. Until 2012, there wasn't any limitation for the new renewable installations in Germany. A renewable power installation could be installed, wheresoever the planning permission was taken and assumed as profitable. This resulted in an uncontrollable solar capacity growth with 7.5 GW in 2011 and therefore a “floating cap” was introduced. An extra decrease of tariffs was brought as a revision of the degression scheme reducing tariffs by 1% on monthly basis. Roof-top facility was introduced as a new category and the total power limitation of 10 MW was introduced and then it was determined as the absolute cap by the 2014 amendment (IEA, 2014; Clean Energy Wire, 2019). With the 2014 amendment, FIT was restructured. The new system was redesigned as a “contract-for-difference” scheme which required most of the producers to market their electricity directly instead of a fixed FIT payment paid to the renewable energy producers in Germany. The scheme obliged producers to sell their production into the market and producers received an additional compensation. This compensation is a premium which is equivalent to the difference between the average monthly wholesale price in the market and the tariff for renewables stated in the law (Clean Energy Wire,

2019). The amendment also brought a competitive bidding model (tenders) instead of a payment set by the government. As of 2017, as a result of the amendment, the investors would be offered the right to install renewable energy plants who bids the lowest price for the electricity produced. However, the model was not detailed within the amendment.

As expressed by the 2014 amendment, the 2017 Renewable Energy Sources Act brought an auction system which changed the way that renewable energy is funded. The mechanism will work as the participants who bid the lowest price for producing electricity from renewable energy would receive funding. Auctions are available to participant as diverse as possible from large companies to energy initiatives by citizens. Regarding PV installations, competitive auctions will be applied for ground-mounted and large roof-top PV installations greater than 750 kW. The installations lower than 750 kW will continue to be remunerated upon the fixed price levels set by the government (BMW, 2018).

### **2.5.2. China**

China has the highest PV installed capacity with 131 GW by the end of 2017. China's rapid deployment of 53 GW led the solar PV's global record growth in 2017. This capacity in China is supported by FIT (IEA, 2018).

In the late 1990s and early 2000s, solar PV market expansion was driven mainly by the Brightness and Township Electrification Programs in China. With the Brightness Program (1996), usage of PV modules and wind turbines for daily requirements of the community (23 millions) to be met was aimed. The targeted capacity was 100 W for each individual. Further, requirements of public utilities and residents of non-electrified remote towns, in Western China, Township Electrification Program was initiated in 2002. 688 towns were determined for the installation of solar PV systems totaling to capacity of 20 MW. Through the program a transition starting from pilot applications to actual projects that would provide rural electrification was realized. The program has triggered the development of China's solar PV industry (Zhang and He, 2013).

In 2009, two national solar incentive programs named as the Rooftop Subsidy Program and the Golden Sun program were announced by the Chinese government. Under these programs, a specified proportion of the investment costs of the PV installations which satisfied the determined criteria was compensated by the government. PV applications were tried to be used in buildings and areas without grid connection and the use of PV cells above certain efficiency levels was encouraged. Through the

programs 50% of the total cost of on-grid systems and 70% of the total cost of off- systems were subsidized (Wang et al., 2018).

In 2009 and 2010, the government initiated a two-stage public procurement process for solar energy projects. The first public tender was organized for a 10 MW project and the second one was realized with a cluster capacity of 280 MW. Since the bid prices were lower than the solar energy sector participants expected, the investment decision of investors companies and equipment suppliers were affected, negatively. As a result of pressures and lobbying of solar equipment suppliers for better incentives, the first national FIT scheme was announced by The National Development and Reform Commission in 2011. First, a single FIT ratio was determined for all of the solar energy systems. With the FIT renewed in 2013 states are divided into three groups according to the average annual irradiation value of the region and the cost of installation. Applied for 20 years purchase guaranteed tariffs are 0,90 RMB/kWh (14.4 USDcent/kWh), 0,95 RMB/kWh (15.2 USDcent/kWh) and 1 RMB/kWh (16 USDcent/kWh) for the three states, respectively. A separate tariff was determined for the distributed solar PV power systems as China is 0.42 RMB/kWh (6.72 USDsent/kWh) (Zhang and He, 2013; Qiang et al, 2014).

China's overall energy policy is determined by five-year plans. By the 13th Solar Energy Development Five Year Plan (2016-2020), installed capacity of solar PV to reach at least 105 GW with a cost reduction of 50% by 2020 in comparison to 2015 costs. The plan also emphasizes further deployment of distributed PV by its increased usage in agriculture, building and fishery sectors (IEA, 2018).

In 2017, National Development and Reform Commission, the Ministry of Finance and the National Energy Administration prepared the “2018 Solar PV Power Generation Notice” which brings quota restrictions on distributed generation capacity of 10 GW, reduced FIT levels and movement toward auction-led solar electricity tariffs. The system obliges electricity users like grid companies, electricity retail companies, and large end-users to purchase a percentage of their electricity from renewable energy. Users will need to show that they have met their obligations by buying renewable energy certificates (RECs), that are issued to renewable energy producers for the electricity they produce (PV Magazine, 2018; IEA 2018).

### 3. MATERIALS AND METHODS

This study aims to find out if environmental markets could provide incentive for solar energy projects and to compare continuation and non-continuation of FIT mechanism (YEKDEM).

#### 3.1. Survey

To assess how renewable energy investors' motivation would be affected without a fixed electricity purchase price secured by regulations, a 10-question survey have been sent to investment companies which have the largest share in renewable energy investments. The survey has been conducted through Survey Monkey which is an online survey tool to capture the voices and opinions of the targeted people.

The questionnaire below has been sent to the investors:

- 1) Would the end of FIT (YEKDEM) affect the new solar energy investments?
  - Yes
  - No
  - Other (please specify)
- 2) If you replied question 1 as "Yes", do you think that it would decelerate the new investments?
  - Yes
  - No
- 3) How would you want to commercialize your electricity production after YEKDEM?
  - Through long term fixed price power purchase agreements (PPAs)
  - Sell the production to the spot electricity market without additional incentive
  - Sell the production to the spot electricity market with an additional incentive
  - Other (please specify)
- 4) Would you prefer to market your electricity production by yourself?
  - Yes
  - No, a regulatory mechanism is needed
  - Other (please specify)
- 5) Would environmental markets ease the transition to post YEKDEM era?
  - Yes
  - No, a regulatory mechanism is needed
  - Not sure

6) Do you think that you could benefit from environmental markets?

- Yes
- No
- Other (please specify)

7) If you replied question 6 as "Yes", from which market do you think you could benefit?

8) Would you prefer a green certificate as a secondary product or a representative of the electricity you produce?

- As a secondary product
- As a representative of the produced electricity
- I don't know anything about it

9) Do you think that Corporate Power Purchase Agreements (PPAs) could support the investment of solar energy projects?

- Yes
- No
- Maybe
- I don't know anything about it

10) What is the major risk or barrier to development of solar power capacity?

The survey results are analyzed Section 4. Results.

### **3.2. SWOT Analysis of Solar Energy Development**

Considering these results and the developments in solar energy sector, a SWOT (Strength, Weakness, Opportunity, Threats) analysis has been conducted and may be seen in Section 4. Through the SWOT analysis, a capacity for solar energy deployment in Turkey is identified and the necessity of regulatory improvements is highlighted to strengthen Turkey's solar energy sector to compete in the global renewable energy market.

SWOT analysis is one of the most important tools make decisions throughout strategic management process, due to facts can deriving from internal and external analysis can explored and collected (Babaesmailli et al. 2012). As the environmental threats and opportunities for an organization are considered by external analysis, internal analysis allows an organization to determine its organizational strengths and weaknesses (Gürel and Tat, 2017). Strengths discloses existing sources which can contribute to an additional development in case that they're utilized. Threats are the external factors that may cause problems (Chen et al., 2014). The optimum combination of

strategies which maximizes the strengths and opportunities and minimizes the weakness and threats is revealed through the method.

In the energy management field, SWOT is generally used to analyze energy situations of a single region or system and evaluate the policies. While current energy policies, strategies and environmental concerns are being considered, key factors are defined in the context of SWOT analysis. This study intends to solar energy policies and development in Turkey by employing the SWOT analysis. Publicly available energy generation capacity scenarios of Turkish governmental bodies are also taken into consideration.

## 4. RESULTS AND DISCUSSIONS

### 4.1. Results of the Survey

#### 4.1.1. Impact of FIT (YEKDEM) on Solar Investments

All of the respondents answered as the end of the FIT mechanism would affect the new solar investments, see Figure 4.1. The thinking behind this may be unpredictability due to loss of a purchase guarantee through a fixed price which is secured for 10 years.

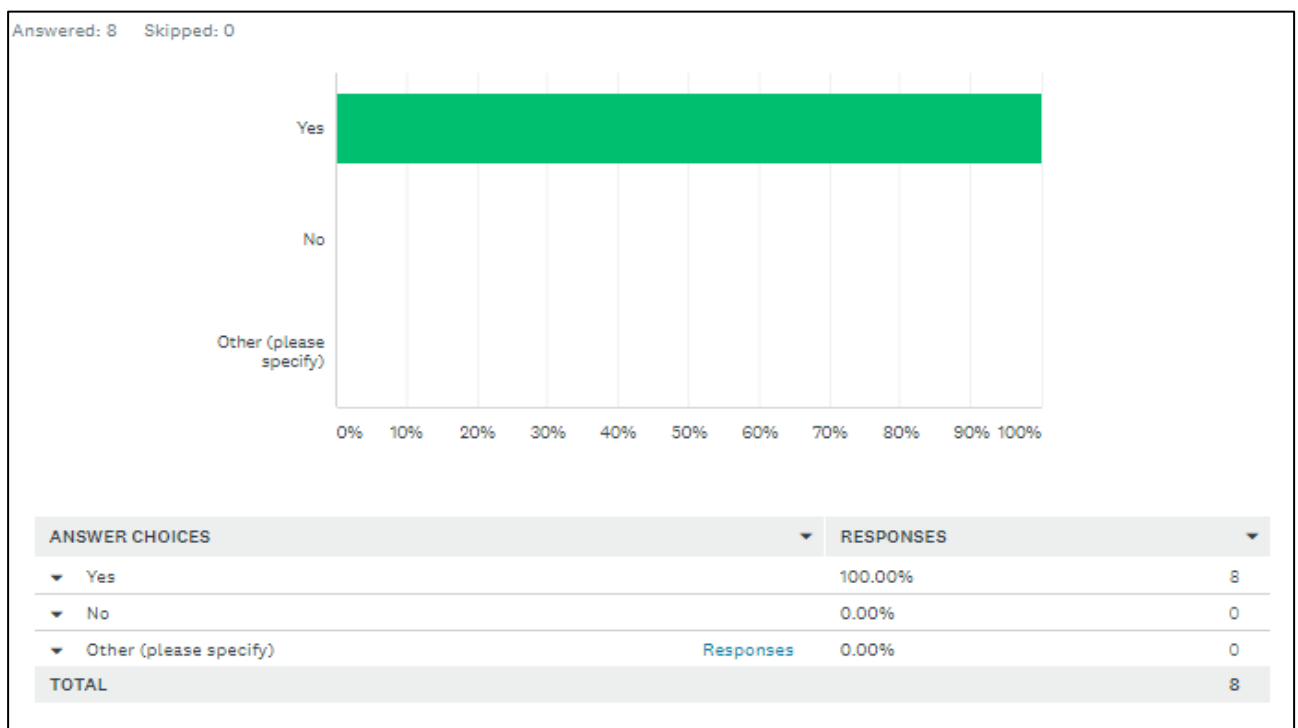


Figure 4.1. Responses to Q1: Would the end of FIT (YEKDEM) affect the new solar energy investments?.

The answers given to the Q2 asking if the end of FIT mechanism would decelerate the new investments reveals a prevailing visibility that the investors give importance to a secure environment for new investments. As regulated under the Law on Utilization of Renewable Energy Sources, the renewable energy power plants benefitted for their first 10 year of operation. This incentive has constituted the major guarantee by the banks to supply project finance. Uncertainty after 2020 - the deadline for Renewable Energy Support Mechanism is determined as December 31<sup>th</sup>, 2020 in the

Renewable Energy Act of Turkey - is defined as a barrier for the development of new projects by the majority.

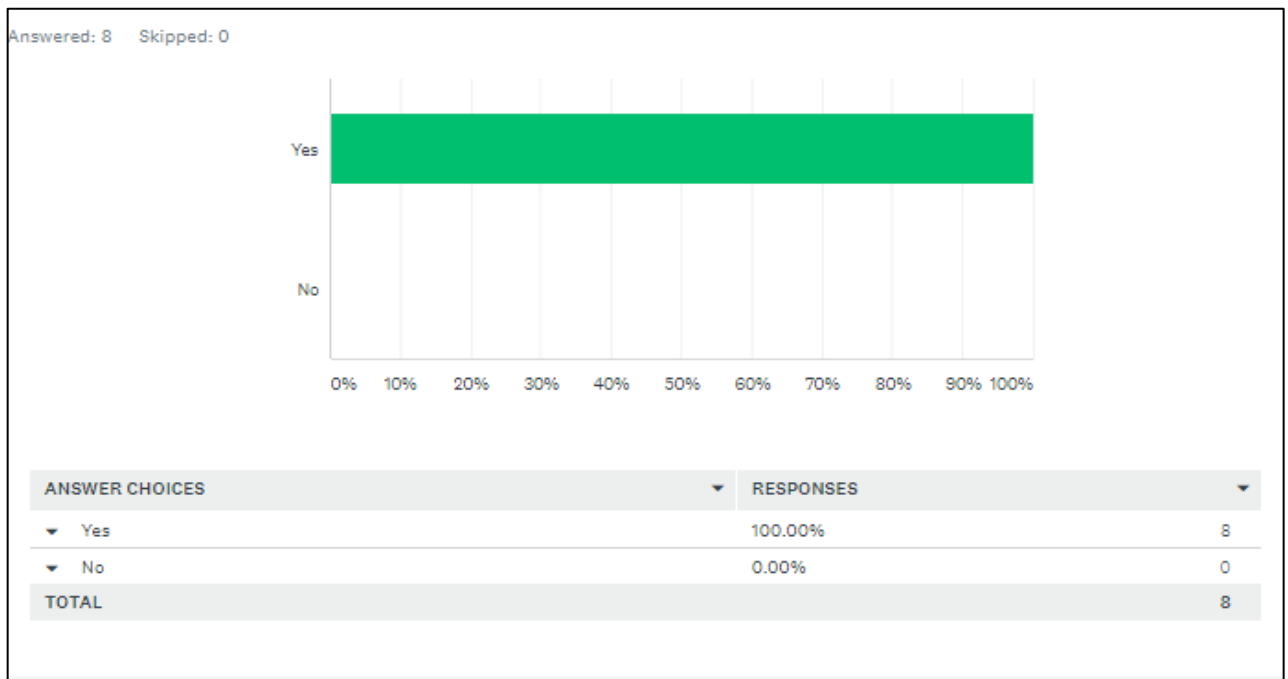


Figure 4.2. Responses to Q2: If you replied question 1 as "Yes", do you think that it would decelerate the new investments?.

#### 4.1.2. Commercialization of Electricity Production after FIT (YEKDEM)

As it's seen through Figure 4.3, most of the respondents (62.5%) prefers to sell their electricity production through a long-term fixed price power purchase agreement (PPA) after the FIT mechanism. As mentioned before, PPA entails a contract between the renewable energy producer and the consumer to sell them a specific amount of energy at a set price for a fixed duration. While consumer demand is growing for environmentally responsible products and services, more corporates are interested in use of green energy. Considering that 2017 has been a record year for renewable corporate PPAs, the answers of the respondents are not surprising. However, it's crucial to state that Turkish consumers' readiness or willingness to invest in renewable energy by such a long-term contract is a question mark. Additionally, corporates willing to commit to long-term PPAs are only interested in new-build rather than existing facilities, according to information from market players.

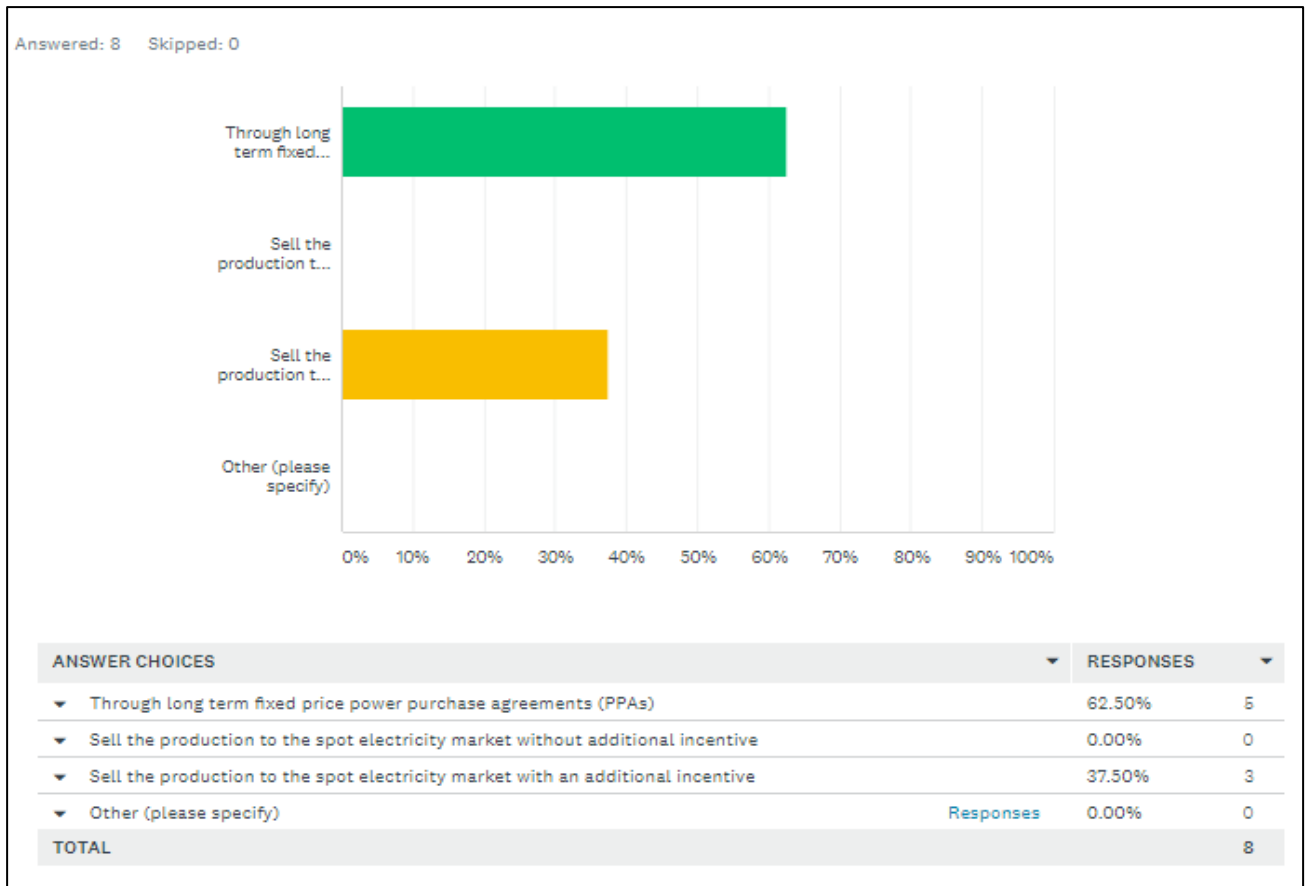


Figure 4.3. Responses to Q3: How would you want to commercialize your electricity production after FIT (YEKDEM)?.

A considerable share of the respondents (37.5%) prefers to sell their production to the spot electricity market with an additional incentive. Herein, feed-in premium can be applied. Feed-in premium is an incentive mechanism which is dependent on the spot electricity market. Producers are paid a premium which enables them to be compensated above the market price. The value of the premium can be constant or variable. This mechanism keeps the renewable energy producers against low prices and thus losses while avoiding them to get high rewards despite low market prices. Payment caps and/or floors can be set (Georgopoulos and Issaias, 2012). These respondents believe that they can manage their revenue from the production in market conditions, however they would need to minimize the downside risks.

The answers to Q4 also support their opinion that they preferred a regulatory mechanism while they're commercializing their production. As may be seen through Figure 4.4, 50% of the respondents think that there should be regulatory structure. While 37.5% of them chooses to do it by themselves, 12.5% of them thinks that they could handle it with an additional incentive.

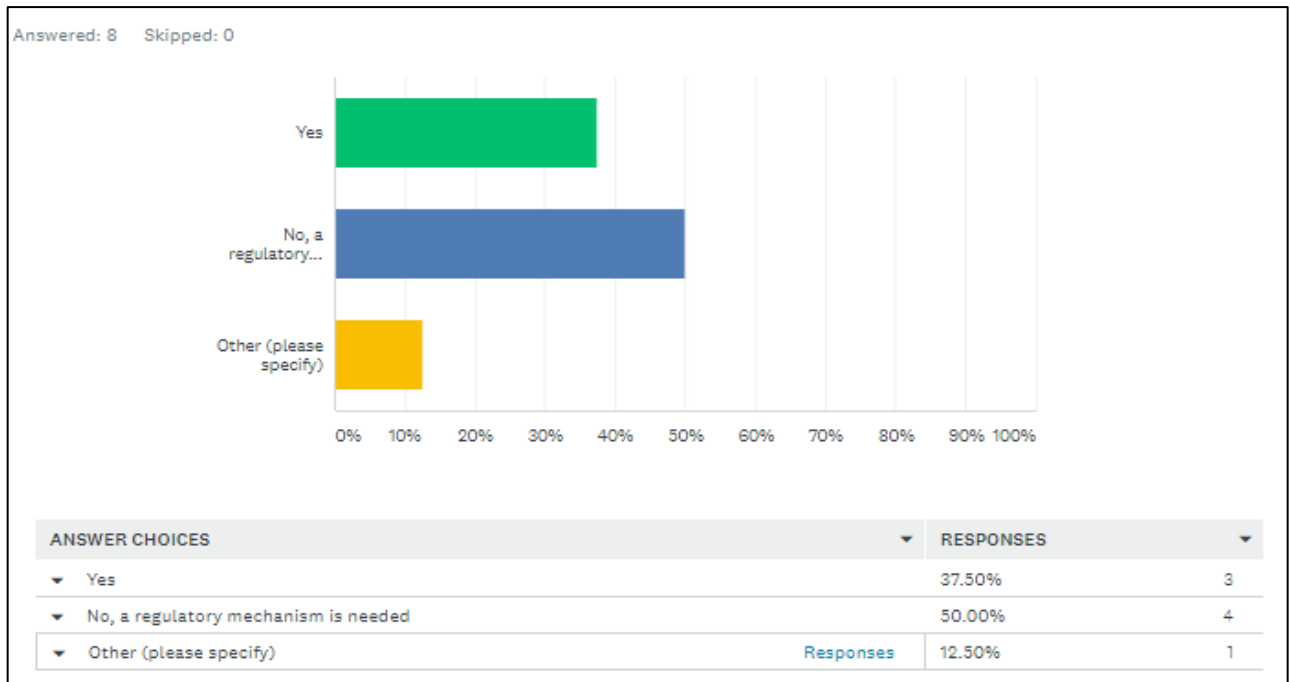


Figure 4.4. Responses to Q4: Would you prefer to market your electricity production by yourself?.

#### 4.1.3. Environmental Markets

“Q5: Would environmental markets ease the transition to post YEKDEM era?” has been asked to find out if they have an awareness of environmental markets and consider them as supportive to electricity markets which bring additional benefit to renewable energy producers. 50% of the respondents are not sure if the environmental markets ease the transition to post FIT (YEKDEM) era. This range is reasonable since majority of the respondents prefer a long-term fixed price to be remunerated and think that a regulatory mechanism was needed.

37.5% of the respondents consider the environmental markets as they would bring value for their electricity production and ease the transition after FIT (YEKDEM). Having looked at these respondents’ background, they are the market players who have experiences in voluntary carbon market (which is detailed in Section 2.3.3). They benefitted carbon revenue for their renewable energy production in the past. The “No” respondents’ share is 12.5% (Figure 4.5.)

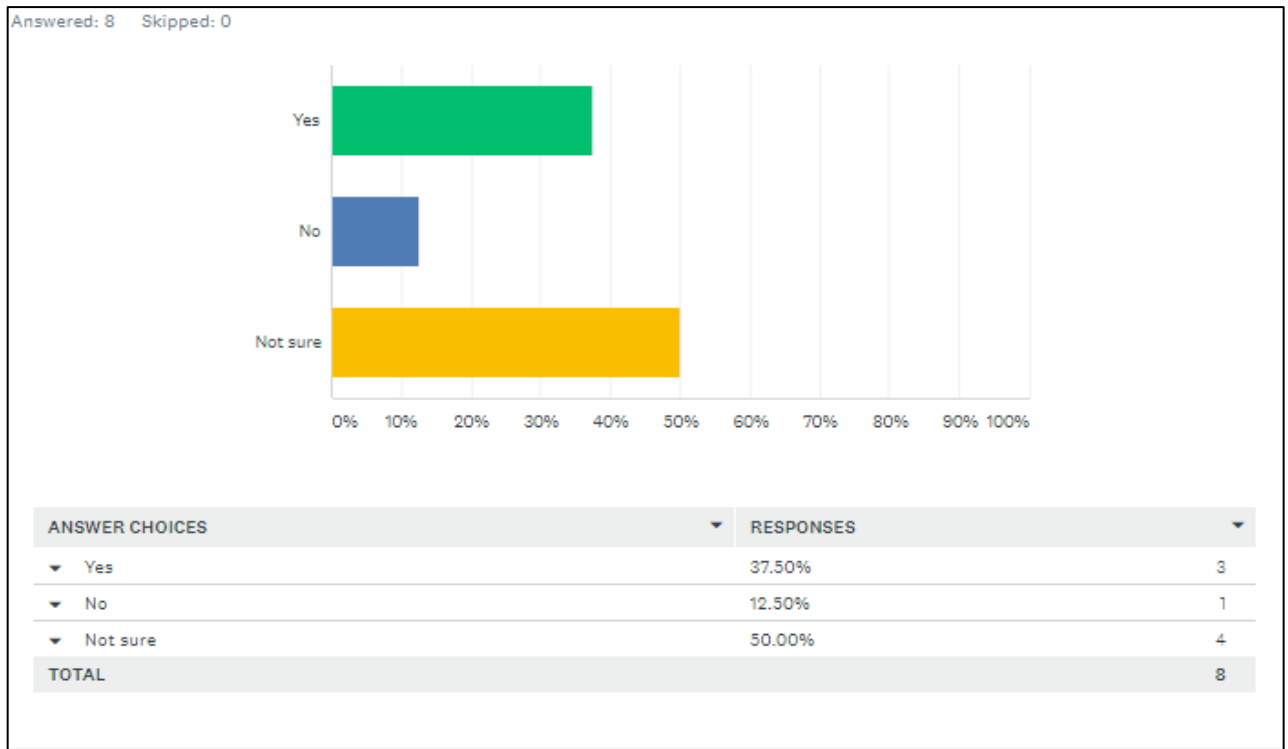


Figure 4.5. Responses to Q5: Would environmental markets ease the transition to post YEKDEM era?.

As may be seen in Figure 4.6, the majority of the respondents (75%) believe that they could benefit from environmental markets. Even most of them do not think that these markets would ease the transition after FIT, they consider them as a medium by which they could create value. In addition to the experiences in voluntary carbon market, the REC market developments in EU and US; and rising trend in renewable PPAs could have influence on this result. As mentioned before, 2017 was another record year for renewable corporate PPAs, with over 5.4 GW installed globally. Corporate PPAs have shown an increase due to cost-competitiveness of renewables and sustainability approaches.

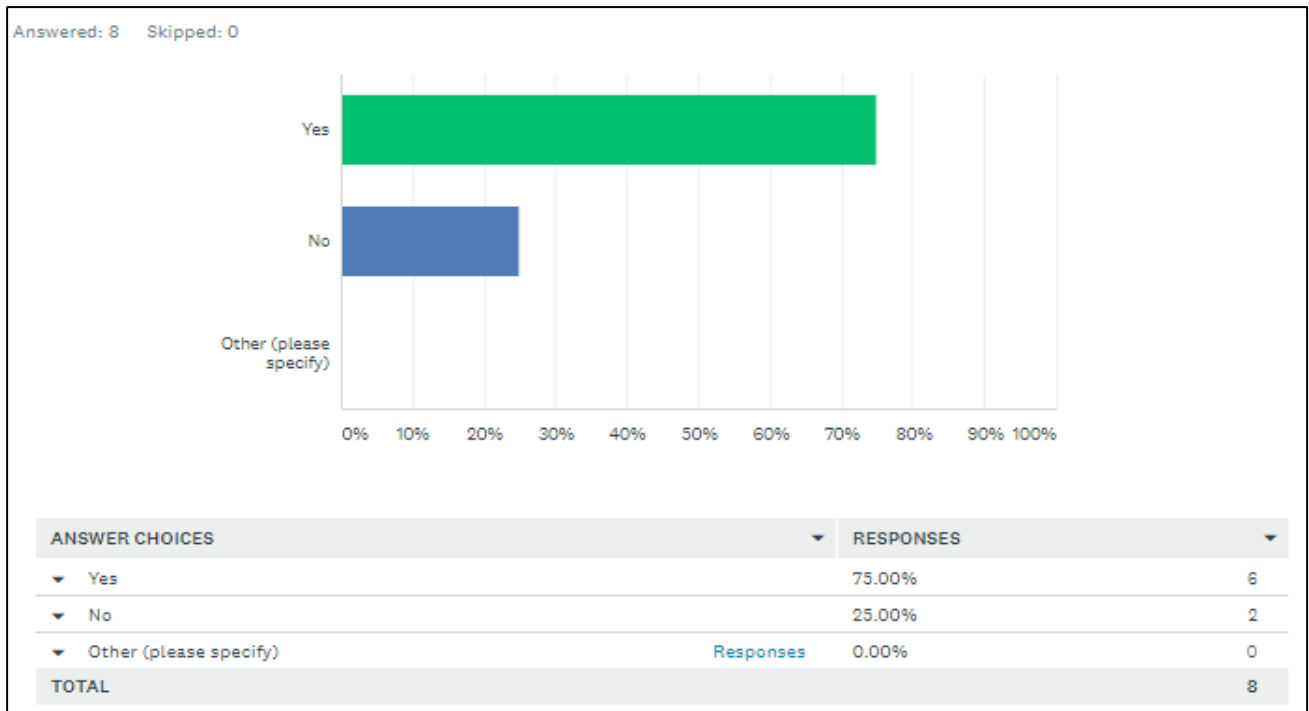


Figure 4.6. Responses to Q6: Do you think that you could benefit from environmental markets?.

The respondents were also asked about the markets from which they could benefit (Q7). Only, the ones who consider environmental markets as revenue-generating specified a market. “Carbon”, “renewable energy certificate” and “green certificate” are the options stated. In addition to these, two respondents answered as “different markets” and “should be investigated”. Thus, it may be deduced that the respondents have less awareness on environmental markets. Another interesting deduction is that corporate or renewable PPAs are not qualified under environmental markets. However, 62.5% of the respondents has chosen the option to commercialize the electricity production through PPAs. This shows that they do not link the corporate or renewable PPAs with the increasing demand for environmentally responsible products/services and interest in use of green energy.

The respondents have also asked about their preference on the design of green certificate. %50 of the respondents answered as they preferred a green certificate (REC) as a secondary product. As a secondary product, REC can be sold, delivered, or purchased independently from the generated electricity. It’s unbundled where there is no need to provide a physical delivery of electricity to the same customer as such the customer is purchasing power from a separate entity than the one selling them the REC (EPA, 2019). 37.5% of the respondents preferred as it as a representative of the produced electricity. In this case, customers purchase bundled electricity and RECs from a competitive electricity supplier in the market. The REC here is a proof of the generation of the electricity from renewable energy resources. Purchasing customers usually pay a premium via their monthly electric utility invoice. Prices of green electricity are generally higher than traditionally

sourced competitive products’ prices (EPA, 2019). The approach of these producers is to market their electricity production to directly to single buyer and not to deal with reaching to end user. They are more likely to proceed through one transaction. Considering the respondent background, the former ones have experiences in managing various commodities and trading with different wholesale companies. The results may be seen in Figure 4.7.

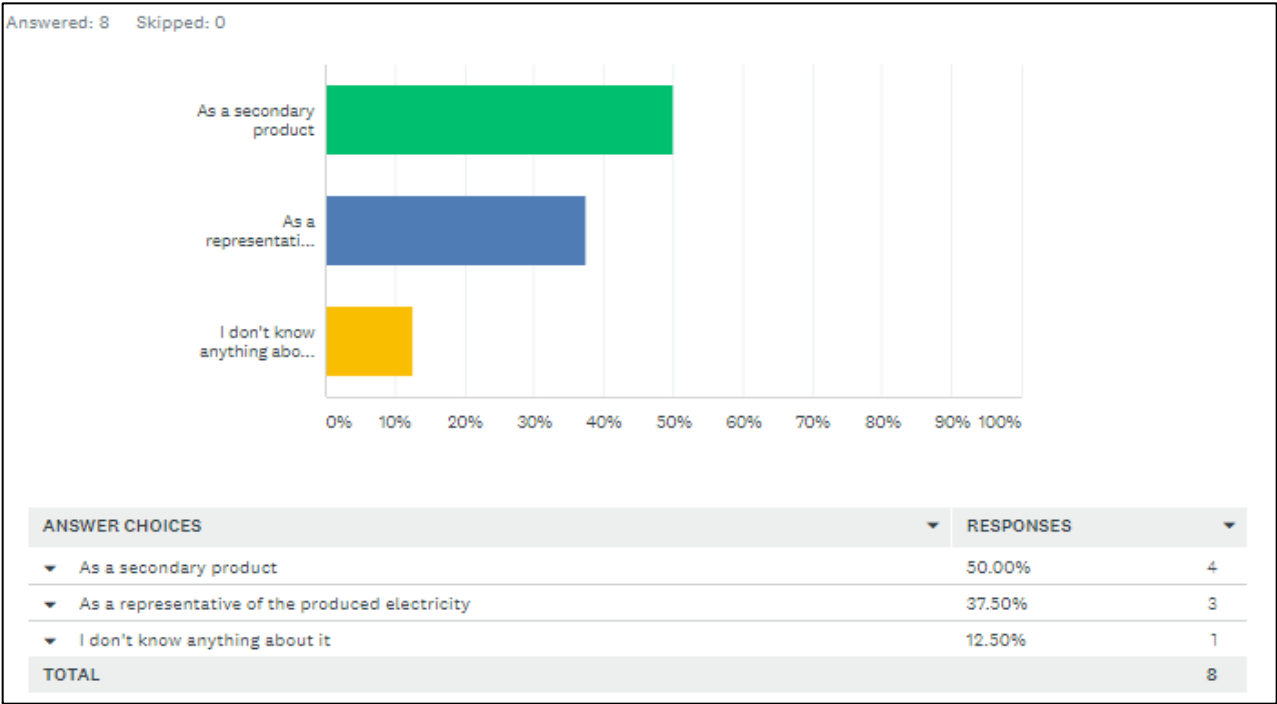


Figure 4.7. Responses to Q8: Would you prefer a green certificate as a secondary product or a representative of the electricity you produce?.

The majority of the respondents (87.5%) think that corporate Power Purchase Agreements (PPAs) could support the investment of solar energy projects. Only 1 respondent selected the choice “Maybe”. As mentioned in Section 2.3.1, corporate PPAs have gained increasing interest due to sustainability initiatives and the increasing cost-competitiveness of renewables. Considering the uncertainty after 2020 for the FIT mechanism and the probability of an insecure income, corporate PPAs could be a solution for the guarantee of purchase to generated electricity and more secure revenue in negotiable conditions.

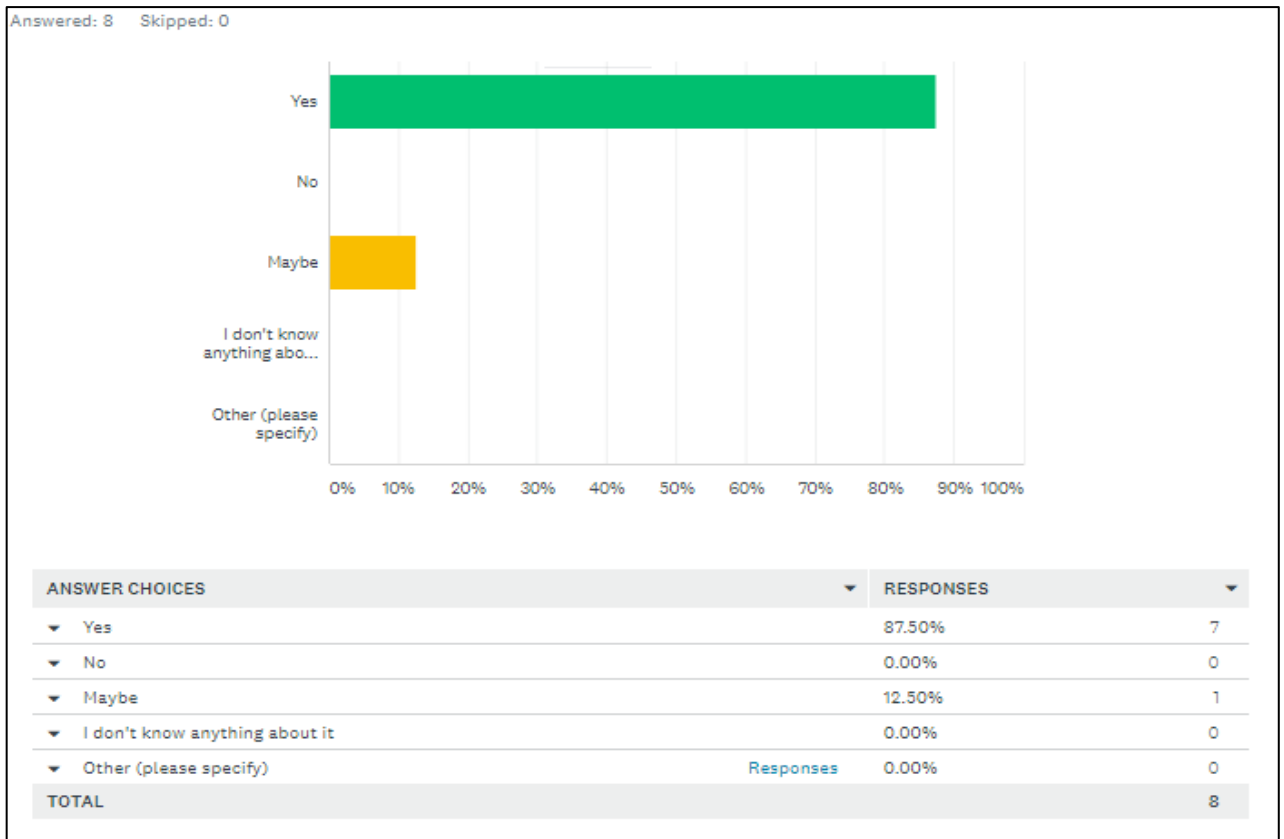


Figure 4.8. Responses to Q9: Do you think that Corporate Power Purchase Agreements (PPAs) could support the investment of solar energy projects?.

#### 4.1.4. Risk or Barriers to Solar Development

The respondents were asked what they considered the major risk or barrier to the development of solar capacity. They pointed out the regulatory risk as the main obstacle to the development of solar energy. Economic slowdown and lack of knowledge are also seen as a risk. This may be due to the fact that solar energy is a foreign dependent technology for Turkey and most of the components and equipment required for initial setup are imported. Additionally, people would avoid trying or switching to new things in economic downturn.

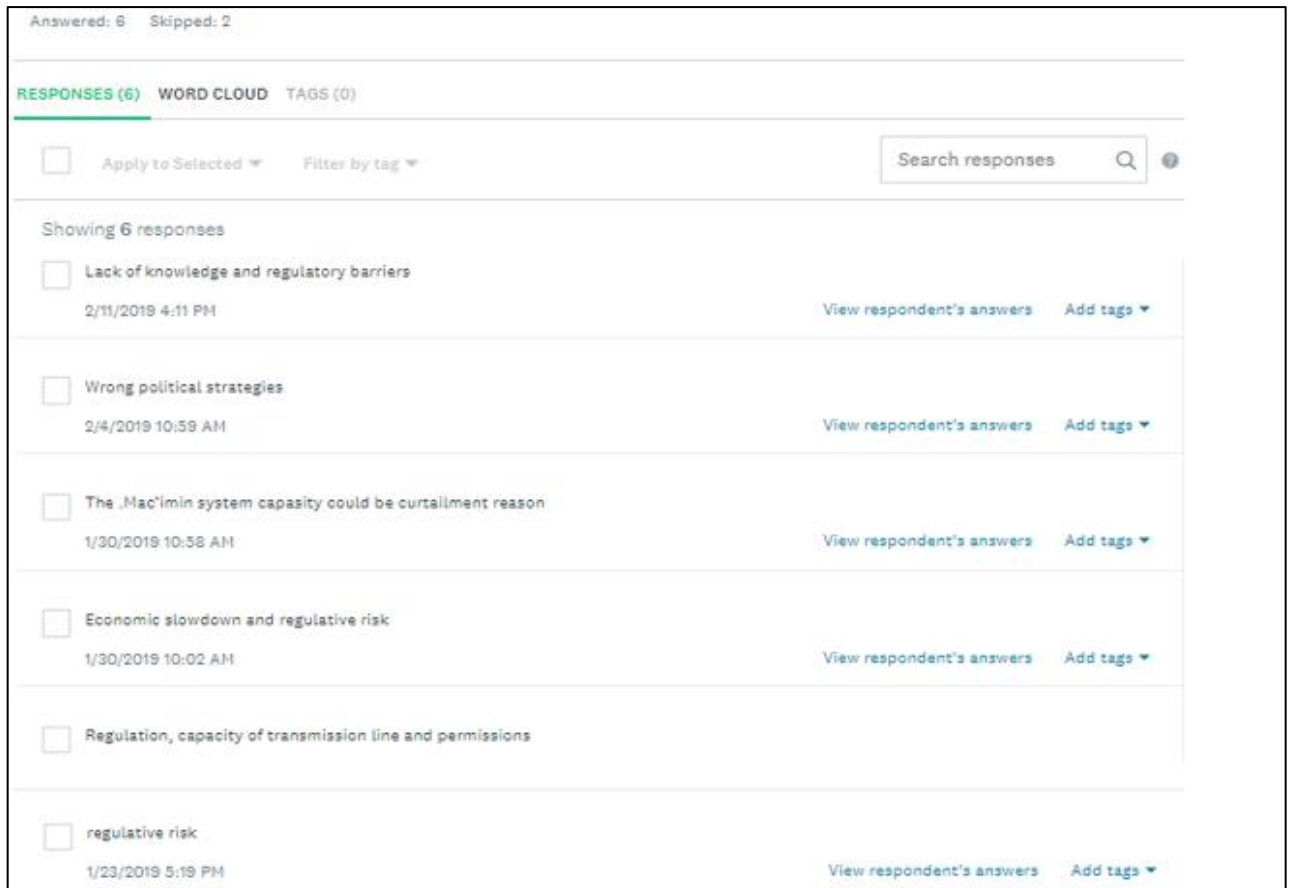


Figure 4.9. Responses to Q10: What is the major risk or barrier to development of solar power capacity?.

## 4.2. SWOT Analysis of Solar Energy Development in Turkey

### 4.2.1. Strengths

Turkey is one of the fastest growing economies. Turkey's gross domestic product (GDP) continued to grow as more advanced OECD economies. GDP growth averaged nearly 7% during 2010-17. With an annual growth of 7.4% in 2017, Turkey has been among the fastest worldwide (OECD, 2018). Between 2010 - 2016, total electricity demand has increased by 5.05%/year in average (TEIAS, 2018).

Among the alternative clean energy resources in Turkey, solar energy is the most important one considering the advantageous position in the Middle East and Europe. According to the SEM of Turkey prepared by YEGM, it has been determined that the total annual insolation time is 2,741 hours (a total of 7.5 hours per day), and the total solar energy derived per year is 1,527 kWh/m<sup>2</sup> per year (total 4.18 kWh/m<sup>2</sup> per day). According to this study, there is a potential of the equivalent of about 56,000 MW thermal power capacity in Turkey, and in case of utilization of the potential, annual

average is calculated to 380,000 GWh of electricity generated. By the end of 2017, only 3,421 MW of this capacity has been utilized and regarding the electricity generation, the installed solar capacity produced 2,889.3 GWh having a share of 1% in total energy mix (TEIAS, 2018). As a significant resource, solar generation potential is a crucial strength of the country.

Additionally, Turkey's power system has the capacity, as more renewables can be integrated into. According to the study conducted by Shura (Energy Transition Center), combined capacity of wind and solar can be reached to 40 GW by 2026 without any additional investment in the transmission system compared to TEIAS planning. The base scenario is built as installed capacities of 14 GW and 6 GW for wind and solar, respectively. The base scenario accepts that transmission system will already be enhanced as planned in TEIAS investment projections. Solar and wind capacities are forecasted to have equal shares, considering the solar potential in Turkey and rapid cost decline in solar PV.

#### **4.2.2. Weakness**

Despite the presence of a high solar potential, priority has been given to conventional technologies in Turkish energy mix. The transmission infrastructure is designed to supply electricity to the grid by baseload power plants. As full load hours differ by technology and position, import coal, lignite and natural gas have higher utilization rates while solar PV technology has a limited number of hours during the day. However, the report of Shura reveals that no additional investment for the transmission system other than TEIAS current planning is needed to reach 40 GW wind and solar capacity by 2026.

Solar energy is a foreign dependent technology for Turkey. Most of the components and equipment required for initial setup are imported. An endeavor is made by different actors in a large supply chain which includes a solar PV system, various components and installation equipment. (WEC, 2016). Local Equipment Support by FIT was structured to overcome this situation, it could not be effective. China has been the main market, in line with global trends in imports. In 2017, Vietnam and Malaysia were the main markets providing PV modules to Turkey (TUIK, 2018). Technical expertise to should be improved.

### 4.3.3. Opportunities

Considering the imports accounting for 85% of the energy supply, Turkey remains mainly dependent on energy imports (EIGM, 2019). Moreover, more than half of the electrical energy is provided from imported fuels. According to TEIAS statistics, the average share of imported fuels was 56.6% between 2007-2017. In recent years, energy supply security has become the first priority issue in countries which are net importers of energy resources. The main reason is the negative impact of fluctuations in energy prices on the national economies. In case of an increase in energy prices, the production costs of the countries that import energy and foreign trade balances are affected negatively as their economic growth slows down. Therefore, domestic resources play a crucial role to reduce energy import. At this point, solar energy as being a domestic resource come to the forefront for Turkey. Diversification of resources in electricity production will contribute to efforts to reduce the dependence on imported energy resources and to ensure supply security in energy.

As solar energy generates electricity without emitting greenhouse gases, it can be a powerful solution throughout combating climate change. 29.3% of global greenhouse gas (GHG) emissions derive from energy supply which puts the energy sector in the first rank (EEA, 2016; IPCC, 2014). In 2017, global energy-related CO<sub>2</sub> emissions increased by 1.4% corresponding to 460 million tonnes and reached to 32.5 gigatonnes (IEA, 2018). When we consider Turkey, GHG emissions originating from energy have the biggest share with 72.8%, while the GHG inventory results revealed that the overall greenhouse gas (GHG) emissions as CO<sub>2</sub> equivalent in 2016 were 496.1 million tonnes. During 1990 and 2016 total GHG emissions increased by 135.4% (TUIK, 2018). These figures show that energy sector is one of the priority areas for measures to be taken within the framework of Turkey's national climate change. Turkey submitted its Intended Nationally Determined Contribution (INDC) to United Nations Framework Convention on Climate Change (UNFCCC) with including a reduction up to 21% in GHG emissions from the Business as Usual (BAU) level by 2030. This means that total GHG emissions to be realized as 929 million tonnes CO<sub>2</sub>eq rather than 1,175 million tonnes CO<sub>2</sub>eq. In INDC it's stated that energy imports had a significant share in Turkey's account deficit and Turkey had to use its limited energy resources. Increasing capacity of production of electricity from solar energy to 10 GW until 2030 is involved in the energy plans to be implemented. If Turkey could utilize the high potential of its clean and carbon free resource, solar energy, and evaluate the opportunity it has, it would contribute to the fight against climate change.

Solar energy can facilitate the involvement by citizens in the renewable sector. Renewable cooperative initiatives are embraced by citizens with the motivations such as contribution to

renewable energy, securing the regional energy supply and contributing to the fight against climate change. Cooperatives constitute a bottom-up and collective solution to local needs and global environmental issues. In Germany, 46% of the installed renewable energy capacity was already owned by individuals or by local and regional energy cooperatives in 2012. Citizens had contributed a third of the total investments in renewable energy generation (EC, 2018). According to German Cooperative and Raiffeisen Confederation's survey, foundations of energy cooperatives increased from 8 to 831 between the years 2006-2016 (DGRV, 2016). Different types of citizens were defined by Leuphana researchers as (Leuphana, Trend Research 2013):

- private individuals or farmers who invest in energy facilities
- the investment is made with own capital, transferring a certain level of control over the project to the professionals
- citizens own at least 50% of voting shares
- citizens have a connection to the region where the facility is operated

The attractive side of the cooperatives is to enable people to participate in the energy transition with a small budget. Of course, financial return is an important driver. The FIT law in 1991 in Germany paved the way for citizens to invest in energy cooperatives. In 2006, the introduction of new provisions for small cooperatives gave cooperative societies a wide margin of self-government to adapt their rules to the needs of the individual society (Münkner, 2013; CelanEnergy Wire, 2018). The increase in the number of energy cooperatives may be seen in DGRV's survey as mentioned above. The FIT had an additive effect in also UK. Solar developments were easier and quicker to develop, therefore most of the initiatives started at this area. Through the FIT, the government aimed to encourage people to invest small-scale low-carbon electricity in return for a guaranteed payment from an electricity supplier (Willis and Willis, 2012). Financial viability of the project is a crucial factor which convince people that they would have a return from their investments. The rate of increase in new energy cooperatives decreased in Germany by the 2014 amendments of Renewable Energy Act as bringing reductions in feed-in tariffs for PV. The willingness of energy cooperatives to make further investments fell from 92% in 2013 to 70% in 2014. And also, 104 new energy cooperatives started in 2013 compared to 183 in 2012 according to Citizen Energy Alliance. Additionally, the first five auctions for free standing PV resulted as only 15% of the bids came from community energy cooperatives (Morris, 2015; Mey et al.,2018). This impact may also be observed in the United Kingdom experience. The change in policy, a decrease in FIT rates for the projects above 50kW, in 2011 had a negative impact on the willingness of solar energy cooperatives (Willis and Willis, 2012).

With regards to cooperatives' nature which distinguishes them from other company models: the principle of social responsibility, they can be a valuable opportunity to integrate community while concern over climate change is increasing and clean, renewable energy is seen as the wave of the future by community. Considering the experiences in Germany and the United Kingdom, uncertainty after 2020 for the FIT mechanism in Turkey could hinder the development of solar cooperatives. While investing in low-carbon electricity, members of the cooperatives would want to trust in a return for a guaranteed payment of their choice for the electricity they produce and use also as having a guaranteed payment for unused surplus electricity they export to the grid. The renewable energy cooperatives are defined officially by the Communiqué on the determination of the institutions of the cooperatives. The initiatives of energy cooperatives are within the context of unlicensed electricity production. According to the figures of General Directorate of Cooperatives, there exists 13 energy cooperatives.

Creation of regional added value through the production of energy where it is consumed by engaging citizens and making them a part of a green development through cooperatives could contribute to sustainable development.

#### **4.4.4. Threats**

Uncertainty after 2020 for the FIT mechanism may be a barrier for the development of new projects. Non-continuation of FIT mechanism would decelerate the new investments with an absence of a fixed and secure purchase price for the generated electricity. Having looked at the figures, all solar capacity benefits from FIT.

Another issue is the situation of the existing unlicensed solar capacity. As a consequence of the increase of the installed capacity cap for unlicensed electricity generation from 500 kW to 1 MW by Energy Market Regulatory Authority (EMRA), 99% of the installed capacity has been developed as unlicensed. According to the Unlicensed Electricity Generation Regulation, unlicensed power plants receive a purchase guarantee for their production through 10 years as starting from the time they export electricity to the grid under FIT mechanism. For this reason, there is an uncertainty for the electricity production of the unlicensed generation after the completion of 10-year period. If the distribution company to which the plant is connected do not want to purchase the production, it's ambiguous what would happen. The reason is that unlicensed producers cannot make sales through bilateral agreements and / or Organized Wholesale Electricity Markets for their production under the Unlicensed Electricity Generation Regulation. At this point, the distribution companies hold the

bargaining power for the purchase price of the produced electricity after the completion of the FIT period. Therefore, this situation increases the ambiguity about the expected revenue.

Considering the capacity allocation reports by TEIAS, capacity which could be connected to the transmission system is determined for imported coal-diesel-fuel oil group and natural gas-LNG group. Therefore, low capacity allocation in the relevant connection points could be another threat for solar facilities. In addition to this, it's stated that all or part of these conventional capacities in line with the energy policies could be covered by domestic and/or renewable resources.

The respondents of the survey consider wrong regulations and insufficient capacity allocation as the main threat/barriers to development of solar power capacity.

## 5. CONCLUSIONS

Solar installed capacity experienced an extraordinary growth since 2014 and the most of this capacity is coming from unlicensed power plants. Due to bureaucratic convenience compared to licensed investment process, the investors who wish to establish a large-scale solar power plant preferred to install more than one PV plant with 1 MW capacity side by side and reached the higher capacities. The progress in 2017 put Turkey in the top five national markets with China, the United States, India, Japan. With 2.6 GW, added solar capacity in 2017 was more than three times that of 2016, making Turkey one of the largest markets for solar PV in Europe. In addition to opportunity of unlicensed application, the rate of cost reduction has played a significant role in this progress.

FIT mechanism has been the main policy used as a support mechanism to accelerate investment in renewable energy. In EU, FIT had a significant impact on the growth of primary production of renewable energy by 75% between the years 2005-2016 (Eurostat, 2018). And according to Research Office Legislative Council Secretariat, FIT has been a common policy initiative taken in 110 places across the globe to incentivize households and businesses to install small-scale solar PV facilities. In Turkey, Law on Utilization of Renewable Energy Sources provided a secure FIT for electricity generation from renewable energy resources for a maximum 10 years of operation. And the FIT mechanism has been the main policy to support all kind of renewable energy technologies. The amendment of the law in 2011, as providing a fixed price level for each renewable resource for 10 years of became the actual accelerator for the progress of renewable energy investments. According the law, the mechanism was valid for the facilities which start operation until the end of 2015. In 2013, the extension of deadline to 2020 and the enactment of the Electricity Market Law as increasing the total installed capacity of an unlicensed electricity generation plant based on renewable energy sources from 500 kW to 1000 kW (1 MW) paved way for solar energy investors to benefit from cost reduction and invest in solar energy. All of the solar capacity including both licensed and unlicensed has benefitted from FIT mechanism. Considering the survey results, investors gives importance to FIT and prefer conditions provided by such a kind of mechanism.

With the development of the market and progress in renewable energy capacity, many countries went to revision of policies. Governments have designed their support policies considering market conditions and applied market-based tariffs, auctions or capacity caps. Turkey has also gone to policy revisions as Renewable Energy Zones (YEKA) Model to both solar and wind energy investments. It is crucial to state that the model is designed for the large-scale investments. The model brings an

auction-based mechanism which involves the condition of the establishment of local manufacturing and R&D facilities or using locally manufactured equipment with an aim to ensure localization. This is an important milestone where local manufacturing is supported through a value-added way. However, in order to maintain the existence of the panel factories established for YEKA, a market should be created that will have predictable growth every year. domestic production solar panels to compete with imported production, a foreseeable and regular demand should be provided, especially in the development stage of the industry. This is crucial for the panel production industry to be sustainable.

The deadline for Renewable Energy Support Mechanism is determined as December 31<sup>th</sup>, 2020 in the Renewable Energy Act of Turkey. There is an uncertainty about how the new renewable investments would be supported after 2020. Within the survey, all of the respondents defined this as a barrier for the development of new solar projects. This is a threat which could decelerate the progress in solar energy. The majority of the respondents in the survey preferred a long-term fixed price for the produced electricity. And the rest preferred to sell the production to the spot electricity market with an additional incentive. Considering these choices, a floor price could be determined based on the investment cost of the facilities. This would constitute fixed income guarantee for both investors and banks providing project finance. This could be applied as “contract-for-difference” scheme experienced in Germany. The producer would be paid the difference between the determined price floor and the sport market price. If the spot market price is higher than the price floor no payment would be made to the solar producers. Thus, this application would not bring any higher financial burden to the market. As mentioned in Section 2.1.1.2, the cost burden borne by the electricity consumers has increased significantly as the development of FIT mechanism unit cost for the supplied electricity.

While determining a floor price, the crucial point is the adjustability of floor price according to the market conditions. Considering the investments to be made after 2020, it is challenging to estimate the unit investment costs. For this reason, a floor price mechanism/formula which could take into account the investment cost change rather than fixed price valid for 10 years for solar investments should be applied. The downward improvements in unit investment costs for solar investments should be reflected to the floor price as setting it for new investments.

With regards to unlicensed solar projects, uncertainty of the purchase guarantee for the production is an important threat for the addition of the new capacities. The distribution companies hold the bargaining power for the purchase price of the produced electricity after the completion of

the FIT period. This increases the ambiguity about the expected revenue. Unlicensed power plants should be able to make sales through bilateral agreements and/or Organized Wholesale Electricity Markets for their production. The regulation should be amended to ensure these sales.

Despite the promising potential, market-driven deployment of solar energy investment still has to overcome technical and financial barriers. Consequently, low capacity allocation and non-guarantee of purchase for unlicensed facilities constitute the technical barriers, while impossibility for unlicensed facilities to make sales through bilateral agreements and/or to Organized Wholesale Electricity Markets and price uncertainty are standing as financial barriers to new solar investments. If the necessary steps are taken and regulative changes are done, solar installed capacity could reach a more ambitious target than 10 GW by 2026 which is stated in INDC of Turkey regards to the Climate Action Plan by 2030. The study conducted by Shura in cooperation with TEIAS revealed that Turkish power system has the capability for 40 GW solar and wind capacity to be integrated without any additional investment in the transmission system compared to TEIAS planning.

Environmental markets are considered as an additional revenue stream to solar energy projects. The sole trusted revenue for the solar energy investments is a fixed or predictable electricity price for a determined period. This is accepted as the major guarantee both by the investors and the banks providing project finance. Environmental markets such as carbon, tradeable green certificates or corporate power purchase agreements can provide additional incentives to solar energy deployment; however, the existing market instruments are still limited. In Turkey, Voluntary Carbon Market has been the main environmental market from which renewable energy projects benefitted. VERs are demanded by companies which want to take responsibility for offsetting their own emissions voluntarily. Generally, foreign companies are the buyers for VERs of Turkish carbon reduction projects. The main motivation of these companies is corporate social responsibility. It is crucial to state that the market has a limited demand and there is a high competition which lowers the expected price. Compared to the foreign companies, the awareness of Turkish corporates is low. In addition to this, there isn't any legal obligation to reduce carbon emissions for the emitters. For this reason, the future of the market is still ambiguous and it doesn't constitute an income-generating market for neither solar energy producers nor any renewable energy producers. Corporate PPAs and green certificates could also be evaluated as an income securing tools provided that regulatory revisions are made. However, the awareness of the electricity consumers should also increase to be willing to buy renewable energy or the green attributes of the renewable production. On the other hand, concerns about climate change provide that more importance is given to renewable energy as being a convenient and tangible alternative. Moreover, ensuring access to affordable, reliable, sustainable and

modern energy for all has been determined among Sustainable Development Goals. Increasing substantially the share of renewable energy in the global energy mix is targeted by 2030 (UN, 2016). This global movement would affect all parts of society and provide them to adopt endeavors for this purpose.

According to prevailing visibility which has been deduced from the survey conducted under this study, solar energy investors think that new solar investments will be affected negatively due to unpredictability as losing a purchase guarantee through a fixed price. And they're not sure if environmental markets could ease the transition to post FIT mechanism (YEKDEM) era. Lack of a regulatory mechanism would decelerate the solar investments according to their experiences. Also, unawareness of environmental markets has a considerable share at this point. Ultimately, these markets depending on the consumer side preferences are emerging markets and need some time for the demand creation.

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