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License Exempted Electricity Generation Educational Book

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INTRODUCTION

Turkey's electricity market has continuously been evolving during the last 15 years. There has been a fundamental transition from a vertically integrated public monopoly model to a model of regulated competition with privatized and unbundled firms. Third party access to network is regulated. Organized wholesale markets such as day-ahead market and intra-day market are in place accompanied by a residual balancing market. Transactions for electricity trade are completed on a bilateral contract basis. All market activities in various rings of the value-chain of electricity must be licensed by the Energy Market Regulatory Authority (EMRA). A pre-license is obtained to get permits and approvals in the first stage. Once obtained, a license enables its licensee to apply for public interest decision from the EMRA for expropriation.

Yet, some activities in electricity generation are exempted from obtaining a license. These activities can be considered under unlicensed electricity generation (UEG). Renewables with a capacity of up to 1 Megawatt (MW) and small-scale cogeneration power plants (up to 100 Kilowatt (kW)) are the main components of UEG in Turkey.

UEG is considered to provide new opportunities for investors and consumers in Turkey. Economic agents can generate electricity to meet individual energy needs without establishing an undertaking and obtaining a license from the (EMRA). UEG is expected to offer a range of benefits for the entire electricity value chain. It will provide a relief for the transmission and distribution grid. Energy losses occurred in networks will be avoided and huge sums of investment in transmission and distribution capacity will not be necessary. Besides the positive externalities on the grid side, there are going to be increased opportunities in electricity sale. Many real and legal persons who own an UEG asset will be able to feed electricity back into the network at predetermined feed-in-tariffs.

In comparison to licensed generation, UEG offers convenience and simplicity to investors in the initial stage of investments. For instance, UEG based on wind and solar power does not require performance measurement of some parameters such as solar radiation or wind speed. Furthermore, there is no restriction for the application dates for UEG. Unlike license applications for wind and solar which can only be made at a pre-set date, applications for UEG can be made every month.

Yet, despite the advantages it offers, UEG is still in its infancy stage in Turkey. Even though there is an enormous potential for investment and generation, little is achieved so far. As can be seen from Table 1, the total installed capacity of UEG assets to be connected to the electricity grid is 0.6 GWh. This number corresponds to less than 1 % of the total installed capacity of the year 2015.

Table 1: The Scope of Projects for which Provisional Acceptance is Given (until 18.07.2016)

TYPE	SIZE	SHARE
Cogeneration	55,243 kW	9.19%
Wind	9,826 kW	1.63%
Solar	517,310 kW	86.03%
Biomass	18,907 kW	3.14%
Total	601,287 kW	

Source: TEDAŞ (Turkish Electricity Distribution Company)

All these numbers indicate that there is a huge potential for investment and generation in UEG in Turkey. Another source of the potential growth in UEG sector is coming from the solar market. According to the Global Market Outlook for Solar Power 2016-2020, Turkey is expected to be the largest European solar market together with Germany and UEG will play a significant role in boosting the Turkish solar market.

All these imply that there will be a great need for training and professional consultancy for relevant matters. With an aim to fill this gap, this book provides information on technical, legal and financial issues related to UEG in Turkey.

FUNDAMENTALS OF UNLICENSED ELECTRICITY GENERATION

WHAT IS UNLICENSED ELECTRICITY GENERATION (UEG)?

UEG is a less-known component of the recently liberalized Turkish electricity market and it has recently been gaining its popularity. It has started in Turkey in 2010 – 9 years after the electricity market reform was initiated. The main aims of UEG are – as stated in the By-Law on Unlicensed Electricity Generation in the Electricity Market[1] - to meet the electricity needs of consumers at the closest generation assets, to bring small-scale generation assets to the economy in order to provide supply security and to ensure their efficient operation, and to reduce losses in the electricity network. The major difference between UEG and conventional

1 Turkish Official Gazette, 02.10.2013, No. 28783.

licensed electricity generation is that there is no legal obligation for establishing an enterprise for the former, which presents a number of advantages and relief for investors.

Figure 1: The Main Aims of Unlicensed Electricity Generation (UEG) in Turkey

to meet the electricity needs of consumers at the closest generation assets	to bring small-scale generation assets to the economy and to ensure their efficient operation	to reduce losses in the electricity network

License-Exempt Electricity Market Activities in Turkey

According to the Article 14 of the Electricity Market Law (EML, Law No. 6446), the following activities are exempt from obtaining a license and establishing a company:

- Emergency groups or isolated power plants without connection to the transmission or distribution system,
- Power plants based on renewable energy sources (RES) with a capacity up to 1 MW,
- Power plants based on municipal solid waste treatment plants and sludge disposal facilities,[2]
- Micro-cogeneration power plants and cogeneration power plants that meet the total efficiency standard defined by the Ministry of Energy and Natural Resources (MENR) and that are in the category defined by the Energy Market Regulatory Board (EMRB),
- RES based power plants that consume all of the generated energy without feeding into the electricity network, that have the generation and consumption points in the same location.
- Power plants established on water supply lines and waste water lines run by municipalities.

These power plants and associated installed capacity limits are displayed in Table 2.

2 This translation is based on Gözen (2015).

Table 2: The Assets to Be Considered Under Unlicensed Electricity Generation

GENERATION ASSET	INSTALLED CAPACITY LIMIT
Emergency groups	NO
Isolated power plants without connection to the transmission or distribution system	NO
Power plants based on renewable energy sources (RES) with a capacity up to 1 MW	1 MW
RES based power plants that consume all of the generated energy without feeding into the electricity network, that have the generation and consumption points in the same location	NO
Cogeneration power plants that meet the total efficiency standard defined by the Ministry of Energy and Natural Resources (MENR)	NO
Micro-cogeneration power plants	100 kW
Power plants based on municipal solid waste treatment plants and sludge disposal facilities	NO
Power plants established on water supply lines and waste water lines run by municipalities	NO

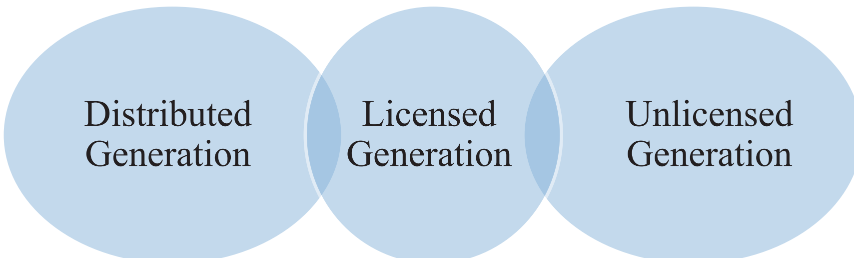
Among these activities, the most attractive option is to set up power plants based on renewable energy sources with a capacity up to 1 MW. The reason is that any excess electricity generated by these producers is fed back into the network at predetermined feed-in-tariffs and, as a result, these producers have less difficulty in financing their investments.

The Differences and Similarities with Distributed Generation (DG)

As such, UEG is similar to distributed generation (DG). Both DG and UEG make it possible to generate electricity at smaller scales in comparison to large and central generation units. The most common sources used in electricity generation in both DG and UEG are renewable sources such as solar and wind. Both DG and UEG aim at avoiding losses in electricity network. The problems of integrating DG and UEG into electric power systems are similar. Yet, they still are different from each other in many ways.

For DG, even though various definitions are given by different institutions and academic studies, the common themes in these definitions are that generation units are connected to distribution network, and that generation capacity is smaller than that of large and central power plants. Some experts also claim that for a generation asset to be considered under DG, meter and generation units should be on the consumption side.[3] However, in the relevant legislation for UEG in Turkey no reference is given to DG and the concept is not mentioned at all. Furthermore, when the relevant legislation is examined in detail, it is seen that the scope of UEG is narrower than that of DG. For instance, the capacity limit for DG is much larger compared to that of UEG. While wind turbines with a capacity of 5 MW can be considered under DG in many countries, they cannot be an element of UEG in Turkey. Therefore, in the words of Gözen (2015)[4], there is no clear-cut distinction between DG and UEG in Turkey.

Figure 2: The Relationship among Licensed Generation, Distributed Generation and Unlicensed Generation



Source: Gözen (2015)

The Comparison of Unlicensed Electricity Generation with Licensed Electricity Generation

Besides providing the opportunity to be exempt from obtaining a license and establishing a company, UEG also offers many other advantages in comparison to licensed electricity generation. For instance, in licensed electricity generation from wind and solar, potential investors should measure relevant performance parameters prior to their application for a license, while the measurement of performance parameters is not required for UEG from wind and solar. Another appeal of UEG for potential investors is that no guarantees by the applicant at the application stage is mandatory and there is no restriction regarding share transfer. In order to see the differences between UEG and licensed electricity generation (LEG), and the advantages of UEG one could check the following table.

3 Pepermans vd. (2005). Distributed generation: definition, benefits and issues. Energy Policy, 33: 787-798.

4 Gözen, M. (2015). Unlicensed renewable energy generation: A review of regulation and applications in the context of Turkey. International Journal of Energy Economics and Policy, 5(1): 1-13.

Table 3: The Comparison of Unlicensed Electricity Generation with Licensed Electricity Generation

		UEG	LG
Issues Related to Capacity Planning and Electricity Trading	Installed Capacity Limit	1 MW for RES based power plants. 100 kW for micro-cogeneration.	No capacity limit.
	Incentives for Electricity Generation	Feed-in-tariffs (FIT) are given for RES based generation and participation in RES support mechanism is mandatory.[5]	Feed-in-tariffs (FIT) are given for RES based generation if generators participate in RES support mechanism. Extra premium is added to the FIT, should generators use domestically produced components.
	Electricity Trading	Not possible. Unconsumed electricity can only be sold via RES support mechanism (for which participation is mandatory).	Possible. License holders can choose to sell their electricity at negotiated prices without participating in RES support mechanism.
Procedural Issues in the Pre- and Post-Application Period	Measurement of Performance Parameters	No measurement is required.	Mandatory for wind and solar license applications.
	Expropriation	Not possible	Possible
	Application Period	Not restricted. Distribution operators receive applications every month.	Restricted for wind and solar based electricity generation. Applications can be made only on the dates specified in the Electricity Market Licensing Regulation.[6]
	Identity of Applicant	Any real or legal person could be an applicant.	The applicant must be a joint stock or a limited liability company.
	Guarantees by Applicant at the Application Stage	No guarantees	Minimum capital requirement Bank letter of guarantee
	Share Transfer	Possible after provisional acceptance of the generation asset	Forbidden in the pre-license period. For license holders, it is subject to the EMRA approval.
	Auditing	Auditing is performed by regional distribution companies.	Auditing is performed by the EMRA.

Source: Adapted from Gözen (2015)

5 Formerly, extra premium was added to the FIT, should generators use domestically produced components. This has been changed with a recent change in the legislation. (Turkish Official Gazette, 22.10.2016, No. 29865).

6 Turkish Official Gazette, 02.11.2013, No. 28809.

THE OVERVIEW OF TECHNOLOGIES USED IN UNLICENSED ELECTRICITY GENERATION

According to the relevant legislation, the following technologies are considered in the domain of UEG in Turkey:

- Renewable Energy Sources up to 1 MW;
    - Wind, solar, geothermal, biomass/ biogas, wave, flow, tidal energy, hydro (run of river or dam (<=15 km^2)),
- Micro-cogeneration plants (<=100 kW)
- Cogeneration plants above 80%[7] efficiency,
- Renewable energy plants that consumes all of its generation without supplying to the grid.

Wind

Small-scale wind turbines can be mostly used in water pumping in farming houses. With the use of these generation assets, savings up to 50%-90 % in electricity expenses can be achieved. Besides these savings, losses in transmission lines can be reduced and resource diversity in electricity generation can be obtained. Another advantage of small-scale wind turbines is that Turkey has sufficient industrial capacity in the manufacturing of small-scale wind energy system instruments such as rotor, blades, generator, invertor etc.[8]

On the other hand, wind is not a reliable source and its speed varies over time. For this reason, wind turbines cannot generate electricity constantly all the time. In Turkey, on average capacity factor can be taken as 35 %, which means that the generated electricity is 35 % of the total installed capacity.

Solar

Photovoltaics is the most important solar technology for UEG in Turkey by far. It uses solar cells assembled into solar panels, and photovoltaic systems convert sunlight directly to electrical energy using semiconductors. Photovoltaic systems can be installed on roof-tops in order to meet daily electricity needs of households. Additionally, they can also be used for agricultural irrigation. However, just like wind energy, solar energy is also a varying source over time. But, it is more predictable than the wind, as the time of sunrise, sunset and

7 Article 6/2/b of the Communique on Procedures and Principles regarding the calculation of the efficiency of co-generation and micro-cogeneration assets for gas turbines, Turkish Official Gazette, 18.09.2014, No. 29123.

8 http://www.eie.gov.tr/eie-web/turkce/YEK/ruzgar/ruzgar_turbin.html

the movement of the sun are known parameters in advance. The only unknown thing is the cloudiness of the sky that affects the generation.

Currently, solar power projects constitute the great majority of UEG projects approved. As of mid-July 2016, 86 % of the UEG projects are solar power projects (see Table 1). This current trend for photovoltaics is expected to continue for the near future. According to the Global Market Outlook of Solar Power, Turkey is expected to be the largest European solar market together with Germany in 2020 and in this growth path for Turkey, unlicensed photovoltaic systems are expected to have an important contribution.

Waste-to-energy

Municipal solid waste and natural waste, such as sewage sludge, food waste and animal manure will decompose and discharge methane-containing gas that can be collected and used as fuel in gas turbines or micro turbines to produce electricity by an UEG unit. Additionally, some processes were developed to transform natural waste materials, such as sewage sludge, into biofuel that can be combusted to power a steam turbine that produces power. This power can be used in lieu of grid-power at the waste source (such as a treatment plant, farm or dairy).

This method is also not suitable for household use. Since the waste is not available in many sectors, this is appropriate only for the industries which are producing or collecting waste, such as chicken farms or municipal waste processing.

Micro-Cogeneration and Cogeneration

Micro-cogeneration plants (<=100kW) and the cogeneration plants which have higher efficiency than the determined level are exempted from licensing procedure. The determined efficiency level is 80% for gas turbine systems with at most 0.95 electricity/heat ratio.[9]

Cogeneration is not suitable to be installed for a household but rather it is suitable for a small-scale industry. Because, cogeneration consumes a fossil fuel, it is less preferable compared to solar or wind energy in terms of environmental impact.

THE MAIN REGULATORY FRAMEWORK FOR UNLICENSED ELECTRICITY GENERATION

The relevant legislation that regulates the provisions for UEG is the By-Law on Unlicensed Electricity Generation in the Electricity Market, for which the Article 14 of the Electricity

9 Communique on the Calculation of Efficiency Levels for Cogeneration and Micro-Cogeneration Plants Article 6/2/b

Market Law (EML, Law No. 6446) constitutes the legal basis. The implementation of the provisions in this By-Law is explained in the Communique on the Implementation of the By-Law on Unlicensed Electricity Generation in the Electricity Market.[10, 11]

The main objective of the By-Law is to determine methods and principals to be applied to real and legal persons that can generate electricity without having to establish a firm and obtain a license. According to the By-Law, the main purposes of UEG are

- to meet the electricity needs of consumers at the closest generation assets,
- to bring small-scale generation assets to the economy in order to provide supply security and to ensure their efficient operation,
- to reduce losses in the electricity network.

On the consumer side, UEG also allows consumers to feed any excess electricity they generated from renewable resources back into the network. Stated differently, UEG enables consumers to become prosumers who can produce and consumer electricity at the same time. The following table gives a brief summary of feed-in-tariffs provided for different renewable energy sources:

Table 4: Feed-in-Tariffs for Unlicensed Electricity Generation Based on a Renewable Energy Source

Production Plant Type (Based on a Renewable Energy Source)	Rate (US Dollar cent per kWh)
Hydroelectric Power Plant	7.3
Wind Power Production Plant	7.3
Geothermal Power Production Plant	10.5
Biomass Power Production Plant (incl. landfill gas)	13.3
Solar Power Production Plant	13.3

Source: The Law on the Utilization of Renewable Resources to Generate Electric Energy (Law No. 5346)

10 Turkish Official Gazette, 02.10.2013, No. 28783.
11 Turkish Official Gazette, 23.03.2016, No. 29662.

The tariffs presented in Table 3 are provided for 10 years and there is legal uncertainty as to whether these tariffs will continue to be given.[12]

As to cogeneration power plants, in order to qualify for UEG, these power plants should meet the total efficiency standard defined in the Article 6/2/b of the Communique on Procedures and Principles regarding the calculation of the efficiency of co-generation and micro-cogeneration assets for gas turbines. In contrast to power plants that are based on a renewable energy source, unlicensed cogeneration power plants cannot feed excess electricity back into the network. The electricity generated by these assets cannot be traded in any organized wholesale power market, cannot be sold via bilateral contracts and can only be used for self-consumption. If a cogeneration asset feeds the electricity grid, no payment is made to the owner and the electricity fed is considered as a "contribution" to YEK Support Mechanism.

The case for unlicensed micro-cogeneration power plants is different than cogeneration power plants. Any excess electricity generated by a micro-cogeneration plant is purchased by the last-resort electricity supplier in the region at the lowest rate indicated in the Law on the Utilization of Renewable Resources to Generate Electric Energy (Law No. 5346). This rate corresponds to 7.3 Dollar cents per kWh. As in the case of cogeneration power plants, any electricity generated by micro-cogeneration power plants can be traded in no organized wholesale power market and nor can it be sold via bilateral contracts.

Table 5: Summary Information for Unlicensed Electricity Generated via Cogeneration and Micro-Cogeneration Power Plants

	Is There a Capacity Limit?	Can Excess Electricity Generated Be Traded in an Organized Wholesale Power Market or Sold via Bilateral Contracts?	Can Excess Electricity Generated Be Fed Back into the Grid?
Cogeneration	No. But the determined efficiency level should be 80% for gas turbine systems with at most 0.95 electricity/heat ratio.	No	No
Micro-cogeneration	Yes (<= 100 kW)	No	Yes. At a rate of 7.3 Dollar cents per kWh.

12 Furthermore, extra premium was added to the FIT, should generators use domestically produced components. This has been changed with a recent change in the legislation.

CHAPTER-2

TECHNOLOGIES USED IN UNLICENSED ELECTRICITY GENERATION

The unlicensed generation technologies designated by the Turkish legislation are as follows:

- Renewable Energy Sources up to 1 MW;
  - Wind,
  - Solar,
  - Geothermal,
  - Biomass/ biogas,
  - Wave, Flow, tidal energy,
  - Hydro (run of river or dam (<=15 km^2)),
- Micro-cogeneration plants (<=100 kW)
- Cogeneration plants above 80% efficiency,
- Renewable energy plants that consumes all of its generation without supplying to the grid.

In this section technical information about these sources will be given. Due to the importance and the great penetration possibility, more emphasis will be put on solar energy.

BASICS OF ELECTRICITY GENERATION

Before going further with the various UEG technologies, firstly the basics of the electricity generation should be known. This information is common for all technologies and should be known to understand the electricity systems. The definitions of the basic terms are listed below.

<u>Power:</u> Produced energy in a unit of time. Watt is the International System of Units (SI) unit for measuring the power, which is equal to 1 joule of energy in a second. For small-scale

power plants kW is used and for large scale-power plants MW is used to indicate the power of the plant. For instance, 500 kW power plant means that the plant is able to produce at most 500 kWh in an hour. This is the maximum power that can be generated, so that the plant may produce less than this amount according to its working hour or used capacity.

Energy: Ability of a system to perform work. It is the output of the power plant. Generally stated as kWh or MWh terms. A 100 kW plant generate at most 100 kWh in an hour. If it runs for 30 minutes, then it produces 50 kWh energy. Generated electricity is the multiplication of power and the time of working. For example, a power plant working at 20 kW power produces 60 kWh in three hours. The produced energy depends on the power and the capacity factor of the plant.

Capacity Factor: Ratio of the actual output of the plant to the maximum possible output. 90% capacity factor means that the power plant produces 90% of its maximum capacity. For example, a power plant with 10 kW power (capacity) is able to produce 10 kWh in an hour in full load. If it actually produced 8 kWh in an hour, then the capacity factor is 80%.

Capacity factor of the thermal power plants depend on the working hours and the working capacity of the plant. If the electricity prices in the market is low, these power plants may reduce or stop production. For this reason, their capacity factors are low if the market prices are low. However, capacity factor of the non-storable renewable energy plants only depends on the source because they have no fuel cost. Unless they are operable (not in maintenance or failure) they are willing to produce the most possible amount regardless of the price.

General capacity factors of the power plants in Turkey can be taken as 35 % for wind, 18 % for solar and 35 % for hydro.

Turbine: Turbine is the mechanical device that extracts energy from a fluid flow (water, wind, steam, etc.) and converts it into useful work. All of the thermal power plants depend on the same principle; water is heated to become steam in the boiler and it is spayed to the turbine. Turbine rotates and the heat energy of the steam is converted to mechanical energy. In hydro power plants, water flow rotates the turbine and in wind turbines wind flow rotates the turbine blades. Afterwards, rotation of the turbine is transferred to the generator.

Generator: Generator converts mechanical energy to electrical energy. As an electrical principal, movement of a conductive material such as copper wire in a magnetic field generates electricity flow in the material. Generators are built according to this principle and they are covered by magnets. Transferred rotation of the turbine rotates the generator mill and electricity is generated in the wires.

WIND ENERGY

Wind is the movement of air and the kinetic energy of this movement can be converted to the electric power via wind turbines. The principle is simple; wind power rotates the blades of the turbine, blades rotate the generator and the electricity is generated in the generator.

As the physics rule, every moving object has a kinetic energy stated as $\frac{1}{2}mV^2$. The energy of wind passing through an area of A m^2, with a speed of V and air density of 'ρ' is calculated as follows:

$$Rüzgar\ Enerjisi = \frac{1}{2}\rho.A.V^3$$

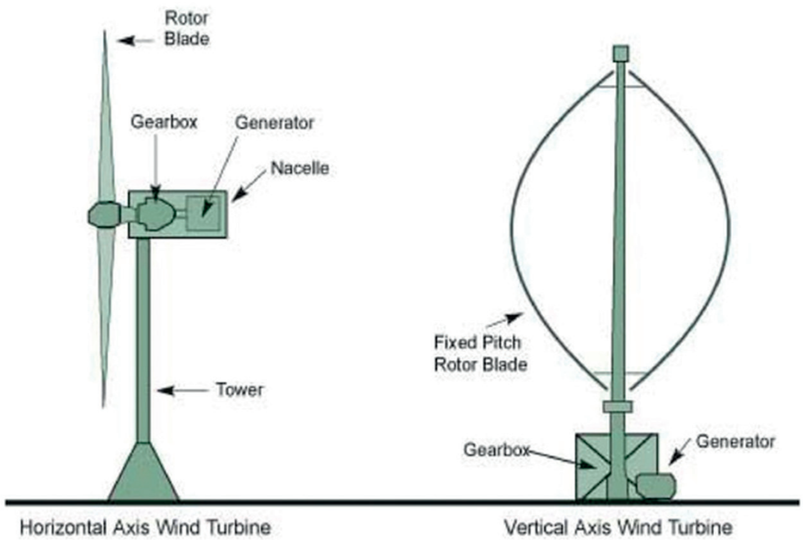
However, not all of the wind energy can be extracted by the wind turbines. Some energy exits the system with the exiting wind at the back of the turbines. Net energy absorption of the turbine is the difference between the energy of the entering wind and the energy of exiting wind. The rule of conservation of energy and mass states that the maximum extractable energy from the wind is 59.3 % of the total energy. This is known as the Betz rule.

$$Elde\ Edilebilecek\ Maksimum\ Rüzgar\ Enerjisi = 0.59.\frac{1}{2}\rho.A.V^3$$

Wind Turbines

There are various kinds of wind turbines and the first group of separation starts with the axis of the blades. Horizontal axis turbine blades stay against the wind while vertical axis turbine blades stay parallel to the wind.

Figure 3: Wind Turbine Parts

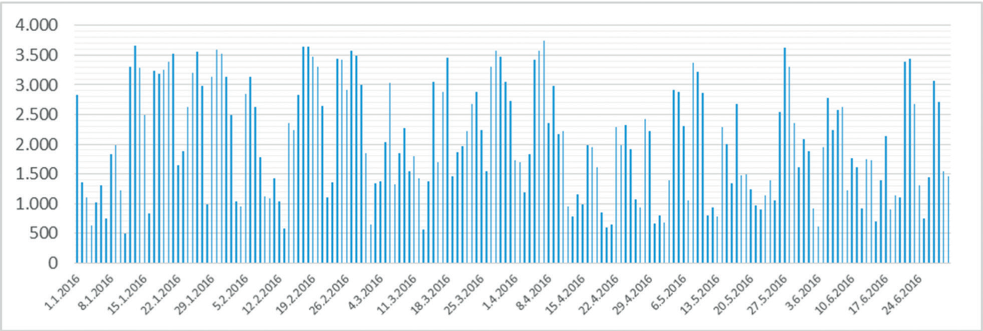


Due to its efficiency, three-bladed horizontal axis turbines are the most widely used ones both in the world and in Turkey.

Capacity Factor

Wind is not a reliable source and its speed varies over time. For this reason, wind turbines cannot generate electricity constantly all the time. In Turkey, on average capacity factor can be taken as 35 %, which means that the generated electricity is 35 % of the total installed capacity. Below figure shows the variation of wind generation in Turkey in the first half of 2016.

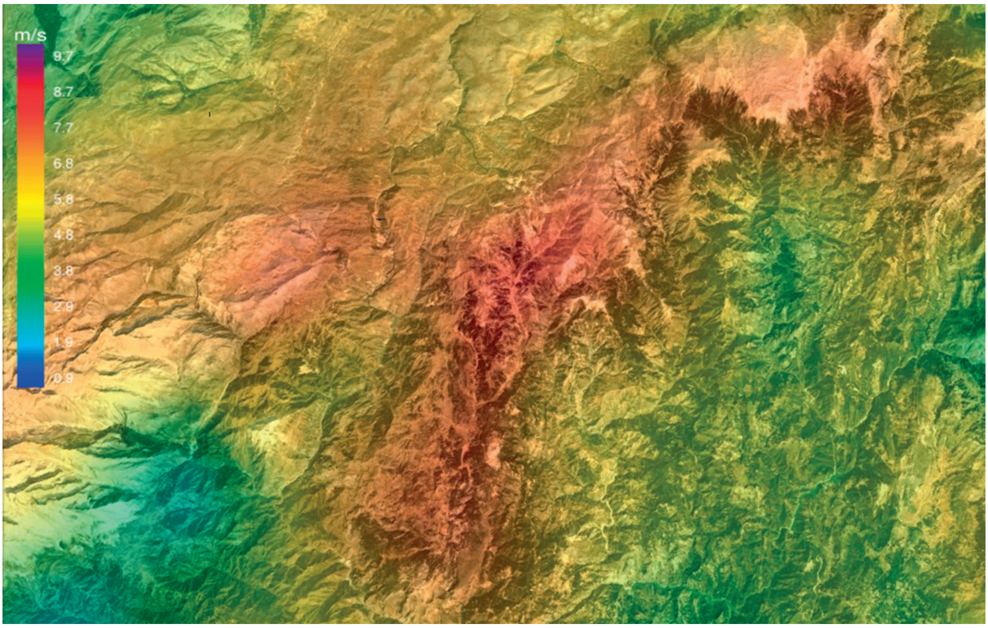
Figure 4: Wind Generation in Turkey (01.01.2016 – 30.06.2016)



Site Selection

Wind power plants should be installed in the most suitable sites to generate the most electricity. For this purpose, wind atlases should be used to find the windiest places. Wind atlases use statistical and geographical approaches to forecast the wind level of the places. These atlases may be in variable resolutions from 200x200 meters to 10x10 kilometers.

Figure 5: Sample Location in a Wind Atlas



Wind atlases give only insight about the project site for deciding the location of the measurement mast. For this reason, an on-site measurement mast is necessary for the real data. At least 1 year of on-site measurement is required to model the wind characteristics of the site.

Figure 6: Wind Measurement Mast

The standards of the measurement are stated in the Communique on Wind and Solar Measurements for Pre-License Applications Based on Wind and Solar Power.[13] Technical properties and the procedure for the measurement mast is as follows;

- Mast must be at least 60 m. height,
- Wind direction and speed measurements must be at 30m. and on top of the mast,
- Wind direction sensor should be 1.5-2.5m. below/above the speed sensor (anemometer) not to be affected by the turbulence,
- Other sensors (temperature, humidity, pressure) should be located at least 3m. height,
- Data should be stored at least 10 minute intervals,

13 Turkish Official Gazette, 17.06.2014, No. 29033

- Data logger should be able to store at least 1 year of measured data,
- There must be a signal light on top of the mast,
- Mast should be painted on red and white,
- Lightning rod should be installed,

» Measurement mast must be located in the project site,

- Coordinate error must be at most 5 m.
- Measurement masts must be at least 5 km. far from the meteorology radars,

» After the mast is erected,

- Application to General Directorate of Meteorology (GDM) is made for the approval of the mast,
- Coordinates and height of the mast is notified to the General Directorate of State Airports Operations,

» Every mast is given a code number by the GDM,

» GDM controls the mast within 15 days after the application,

» Control of the mast is done by at least 3 personnel of the GDM,

» Official measurements start after the approval of the mast erection,

- Approval of the mast requires the land usage right, types of equipment, manufacturer, serial number, height of the equipment and calibration date,

» Measurement data is sent to the GDM daily,

- Wind measurement data (direction, speed) is put in to file …_R.txt,
- Other data (temperature, humidity, pressure) is put into file …_D.txt,

» With the measurements;

- Prevailing wind direction,
- Wind speed pattern daily and monthly,
- Air pressure, temperature and density,

- Surface roughness,

data is collected and calculated.

» Missing data is limited to the 20 % of the all data.

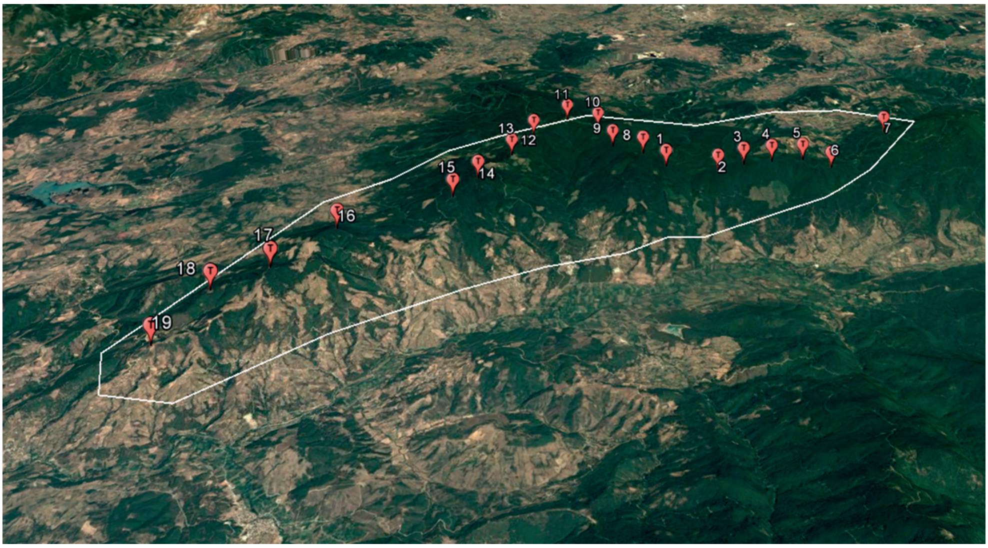
- If this limit is exceeded, then the measurement is invalid for the license application.
- Missing data below 20 % is completed by the statistical methods and using other measurements,

» After the measurement is completed, Measurement Report is prepared and submitted for GDM approval.

- Measurement Report is based on the top-level measurements,
- Calculations are done according to the 10-min interval measurements,

While the measurement is ongoing, preliminary energy analysis may be done with at least 6 months' data. For a normal energy analysis, at least 1 year of data is required. Energy analysis also contains micro-siting, which is the placement of the turbines in the project site. Placement of the turbines are done according to the technical characteristics of various turbine types. Energy analysis software suggests the optimal turbine size and coordinates according to the available data.

Figure 7: Sample Micro-siting in the Project Site



SOLAR ENERGY

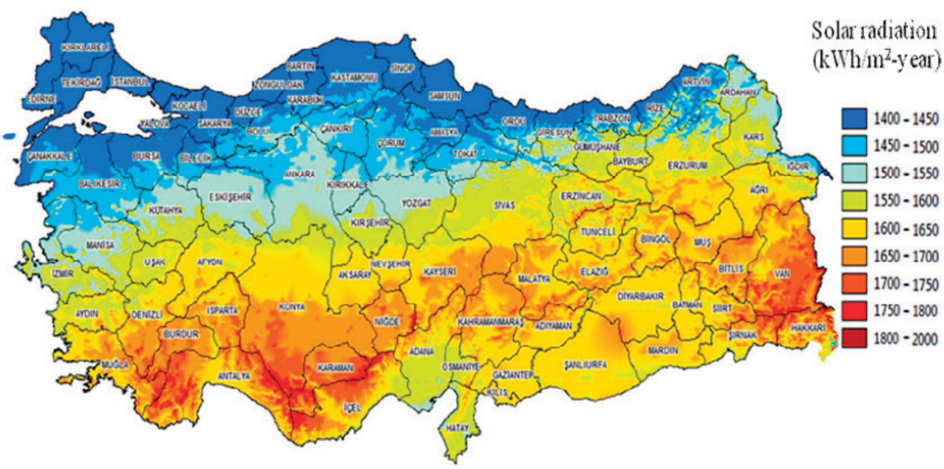
Source of the Solar Energy

Sun is mainly composed of hydrogen molecules and there are nuclear fusion reactions within the sun which is the source of the outgoing energy. Energy of the sunlight out of the atmosphere is 1.370 W/m^2 and this reduces to 0 - 1.100 W/m^2 on the surface of the earth[14].

Distance between the sun and the earth is 150 million km. and the total energy arriving from the sun is 20,000 folds of the energy used in the world. Not all of the solar energy arrives the earth surface and 30 % of this energy is reflected by the atmosphere. 20 % of the energy is absorbed by the atmosphere and 50 % arrives the surface. Less than 1 % is used for photosynthesis. Sun is the source of all energy forms in the world, other than the nuclear energy.

Solar energy distribution among Turkey is shown in below map, prepared by the General Directorate of Renewable Energy (GDRE).

Figure 8: Solar Energy in Turkey



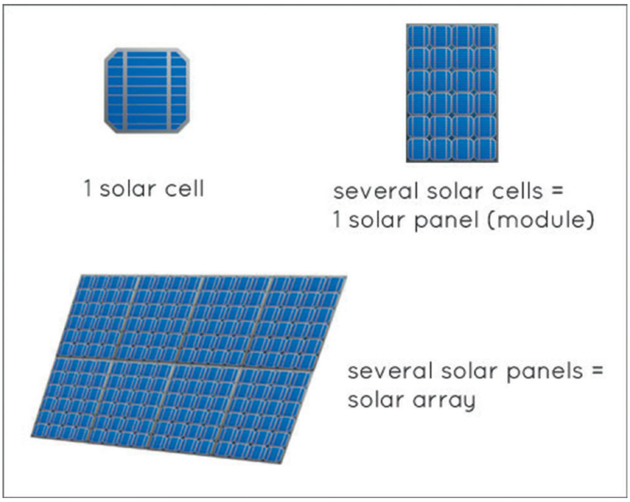
14 General Directorate of Renewable Energy (http://www.yegm.gov.tr/yenilenebilir/g_enj_tekno.aspx), 01.10.2016

Electricity Generation from Solar Energy

Solar electricity is the conversion of sunlight to electricity either directly (photovoltaics) or indirectly (concentrated systems). These methods are described below.

Photovoltaics, by far the most important solar technology for distributed generation of solar power, uses solar cells assembled into solar panels. Photovoltaic system converts sunlight directly to electrical energy using semiconductors. The direct conversion of sunlight to electricity occurs without any moving parts.

Figure 9: From Solar Cell to Array



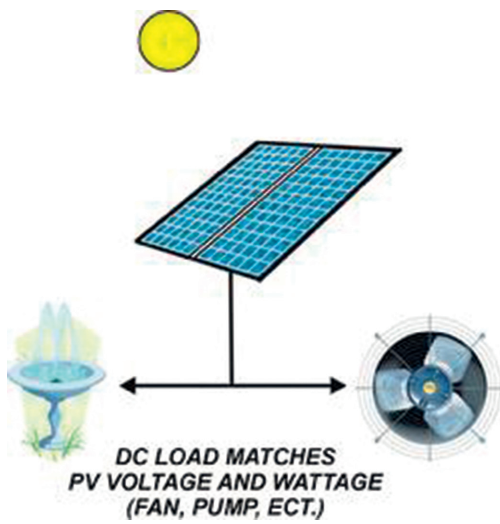
The record lab cell efficiency is 25.6 % for mono-crystalline and 20.8 % for multi-crystalline silicon wafer-based technology. The highest lab efficiency in thin film technology is 21.0 % for CdTe and 20.5 % for CIGS solar cells. In the last 10 years, the efficiency of average commercial wafer-based silicon modules increased from about 12 % to 17 % (Super-mono 21 %). At the same time, CdTe module efficiency increased from 9 % to 16 %. In the laboratory, high concentration multi-junction solar cells achieve an efficiency of up to 46.0 % today. With concentrator technology, module efficiencies of up to 38.9 % have been reached.[15]

The efficiency level should not be confused with the capacity factor. Efficiency is the ratio of generated electricity to the incoming sunlight. Efficiency of the solar cell determines the size of the solar panel. The more efficient cell causes the lesser size of the panel so that the required land for installation.

15 https://www.ise.fraunhofer.de/de/downloads/pdf-files/aktuelles/photovoltaics-report-in-englischer-sprache.pdf, June 2016.

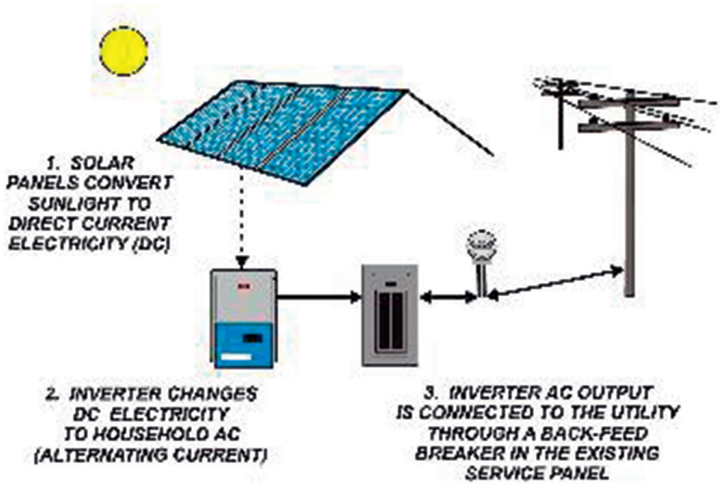
Generated electricity from the cells are direct current (DC). So, electrical devices that are using DC can be directly connected to the solar panels.

Figure 10: Using Direct PV



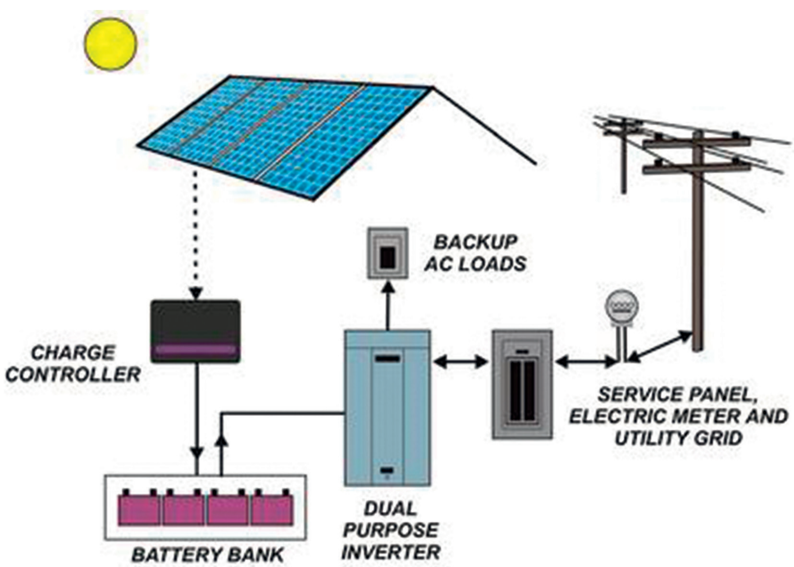
However, most of the electrical devices at home and industry use alternative current (AC). Therefore, transmission and distribution system are designed to carry AC. For this reason, an inverter is used for the transformation of this current before using.

Figure 11: Using Invertor after PV (without storage)



Whether using direct DC or converted AC, without a storage or a back-up system, continuous energy usage is not possible. If there is a balanced grid and the imbalances of the PV system is absorbed, then there is no need for a storage system. Excess electricity can be given to the grid and lacking electricity is taken from the grid. On the other hand, if there is a cost difference between the given and taken electricity from the grid, then there can be a need of storage. Or, if the system is standalone and cannot connect to the grid, storage becomes a necessity.

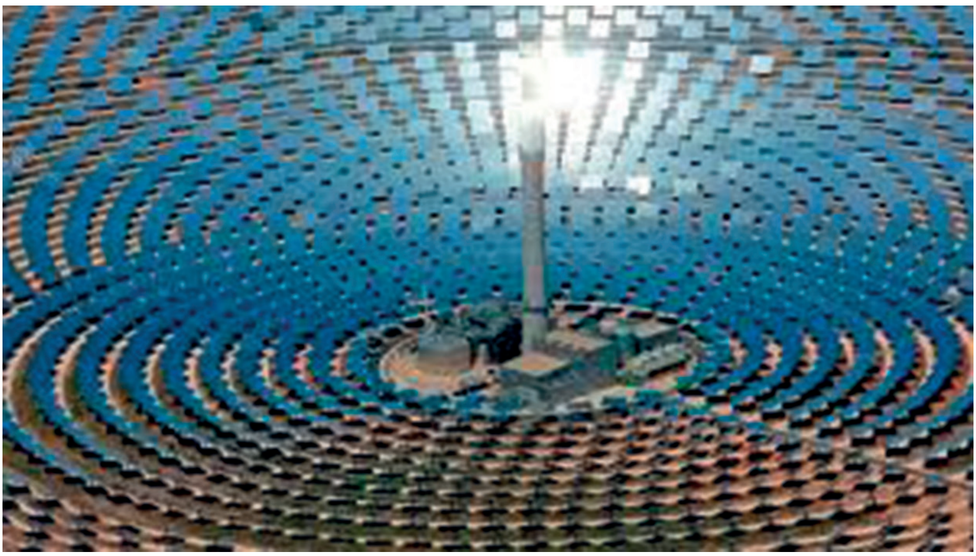
Figure 12: Using Storage after PV



Thin film technology is a cheaper alternative to PV, however, with a lower efficiency. This means that thin film instalments require more space. If the land availability is no problem and the land cost is low, thin film can be an option.

Another technology is the concentrating solar power or CSP. It is used primarily in very large power plants and is not appropriate for residential use. This technology uses mirrors to reflect and concentrate sunlight onto receivers that collect solar energy and convert it to heat, which can then be used to produce electricity.

Figure 13: Sample CSP Plant



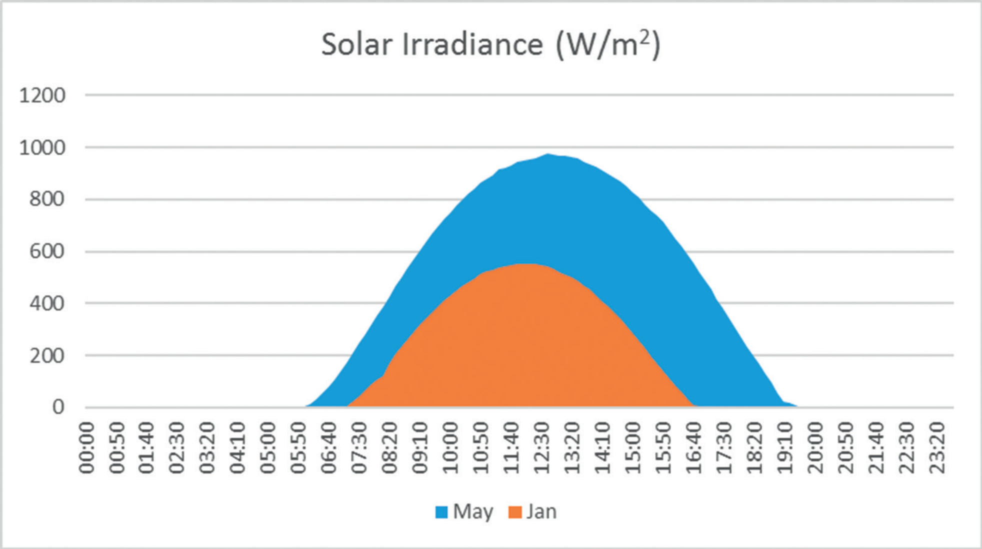
CSP systems do not generate electricity directly but rather they produce heat. The heat is then transferred to a steam turbine and generator system to generate electricity. The process is similar to that of thermal power plants. The difference is that the fuel is the sun.

Capacity Factor

Solar energy is also a varying source over time like the wind energy. However, it is more predictable than the wind, because the time of sunrise, sunset and the movement of the sun are known parameters in advance. The only unknown thing is the cloudiness of the sky that affects the generation.

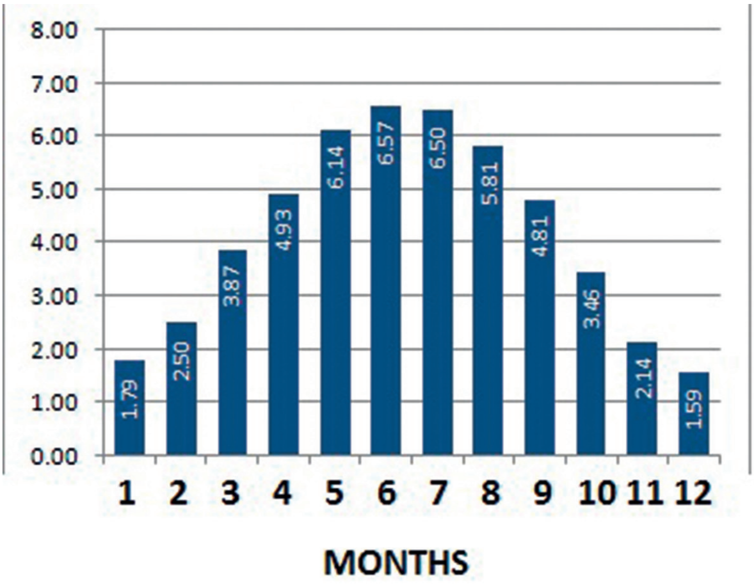
A typical pattern of the solar irradiance per m^2 is shown in below figure. It should be noted that both the width and height of the graph differs among the year.

Figure 14: Typical Solar Irradiance in January and May (W/m2)



Global irradiation of Turkey during the year is shown in below figure.

Figure 15: Average Solar Irradiance in Turkey (kWh/m²/day) [16]



16 General Directorate of Renewable Energy (http://www.yegm.gov.tr/MyCalculator/Default.aspx)

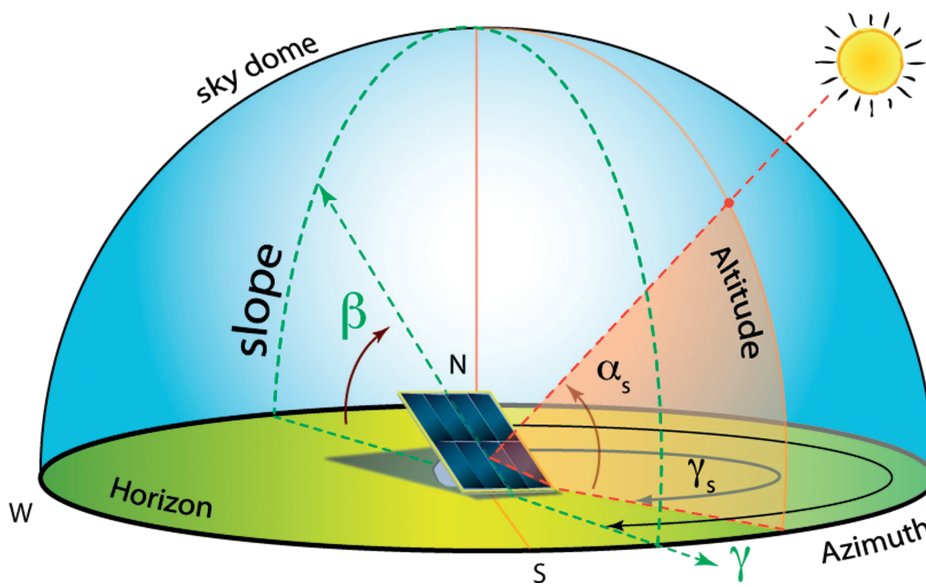
Due to the solar pattern during a day and during the year, capacity factor of solar system is assumed to be 18 %. This means that a solar system generates 18 % of the installed capacity on average. For this reason, if a utility needs 18 kWh during a year, it should install 100 kW solar panel to cover all its needs.

Site Selection

To get the highest efficiency from the solar energy systems, below simple conditions should be satisfied for the selected site:

- Latitude of the site should be as low as possible to get the highest solar irradiation during the year. The site should be in the southest part of the country as possible.
- The site should be inclined to south or at least flat to get sunlight easily,
- There should not be obstacles (hills, trees to the south) that prevent the sunlight to reach the site.

Figure 16: Demonstration for Site Selection



As a rule of thumb, the solar panel should be inclined as the latitude of the project site. If the project site is at 35° latitude, then the inclination should be 35° for a year. However, if there are tracking systems, then this angle will be applied automatically.

European Commission's Institute for Environment and Sustainability supplies the solar map of the world in Pvgis system. This map can be used to determine the solar irradiation level of an area. For a sample project site, data provided by the Pvgis is shown below.

Figure 17: Sample Project Site in Ankara

Figure 18: Average Monthly Electricity Production for 1 kWp

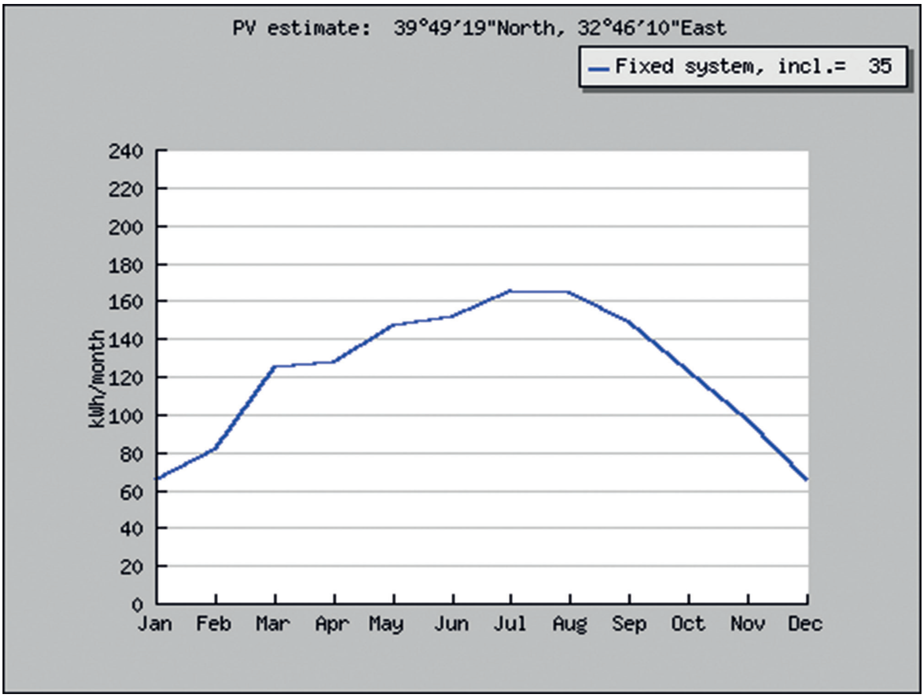


Figure 19: Average Monthly Irradiation kWh/m^2

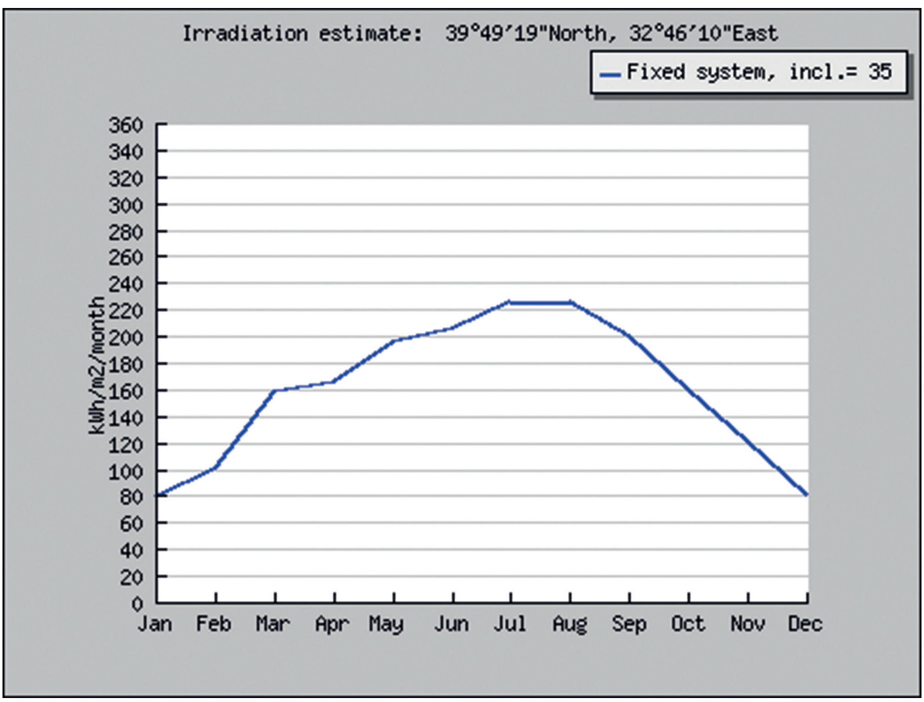
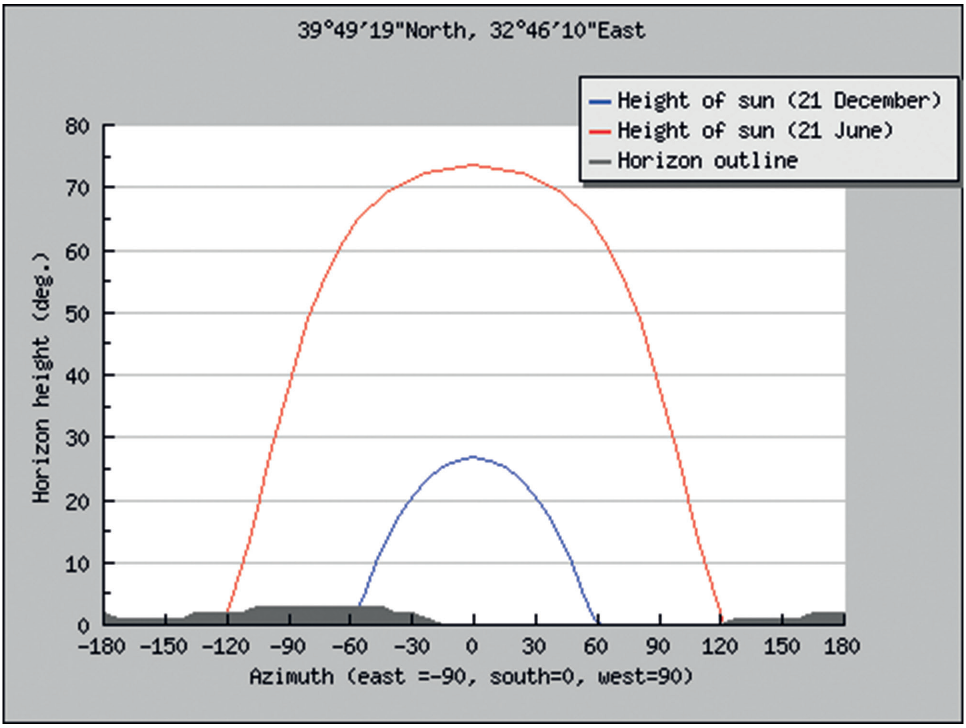


Figure 20: Horizon Height (degrees)



Solar measurements are not as much as required as the wind measurements, because they are predictable and known values according to the site. However, Electricity Market Licensing Regulation requires at least 6 months on-site measurement.

The standards of the measurement are stated in the Communique on Wind and Solar Measurements for Pre-License Applications Based on Wind and Solar Power.[17] Technical properties and the procedure for the measurement mast is as follows;

- In the mast, the following values should be measured:
  - Solar radiation via pyranometer,
  - Sunshine duration via sunshine duration sensor,
  - Wind speed via anemometer,
  - Wind direction via wind direction sensor,
  - Temperature via thermometer,

17 Turkish Official Gazette, 17.06.2014, No. 29033.

    - Humidity via humidity sensor,
- Mast should be at least 10 folds far from the nearest obstacle,
- Data should be stored at least 10 minute intervals,
- Data logger should be able to store at least 1 year of measured data,
    - » Measurement mast must be located in the project site,
- Coordinate error must be at most 5 m.
    - » After the mast is erected,
- Application to General Directorate of Meteorology (GDM) is made for the approval of the mast,
    - » Every mast is given a code number by the GDM,
    - » GDM controls the mast within 15 days after the application,
    - » Control of the mast is done by at least 3 personnel of the GDM,
    - » Official measurements start after the approval of the mast erection,
- Approval of the mast requires the land usage right, types of equipment, manufacturer, serial number, height of the equipment and calibration date,
    - » Measurement data is sent to the GDM daily,
- Wind measurement data (direction, speed) is put in to file …_G.txt,
    - » Missing data is limited to the 20% of the all data.
- If this limit is exceeded, then the measurement is invalid for the license application.
- Missing data below 20% is completed by the statistical methods and using other measurements,
    - » After the measurement is completed, Measurement Report is prepared and submitted for GDM approval.
- Calculations are done according to the 10-min interval measurements.

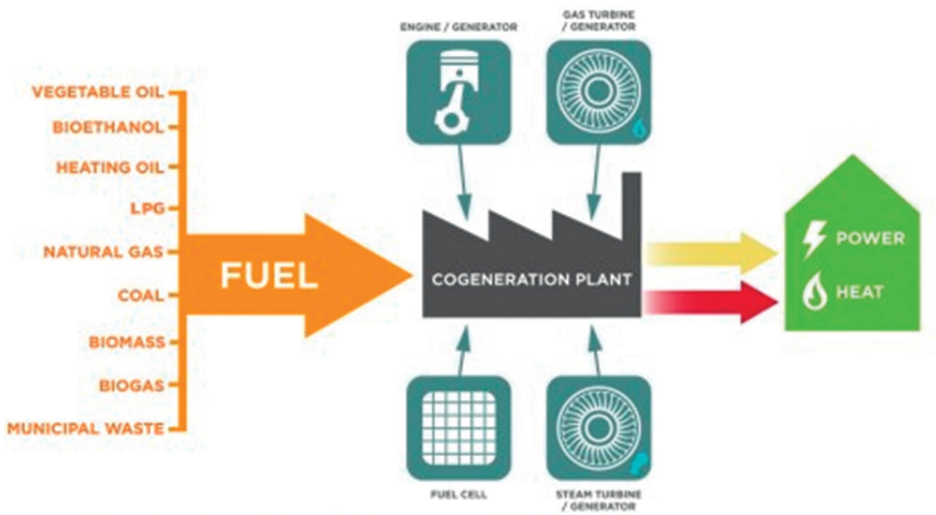
Cogeneration

Distributed cogeneration sources use steam turbines, natural gas-fired fuel cells, micro turbines or reciprocating engines to turn generators. The hot exhaust is then used for space or water heating or to drive an absorptive chiller for cooling such as air-conditioning. In addition to natural gas-based schemes, distributed energy projects can also include other renewable or low carbon fuels including biofuels, biogas, landfill gas, sewage gas, coal bed methane, syngas and associated petroleum gas.

Micro-cogeneration plants (<=100 kW) and the cogeneration plants which have higher efficiency than the determined level are exempted from licensing procedure. The determined efficiency level is 80 % for gas turbine systems with at most 0.95 electricity/heat ratio.[18]

Cogeneration is not suitable to be installed for a household but rather it is suitable for small-scale industry. Because, a cogeneration asset consumes a fossil fuel, it is less preferable compared to solar or wind energy.

Figure 21: Cogeneration Principle



Waste-to-energy

Municipal solid waste and natural waste, such as sewage sludge, food waste and animal manure will decompose and discharge methane-containing gas that can be collected and used as fuel in gas turbines or micro turbines to produce electricity as a distributed energy resource.

18 Communique on the Calculation of Efficiency Levels for Cogeneration and Micro-Cogeneration Plants Article 6/2/b.

Additionally, some processes were developed to transform natural waste materials, such as sewage sludge, into biofuel that can be combusted to power a steam turbine that produces power. This power can be used in lieu of grid-power at the waste source (such as a treatment plant, farm or dairy).

This method is also not suitable for household use. Since the waste is not available in many sectors, this is appropriate only for the industries which are producing or collecting waste, such as chicken farms or municipal waste processing.

CHAPTER-3

LEGAL ISSUES IN UNLICENSED ELECTRICITY GENERATION

THE LEGISLATION IN THE BACKGROUND

The components of the relevant legislation for UEG in Turkey is demonstrated in Figure 22. As mentioned in section for the main regulatory framework for UEG in Turkey, the provisions for UEG are regulated by the By-Law on Unlicensed Electricity Generation in the Electricity Market. The Communique on the Implementation of the By-Law on Unlicensed Electricity Generation in the Electricity Market[19, 20] provides explanations about the implementation of the provisions in the By-Law. And the legal basis for the By-Law is constituted by Article 14 of the Electricity Market Law (EML, Law No. 6446).

Investors of electricity generation assets based on renewable energy sources such as solar, biomass and wind, and micro co-generation investors can benefit from feed-in tariffs defined under the YEK Support Mechanism should they wish to sell excess electricity produced. The rates for feed-in-tariffs are indicated in the Law on the Utilization of Renewable Resources to Generate Electric Energy (Law No. 5346).

On the other hand, when choosing the appropriate sites for UEG assets from renewable sources, it should be the case that these sites should not be absolute agricultural land, irrigated agricultural land or planted agricultural land. Furthermore, the sites for UEG assets from renewable sources should not disrupt the agricultural use integrity in surrounding lands. This part of the relevant legislation concerns the Soil Protection and Land Use Law (Law No. 5403).

Finally, another part of the legislation concerns the qualification of cogeneration power plants for UEG. In order to qualify for UEG, these power plants should meet the total efficiency standard defined in the Article 6/2/b of the Communique on Procedures and Principles regarding the calculation of the efficiency of co-generation and micro-cogeneration assets for gas turbines.

19 Turkish Official Gazette, 02.10.2013, No. 28783.
20 Turkish Official Gazette, 23.03.2016, No. 29662.

THE LEGAL PROCEDURES IN UEG INVESTMENT

In this section, the steps to be followed while developing an UEG project are explained in detail. The development process starts with the application stage. However, before making an application, the following issue must be taken into account:

- It is essential that the owners of UEG assets do generate electricity primarily for fulfilling their own energy needs.[21] The electricity generated at an UEG asset cannot be traded. Furthermore, it cannot be consumed in a place outside the distribution region where the UEG asset is located. An UEG asset cannot be a balancing unit, either.[22] Thus, an UEG asset owner can only use the generated electricity for self-consumption.
- TEİAŞ (the transmission company) announces maximum available capacities for Transformer Stations to which unlicensed electricity generation assets will be connected. Therefore, if the generation asset is to be connected to the network, the applicant should check the capacities at the transformer station to which the generation asset is expected to connect.
- Air distance (line distance) between the power plant and grid connection point cannot be higher than[23]
    - 5 km (6 km) for the plants with 0.499 MW capacity at most
    - 10 km (12 km) for the plants with a capacity between 0.5 MW and 1 MW.
    - The capacity of the wind and solar power plants (with 1 MW capacity at most) shall not exceed 30 times of the contractual capacity of the associated consumption point.[24]
    - Except for roof-top based solar power plants, for wind and solar power plants maximum 1 MW capacity can be allocated to the same real or legal person at the same transformer station.[25]
    - Transfer of shares of the generation asset is not permitted until provisional acceptance is given.[26]

21 Article 19 of the Communique.
22 Article 28 of the By-Law.
23 Article 6(8) of the By-Law.
24 Article 6(12) of the By-Law.
25 Article 6(10) of the By-Law.
26 Article 29 of the By-Law.

Application Stage

In carrying out an UEG project, the first step is the application process. The applicant makes his application to the electricity distribution company (Network Operator) in his region.[27] According to the Article 7 of the By-Law on Unlicensed Electricity Generation in the Electricity Market and the Communique on the Implementation of the By-Law, the following documents should be prepared by the applicant in the application stage:

- The Unlicensed Generation Connection Application Form,28
- Title deed or rental lease agreement (for at least 2-year term) or right of use document of the site on which the generation asset will be established,
    - » If the generation asset is to be established on a public or treasury plot or on a forestland, then a document showing that right of use is obtained according to the relevant legislation is required.
    - » If the geothermal power-based generation asset is to be established on a public or treasury plot or on a forestland, then an exploration license should have been obtained according to the relevant legislation.
    - » If the wind or solar power-based generation asset is to be established on a public or treasury plot or on a forestland, then the generation site should have been allocated according to the relevant legislation.
- For solar based generation plants except for roof-top project applications, a document showing that the generation site is not an absolute agricultural land, special product land, planted agricultural land, irrigated agricultural land or does not contain any area which disrupt the integrity of agricultural use in surrounding lands. This document is obtained from the Ministry of Food, Agriculture and Livestock or from the Provincial Directorates of the Ministry.
- For cogeneration plants, a document on the total plant efficiency,
- Except for power plants based on biomass, biogas (including landfill gas), wind and solar power, a document that shows that the right to use renewable energy sources has been obtained,[29]
- The voucher or bank receipt showing that the application fee has been deposited to the

27 For hydro power plants, the application is made to the Special Provincial Administration in the city where the generation asset is located. Since there is no hydro power plant project for which provisional acceptance is given, the emphasis will be put on unlicensed electricity generation based on non-hydro sources.

28 Can be found in the Appendix.

29 This document is related to power plants based on hydro power or geothermal sources.

account of the relevant network operator,

- Single-Line Diagram that shows the technical features of the generation plant to be established,
- Technical Assessment Form to be prepared by the General Directorate of Renewable Energy (GDRE),
- Application sketch with coordinates,
- Documents showing the partnership structure of the applicant legal entity and of real or legal persons that directly or indirectly hold the shares of the applicant legal entity or that has a control relationship with the applicant legal entity,
- A document obtained under the scope of the Environmental Impact Assessment By-Law,30, 31
- The subscription number of the consumption asset to be linked to the generation asset to meet its energy needs,
- For solar based applications, should the sufficiency of the generation site with respect to the installed capacity is markedly different from the widely accepted technical criteria, then the Network Operator might ask the applicant to document the generation site's sufficiency.

If the documents mentioned in the By-Law and the Communique are complete, then the Network operator cannot ask any additional documents or cannot reject the application based on the so-called missing documents.

Assessment Stage

Once the applications are collected by the Network Operator, a commission assesses and finalizes the applications in the first 20 days of the calendar month. The commission comprises 3 members: the representative of TEİAŞ (the transmission company), the representation of TEDAŞ and the representative of the Network Operator. The TEİAŞ representative is the head of the commission. The decisions in the commission are made by majority of votes.

If the documents handed in by the applicant are not complete, then the Network Operator notifies the applicant in 3 working days following the assessment outcome for the missing

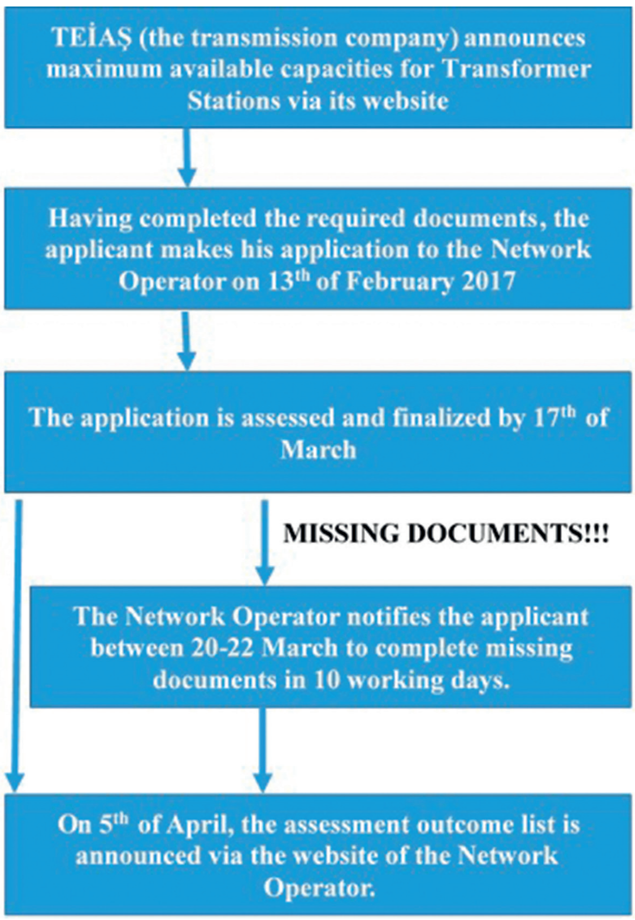
30 Turkish Official Gazette, 25.11.2014, No. 29186.

31 Among the assets or projects mentioned in this By-Law, the items that could be relevant to unlicensed electricity generation are hydro power plants with 1-10 MW capacity, wind power plants with 10-50 MW capacity, industrial plants that generate electricity, gas, steam and hot water and geothermal exploration projects. In order to be considered under the scope of unlicensed electricity generation though, these assets or projects should meet the criteria set out in the By-Law on Unlicensed Electricity Generation in the Electricity Market.

documents to be completed in 10 days. If the documents are not completed in 10 days, then the application is rejected.

The assessment outcome list for the accepted or rejected applications is announced via the website of the Network Operator in the first 5 days of the month following the month in which assessment is made. If the application is rejected, then all the documents are returned to the applicant in 10 working days and the rejection reasons are reported to the applicant in written form. An example about the timeline of the application stage is provided in the flowchart below.

Figure 22: The Flowchart for the Timeline of an Application: An Example



Once the documents are complete, the appropriateness of the Connection Point application of the generation asset is decided based on the assessment made under Article 8 of the By-Law. In this assessment, each application is evaluated independent of other applications in terms of connection and system usage. As mentioned previously, if the application is turned down, then all the documents are returned to the applicant and the rejection reasons as well as technical assessments are reported to the applicant in written form.

Based on the technical assessment outcomes, the applications with a potential to be connected to the network are then subject to priority evaluation. The ordered priority criteria for assessments are as follows:

- If the generation asset in the application is based on renewable resources
- If the generation asset in the application is a cogeneration asset
- If the applicant's last year consumption is greater than those of other applicants'
- If the generation asset and consumption asset is in the same place
- If the application falls under the scope of demand aggregation provisions
- If the applicant has no former application for which a positive connection opinion is given

An applicant might also be given an alternative connection opinion different than his original application. The Network Operator also announces these alternative connection opinions (if any) for applications for which connection points are deemed inappropriate together with the other results through its own website for 1 month. The applicant who is provided an alternative connection opinion informs the Network Operator in registered form in 1 month that he/she accepts the connection agreement.

For wind or solar based power plant applications that are deemed appropriate, the information in the Unlicensed Generation Connection Application Form is sent to the General Directorate of Renewable Energy (GDRE) in 10 days for technical assessment. The GDRE completes the assessment in 30 days and sends the Technical Assessment Report to the Network Operator. If the Technical Assessment Report is negative, then the application is rejected.

For wind-based generation applications, an additional document is required. Once the wind based applications that are deemed appropriate by the GDRE are announced in the website of YEGM, the applicant has to apply to the Informatics and Information Security Research Center of the Scientific and Technological Research Council of Turkey (TÜBİTAK) in 30 days for Technical Interaction Permit. Technical Interaction Analysis Report and the Technical Assessment Report are sent to the Network Operator in 10 days. If the outcome of any of these two reports is negative, the Network Operator returns the application documents to the applicant.

At this stage, “Invitation Letter for Connection Agreement” is given by the Network Operator for the following applications:

- The applications that are deemed appropriate,[32]
- The applications that are provided and accept an alternative connection opinion,
- The wind or solar power based applications for which the Technical Assessment Report is positive.

Once the applicant is given the “Invitation Letter for Connection Agreement” by the Network Operator, he has 180 days. In the first 90 days of these 180 days, the applicant submits his project to the Turkish Electricity Distribution Company (TEDAŞ) for approval. If the applicant does not apply to TEDAŞ in 90 days, his application is considered invalid. Once the project approval (and the Technical Interaction Permit for wind based projects) is sent to the Network Operator in a timely and complete manner, the Network Operator has to sign the connection agreement with the applicant in 30 days. When the connection agreement is signed, the construction period starts. According to the Article 24 of the By-Law, following the signing of the connection agreement, provisional acceptance of

- hydro based generation assets that are connected to the network at high-voltage level will be completed within 3 years.
- non-hydro based generation assets that are connected to the network at high-voltage level will be completed within 2 years.
- generation assets that are connected to the network at low-voltage level will be completed within 1 year.

Provisional Acceptance and Commissioning of the Generation Asset

After the construction of the UEG asset is completed, the applicant who is a real or legal person notifies the Network Operator that the generation asset meets the technical criteria in the By-Law and the Communique, in addition to the conditions in the connection agreement. The Network Operator then signs that the generation asset is ready for provisional acceptance with a protocol.[33]

The applicant presents the protocol on the readiness of the generation asset for provisional acceptance and a compliance report that includes technical data and parameters about the manufacturing test, type tests or certificates to the Ministry or the institutions and/or legal persons authorized by the Ministry. All these acceptance transactions are carried out according to the Applicable Technical Legislation.

32 Except for applications that are hydro-based.
33 Article 15 of the By-Law.

Following the provisional acceptance of the generation asset by the Ministry of Energy and Natural Resources or an institution authorized by the Ministry, System Usage Agreement is signed within 1 month and the unlicensed electricity generation asset is commissioned.

All these stages are also demonstrated in Figure 23 as a flowchart.

COMMERCIAL PROVISIONS

Feed-in-Tariffs

Unlicensed electricity generators can sell the surplus electricity they generate. This electricity is purchased by the last-resort electricity supplier in the region for a period of 10 years[34] at the rates indicated in the Law on the Utilization of Renewable Resources to Generate Electric Energy (Law No. 5346). The 10-year period starts with the commissioning of the UEG asset. The rates are displayed in Table 5.

Table 6: Feed-in-tariffs for the Excess Electricity Generated

Asset	Source Type	Feed-in-Tariffs
Power plants based on renewable energy sources (RES) with a capacity up to 1 MW	Renewable Energy Sources	The source-based feed-in-tariffs in Sheet No. 1 attached to the Renewable Energy Sources Law
Micro-cogeneration	Non-Renewable Energy Sources	The lowest of the feed-in-tariffs in Sheet No. 1 attached to the Renewable Energy Sources Law (7.3 Dollar cents/kWh)
Power plants based on municipal solid waste treatment plants and sludge disposal facilities	Renewable Energy Sources	The source-based feed-in-tariffs in Sheet No. 1 attached to the Renewable Energy Sources Law
	Non-Renewable Energy Sources	The lowest of the feed-in-tariffs in Sheet No. 1 attached to the Renewable Energy Sources Law (7.3 Dollar cents/kWh)
Power plants established on water supply lines and waste water lines run by municipalities	Renewable Energy Sources	The source-based feed-in-tariffs in Sheet No. 1 attached to the Renewable Energy Sources Law

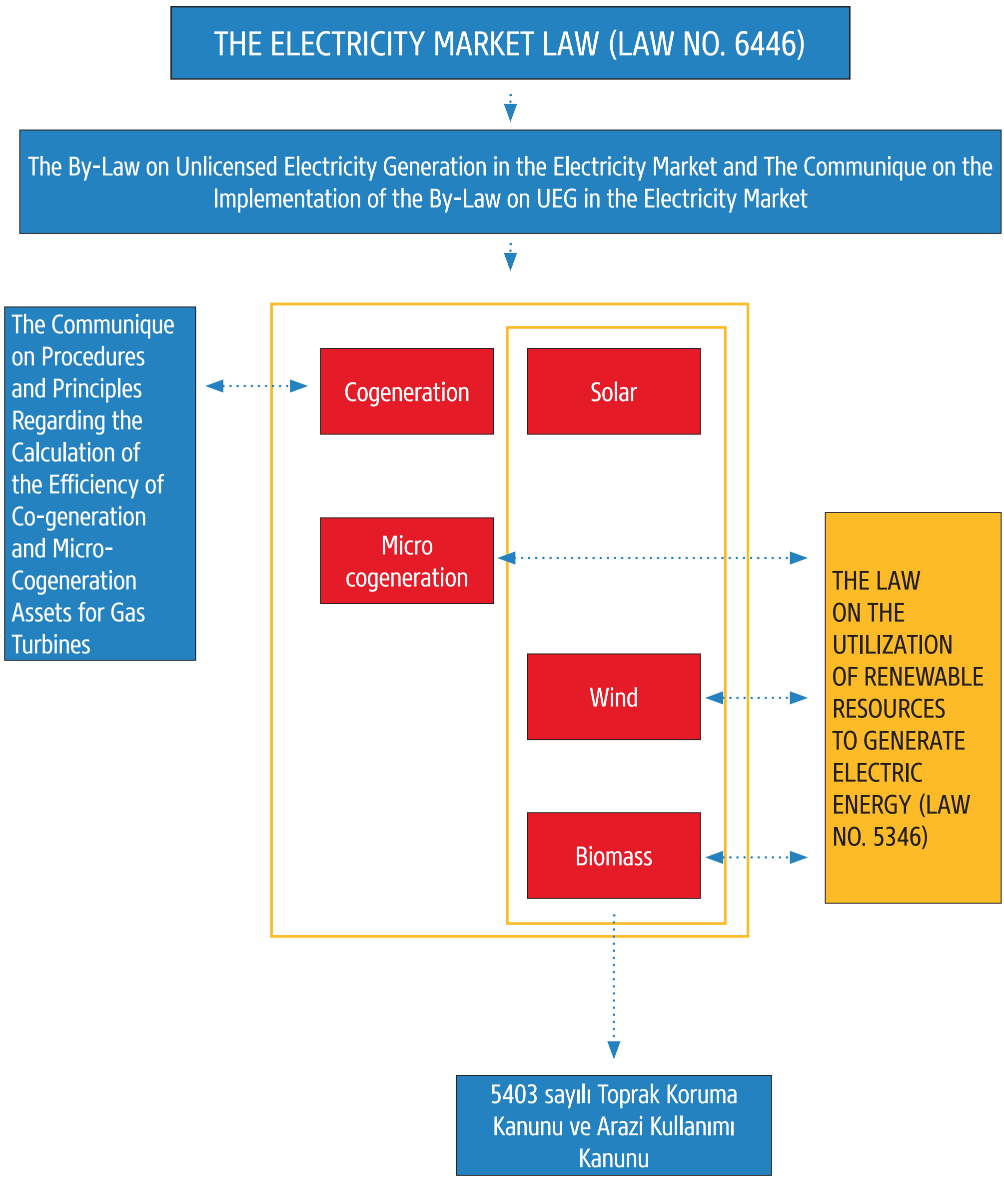
A relevant question concerning commercial provisions is whether it is mandatory to have the consumption unit and UEG asset in the same place. According to the Communique[35], UEG asset owners can consume surplus electricity at another consumption unit they own in a different location. In this case, system usage fee is paid for the electricity consumed at other consumption units.

34 Article 18 of the By-Law.
35 Article 19 of the Communique.

Consumption Aggregation

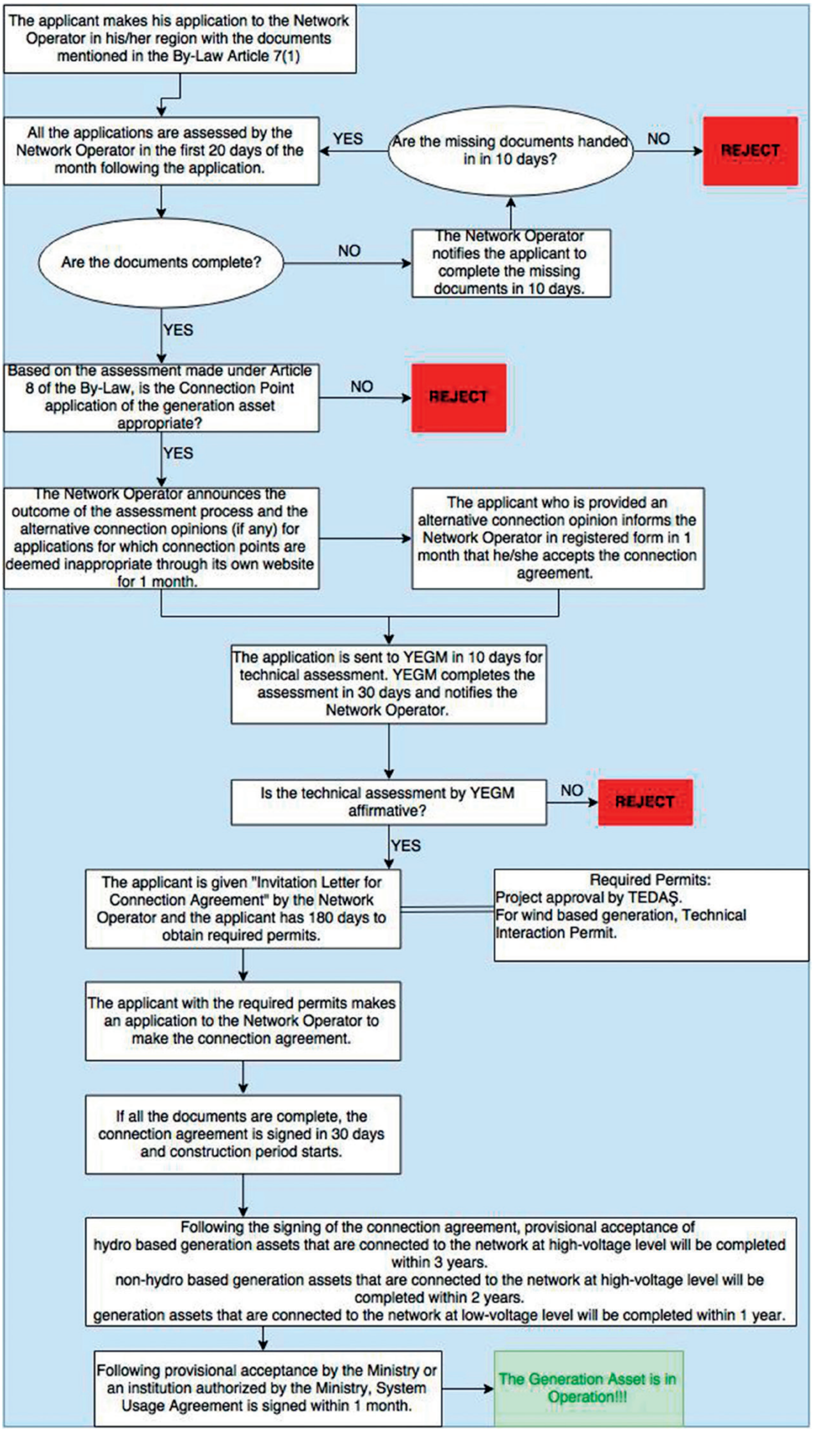
Consumption aggregation is possible for UEG asset owners. So long as they are in the same tariff group, a real and/or legal person or multiple real and/or legal people can aggregate electricity consumption in the consumption units they own in order to set up an unlicensed electricity generation power plant.[36]

However, these consumption units and the unlicensed power plant should be located in the same distribution region.



36 Article 23 of the By-Law.

Figure 24: Flow Chart for Unlicensed Electricity Generation Applications



Source: http://www.eie.gov.tr/yenilenebilir/document/lisanssiz_akis_semasi.pdf

APPENDIX

THE UNLICENSED GENERATION CONNECTION APPLICATION FORM

Information About the Applicant			
Name-Surname/Title			
Address			
Phone			
Fax			
E-mail			
T.C. Tax/ T.C. ID Number			
Bank Account Number			
Information About the Generation Asset			
Address			
Geographic Coordinates (UTM 6-ED50)			
Installed Capacity			
Requested Date for the Connection			
Projected Date for the Commencement of System Usage Agreement			
Type / Resource Used			
Connection Type	O LV[37] Single Phase	O LV Three-Phase	O HV[38]
Information About the Connection Transformer			
Other Information			
All the information provided in this form has been filled out correctly by myself. In case my application is accepted, I hereby accept and promise that I will construct the generation asset in compliance with the conditions mentioned in this form, that I will not carry out any transaction without obtaining the required permits from the Network Operator during the construction stage, that the Network Operator cancels my application at any stage should it identify a situation that is contradictory to the information in this form.			
Name-Surname/Title	Signature	Date	

37 Low Voltage
38 High Voltage

CHAPTER-4

FINANCIAL VALUATION OF LICENSE-EXEMPT ELECTRICITY GENERATION INVESTMENTS: A SOLAR POWER PLANT INVESTMENT CASE

INTRODUCTION

When the electricity sector is approached from a technical perspective, it is easy to see that the network structure has changed in recent years. The traditional grid method, which includes large and remote power plants, high voltage transmission lines, centrally managed distribution and consumers, is replaced by the distributed network model in which distribution-integrated generation assets are installed where the consumption takes place. The strong network infrastructure and the facilitation of connection processes that are needed during the implementation of this method is of great importance for every potential consumer to be a producer at the same time. With this network structure, long transmission and distribution lines are also replaced by shorter lines, which means that losses are minimized. One of the greatest efforts to be adapted to this evolving structure is the regulatory updates. At this stage, it is inevitable to follow a liberalized and privatized market infrastructure. The netting of network-integrated consumption and generation also creates the financial dimension of the change.

The most prominent example of this structure in Turkey is the so-called “unlicensed” investments with an installed capacity below 1 MW. Modern and renewable energy systems in this structure are preferred because of the difficulty of establishing the installed capacity of this level with the traditional type of conventional generation assets. In particular, some factors, such as population growth, high rate of energy demand increase, increased importance of the concept of energy supply security, and climate change have initiated a favorable era for renewable energy technologies around the world.

The most important source that investors follow in this regard is the Sun. Even a small portion of the energy of solar radiation coming to Earth is greater than the current energy consumption of mankind. In recent years, solar energy systems have technologically improved and their costs have gone down, and they have established themselves as an environmentally-friendly basic energy source. The use of this source, which is more convenient for small applications, in electricity generation is indispensable for distributed network construction.

PROJECT PHASES

The first step for the development of solar energy projects is to determine the site of application. The area required for a solar power plant investment can be obtained either by roof-top applications or by floor-mounted applications.

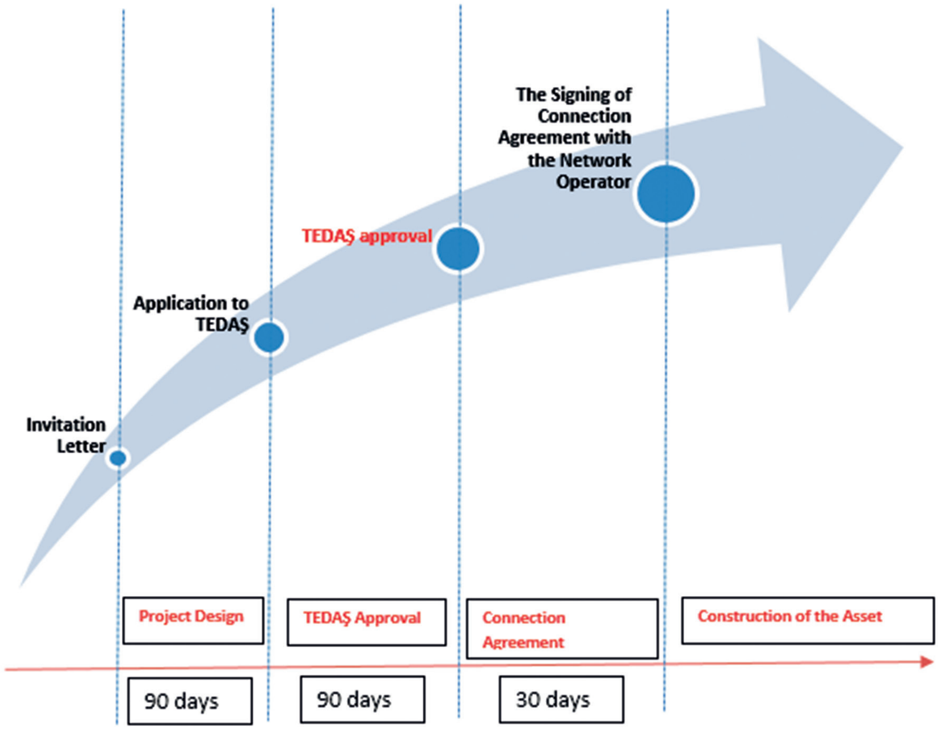
The area required for a 1 MW application is approximately 20 decares. This figure can be lower based on the availability of natural conditions, the shading, the inclination of the ground, and many other parameters. In order to obtain high production values, it is important that the annual total horizontal irradiance is greater than 1620 kWh/ m2-year, when a solar power plant is established on a land that is not forestland or dry, irrigated or planted agricultural land. Especially in sloping roofs, the direction in which the panels are to be placed, the type of roof, the slope, whether the roof is south-facing, the absence of obstacles to cause shadowing around, the correctness of static calculations and the ease of logistics play an important role in determining the capacity to be installed.

Optimum project planning for the selected site and maximum performance should be prioritized. It should not be forgotten that different results may be obtained in different designs. It should also be noted that these values will significantly affect the payback period for such long-term investments. After a proper project planning, the feasibility of the site is determined and approximate values can be reached through simulations.

In addition to these technical processes, it should not be forgotten that the application file will be assessed if the network or transformer station to which these systems to be installed will be connected have sufficient capacity. Legal application processes, project evaluations, financial plans and studies are important business items that continue during this period.

The legal application steps for unlicensed electricity generation are demonstrated below. In the application process to TEDAŞ, it is of great importance that the system in the projects should be designed at the level that will provide maximum performance in order for the implementation to begin right after the approval process.

Figure 25: Unlicensed Electricity Application Process[39]



Following the construction of the plant, provisional acceptance process will be carried out and then the system will generate electricity and feed it to the network. The invoicing of the generated electricity by the netting method will also be ensured by the completion of the approval processes.

BUDGETARY ACCOUNT

Investments in the energy sector are long-term, technological and large investments. Therefore, the correctness of financial analysis of such investments has great importance for the future of investments. Financial analysis of such investments should be examined in three main sections. These are: return of the system, system fixed costs and variable costs. While fixed costs are the amount spent during the investment, variable costs are treated annually and vary depending on the size of the investment and some other parameters. The returns are calculated by the cumulative summation of the inputs of the system on an annual basis. Then, the variable costs, which are annual costs, must be summed cumulatively and deducted from

39 ŞİMŞEK, B., "Solar Energy Potential and Legislation in Turkey", http://emhk.itu.edu.tr/wp-content/uploads/2015/03/BilalSimsek_TEDAS_10Mart2015V2.pdf, Access: 29.12.2016

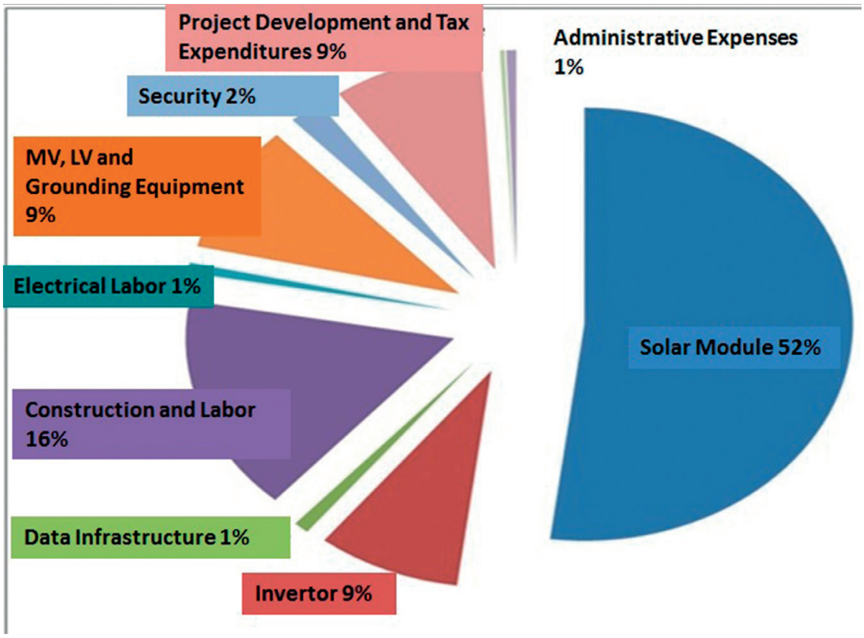
the system's return. Similarly, the fixed costs, which are the investment costs of the system, should also be deducted from the income. Furthermore, the financial calculations that need to be taken into account are also part of a professional payback period calculation.

FIXED EXPENDITURES

Investment costs spent in a power plant installation are called fixed costs. These costs may or may not show significant differences for each investment. The first of these is the payment made for the site where the plant is established. It should be borne in mind that 20 decares of land will be priced differently at very different locations. In addition, there are no such expenditures, in general, in roof-top applications, as the consumer builds the generation asset on his/her own roof within the scope of the self-consumption model. However, the amount of roof reinforcement that will be needed in case the roof is not convenient should also be taken into account.

The largest part of the expenditures is for solar panels. This amounts to about 50%-55% of the total investment cost. Despite the improvements in panel technology and the decline in unit price per Watt, there is no doubt that the biggest cost item will be solar panels for a while. Another major item of the technical costs is the invertors. While these devices are used to convert the DC power generated by the panel into AC power, they are also regarded as an important parameter for the efficiency of the system. The amount paid to these equipment constitutes about 10% of the total investment cost. Construction and labor are other major items and their shares in total investment costs range from 15% to 20%. The main reason why a precise value for construction and labor cannot be provided is the feasibility of the application site for investment. Especially in site applications, the amount to be paid to the equipment that keeps the investments intact -investments for which different methods such as concrete flooring has been developed and 25 years of system guarantee has been promised- should not be avoided. Another major item can be MV/LV (Medium Voltage/High Voltage) and grounding costs. The reason for this is that it also contains components such as wiring that make up the core of the investment. Of course, one of the biggest parameters that interest the optimal design of the investment to be made is this equipment.

Figure 26: Items of Investment Costs and Their Shares[40]



In addition, there are expenses such as electrical labor, data infrastructure, security, project development, tax expenses, administrative expenses. However, these constitute a smaller component and can vary according to the characteristics of the investment.

Since roof-top applications are usually installed in smaller capacities, the installation cost of the plant declines linearly, as the installed power decreases. However, the unit cost of the plant increases as the purchasing power decreases. It will be difficult to calculate the feasibility of such systems. For example, electricity consumption is calculated as 240 kWh per month for a standard family of 4 persons. However, even the electricity consumption of a standard family will vary only because the socio-economic conditions differ. In addition, the amount paid by the investor will vary according to the type of electricity subscription, the tariff period and the consumption habits of the consumer.

VARIABLE EXPENDITURES

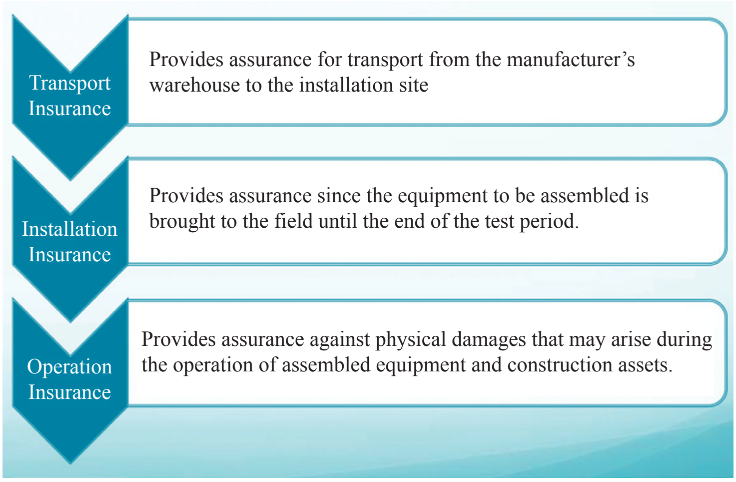
Variable costs are amounts that vary from year to year, and that are usually calculated based on the size and cost of the investment. The first item of these costs is operational, maintenance and repair costs. This amount in solar energy systems is less than that in other mechanical systems that generate electricity. The operating, maintenance and repair costs of

40 BAŞLAK, O., "Solar Energy Investment Approach", http://www.solarbaba.com/uploads/files/066-dosya-ges-yatirim-orcun-baslak.pdf, Access: 30.12.2016

power plants that have not faced any problem in the installation and regular controls are approximately 1-2% of the annual investment amounts. These values are directly related to the system's installation and device quality as well as to the capacity.

In addition, since solar energy projects have high investment costs, investors prefer to insure projects during the installation phase and the operation to minimize risks. These insurances can often be classified into 3 categories as transport, installation and operation insurance.

Figure 27: Different Types of Insurance and Their Content[41]



Investment should be guaranteed for the 25-year system life, after minimizing the risks of transportation and installation. Operation insurance constitutes about 0.5% of annual system value.

INCOME ELEMENTS

The Role Of State Subsidies (Feed-In-Tariffs)

Feed-in-tariffs are the most common energy subsidies in Turkey. These subsidies are expected to lower entrepreneurs' risk perception and to accelerate their investments by increasing the economic value of their projects, and to help create added value. More importantly, the effect of feed-in-tariffs on cash flows must be fully understood and assessed by market players. This process is one of the most important elements in the accurate assessment of energy projects. It should be noted that feed-in-tariffs should not adversely affect price formation in energy investments in terms of social benefit and should not lead to value losses.

As mentioned in the previous chapters, electricity generated by unlicensed power plants can-

41 Life Enerji, "Solar Power Plant Project Financial Analysis and Insurance", Access: 31.12.2016

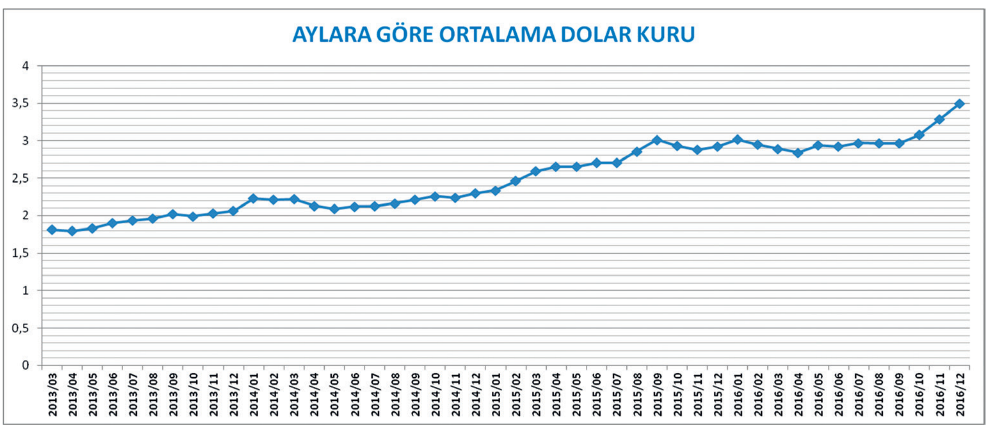
not be sold to free market or via bilateral agreements. Investors establishing unlicensed power plants based on renewable energy sources -be it a real or legal person- can sell the surplus electricity they generate for 10 years at the rates displayed in the table below. The consumption unit and the unlicensed power plant should be located in the same distribution region.

Figure 28: Feed-in-Tariffs for Unlicensed Electricity Generation Based on a Renewable Energy Source[42]

Production Plant Type (Based on a Renewable Energy Source)	Rate (US Dollar cent per kWh)
Hydro	7.3
Wind	7.3
Geothermal	10.5
Biomass	13.3
Solar	13.3

Although the production of solar power plants varies greatly from day to day, the production risk is very low when viewed on a monthly or yearly basis. Price risk depends on economic and political uncertainties and is difficult to predict and manage. Feed-in-tariffs, at this point, play an important role in eliminating these uncertainties. Moreover, question marks in many investors' minds arising from that the vast majority of investments are made in foreign currency are resolved since the unit price in feed-in-tariffs are in dollar terms. In addition, the exchange rate variability will be minimized and more accurate estimates will be available during the pre-investment stage in which payback periods are determined.

Figure 29: Change in Exchange Rates in Recent Years



42 AYTAÇ, A. E., "Electricity Sale Processes of Solar Power Plants" http://www.solarbaba.com/uploads/files/045-dosya-yekdem-ges.pdf Access: 02.01.2017

On March 14, 2013, the upper limit of unlicensed power generation based on renewable energy sources was raised from 500 kW to 1 MW by the Electricity Market Law. The Dollar exchange rate in those days and the Dollar exchange rate in December 2016 are seen in the figure above.

The netting of the surplus energy produced by unlicensed generation assets will be different depending on whether or not the power plant and the consumption unit share the same location. The definition of the "same location" is as follows: If the generation asset and the consumption unit are connected to the distribution network at the same busbar, then these are accepted to be in the same location. If the generation asset and the consumption unit are installed in the same place, as the surplus energy fed into the system will be measured daily by a bi-directional meter, the daily consumption will be deducted from the daily production (as of 24:00) and if there is production surplus (= surplus energy), the value obtained by multiplying the feed-in-tariff rate based on the relevant renewable energy source by the current exchange rate of the Central Bank for the dollar is recorded to the receivable accounts of the producer. If the generation asset and the consumption unit are in different places, the energy fed into the system and drawn from the system are recorded separately. The energy drawn is deducted from the energy fed. Consequently, it is concluded that either the surplus energy is supplied to the system or the energy is drawn from the system. However, in this case, the system usage fee is charged separately for both the energy drawn from the system and the energy supplied to the system.[43]

GENERATION EFFICIENCY OF ELECTRICAL ENERGY

There has been a great deal of progress in the process in which solar radiation, which is turned on by the fusion process that takes place in the core of the Sun, is converted into electricity and used by the end consumer. Passing through different efficiency filters, solar radiation is exposed to various losses. Some of the radiation reaching to the earth from the sun are interrupted by shadings or the obstacles they face on the horizon. Later, some of this radiation striking on panels are lost to the near shadings. Among these shadings are the shadings of the structures around the panel or the shadings of other panels. Some of the radiation reaching to the panel cannot be utilized due to dust (or snow) on the panel glass. Some of the solar radiation striking on the module surface is reflected back from the module surface without being absorbed by the cells. The loss due to the reflected part of the radiation is also called the reflection loss. In addition, fluctuations in performance due to the angular change occurring during the movement of the sun cause losses, too. Radiation as large as the surface of the panel is taken in and used in electrical power generation. There will be filtering

43 Unlicensed Electricity Generation Guide", http://enerjienstitusu.com/elektrik-piyasasi-lisanssiz-elektrik-uretimi-rehberi/, Access: 02.01.2017

in the transition from radiation to electricity according to the panel efficiency. Later, due to temperature loss and DC cable losses at the panel exit, generation will further decrease. The efficiency of the invertors by which electricity is converted from DC to AC in order for the generated electricity to be transmitted to the grid will cause losses in electricity. Then, having losses on the AC cable, the electricity reaching to the transformer station will be transmitted to the system, being exposed to similar losses.

Among the losses, the largest one arises from the inefficiency of the panel. The performance of the solar panel will not be constant; however, it will be interrupted over the years and the performance will decrease. The data sheets of all panel manufacturers include explanations of how this performance changes over the years and how performance guarantees are described. As can be observed from the linear performance guarantee graphs, there is a 25-year linear power guarantee and a 10-year product warranty. Typically, performance with an annual decline of 1% over the first decade shows an accelerated decline in the following years. At the end of 25 years, the performance of the panel is not depleted. This shows that the panel can generate electricity for a while. Among other important components of the electricity generation assets from solar energy that are given 25 years of system life, invertors are given 5-year, load-bearing constructions are given 10-year, solar cables and collectors are given 5-year, and AC cables and fittings are given 5-year product warranty. While these values can vary from firm to firm, it is easily observed that these components continue to work after product warranties are over.

ELECTRICITY GENERATION AND RETURN

Various simulation applications have been developed to approximately calculate the generation values of a solar power plant. In order to calculate these values correctly, all technical data must be correctly filled into the simulation application. The average of meteorological data collected for many years should also be included in the assessment. The approximate level of generation obtained from the simulation (including all losses, efficiencies and gains) is given below. Generation can cruise at the following level with an annual average decrease of 1% under the 10-year product warranty. The approximate production values for a plant in a >1MW_{dc} power plant installed for a 1MW_{ac} power plant with an approximate 1,650 kWh/m2 global horizontal irradiance are given as follows. Since the values obtained may vary from plant to plant and from design to design, a sample application has been considered.

Figure 30: The Results of a Simulation: Electricity Generation and Its Monetary Value

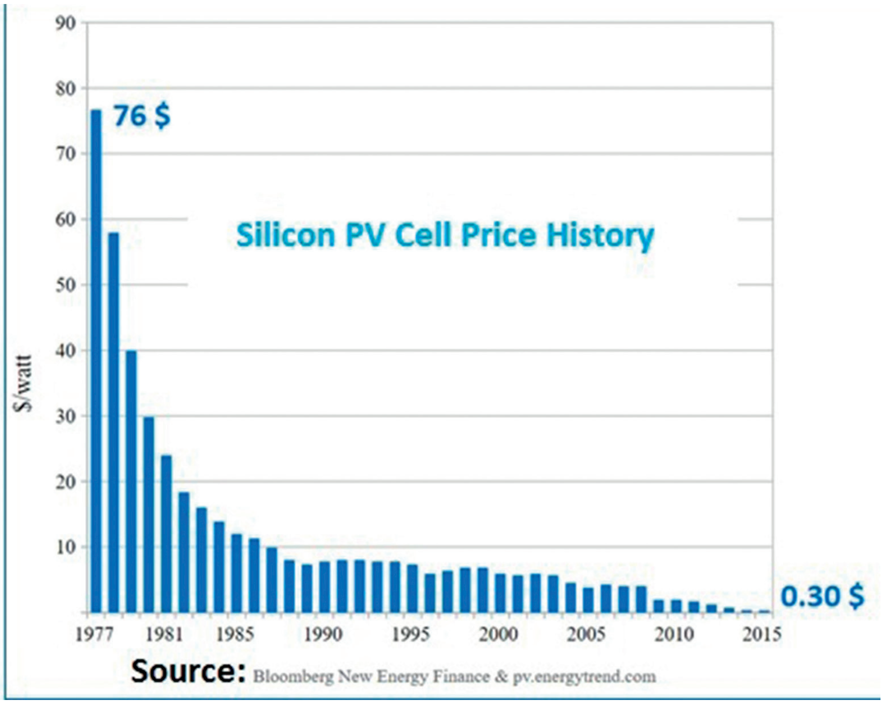
YEAR	PRODUCTION	UNIT PRICE	INCOME
1	1,766 MWh	¢13.3/kWh	$234,878
2	1,748 MWh	¢13.3/kWh	$232,484
3	1,730 MWh	¢13.3/kWh	$230,090
4	1,712 MWh	¢13.3/kWh	$227,696
5	1,694 MWh	¢13.3/kWh	$225,302
6	1,677 MWh	¢13.3/kWh	$223,041
7	1,660 MWh	¢13.3/kWh	$220,780
8	1,643 MWh	¢13.3/kWh	$218,519
9	1,626 MWh	¢13.3/kWh	$216,258
10	1,609 MWh	¢13.3/kWh	$213,997

Roof-top applications are usually installed in smaller capacities in order to produce electricity where it is consumed, which is also known as the so-called self-consumption model. In such capacities, the electricity generated by the plant decreases linearly with the installed power.

CHANGE IN SOLAR PANEL PRICES

Solar panels are the most important component of solar energy systems and the largest component of investment costs. The cells -which are also materials that generate electricity-forming the panel are the basic elements of the panel. These materials are the products of major research and development activities, and any improvement at this level will directly contribute to the improvement of the production, efficiency and performance of improvement system. Such an effective component will naturally constitute a large part of the panel cost. Large reductions in the unit costs have been observed thanks to the development of the cells together with the changing and evolving technologies. One thing to note at this stage is that the panel unit prices are given in Watts. While the cost of each Watt contributing to power was $76 in 1977, according to 2015 data it decreased to the level of $0.30 per Watt.

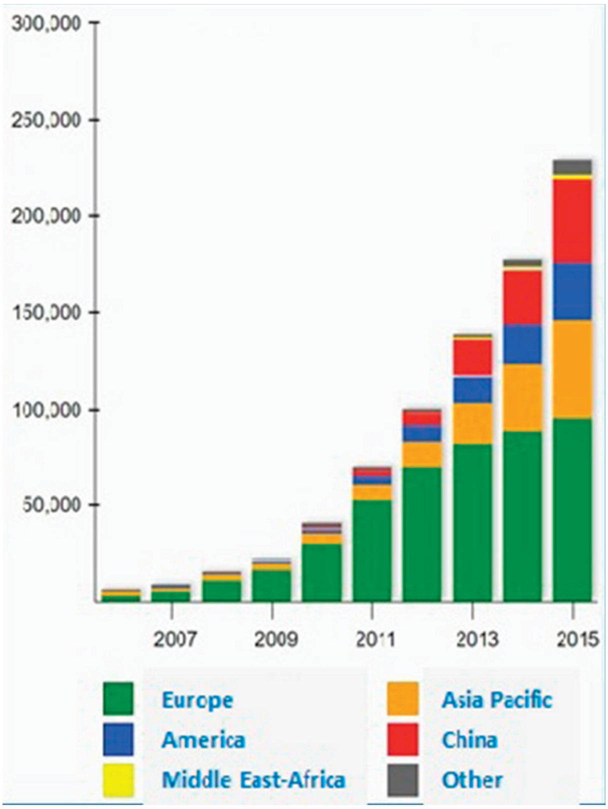
Figure 31: Silicon PV Cell Price History[44]



This major change is of great importance for boosting the installation of a system that is easy to use and of which source is readily accessible. Accompanied by the exponential decline in unit cost per Watt, especially after 2007, the increase in installed capacity has been so high that it impacts market players. By the end of 2015, the total installed capacity in the world reached 250,000 MW. When the installed capacities of countries are examined in the international PV market, it is seen that the major players in the renewable energy market such as the US, Germany and China maintain their leadership in the top five. These countries also play an important role in the development of these technologies. As of January 2017, Germany had an installed capacity of 194.5 GW, and the solar power with a capacity of 40.41 GW accounted for almost 21% of this installed capacity. China, on the other hand, had a solar power capacity of 45 GW by the end of 2015, and in the first half of 2016 it commissioned new power plants with a capacity of 20 GW. Improvements in the supply-chain of production, as well as increased investments and falling prices due to technology, prove that this industry will remain its popularity for a long time.

44 Price history of silicon PV cells since 1977 https://commons.wikimedia.org/wiki/File:Price_history_of_silicon_PV_cells_since_1977.svg, Access: 03.01.2017

Figure 32: Development of PV Sector in the World (MW)[45]

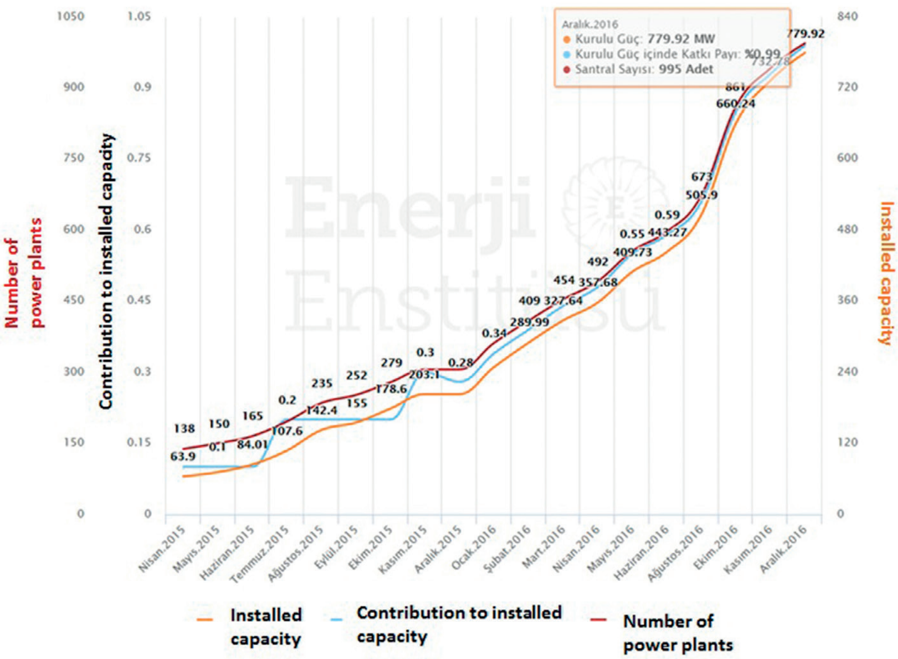


INSTALLED CAPACITY FOR UNLICENSED SOLAR POWER PLANTS IN TURKEY

As Turkey has developed, the ability to meet the energy needs of her raises the concept of energy supply security. In this regard, clean energy produced with diversified environmentally-friendly technologies is becoming a popular agenda topic, and thus, the use of renewable energy resources in electricity generation is becoming more important. In particular, with the enactment of the Electricity Market Law on 14 March 2013, the upper limit of 500 kW for unlicensed electricity generation plants based on renewable energy sources was raised to 1 MW. After this development, energy investors' interest to solar power plants has started to increase rapidly.

45 Growth of photovoltaics, https://en.wikipedia.org/wiki/Growth_of_photovoltaics, Access: 03.01.2017

Figure 33: Installed Capacity For Unlicensed Solar Power Plants[46]



The unlicensed solar power plant capacity, which was about 0.3 MW at the beginning of 2013, accelerated in 2014 and reached an installed capacity of about 250 MW in 362 power plants by the end of 2015. According to the late November 2016 statistics, the installed capacity of 995 unlicensed solar power plants reached 780 MW. In addition to unlicensed solar power plants, a total of 12.9 MW of capacity from two licensed plants have been added to the system. With these values, the share of solar energy in total installed capacity has reached 1%. When assessing the current situation in renewable energy, it is not sufficient to just look at the installed capacity. Along with the installed power, the share of the electricity generated from the source of interest in the production of the total electricity must also be considered. The share of electricity generated from solar energy investments with low capacity factor, however, in total electricity consumed is low.

ISSUES TO CONSIDER

Each phase must be meticulously studied during the construction of solar energy plants. This contributes to the prolongation of the system lifetime and maximizes the performance and production efficiency. Despite the fact that there are a lot of details to be taken into account

46 Turkey's Installed Capacity According to Fuel Types (MW) http://enerjienstitusu.com/turkiye-kurulu-elektrik-enerji-gucu-mw/ Access: 03.01.2017

in this regard, there are some issues that are not popular but are gaining importance. Although the cost of purchasing land near asphalt road or land with even/soft ground is high, it recoups itself in construction costs of the power plant. It is important that the companies that promise 25-year performance guarantee for panels, which bear the largest part of the costs, survive for 25 years, too. When the invertor is broken down, the time required for its re-commissioning is important. If the invertor is disabled for one day, it shouldn't be forgotten that a generation loss of approximately 0.27% (1/365) will be experienced. It is necessary to make sure that the panels to be replaced under warranty are in stock in Turkey, because using a panel with technical features other than the panel used in the power plant negatively affects the system. Monitoring infrastructure is the only way to manage the companies that promise performance. By regularly monitoring the production reports, it is possible to track of an instantaneous or continuous problem in the performance and prevent the production from falling down. The convenience of logistics is an important factor for the construction stages of the plants. On roof-top applications, however, necessary precautions should be taken not to be exposed to the impact of birds. In roof-top applications, roof durability and operation/maintenance/repair issues should be examined in detail during project planning.

CONCLUSION

The economic life span of solar energy power plants is accepted to be over 20 years and this is taken into account in the financial analyses. The cumulative effect of very tiny changes on the efficiency of a system that will generate electricity for 20 years could become significant. Losses in electricity generated determine the efficiency of the solar power plant. Losses of solar power plants depend on many factors ranging from environmental conditions to design, from materials used to workmanship, and they should be well analyzed by both investors and practitioners. In this study, possible losses in solar power plants are classified and examined. The possible consequences of these losses and the impact on solar power plant performance are explained. Moreover, the approximate investment costs of solar power plants and the approximate ratio of these values to total costs are determined. Expenses are not only limited to the cost of the investment. There are also operational / maintenance / repair costs. The effects of these annual variable costs are examined. The annual production amount of the plant is determined and the change of this value according to performance guarantee is calculated. The cumulative sum of the return obtained by multiplying the production by the feed-in-tariffs is determined, and fixed and variable expenses are deducted from this value. It should be noted that the unit cost of the investment cost, which constitutes the fixed cost of the plant, increases as the installed capacity decreases. In this case, the payback period of the investment is prolonged.