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MSc Program
Renewable Energy in Central and Eastern Europe

Base Load Energy Generation by Combined Renewable Energy Systems with Hydrogen Storage Technologies

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

supervised by
Univ.Prof. Dipl.Ing. Dr. Reinhard Haas

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Vienna-23.11.2017

Affidavit

I, **Jiren Özarmağan**, hereby declare

1. that I am the sole author of the present Master Thesis, "Base Load Generation by Combined Renewable Energy Systems with Hydrogen Storoge Technologies", 93 pages, bound, and that I have not used any source or tool other than those referenced or any other illicit aid or tool, and
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ABSTRACT

Hydrogen is a fuel that can be used to meet many different demands. Hydrogen, mechanical work, storage, reacting with another fuel and giving a new product suitable for the needs, electricity generation are the main ones. Hydrogen generation, storage and energy conversion technologies are developing and will take the role of many types and it is expected to reach an important place for the increasing energy needs of the human beings.

In this thesis, I focused on the potential of a renewable energy power solutions for generating base load electricity. Peak load generation is not previously estimated and has not predictable characteristic.On the other hand,base load can be previously estimated. For this reason, the base load is used in the day ahead market. The aim of this thesis is to create a base load from the renewable energy sources. Thus, base load pricing that the state has provided can be used. In addition, Hydrogen which is the storage system with the lowest operational and maintenance costs was preferred to properly store peak loads.

The multi type renewable plant, that I designed, which is planned to be constructed in Usak province of Turkey, was realized by integrating hydrogen storage with solar, wind and biomass energy from renewable energy sources.

The result is that Usak province in Turkey has the necessary potential for the related project.

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1. Introduction

A number of countries, including Turkey, have worked to prevent global warming and have reached international agreements. Subsequent fossil fuels seem to be the greatest cause of climate change. Moreover, according to expert’s estimates, the world's fossil resources will be over in 70 years.

These developments makes renewable energy sources more attractive. Renewable energy sources do not pollute the environment and they are unlimited For this reason, it is expected to play a key role in the future of the world.

According to the researches, one of the best solution for storing energy is hydrogen. Hydrogen has much lower emissions than the other fuel sources. Many technological studies are currently being conducted to make hydrogen fuel more widely available.

This thesis will be to search the opportunities to store and spread the peak load renewable energy generation to the base load.

The topics which are based on the key study had researched before beginning of the key study and they are given previous than key study in this thesis. This thesis try to provide a basic before the key structure. In the first four sections, include renewable energy sources and energy storage systems. The results of the researching are summarized in the related sections. The review will benefit the better understanding of the key study. Thesis gives a lot information about key study after the fourth part. The key study is researched and calculated detailed.

2. Wind Energy

Environment pollution and global warming effects, which are associated with it, increases every day. Also, many countries concern about energy security. For this reason, interest in the development of renewable and environmentally friendly energy sources like wind energy. Wind energy can provide solutions to global climate change and energy crisis. The use of wind energy essentially eliminates the emissions of CO2, SO2, NOx and other harmful wastes or radioactive wastes as it is in coal-fired power plants. By further diversifying its energy source, wind energy strengthens global energy security by significantly reducing dependence on fossil fuels exposed to price and supply instability.

Wind energy usage has been tremendous raised in the world for since 1990's years. A total of 55.6 GW of wind energy installed in 2016, total installed power of 486.8 GW at the end of 2015 [1] Wind energy, the most promising renewable, clean and reliable source of energy, will have a much higher share in energy production over the next decade.

2.1. Current Installation Status of Wind Power

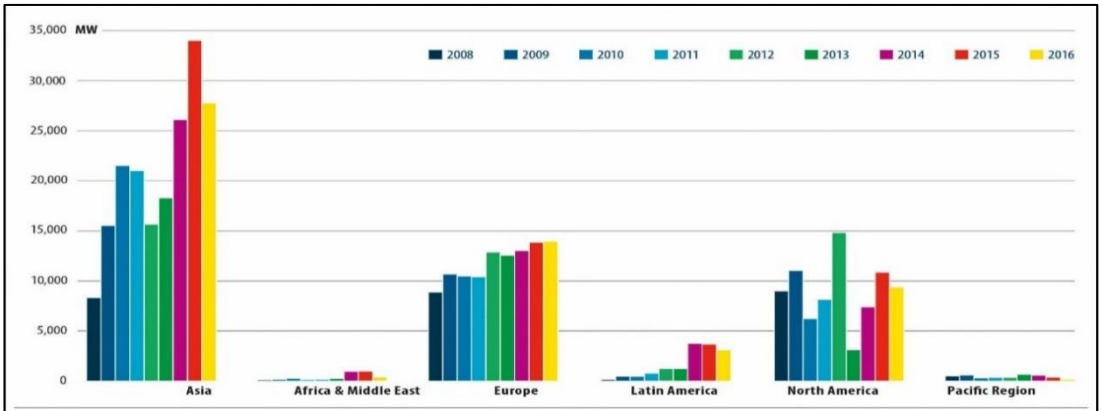
Wind energy is almost available in many parts of the Earth, but there is a wide variety in terms of wind power and consistency. According to them, the Earth has 1 million GW of wind energy from its total territorial coverage, and only 1% of this land is used at reachable efficiencies it is expected that the global electricity demand will be met. If there is a wind above 6.9 m / s at an altitude of 80 m from the ground, a zone is considered ideal for wind energy production

Off-shore wind farms are becoming more popular as a larger source of environmental impacts (especially considering noise and visual pollution), although most wind energy is currently available on the coast. World wind energy production capacity reached about 435 GW by the end of 2015, 7% of total global energy production capacity. Global wind energy production reached 13950 TWh in 2016, approximately 4% of total global energy production (Global Wind Energy Council, 2017)

Potential wind energy market capacity is on off shore region (422 GW, about 210,000 machines), little land wind (less than 1 GW installed 2015, more than 800,000 machines) and at sea (about 12 GW board finish 2015, about 4,000 machines). Large land and sea wind turbines are usually arranged in a wind park. Biggest wind parks such as Gansu Wind Farm in China, Muppandal Wind Park in India or Alta Wind Energy Center in USA are bigger than 1 GW. (Global Wind Energy Council, 2017)

[1] http://gwec.net/global-figures/wind-in-numbers/ - accessed on 2017

Table 1. Annual Installed Capacity By Region 2008-2016 Source: GWEC Report,2017.



	2008	2009	2010	2011	2012	2013	2014	2015	2016
Asia	8,320	15,507	21,481	20,981	15,624	18,252	26,058	33,962	27,721
Africa & Middle East	96	251	153	8	131	240	934	953	418
Europe	8,851	10,660	10,466	10,393	12,862	12,524	12,988	13,831	13,926
Latin America	128	471	459	771	1,248	1,240	3,744	3,678	3,079
North America	8,969	11,008	6,208	8,137	14,807	3,112	7,382	10,829	9,359
Pacific Region	482	578	294	345	358	655	568	381	140
	28,854	**38,475**	**39,061**	**40,635**	**45,030**	**36,023**	**51,674**	**63,634**	**54,642**

China has the largest wind energy installed capacity with 145 GW, followed by the United States with 73 GW, Germany 45 GW, India 25 GW, Spain 23 GW and the UK 14 GW (Global Wind Energy Council, 2017).

Our project is based on Turkey values measured in Uşak province. Zones where the wind power plant can be installed depending on the wind speed values of the Uşak province are given on the Fig.1[2].

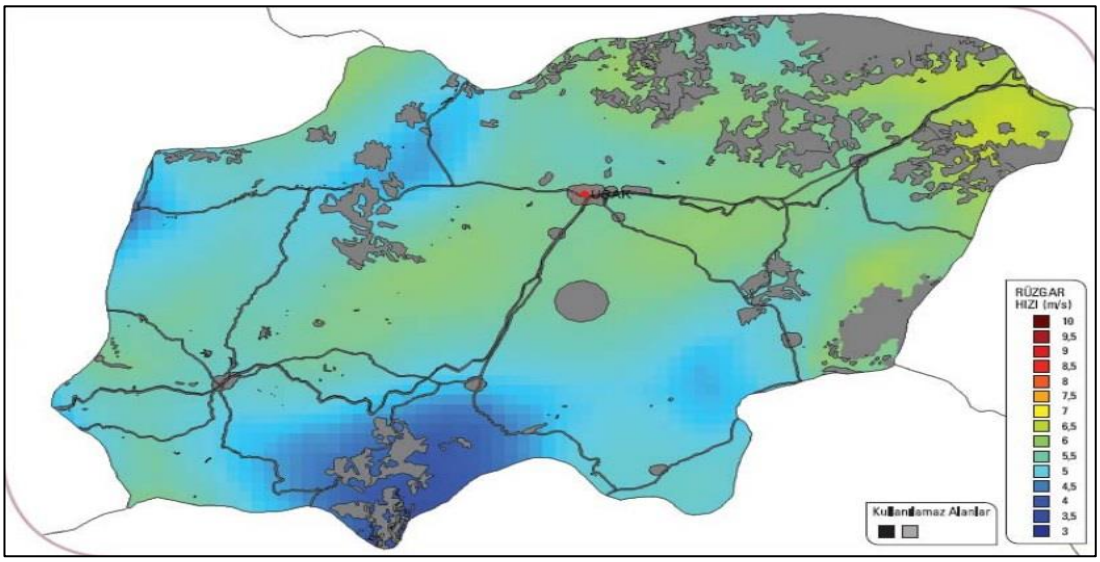


Figure 1. Wind Energy Asistance Installed Areas in Usak Source:Turkey General Directorate of Renewable Energy (2017)

[2] http://www.eie.gov.tr/yekrepa/repa-duyuru_01.html

2.2. Basics of Wind Energy

Wind energy is comprised of kinetic energy from large air masses which are move on above the world.. Wind turbines take this knife to kinetic and convert it into mechanical or electrical forms. The efficiency of converting wind energy into other energy types depends on the efficiency of the effect between rotor and wind.In this section technical and mathematical data about wind energy will be shown (Mathew, 2006).

2.2.1. Power Available in the Wind

In case m is described airflow mass and V is defined the Velocity. Kinetic energy must be calculated as

$$E = \frac{1}{2}\, m\, V^2 \qquad (1)$$

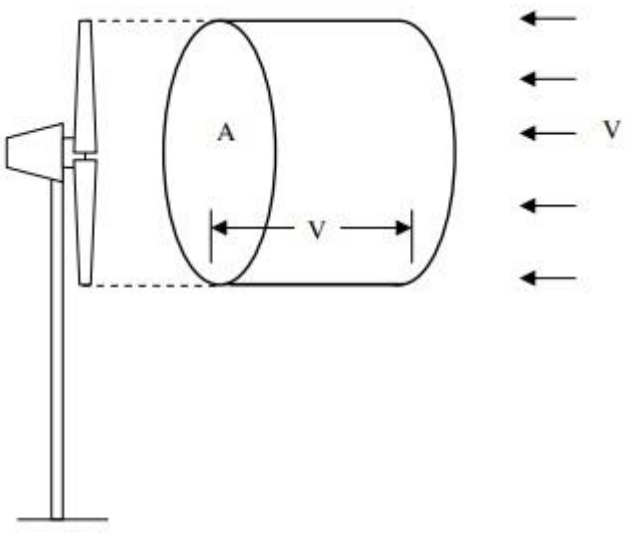


Figure 2. An Air Parcel Moving Towards a Wind Turbine

When we consider wind rotor which is like in Figure2,sectional area must be defined A. The kinetic energy formed by the wind in the turbine is found as follows

$$E = \frac{1}{2}\, \rho_a v\, V^2 \qquad (2)$$

where ρ_a defines the air density and v gives the volumetric flow for the rotor.The cross-sectional area of the air interacting with the rotor is the (A_T). Thus, power or energy per time can be calculated as

$$E = \frac{1}{2}\,\rho_a A_T\, V^3 \qquad (3)$$

The factors affecting the wind power are the air density, the area of the wind rotor and the wind speed that they can be seen from Eq.(3). The wind speed has a cubic characteristic on relationship with power.

If we defines the elevation Z and temperature T at a site, the air density can be calculated with this formula

$$\rho_a = \frac{353.049}{T}\; e^{(-0.034\frac{Z}{T})}$$

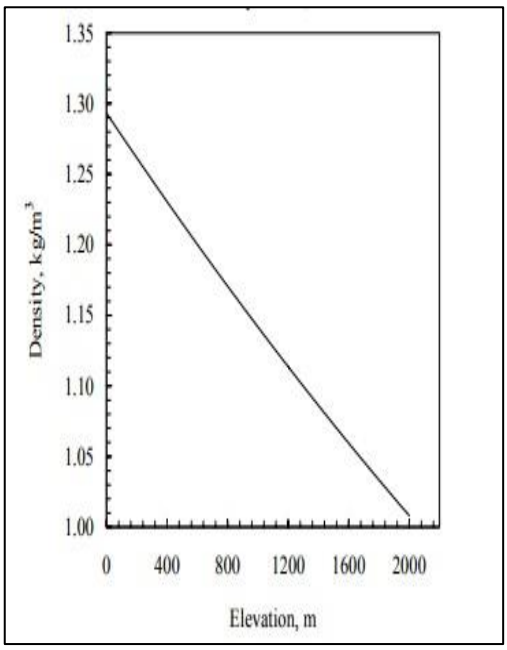


Figure 4. Effect of elevation on air Density

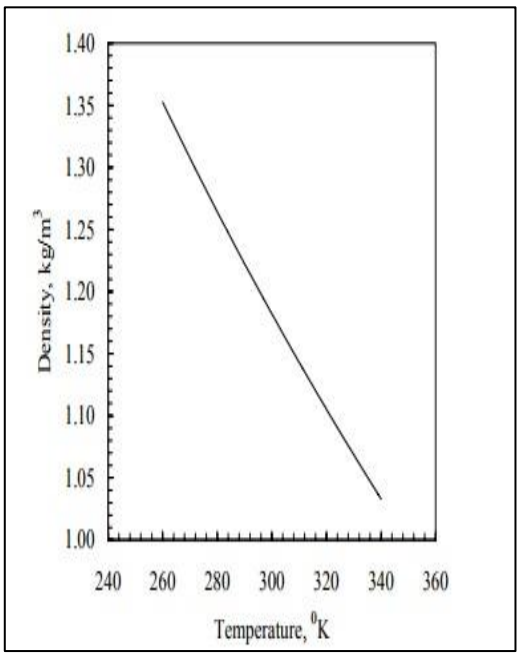


Figure 3. Effect of Tempature on Air Density

2.2.2. Wind Turbine Power and Torque

The available theoretical power that can be obtained from the wind is given by Eq. (3). However, a turbine can not use the full of theoretical power. When the wind mass

passes through the turbine, some of the kinetic energy is transferred to the rotor, and the air separated from the turbine returns the rest. For this reason, the actual power generated by a rotor will be determined by the efficiency achieved by this energy transfer, which is the wind rotor. This efficiency is generally called the power coefficient (Cp).Power coefficient values of wind turbines have 0.35- 0.45 ratio common even in the best designed wind turbines.. The rotor power coefficient is found from ratio of the theoretical power to actual power produced by the rotor.

$$C_\rho = 2\,\frac{P_T}{\rho_a A_T\, V^3}$$

where P_T is the power developed by the turbine. The power factor of a turbine depends on many parameters. The main parameters are rotor blade profile, blade arrangement and tuning. A designer must try to set these parameters at the optimum level. Thus, it can reach maximum C_ρ in a wide range of wind speeds.

The thrust applied to the rotor (F) is found as

$$F = \frac{1}{2}\,\rho_a A_T\, V^2 \tag{1}$$

Thus, we can write the rotor torque as

$$T = \frac{1}{2}\rho_a A_T\, V^2 R \tag{2}$$

where R is the radius of the rotor. The value found gives the maximum torque. In practice, the rotor shaft can reach up to a limited amount of this maximum limit. The ratio between the actual torque developed by the rotor and the theoretical torque is termed as the torque coefficient (C_T). For these reasons, the torque coefficient can be calculated with this way

$$C_T = 2\,\frac{T_T}{\rho_a A_T\, V^2 R} \tag{3}$$

At a given wind speed, the power the rotor has is dependent on the relative speed of the wind between the rotor tip and wind. For example, consider a situation where the rotor rotates at a low speed and the wind approaches the rotor at a high speed. For this condition, as the blades are moving slowly, an approaching portion of the air stream may pass without interfering with the blades and therefore without energy transfer. Likewise, if the rotor rotates fast and the wind speed is low, the wind current may deviate from the turbine. As a result, energy may be lost due to turbulence and vortex shedding. In both the above cases, the interaction between the rotor and the wind

stream is not efficient and thus would result in poor power coefficient. Tip speed ratio (λ) can be calculated with the ratio between the rotor speed and the wind speed Therefore,

$$\lambda = \frac{R\,\Omega}{V} = \frac{2\,\pi N R}{V} \tag{4}$$

where is the angular velocity and N is the rotational speed of the rotor. The torque coefficient power coefficient of a rotor vary with the tip speed ratio. the value for which the energy transfer for a rotor is most efficient (Cρ) is maximum. Equation which is shown the relationship between the power coefficient and the tip speed ratio can be calculated with this way.

$$C_\rho = 2\,\frac{P_T}{\rho_a A_T\,V^3} = 2\,\frac{T_T\,\Omega}{\rho_a A_T\,V^3} \tag{5}$$

Dividing Eq. (5) by Eq. (3) we get

$$\frac{C_\rho}{C_T} = \frac{R\,\Omega}{V} = \lambda \tag{6}$$

Thus, the tip speed ratio can be calculated from the ratio between the power coefficient of the rotor and the torque coefficient..

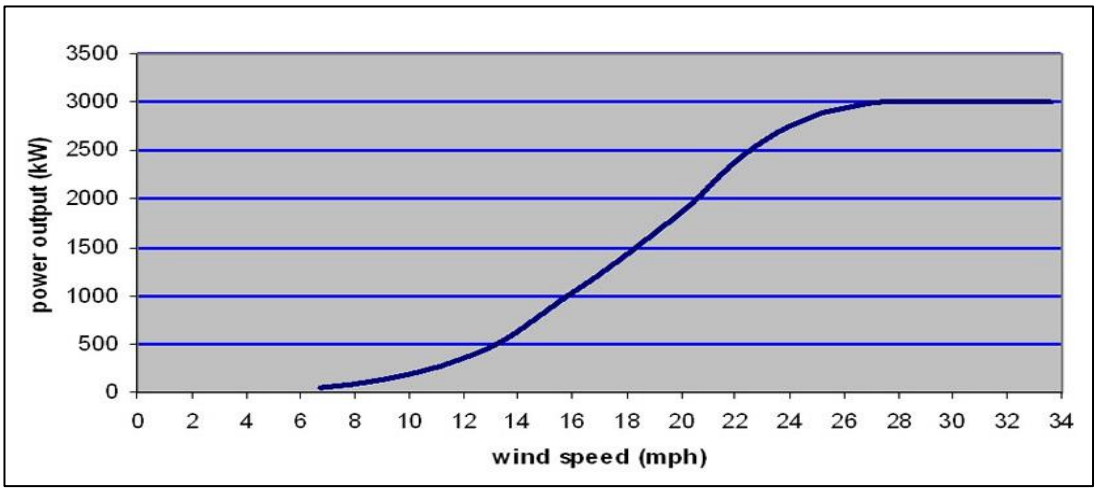


Figure 5. 3MW Wind Turbine Typical Power Curve

2.3. Cost Assumptions of Wind Energy

Similar to other renewable energy technologies, wind energy is high in terms of capital but does not have fuel cost. Key parameters governing the wind energy economy are:

- Investment costs (including costs related to project financing);
- Operating and maintenance costs (fixed and variable);
- Capacity factor (depend on wind speeds and turbine availability factor);
- Economic life;
- Cost of capital.

The capital cost of wind power plant installation is high. However, the LCOE values of the produced electricity are better than other renewable energy technologies.

Table 2. Comparison of Capital Cost Distribution for Wind Power Systems in Developed Countries Source: Blanco, 2009; EWEA, 2009; Douglas-Westwood, 2010; and Make Consulting, 2011c

	Onshore	Offshore
Capital investment costs (USD/kW)	1 700-2 450	3 300-5 000
Wind turbine cost share (%)[1]	65-84	30-50
Grid connection cost share (%) [2]	9-14	15-30
Construction cost share (%) [3]	4-16	15-25
Other capital cost share (%) [4]	4-10	8-30

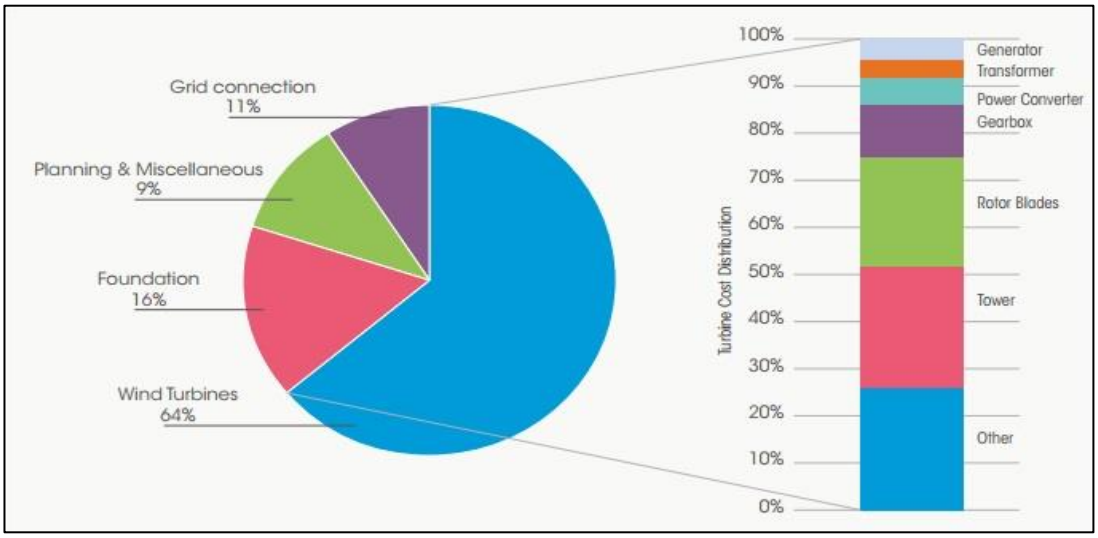


Figure 6. Capital Cost Analysis for an Onshore Wind Power System

In the previous table and figure are prepared by using the sources mentioned in footnote[34].

[3] (International Renewable Energy Agency, June 2012)
[4] (Blanco, 2009)

3. Solar Energy

Solar energy is created by the radiation that occurs as a consequence of the thermonuclear fusion reaction that occurs when the hydrogen in the sun is converted into helium. Solar light comes from a thermonuclear reactor (62 MW / m2) and the energy emitted by the entire surface of the sun is only two billion worlds. The 150 million km of energy that reaches the Earth from the Sun is about 15 thousand times the energy used in the world every year. The radiation outside of solar energy is about 1.370 W / m2. Solar energy distribution on our planet is really high different due to the shape of the world and the average solar energy in the world is 0-1,100 w/m2 (Sen, 2008).

46% of the solar radiation is in the infrared region of the spectrum, 45% is in the visible light regions and the remaining percentage is in the purple region. The sun's rays of 50% reach the earth through the atmosphere and the not reaching part of our planet, 30% is reflected from our planet to atmosphere and 20% of the radiation in the sun is trapped in the atmosphere and in the clouds With this energy, the temperature of the Earth rises and life on earth becomes possible. This warming also causes wind movements and ocean ripples. Plants are using less than 1% of the solar rays reaching to the earth by photosynthetic plants (Sen, 2008). During photosynthesis, plants produce oxygen and sugar with carbon dioxide and water and sunlight. Photosynthesis is the source of plant life on earth.

The work on the use of solar energy, especially after the solar energy systems of the 1970s, has shown technological progress and cost reduction, and solar energy has recognized itself as a clean energy source with environmental care.

3.1. Current Installation Status of Solar Energy

During 2016, at least 75 GWdci of solar PV capacity was added worldwide – equivalent to the installation of more than 31,000 solar panels every hour. Compared with the previous year PV capacity was installed in 2016 is % 46 higher than the cumulative world capacity five years earlier. The global solar energy capacity was at least 303 GW at the end of 2 years. (REN21, 2017)

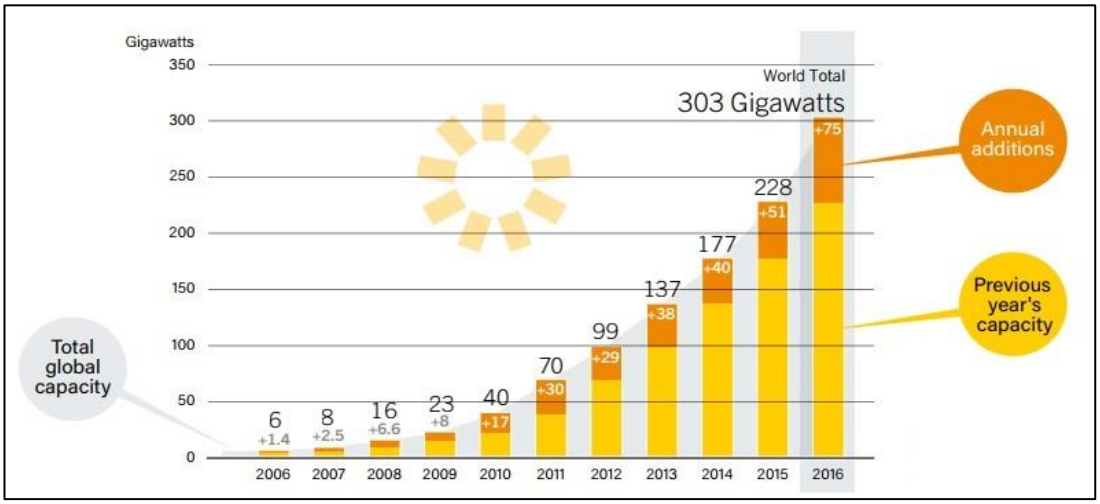


Figure 7. Global PV Capacity and Annual Increases, 2006-2016 Source: RENEWABLES GLOBAL STATUS REPORT,2017.

For the fourth successive year, Asia ousted all other markets and made up about two-thirds of the global access.. The biggest markets are China, United States, Germany, Australia, japan, India and the United Kingdom Others in the top 10 for additions were the Republic of Korea, Australia, Germany, Philippines and Chile.For cumulative capacity, the top countries were China, Japan (which passed Germany) and the United States, with Italy a distant fifth.. (REN21, 2017)

While China continued to dominate both the use and manufacturing of solar PV, emerging markets on all continents have begun to contribute significantly to global growth. Each continent had at least 1 GW installed, at least 1 GW of capacity in 24 countries, or more than 10 MW of energy in at least 114 countries until the end of 2016.The leaders for solar PV capacity per inhabitant were Germany, Japan, Italy, Belgium and Australia. (REN21, 2017)

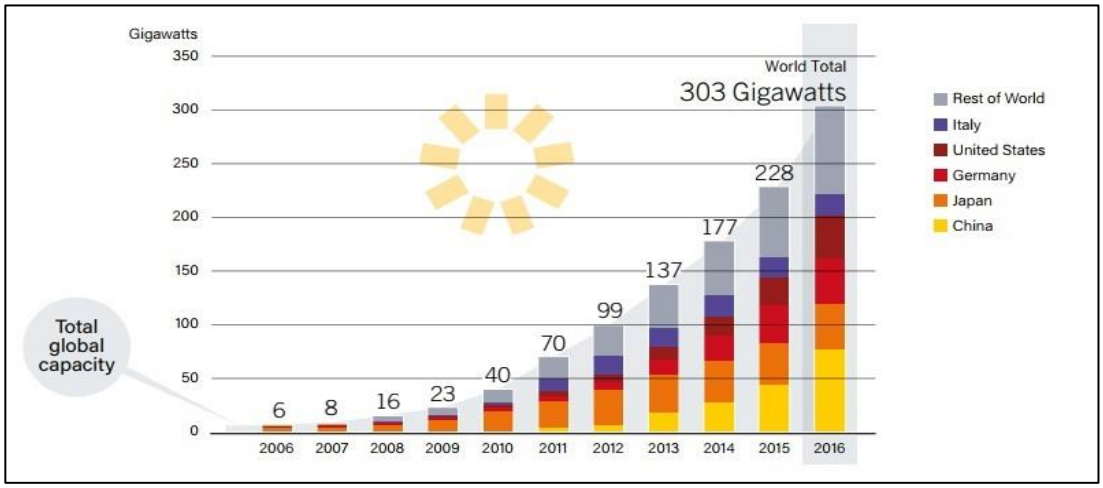


Figure 8. Solar PV Global Capacity, by Country and Region, 2006-2016 Source: RENEWABLES GLOBAL STATUS REPORT,2017.

Our project is based on Turkey values measured in Uşak province. In figure 9, a yearly solar radiation map of Turkey and Uşak province is given.

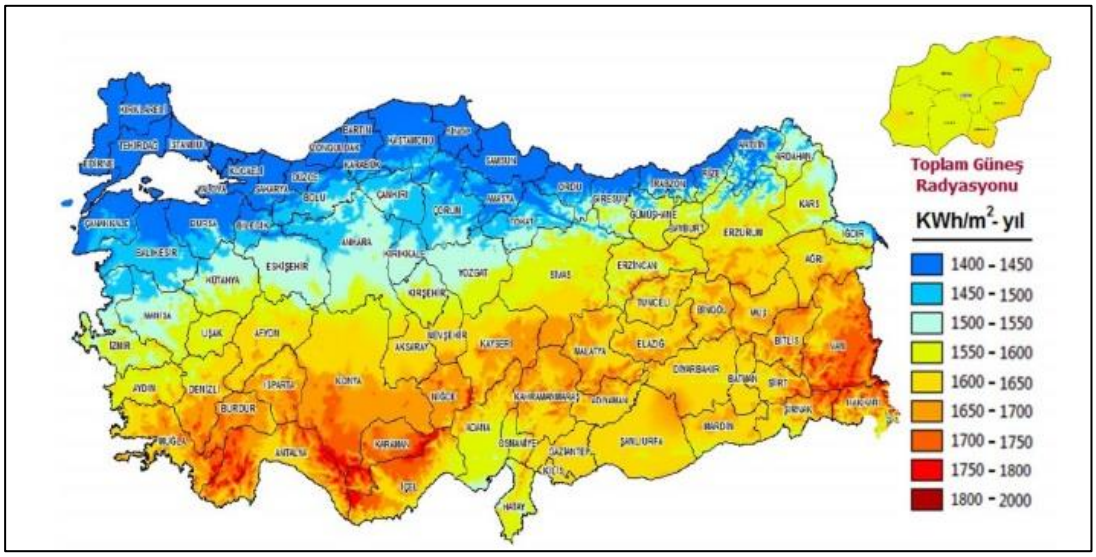


Figure 9. Radiation Map of Turkey Source : Journal of Geomatics, 2017.

Figure 10. Usak Sunrise Times (Hours) Source : Journal of Geomatics, 2017

3.2. Basic of Solar Energy

Solar energy is actually a nuclear energy. Hydrogen and helium form a fusion reaction at 25% of the sun's temperature. Approximately 7x1011 kg of hydrogen is consumed every second. Energy production is combined with compression of gravity. Thus, the center of the sun is kept at about 16 million K temperature. Convection spreads to the surface of the solar heat. It reaches 5800 K. (Sen, 2008)

The heat transfer from the surface of the sun is provided by electromagnetic radiation. The shape and the surface temperature of an object leads and shapes the heat transfer, also the amount of energy and the type of energy. Amount of energy emitted per unit area from the surface depends on the fourth energy temperature of the Energy/Area is proportional to T^4 object is called by The law of Stefan-Boltzmann. (Sen, 2008)

The sun is emitting radiation in various wave lengths. Radiation type coming from the surface is depended on the temperature. In addition, most radiation types are also sent in visible spectrum due to the surface temperature. Wien law says that the spread of the energy is inversely proportional to the temperature. Thus, when an object is heated, the peak radiation will be at a shorter wave length. Figure 11 shows a theoretical representation of the energy emitted by three perfect black emitters at different temperatures. The maximum energy of a matter at a temperature of 4000 K spreads to approximately 750 nanometers. Peak irradiation of a matter with a surface temperature of 6000 K, approx. 500 nanometer. It has a visible spectrum. It depends on how much energy the object will look in the human eye and how much energy it has in visible wavelength. The primary matter looks too dark red, and also the the second object, which is almoustly same temperature of 5800 K will seems a white, which is really bright and with a trace of yellow. (ESA21, 2016).

Although our sun is not a perfect carbon dioxide emitter, the power is quite close to what was described above. It absorbs 1680 w/m2 from the surface of him at each

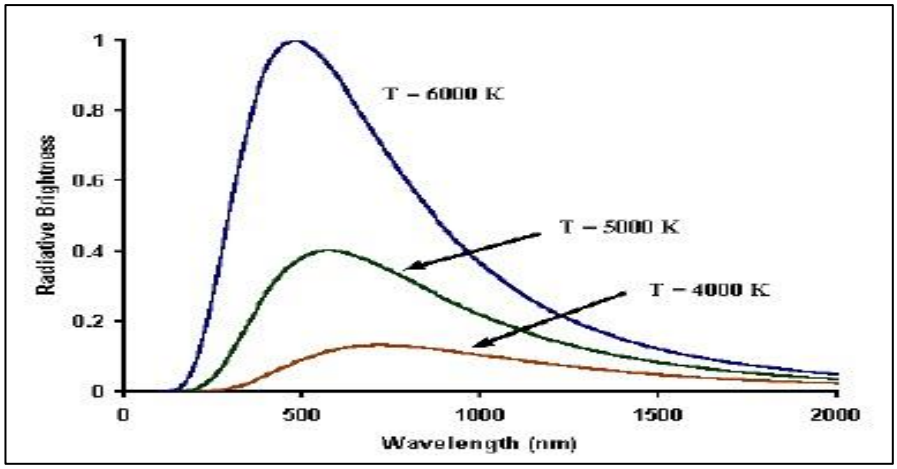


Figure 11. Brightness vs. Wavelength for Various Temperatures Source:ESA21

wavelength. However, this value is greatly reduced until the earth's surface is reached. Between the surfaces of the sun and the earth, the energy density of the radiation is reduced by diffusion and absorption. The light, which spreads from a spherical object, like the sun, must spread to hole surface. Because the sum of all amount of the energy of the radiation is the same, the energy amount, which leaves one square meter area is reduced by the distance between the object and the object area multiplied with again this distance. The sun is almost 150 million kilometers from the earth. For this reason,

the energy this intensity of sunlight decreases until it reaches the earth. The energy intensity that reaches the Earth's upper atmosphere is only 1340 W / m2 (ESA21, 2016).

When you travel through the near-perfect vacuum of space, there is almost nothing that absorbs or reflects any of this energy. The place where the absorption of sunlight is greatest is the world's atmosphere. Most of the visible portion of the spectrum passes through the low atmosphere of the attenuation. The unabsorbed small portion is dispersed by nitrogen and oxygen and is absorbed or reflected by the clouds, and most of the invisible portion of the spectrum cannot penetrate the atmosphere Chemical species such as ozone, water vapour and carbon dioxide absorb the wavelengths of light in the infrared and ultraviolet range of the spectrum.. (ESA21, 2016)

Figure 12 shows the percentages of the wave lengths of the sun's rays reaching the atmospheric air on a cloudless day. We can see in the graph, There are only a few small sections of the spectrum visible and radio fragments as well as the infrared spectrum of energy transmitted. Approximatively, only half of the solar energy is at its peak. the atmosphere and actually goes below the surface. (ESA21, 2016)

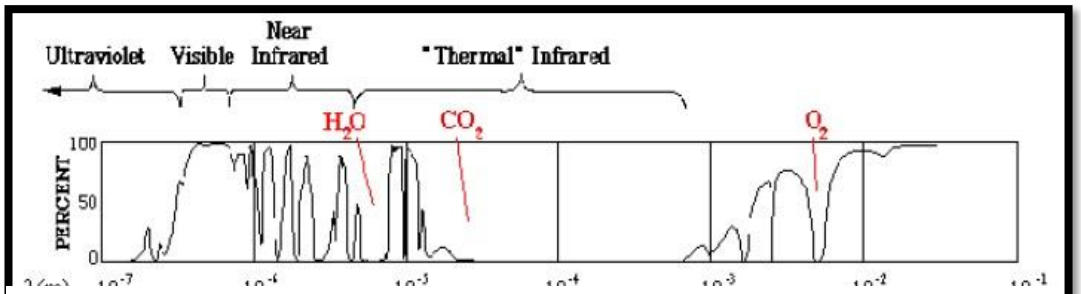


Figure 12. Sunlight Transmitted Through the Atmosphere Versus Wavelength *Source: NOAA*

Latitude and Longitude Factor : : The factors mentioned above are some of the factors that influence a solar energy system. Another factor that has serious consequences is the number of hours of sunshine a site receives per day. When sunlight spends more time in a day, more total energy is given and vice versa. How long daylight shines during the day depends on both the location and the season. The reason for this is that the Earth is a sphere orbiting the Sun around its own axis with an angle of 23.5° perpendicular to the plane of the orbit. This means that the sun has changed its course on a certain day in the sky. (Sen, 2008)

The Sun's pre-noon angle in the sky can also be effective in solar energy. If it is hart to follow the sun, it can be done by the system that can always keep the collector's surface perpendicular to the sun's rays, thereby maximizing the energy impact. If this is not possible, sunlight will always cause the system to collect. This distributes the

energy over a larger area and reduces the impact on the surface. As in Fig. 13, the angle of the sun's rays changes throughout the year and the day.

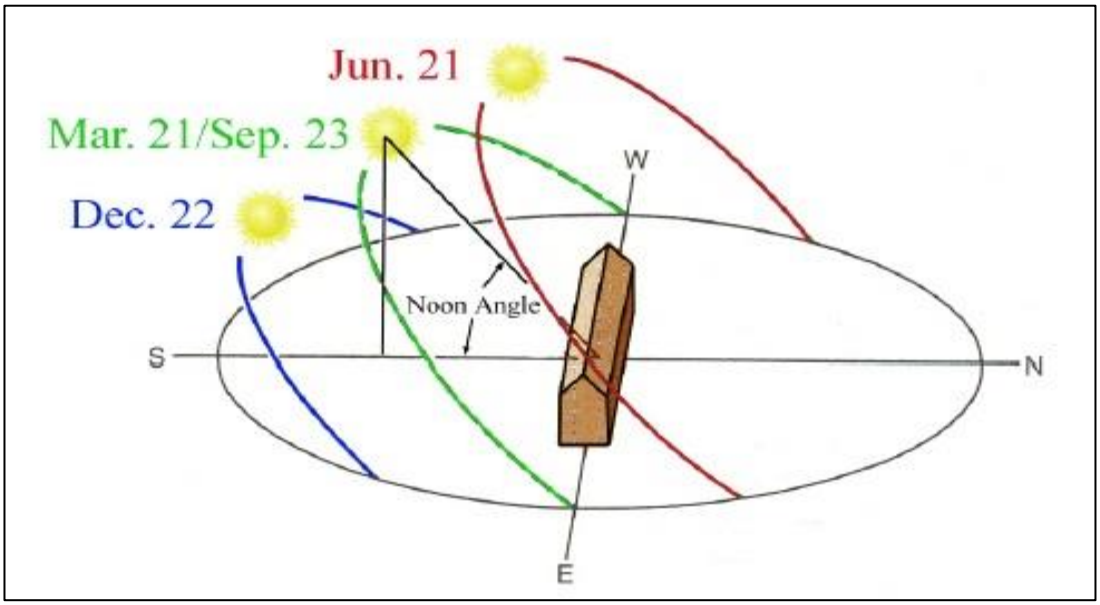


Figure 13. The Sun's Path Diagram in The Sky on Different Days

As mentioned earlier, these angles will depend on the position of the system on Earth's surface. (ESA21, 2016)

3.2.1. Components and Types of Solar Systems

Photovoltaic systems are solar energy supply systems, which convert sunlight directly to electricity. The main component of PV systems is the solar panel formed by combining several PV cells. Bringing together several PV cells creates a PV module; Create several module arrays and create several arrays of panels. The modular structure of PV cells makes it possible to use a on different range of power applications ranging from several milliliters computer mouse's and calculator to several megawatts of central power plants. Solar cells are usually made of silicon, gallium arsenide, cadmium telluride or copper indium diselenide.(German Solar Energy Society, 2008).

Solar cells are produced in two basic forms according to the characteristics of the materials used. There are two main types of cells, which is called crystalline solar cells and thin film solar cells. Crystalline solar cells have the highest conversion efficiency when they come to photovoltaic cells and basic types of monocrystalline and polycrystalline cells, until the now. (German Solar Energy Society, 2008).

Although thin film cells are less efficient than crystalline silicon, they offer great promise for large-scale power generation due to mass production ease and lower material cost. The most common example of thin film cells is amorphous silicon. We

can divide the Photovoltaic systems into two groups; off-grid systems and grid-connected systems.

3.2.1.1. Off-Grid Systems

A typical off-grid system comprises the following main components:

• Solar PV Modules: These equipment's convert sunlight directly to electricity.

• Charge Controllers: Charge and discharge batteries, maximize lifetime and reduce operational problems the most

• Battery or Battery Bank: Energy storages generated by PV modules

• Inverter: This equipment converts DC current generated by PV modules to AC current This equipment is used for AC consumer load

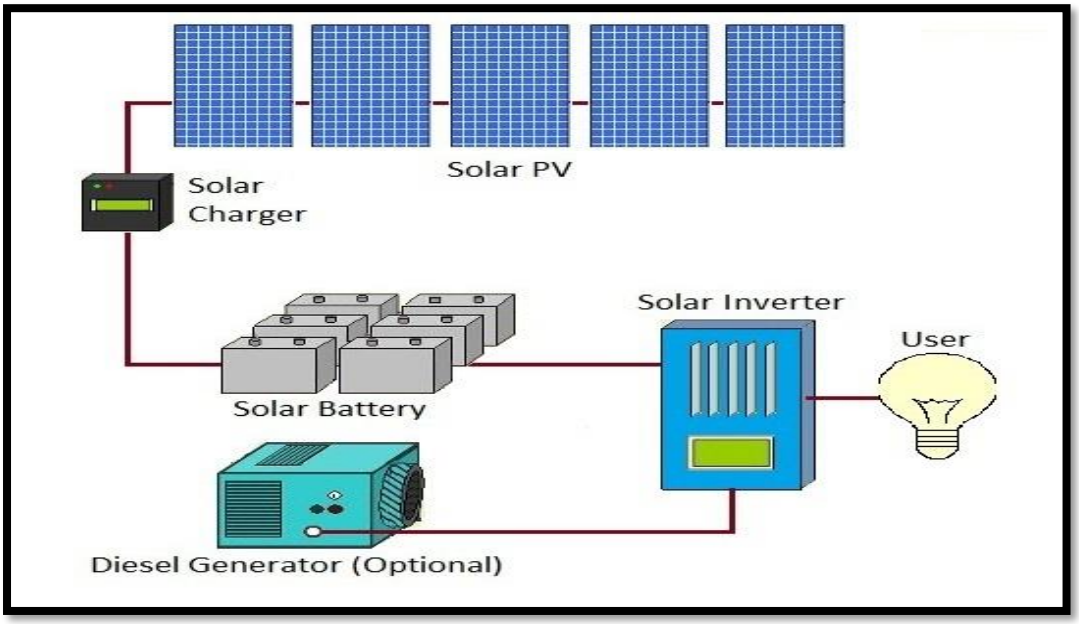


Figure 14. A Sample of Off-Grid PV Systems

3.2.1.2. Grid-Connected PV Systems

A typical grid-connected PV system comprises the following components:

- Solar PV Modules: These equipment convert sunlight directly to electricity.
- Inverter: This equipment converts DC current generated by PV modules to AC current.
- Main disconnect/isolator Switch
- Utility Grid

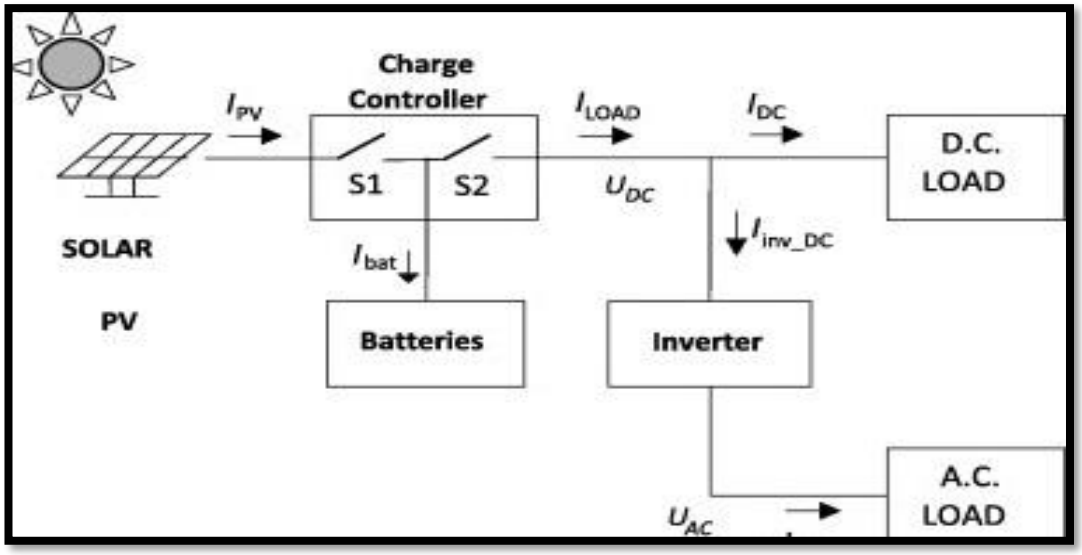


Figure 15. A Sample of Grid PV System

3.3. Cost Assumptions of Solar Energy

There are three categories for grouping the solar power plants, according to the (IEA) and (NREL) .These are:

- Investment Costs (CAPEX),
- Operation and maintenance costs (O&M)
- Financing costs

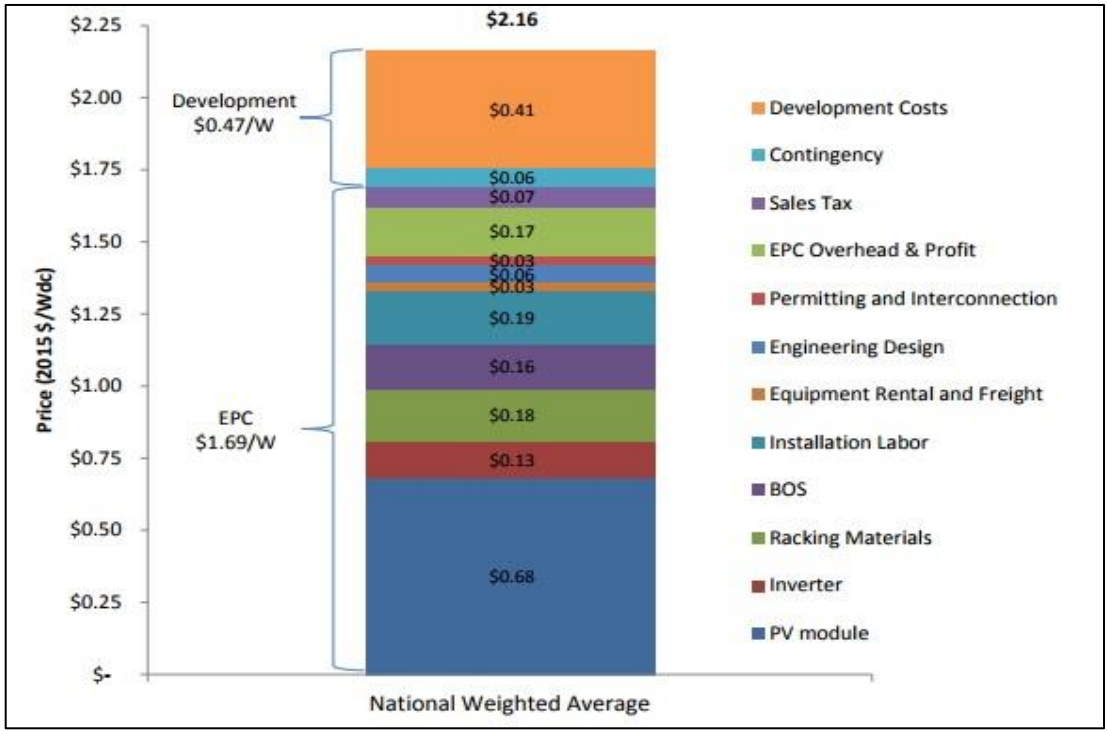


Figure 16. PV System Price (National Weighted Average, 200-kW) Source:NREL

Table 3. Key Commercial Modeling Cost Assumptions Source:NREL

Category	Modeled Price (Price Range)	Description	Sources
EPC-Module, $/Wdc	$0.68 ($0.65–$0.70)	Ex-factory gate prices. 310-W multicrystalline, 72-cell, 6-inch cell, at 16% efficiency	BNEF (2014), GTM Research and SEIA (2015), industry interviews
EPC-Inverter, $/W	$0.13/Wdc ($0.15–$0.17/Wac, $0.12–$0.13/Wdc)	Ex-factory gate prices; three-phase string inverter; Per-Wdc pricing assumes a 1.3 inverter-loading ratio	GTM Research and SEIA (2015), industry interviews
EPC-Racking, $/Wdc	$0.21 ($0.16–$0.22)	Ex-factory gate prices; flat-roof ballasted racking system	Industry interviews
EPC-BOS Materials, $/Wdc	$0.18	Conductors, conduit and fittings, transition boxes, switchgear, panel boards, etc.	RSMeans (2013), industry interviews
EPC-Sales Tax	0%–6%	Percent markup on equipment only	DSIRE (2015), RSMeans (2015)
EPC-Installation Labor, $/Wdc	$0.19	All direct installation labor	BLS (2013), RSMeans (2013), industry interviews
EPC-Permitting and Commissioning, $/Wdc	$0.09	$0.03/W construction permit fees and inspection costs; $0.06/W for interconnection, testing, and commissioning	Industry interviews
EPC-Overhead and Profit	20% (5%–20%)	Markup on all direct costs; covers all overhead items such as back office staff, office space, etc. and profit; We use the upper range of markups because we benchmark a relatively small system size at 200 kW.	Industry interviews
Developer-Contingency	4%	Estimated as markup on EPC price	Industry interviews
Developer-Overhead, $/Wdc	$0.41	Includes fixed overhead expenses such as payroll, facilities, travel, insurance, etc. across administrative, business development, finance, and other corporate functions; assumes 10 MW/year of system sales	Feldman et al. (2013), industry interviews

4. Biomass Energy

Humans from the very beginning of civilization have almost used the use of biomass for heating and light. Biomass has been an important part of the energy supply in human societies since the first torch was lit. In the developed world, biomass has been retreating since the beginning of the industrial revolution when high-energy-density fuels such as peat, coal, gas and oil have been obtained - but biomass has become an increasingly important part of the energy mix because of global warming and increased energy security concerns. The use of biomass for energy production is seldom used in large quantities. It is used only as a means to benefit from the presence of residues from timber factories or other industrial processes. In the last decade, biomass has become more popular as it is seen as the only major renewable fuel source available for power generation when it is needed.. The first movement of the large-scale installation resulted in a common ignition in coal-fired power plants. However, when the issue of climate change becomes more important, policies have moved away from co-fi ring towards full plant conversions or new builds since co-firing still burns coal.

4.1. Current Installation Status of Biomass Energy

Traditional and modern methods of using Bio Energies provide the greatest contribution to the supply of global renewable energy. Total primary energy provided by biomass in 2016 about 62.5 exajoules (EJ). Biomass supply for energy has increased by about 2.5% per year since 2010. The percentage of bioenergy consumption in total global primary energy consumption has remained unchanged at around 10.5% from 2005, despite 21% increase in global energy demand in the last 10 years. Heat and energy demand from biogeetics in buildings and industry is preferred more than combined electricity and transportation.. (REN21, 2017).

Global biological power capacity increased to 112 GW in 2016, an increase of approximately 6%. Electricity production increased by 6% to 504 terawatt hours (TWh). According to REN2 the top five countries generation with in 2016 are the United States- 68TWh, followed by China- 54TWh, Germany-52TWh, Brazil-51TWh and Japan 38TWh.

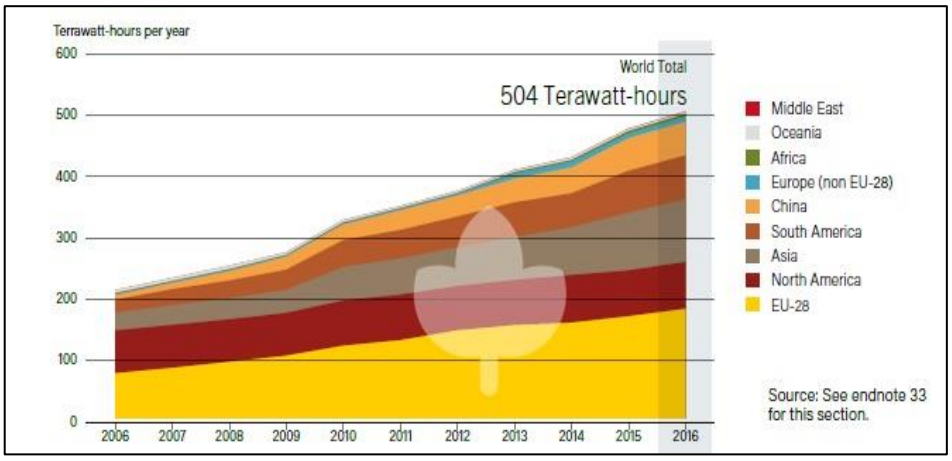


Figure 17. Global Bio-Power Generation,by Region,2006-2016 Source:REN21,2017.

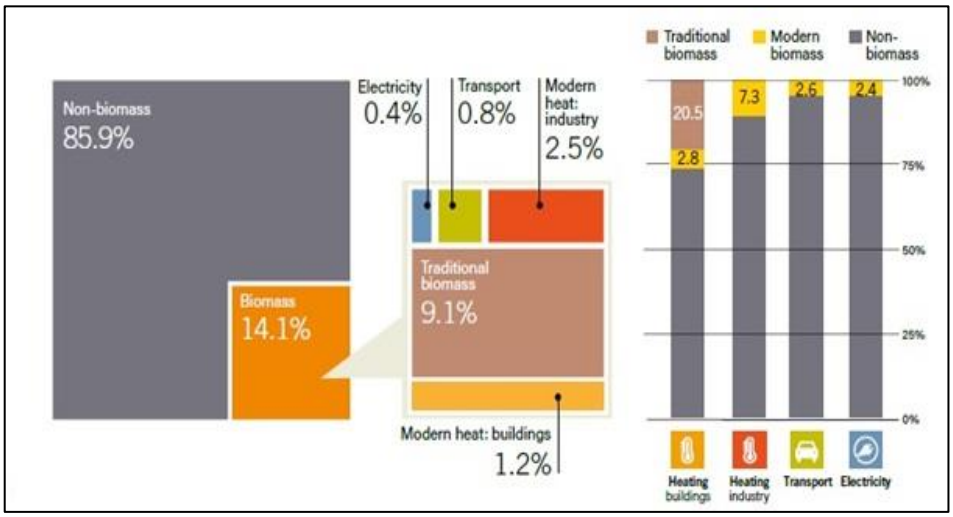


Figure 18. Global Bio-Power Generation, by Region, 2006-2016 Source:REN21,2017.

Our project is based on Turkey values in Usak province. Animal and plant source biomass energy potential maps of Usak province are given in this page. Red places have high biomass potential and yellow places have low biomass potential.Below graphs show biomass potential of animal and vegetative origins in Usak according to color scale.

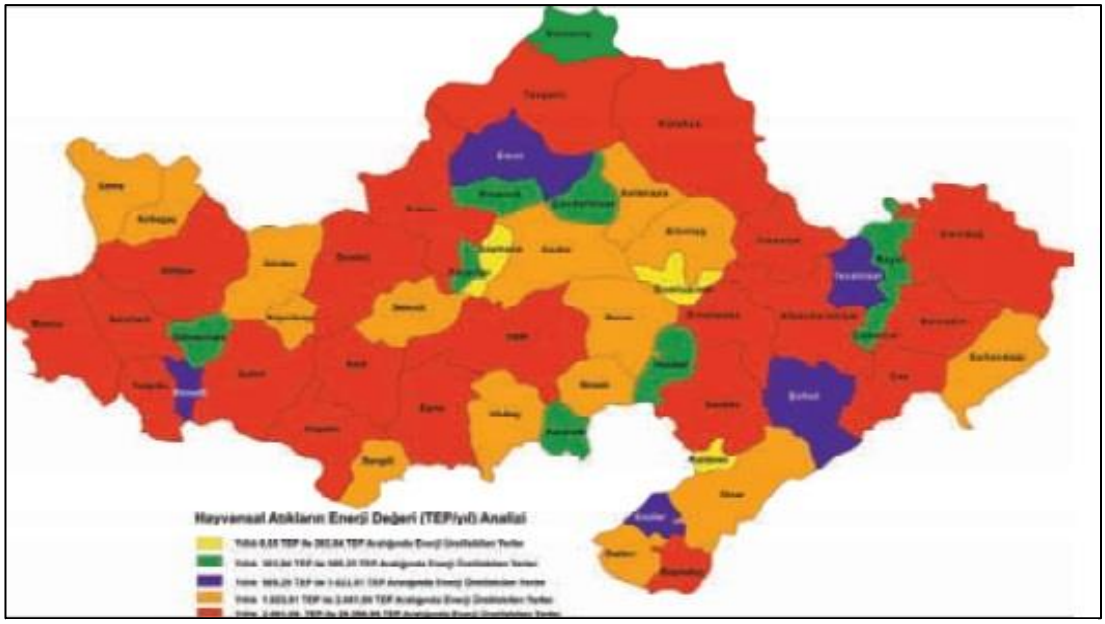


Figure 19. Bioenergy Potential Map of Animal Origin in Usak Source: Turkey General Directorate of Renewable Energy,2016.

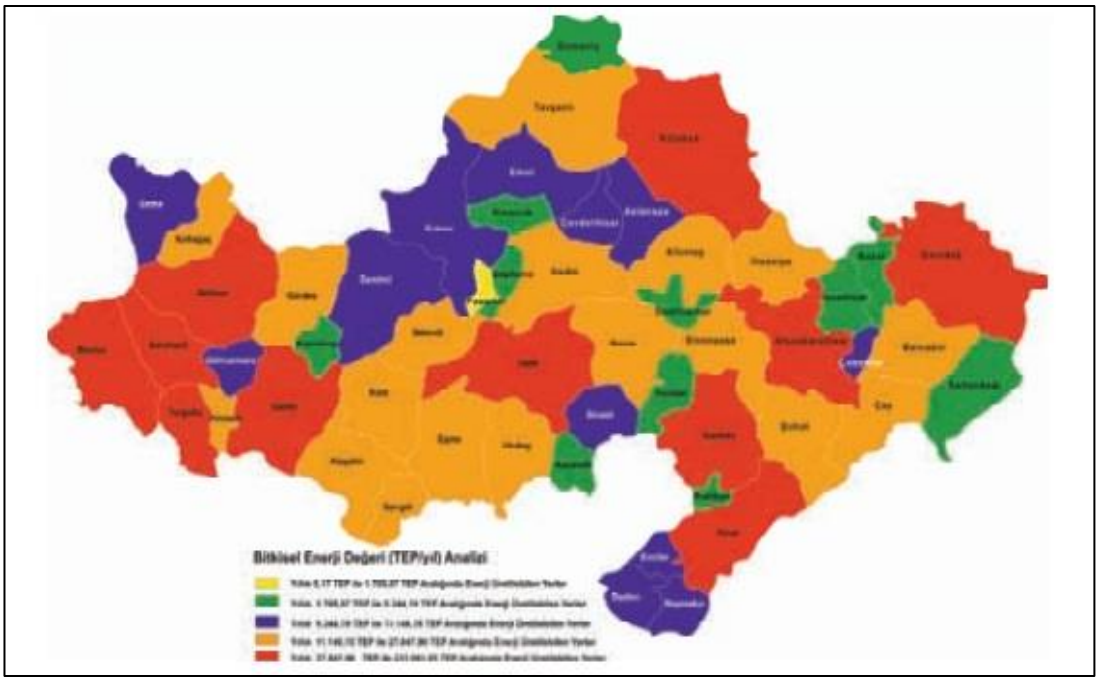


Figure 20. Bioenergy Potential Map of Vegetative Origin in Usak Source: Turkey General Directorate of Renewable Energy ,2016

4.2. Basics of Biomass

- Industry

Food,fibre and wood process residues

- Agriculture

Energy and short rotation crops,crop residues and animal wastes

- Forestry

Forest harvesting and supply chain.Forest and agroforest residues

- Waste

Organic wastes to energy.Landfill.

- Tradational biomass

Which is charcoal, animal drung from agricultural side and fuelwood

Table 4. Typical Properties of Solid Fuels Source: CEN-335 ,2003.

Property	Coal	Peat	Wood without bark	Bark	Forest residues (coniferous tree with needles)	Willow	Straw	Reed canary grass (spring harvested)	Olive residues
Ash content (d)	8.5-10.9	4-7	0.4-0.5	2-3	1-3	1.1-4.0	5	6.2-7.5	2-7
Moisture content, w-%	6-10	40-55	5-60	45-65	50-60	50-60	17-25	15-20	60-70
Net calorific value, MJ/kg	26-28.3	20.9-21.3	18.5-20	18.5-23	18.5-20	18.4-19.2	17.4	17.1-17.5	17.5-19
C, % (d)	76-87	52-56	48-52	48-52	48-52	47-51	45-47	45.5-46.1	48-50
H, % (d)	3.5-5	5-6.5	6.2-6.4	5.7-6.8	6-6.2	5.8-6.7	5.8-6.0	5.7-5.8	5.5-6.5
N, % (d)	0.8-1.5	1-3	0.1-0.5	0.3-0.8	0.3-0.5	0.2-0.8	0.4-0.6	0.65-1.04	0.5-1.5
O, % (d)	2.8-11.3	30-40	38-42	24.3-40.2	40-44	40-46	40-46	44	34
S, % (d)	0.5-3.1	<0.05-0.3	<0.05	<0.05	<0.05	0.02-0.10	0.05-0.2	0.08-0.13	0.07-0.17
Cl, % (d)	<0.1	0.02-0.06	0.01-0.03	0.01-0.03	0.01-0.04	0.01-0.05	0.14-0.97	0.09	0.1*
K, % (d)	0.003	0.8-5.8	0.02-0.05	0.1-0.4	0.1-0.4	0.2-0.5	0.69-1.3	0.3-0.5	30*
Ca, % (d)	4-12	0.05-0.1	0.1-1.5	0.02-0.08	0.2-0.9	0.2-0.7	0.1-0.6	9	

4.3. Production Ways of Biomass Energy

- Combustion
- Gasification
- Pyrolysis
- Transesterification
- Fermentation
- Anaerobic digestion

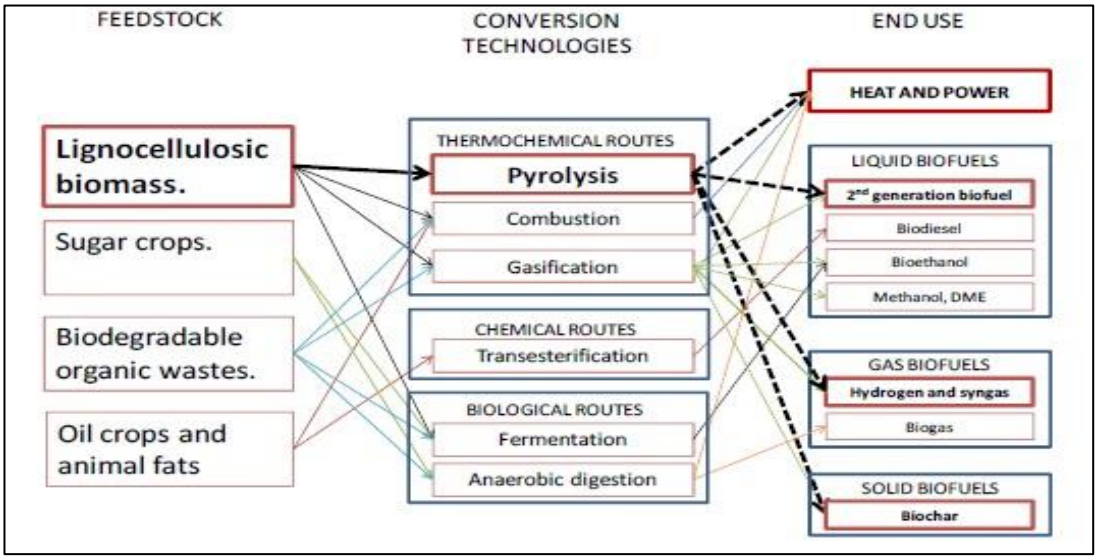


Figure 21. Alternative Biological and Thermochemical Pathways for Biomass Energy Source: Haggerty ,2011.

- **Combustion**

Combustion is defined as the exothermal reaction between fuel and oxygen to form mainly carbon dioxide and water vapour. The heat released can be used to produce electricity via a Rankine cycle. Depending on the condition and combustion properties of the fuel that is to be burned, different furnace designs and firing parameters can be selected to ensure optimal efficiency or uptime. Direct combustion is based on well-established technology, which currently is the principal method of generating electricity around the world. Modern combined heat and power (CHP) facilities that generate additional heat for district heating can provide plant efficiencies of around 90% for combined heat and power (DONG Energy, 2012).

- **Pyrolysis**

Pyrolysis is thermal decomposition occurring in the absence of oxygen. Lower process temperatures and longer steaming times support wood charcoal production. High temperatures and longer residence times increase conversion to biomass gas, and medium temperatures and short steam residence times are optimal levels for producing liquids. Product distribution from different process conditions shows considerable flexibility that can be achieved by changing process conditions. Three products – gas, liquid and solid – are always produced, but the proportions can be varied over a wide range by adjustment of the process parameters.

- **Gasification**

Gasification processes aim to maximize the conversion of a solid feedstock into useable gases. In the reactor the feedstock is exposed to a high- temperature atmosphere and hot particles, which heat the fuel leading to thermal decomposition. In addition and in contrast to pyrolysis, the material is brought into contact with a gasifying agent. At reasonably high temperatures (ca. 800–1400°C), the reactions between the gasification agent and the solid carbon structure resulting from the feedstock supplied are formed, and carbon oxides or hydrocarbons (the main components of the product or the producer) are formed. Using steam as a gasifying agent, lower temperatures (down to about 600°C) can be applied and this is called steam reforming. (Rosendahl, 2013)

Table 5. Typical Product Yields, Reaction Conditions and Enthalpy In the Biomass Production Technologies Source: Haggerty (2011)

Process		Product yields (wt%)			Conditions	Enthalpy
		Liquid	Char	Gas		
Pyrolysis	Slow	15-25	30-40	30-40	Low temperature (300-600°C). Long vapor residence time (> 1 min) Inert atmosphere	Endothermic/ Exothermic
	Fast	60-75	10-15	15-30	Moderate temperature (450-500°C). Short vapor residence time (< 2 sec) Inert atmosphere	Slightly endothermic
Gasification		0-5	5-10	85-95	Very high temperature (850-1000°C). Mildly oxidizing conditions	Endothermic
Combustion		0	0-5	95-100	High temperatures (700-850°C). Highly oxidizing conditions.	Highly exothermic

4.4. Biomass Electric Power Generation

Biomass power plants are very similar to coal-fired power plants during operation;, as illustrated in Figure 22. Biomass is delivered to the facility where storage piles or silos contain extra biomass that does not feed immediately. The biomass may be subjected to various pretreatment steps such as size reduction, separation and drying before feeding to the combustion regime. In the combustor, biomass oxidation occurs under excess air. The exothermic reaction heats the combustion gases that generate steam by means of a typical Rankine cycle turbine and heat exchangers to operate the electric generator.

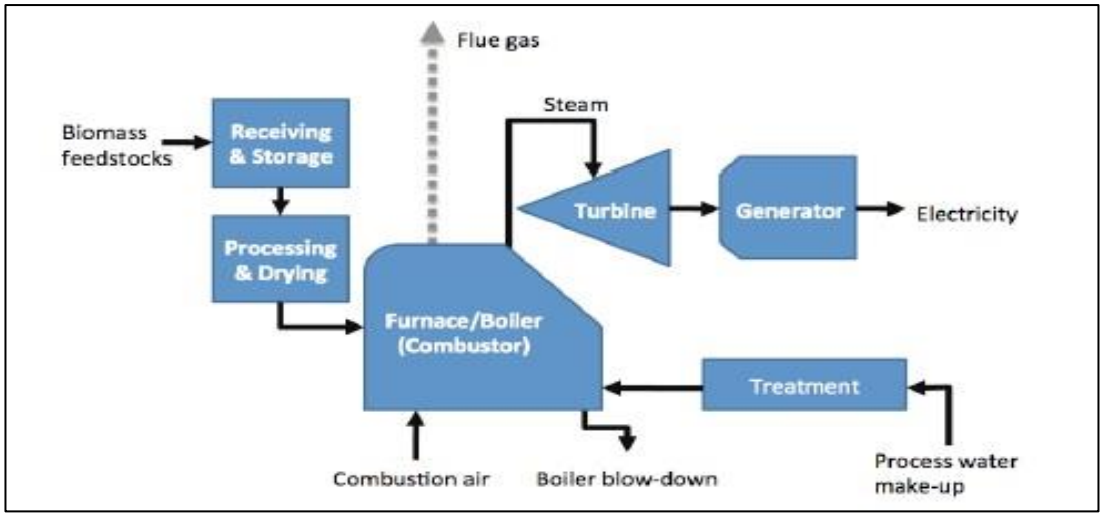


Figure 22. Biomass Combustion Power Process Flow Diagram

Combined heat and power (CHP) is to produce electricity and heat at the same time. It is also known as cogeneration system. When the produced heat is used by industrial and / or district heating systems, CHP systems can achieve higher overall efficiency than separate electricity production and heat generation (Figure 23). Biomass fueled CHP systems can provide heat or steam for industry (eg, pulp and paper, steel or processing industries). They can also be used for space and water heating directly or via a regional heating network. The viability of biomass CHP plants is usually governed by the availability and cost of electricity prices and biomass raw materials. Although there are many biomass sources available for cogeneration, the greatest potential lies in sugar cane and wood processing industries because the raw material can easily be obtained at low cost and the process heat is in demand (UNIDO, 2008).

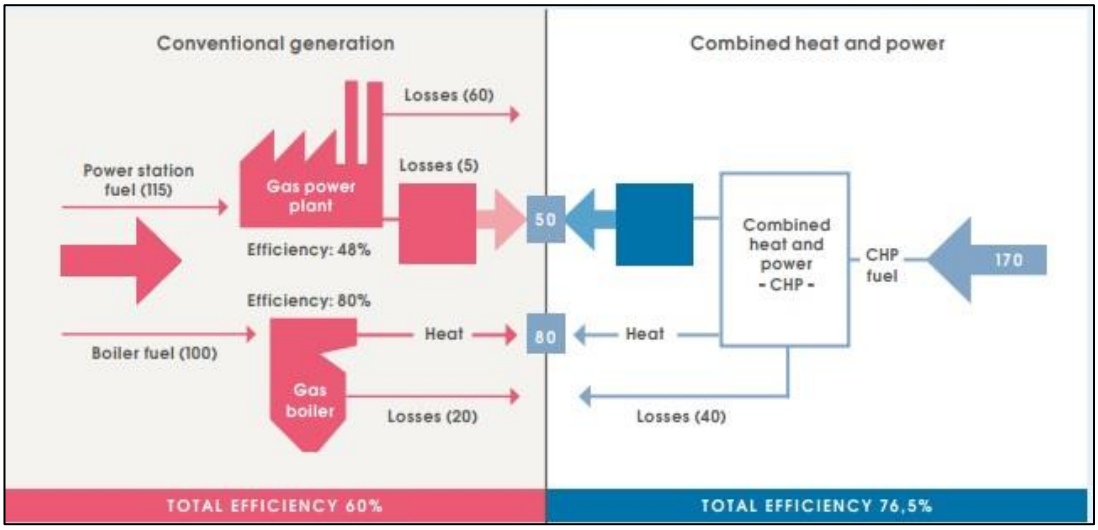


Figure 23. A Sample of Efficiency Gains from CHP

4.5. Cost Assumptions of Biomass Energy

Costs of biomass power plants can be grouped into three distinct categories:

- Feedstock Prices
- Biomass Power Generation Costs
- Operation and Maintenance Expenditure (OPEX)

Table 6. Feedstock and Transport cost in Europe Source: European Climate Foundation ET AL. 200.

		Feedstock		Transport		Total costs	
		USD/GJ	USD/tonne	USD/GJ	USD/tonne	USD/GJ	USD/tonne
Woodchips from local energy crops		5.2 - 8.2	60 - 94	-	-	5.2 - 8.2	60 - 94
Woodchips from Scandinavian forest residues to continental Europe		5.6 - 6.7	64 - 77	3.0 - 3.4	34 - 38	8.6 - 10.1	98 - 115
Local agricultural residues		4.8 - 6.0	55 - 68	-	-	4.8 - 6.0	55 - 68
Imported pellets (from U.S. to continental Europe)	Feedstock	3.0 - 3.7	50 - 63	-	-	3 - 3.7	50-63
	Pelletising	3 - 3.4	50 - 56	-	-	3.0 - 3.4	50-56
	Total	6.0 - 7.1	100 - 119	3.4 - 3.7	56 - 63	9.3 - 10.8	157-182

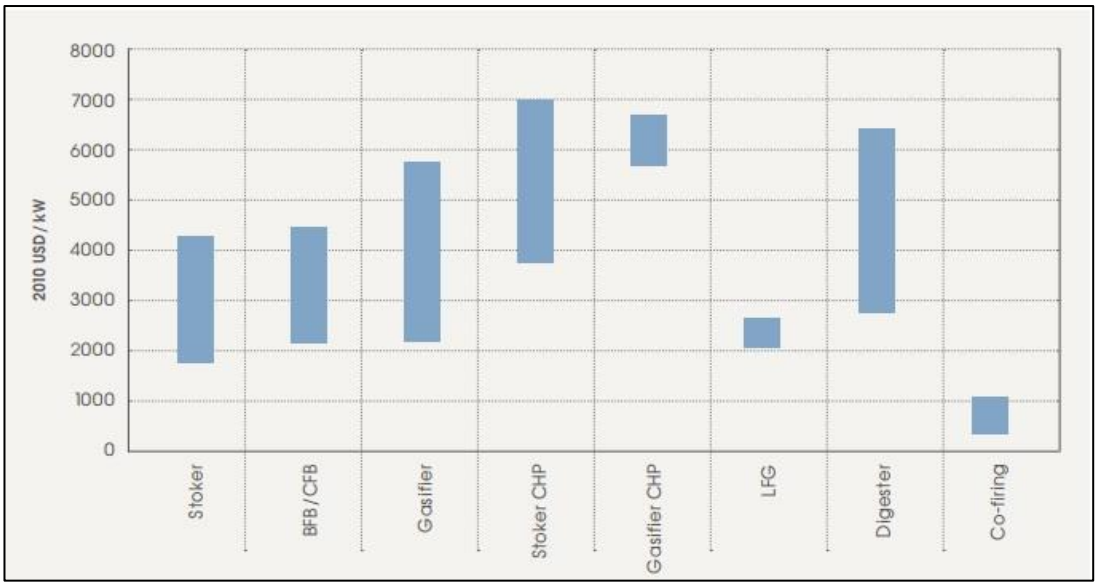


Figure 24 Fixed and Variable Operations and Maintenance Costs Sources: US DOA, 2007; US EPA, 2009; and MOTT Macdonald, 2011.

5. Energy Storage Methods

Electrical energy can be storage with a lot of different methods:

- Storing as Water reservoirs for potential energy
- Storing as compressed air
- Storing as magnetic forces in inductors
- Storing with chemical reactions in the fuel cells
- Storing in batteries and flow batteries with the electrochemical energy form
- Storing in flywheels in kinetic energy form
- Storing in capacitors with the form of electric field..

Figure 25 graphically depicts the storage classification presented

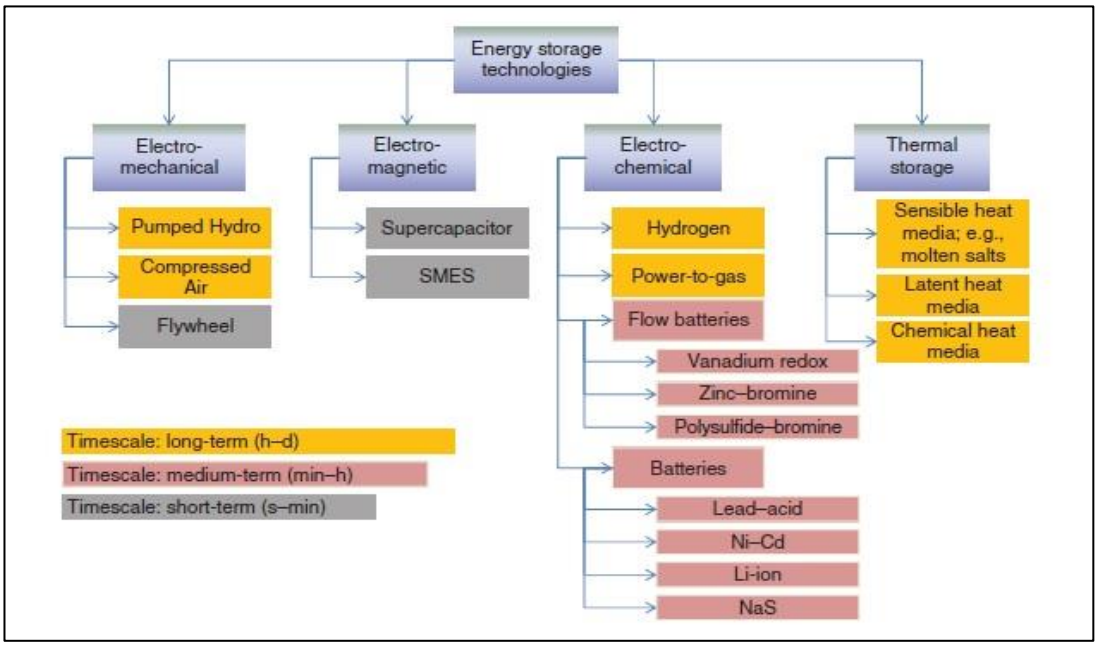


Figure 25. The Catalog of Storage Technologies

5.1. Mechanical Storage

5.1.1. Pumped Hydro Storage (PHS)

Pumped hydro storage is the way of storage mostly used as a huge energy storage for power plants. For years, utilities have been using pumped hydro storage power plants as an economic way to harness peak load by pumping water at a higher level into a dam. When the peak load energy need is occurring, the water in dam is let flow back through the turbines for generating electrical power. Thus, the basic idea is conceptually simple. Energy is stored as hydraulic potential energy by pumping water

from a lower level to a higher level dam, if energy is needed, the water is returned to the lower dam through turbines that drive electricity generators (Ter-Gazarian, 2011).

Pumped hydro storage systems including the following equipmens: an upper dam, waterways, a pump, a turbine, a motor, a generator and a lower dam, shown schematically in Figure 26.

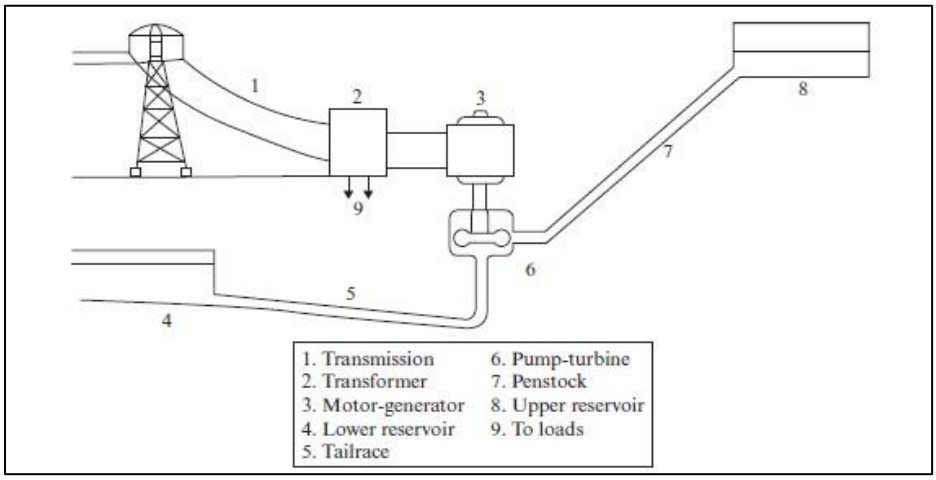


Figure 26. Pumped Hydroelectric Energy Storage

5.1.2. Compressed Air Storage (CAES)

Compressed Air storage systems are using the technology of conventional gas turbine. The electric energy produced is stored as compressed air in an underground storage cavern at pressures of 40-70 bar at ambient temperature. Another possibility is to store the air in above-ground tanks. For increasing the energy efficiency, the air is mixed with natural gas. The compressed air sent from the storage caves heated and bolster in the low-pressure turbines, when energy is needed. Low-pressure turbine converts energy of the compressed air into rotational kinetic energy and this kinetic energy is converted into electrical power via generator. Figure 27 shows a descriptive schematic of the system.

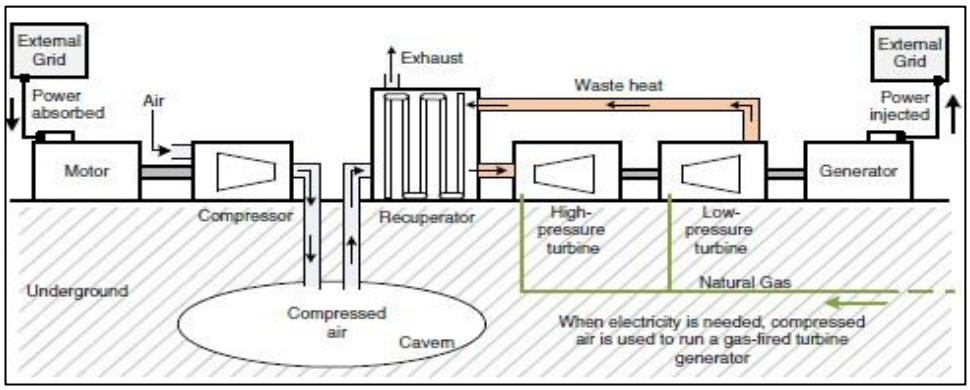


Figure 27. The Operating Principle of Compressed Air Energy Storage (CAES)

5.1.3. Flywheel Storage

Flywheels store kinetic energy in a rotating disk that is mechanically coupled to the shaft of an electrical machine. When the machine accelerates – that is, operates as a motor – energy is transferred to the flywheel and stored in the form of kinetic energy. In opposite terms, the flywheel is discharged when the electrical machine regenerates through the drive; that is, when the speed of the system is reduced. Thus, the energy stored by flywheels can be expressed by

$$E_{FW}(Joules) = \frac{1}{2}J\omega^2$$

where J (in kgm^2) is the inertia of the rotationg parts – that is, the flywheel itself and the rotor of the machine to which it is connected-and ω is the rotaional speed, in rad/s. (Ter-Gazarian, 2011)

5.2. Electrochemical Storage

5.2.1. Secondary Batteries

5.2.1.1. Lead Acid Batteries

Commonly, lead–acid battery cells are built up of several lead plates arranged in parallel. These are alternatively polarized, so that the catholic plates are coated with lead dioxide PbO2 and the anodic plates with porous lead Pb. The plates are immersed in the electrolyte, which is made up of sulfuric acid H2SO4.The global oxidation and reduction reactions in the cell can be summarized as follows.

$$\mathrm{Pb} + \mathrm{SO_4^{2-}} <=> \mathrm{PbSO_4} + 2\mathrm{e^-} \qquad \text{(anode)} \quad (1)$$

$$\mathrm{PbO_2} + 4\mathrm{H^+} + \mathrm{SO_4^{2-}} + 2\mathrm{e^-} \leq> \mathrm{PbSO_4} + 2\mathrm{H_2O} \qquad \text{(cathode)} \quad (2)$$

$$\mathrm{Pb} + \mathrm{PbO_2} + 2\mathrm{H_2SO_4} <=> \mathrm{PbSO_4} + 2\mathrm{H_2O} \qquad \text{(total)} \quad (3)$$

During the discharging process, the porous lead anode reacts with the sulfuric acid, yielding lead sulfate PbSO4 and an excess of electrons, which are transmitted through the external circuit of the cell (the connected external load) to the cathode. These electrons, among with the sulfuric acid, react with the lead dioxide to also form lead sulfate PbSO4. In addition, water is formed in this process. Since the electrolyte is consumed in the reactions, the specific gravity serves as a guide for estimating the SoC of the battery. The electrical potential between the two electrodes of the cell due to the reactions described above results in around 2.04 V. (Díaz-González, 2016)

5.2.1.2. Nickel–Cadmium Batteries

Ni–Cd batteries are primarily produced using nickel and cadmium hydroxide. These materials are then polarized into nickel ox hydroxide NiO(OH) cathodic plates, and anodic plates of porous cadmium. The battery cells are immersed in an electrolytic aqueous alkaline solution based on potassium hydroxide KOH.To prevent short circuits between adjacent anodic and cathodic plates in the cell, a separator is used. This is generally based on polystyrene or polypropylene, but other options are suitable, such as fibrous polyamide. The selection of the separator is critical, as it can constrain the easy mobility of ions produced in chemical reactions between the electrodes, and this is translated into an increment in the internal resistance of the cell.The global oxidation and reduction reactions in the cell can be summarized as follows :

$$\mathrm{Cd} + 2\mathrm{OH}^- <=> \mathrm{Cd(OH_2)} + 2\mathrm{e}^- \quad \text{(anode)} \quad (1)$$

$$2\mathrm{NiOOH} + 2\mathrm{H_2O} + 2\mathrm{e}^- <=> 2\mathrm{Ni(OH_2)} + 2\mathrm{OH}^- \quad \text{(cathode)} \quad (2)$$

$$2\mathrm{NiOOH} + \mathrm{Cd} + 2\mathrm{H_2O} <=> 2\mathrm{Ni(OH)_2} + \mathrm{Cd(OH)_2} \quad \text{(total)} \quad (3)$$

Discharging process, the porous cadmium Cd in the anode comes to the reaction with the ion OH^-, resigned $\mathrm{Cd(OH)_2}$and the electrons that flows through the external channel of the cell to the cathode. These electrons, reacts with NiO(OH) to form Ni(OH)2 and the ion OH^- The electrical potential between the two electrodes of the cell due to the reactions described above results in around 1.2 V, and hence in a lower potential than in lead–acid batteries. (Díaz-González, 2016)

5.2.1.3. Lithium-Based Batteries

The active material in the cathode (positive electrode) of Li-ion cells is usually lithium metal oxide, in the form of lithium cobalt (LiCoO2). The negative electrode is mainly carbon (C) and lithium atoms are actually in the electrode. The electrolyte is an organic solution containing lithium-based dissolved salts, such as LiClO4 and LiPF6 [105]. Finally, porous separators based on polyethylene or polypropylene separate the electrode areas. The global oxidation and reduction reactions in the cell can be summarized as follows:

$$\mathrm{Li(C)} <=> \mathrm{Li}^+ + \mathrm{e}^- \quad \text{(anode)} \quad (1)$$

$$\mathrm{Li}^+\mathrm{e}^- + \mathrm{CoO_2} <=> \mathrm{LiCoO_2} \quad \text{(cathode)} \quad (2)$$

$$\mathrm{Li(C)} + \mathrm{CoO_2} <=> \mathrm{LiCoO_2} \quad \text{(total)} \quad (3)$$

During charging, Li + lithium ions,(negative electrode) are placed on the plates of the graphene. As always, electrons from chemical reactions, in this case, flow from the

positive electrode to the negative electrode through an external energy source, so that the electrical circuitry. Due to the reactions described above (open-circuit voltage), the electrical potential between the two electrodes of the cell, 3.7 V (Díaz-González, 2016).

5.2.1.4. Sodium-Sulfur Batteries (NaS)

The low atomic weight of sodium and the high thermodynamic voltage configure sodium-based battery cells with a high specific power. The cell construction is rather different from those presented so far. The electrodes of NaS battery cells are liquid, while the electrolyte, which in turn acts as a separator, is solid. The negative electrode (liquid sodium) is surrounded by the electrolyte. The material of the electrolyte is ceramic beta-alumina, and the material for the positive electrode is liquid sulfur (usually embedded in a carbon felt). To bring the electrodes to their liquid state, they have to be melted, imposing operating temperatures for NaS batteries of around300–400 ºC. At this temperature, the ceramic electrolyte is a good conductor of the ions produced in the chemical reactions inside the cell. The global oxidation and reduction reactions in the cell can be summarized as follows:

$$2\mathrm{Na} <=> 2\mathrm{Na}^{+} + 2\mathrm{e}^{-} \qquad \text{(anode)} \qquad (1)$$

$$\mathrm{xS} + 2\mathrm{e}^{-} <=> \mathrm{S}_{\mathrm{x}}^{2-} \qquad \text{(cathode)} \qquad (2)$$

$$2\mathrm{Na} + \mathrm{xS} <=> \mathrm{Na}_2\mathrm{SX}_2 \qquad \text{(total)} \qquad (3)$$

During the discharging process, the sodium in the anode is oxidized into sodium ions, which flow through the electrolyte to the cathode. Then, they combine with reduced sulfur anions to generate sodium polysulfide, all of this yielding the above cell reaction. The electrical potential between the two electrodes of the cell due to the reactions described above (the open-circuit voltage) results in around 2.075 V at 350 ºC (Díaz-González, 2016).

5.2.2. Flow Batteries

As in the case of conventional batteries, the operating principle of flow batteries (FBESS) is based on the electrochemical reactions that occur in electrochemical cells. Also, Difference between flow batteries and conventional batteries is electrolyte is not permanently stored in the cells but, i two aqueous electrolytic solutions (A and B) are filled in separate tanks. During the charging process, these aqueous solutions are pumped through the electrochemical cells, where the electrochemically active material dissolved in electrolyte A is oxidized at the anode, and the electrochemically active material in electrolyte B is reduced at the cathode. The discharge cycle comprises the

reverse process. Figure 28 depicts the operating principle of flow batteries (Díaz-González, 2016).

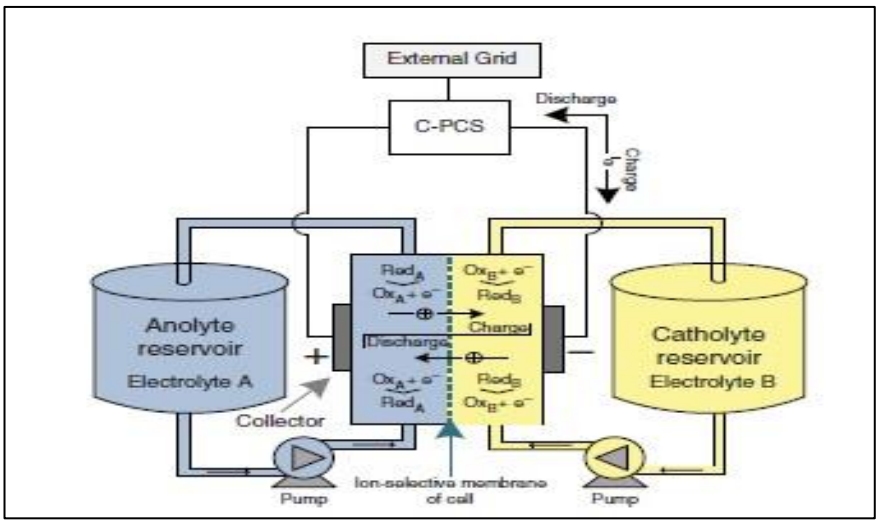


Figure 28. The Operating Principle of Flow Batteries

5.3. Electrical Batteries

5.3.1. The Super capacitor Energy Storage System (EDLC)

Super capacitors are based on electrochemical cells that contain two conductor electrodes, an electrolyte and a porous membrane that permits the transit of ions between the two electrodes. Thus, the presented layout is similar to the electrochemical cells of batteries. The main difference between super capacitors (or ultra-capacitors, or double layer capacitors, depending on the literature) and batteries lies in the fact that no chemical reactions occur in the cells, but the energy is stored electrostatically in the cell. In super capacitors, the electrodes and the electrolyte are electrically charged (the cathode is positively charged, the anode is negatively charged, and the electrolyte contains both positive and negative ions).

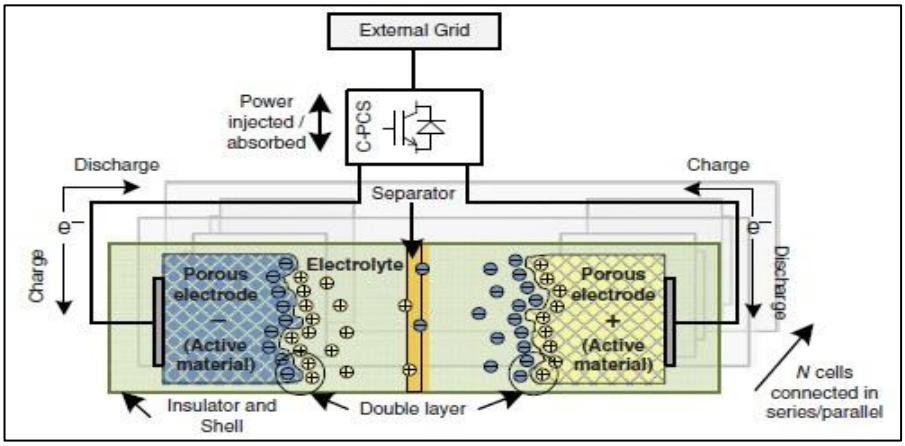


Figure 29. The illustrative Topology of a Supercapacitor, Depicting The Electrical Double Layers at Each Electrode/electrolyte Interface

At each of the electrode surfaces there is an area that interfaces with the electrolyte, and it is in each of these areas where the phenomenon of the “electrical double layer” occurs. By applying a voltage between the electrodes, both the electrodes and the electrolyte become polarized. This means that the positive charge of the cathode is transferred to the area interfacing with the electrolyte, forming a layer of positive ions. In turn, the negative ions of the electrolyte are transferred to the same electrolyte/cathode interface, forming a negative charge-balancing layer of ions. These two layers buildup an “electrical double layer.” The mechanism behind the operating principle of such a double layer can be explained using the Helmholtz model. The model establishes that a layer of solvent molecules of the electrolyte, called the inner Helmholtz plane, separates the two layers. This layer of solvent molecules actually separates the positive and negative charges of the electrode and electrolyte, thus acting asa dielectric. Ultimately, there is a potential difference between the two positive and negative ion layers derived from the contained electric field, and the double layer can be taken to resemble a capacitor. The disclosed double layer concept is shown in Fig.29 (Díaz-González, 2016);

5.3.2. Superconducting Magnetic Energy Storage (SMES)

In such a system, energy is stored in a magnetic field. This magnetic field is created at cryogenic temperatures by a DC current flowing through a superconductor coil. Superconductor materials present almost negligible resistance while at cryogenic temperatures, so the magnetic field in the coil can be created and maintained with a very small amount of current flowing through it; very little energy is dissipated by ohmic losses. The energy stored is determined by the self-inductance of the coil *L* (in henries)and the square of the electric current *I* (in amperes).

$$\mathrm{E_{SMES}(joules)} = \frac{1}{2}\mathrm{LI^2}$$

There are two types of SMES systems, depending on the working temperature of the coil: SMES systems based on high-temperature coils (HTS) and low-temperature coils (LTS). The former work at temperatures around 70 K, while the latter work at temperatures around 5 K. Therefore, a key aspect for proper operation of the latter system is to maintain these low operating temperatures. Also, However, because of the really low energy demand utilization of the system’s cryocoolers,the energy efficiency of SMES is around %89. Frameworks may be exact high, In around 90%. The major advantage of SMES systems is related to their ability to inject or absorb vast amounts of energy in a very short time. In fact, in this regard they compete with super capacitors. We can establish an analogy between the charge/discharge temporal profiles of super capacitors and SMES systems: while the charging time constant of

super capacitors is proportional to the equivalent resistance of the electrolyte and the capacity of the super capacitor cell, in SMES devices it is proportional to the resistance of the coil and its self-inductance. (Díaz-González, 2016)

5.4. Thermal Storages

5.4.1. Molten Salt

In solar power plants, molten salts are widely used as sensible heat media. There are several practical examples of such systems worldwide. Normally, the salts utilized can be either organic or inorganic: examples include sodium nitrate, potassium nitrate, and lithium salts. The operating temperature of the salts, and therefore, of the thermal storage system, oscillates between 292 and 386 ◦C. The particular example of the Andosol I to III solar power plants (in Granada, Spain) is reported in Solar Millennium AG. As presented in that article,28 500 tons of molten salts are heated, using part of the heat collected from the sun by the solar field and transmitted by a heat transfer fluid (HTF) to a HTF/molten salts heat exchanger. Through this exchanger, “cold” molten salts from one of the two storage tanks are heated and stored in the “hot” molten salts tank. These hot molten salts are used to heat the HTF, which is used to operate the turbine-generator system and therefore generates electricity. Figure 30 shows the system topology. (Díaz-González, 2016)

In this way, thermal storage can be used in the plant for various purposes. Amongst the possible applications, the stored thermal energy can be used to prevent steam turbines from being shut down due to intermittent steam production from solar isolation in cloudy periods. Also, the stored energy can be used to run a steam turbine during hours with no sun, thus time-shifting the electricity production when required.

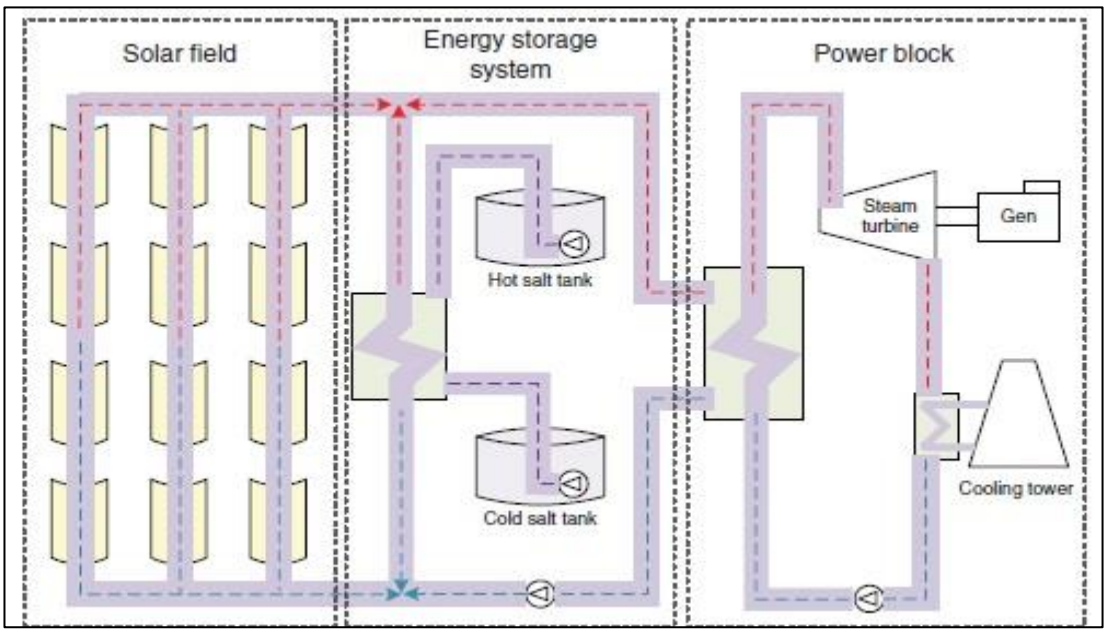


Figure 30. The Topology of a Solar Power Plant with a Storage System Based on Molten Salt.

In the particular case of the Andosol plant, the capacity of the storage system permits the plant to continuously generate electricity for up to 7.5 h of no sun.

5.5. Hydrogen Based Storage System

Owing to an increasing world population and demands for higher standards of living and better air quality, the future energy demand is expected to increase significantly. To meet this demand poses great challenges. Nowadays, most of the world energy need is for transportation and heating and as a source for this energy need mostly petroleum or natural gas is using. These fossil fuels are generally used because the serves opportunity of easy transport in forms liquid or gas. Lamentably, the usage of hydrocarbon fuels for transportation and heating increases all greenhouse gas emissions and a air pollution. That is why all experts and science people is working to develop alternative fuel types, like hydrogen. Hydrogen has the highest potential and also it is easier to transport in gas or liquid . For the past 40 years, all public and organizations supported and mentioned as the solution for stopping airpollution and also global warming. The most important properities for being the best fuel are transportable, clean, accessibility, and control independent.. Hydrogen acquire all these specifications', and it will take the place of fossil fuels, which is used on transportation and heat. (Gupta, 2009).

Table 7 Hydrogen Properties

Property	Value
Molecular weight	2.01594
Density of gas at 0°C and 1 atm.	0.08987 kg/m^3
Density of solid at −259°C	858 kg/m^3
Density of liquid at −253°C	708 kg/m^3
Melting temperature	−259°C
Boiling temperature at 1 atm.	−253°C
Critical temperature	−240°C
Critical pressure	12.8 atm.
Critical density	31.2 kg/m^3
Heat of fusion at −259°C	58 kJ/kg
Heat of vaporization at −253°C	447 kJ/kg
Thermal conductivity at 25°C	0.019 kJ/(ms°C)
Viscosity at 25°C	0.00892 centipoise
Heat capacity (Cp) of gas at 25°C	14.3 kJ/(kg°C)
Heat capacity (Cp) of liquid at −256°C	8.1 kJ/(kg°C)
Heat capacity (Cp) of solid at −259.8°C	2.63 kJ/(kg°C)

5.5.1. Fuel Properties

Hydrogen is turning to a flame large range of temperature and combination. Despite combustion, efficiency is truly dominant and is hailed as a fuel of the next generations, it surely has some technological challenges about safety during the producing, storing and transporting. If the reaction between oxygen and hydrogen happens energy flows explosively in combustion engines or in fuel cells to generates water as its only by-product. Hydrogens energy content per mass is the highest energy content compared to other any fuel. As an example, hydrogen has almost three-time energy content compared to gasoline (140.4 MJ/kg to 48.6 MJ/kg). If we can compare the volumes the scenario is totally different : For liquid hydrogen 8,491 MJ/m3 and for gasoline 31,150 MJ/m3. The energy intensity of the Hydrogen is also influenced by the physical nature of the fuel, if the fuel is stored as a liquid or gas; And if it's a gas, at what pressure. Energy-related properties of hydrogen are compared with other fuels in Tables 7 and 8 (Gupta, 2009).

Table 8. LHV Energy Densities of Fuels

Fuel	Energy Density (MJ/m^3 at 1 atm., 15°C)	Energy Density (MJ/m^3 at 200 atm., 15°C)	Energy Density (MJ/m^3 at 690 atm., 15°C)	Energy Density (MJ/m^3 of Liquid)	Gravimetric Energy Density (MJ/kg)
Hydrogen	10.0	1,825	4,500	8,491	140.4
Methane	32.6	6,860		20,920	43.6
Propane	86.7			23,488	28.3
Gasoline				31,150	48.6
Diesel				31,435	33.8
Methanol				15,800	20.1

Table 9. Comparison of Hydrogen with Other Fuels

Fuel	LHV (MJ/kg)	HHV (MJ/kg)	Stoichiometric Air/Fuel Ratio (kg)	Combustible Range (%)	Flame Temperature (°C)	Min. Ignition Energy (MJ)	AutoIgnition Temperature (°C)
Methane	50.0	55.5	17.2	5–15	1914	0.30	540–630
Propane	45.6	50.3	15.6	2.1–9.5	1925	0.30	450
Octane	47.9	15.1	0.31	0.95–6.0	1980	0.26	415
Methanol	18.0	22.7	6.5	6.7–36.0	1870	0.14	460
Hydrogen	119.9	141.6	34.3	4.0–75.0	2207	0.017	585
Gasoline	44.5	47.3	14.6	1.3–7.1	2307	0.29	260–460
Diesel	42.5	44.8	14.5	0.6–5.5	2327		180–320

5.5.2. Renewable Hydrogen Production

The main pathways for hydrogen from renewable energy sources are schematized in Figure 31.

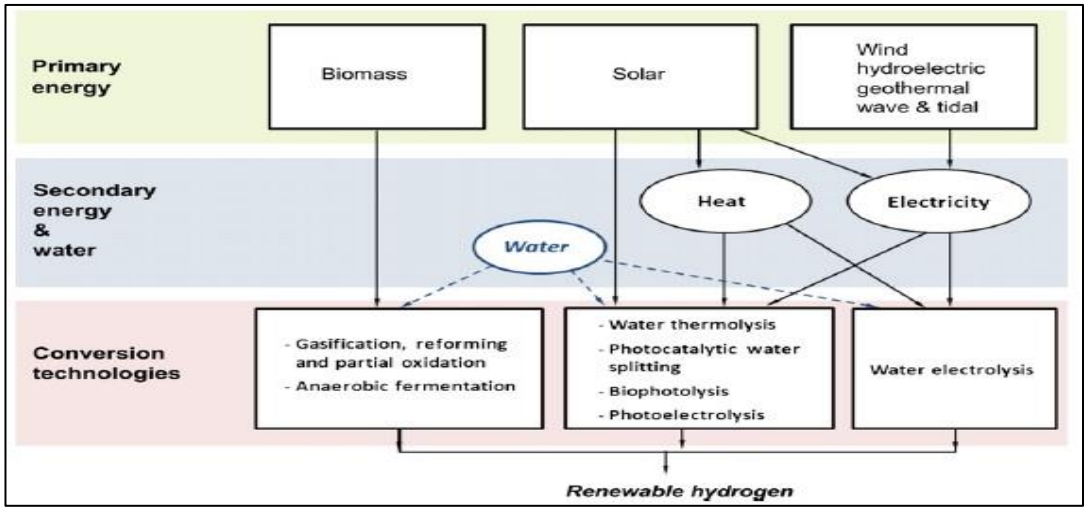


Figure 31. Scheme of The Main Hydrogen Production Ways from Renewables.

5.5.3. Water Electrolysis Technologies

5.5.3.1. Alkaline Water Electrolysis

The general features of alkaline water electrolysis cells are pictured in Fig.24.Two metallic electrodes are immersed in a liquid electrolyte. For this purpose, aqueous solutions of KOH or NaOH are generally used. Only water is consumed during the process, and therefore the cell should be watered to feed the reaction and to adjust the concentration of the electrolytetrene to an optimum value. Water vapor at normal operating temperature (60-80 ° C) and electrolyte residues are carried by gas products. On a dry basis, hydrogen purity is usually 99.9% (Luis M. Gandia, 2013).

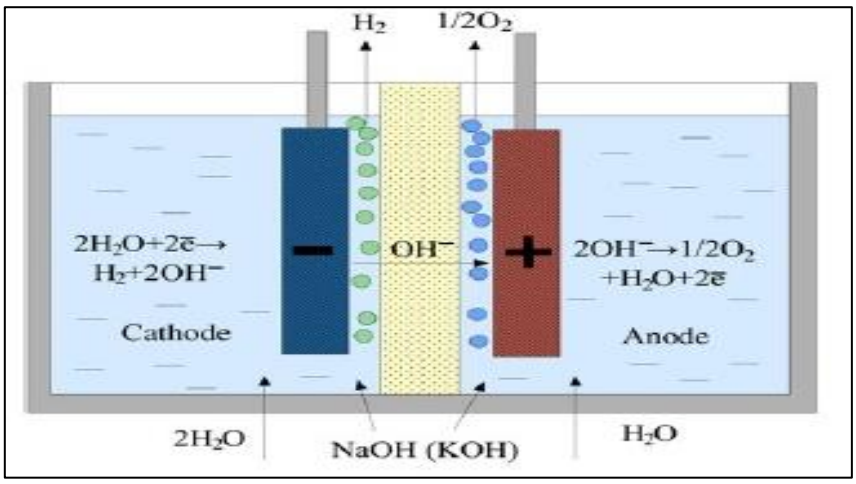


Figure 32. Schematic diagram of the alkaline electrolysis cell

As can be seen from Fig. 33, a cell separator (usuallya porous and electrolyte-impregnated material) is placed between the two electrodes to avoid the spontaneous back recombination of H2 and O2 into water. In a gap-cell configuration, the two massive electrodes are placed face to face, allowing a small (a fewmmthick) electrolyte gap between the electrodes and the separator where gaseous H2 and O2 are evolved. So the current density increases, gas bubbles occurs on the resistive film on the surface

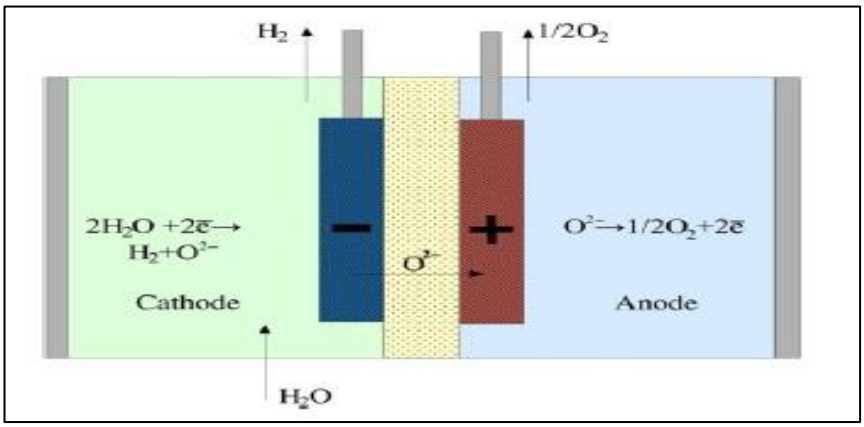


Figure 33. Schematic diagram of PEM electrolysis cell.

of both electrodes and as a result, operating current densities are maximum up to 100mA/cm2. In the more efficient zero-gap cell configuration, the two electrodes are porous and pressed against the cell separator. Therefore, the inter-polar gap is shorter and gases are appearing at the back of the electrodes, avowing higher current density values to be reached.

- **Proton Exchange Membrane Water Electrolysis**

The common specification of proton-exchange membrane (PEM) water electrolysis cells are pictured in Fig. 33 Two electrodes are slicked against a proton-conducting polymer electrolyte . The Membrane Electrode Assembly is engaged in pure (18MU cm) water. Mobile protons species remain confined inside the polymer membrane. Although protons remain in the membrane, the acid is too high (similarly, 1M sulfuric acid solution).For this reason, only noble metal catalysts are required for this acidity, both anodic and cathodic PEM water electrolysis has developed for space vehicles, and oxygen generation in submersibles but it is too expensive to use on other needs. (Luis M. Gandia, 2013)

- **High Temperature Electrolysis**

The general features of SOWE cells are pictured in Fig. 34 Oxide-ion conducting ceramics is used as solid electrolyte and cell separator Such solid-oxide electrolysis cells usually operate in the 800-1000 °C temperature range. The most common electrolyte (like in solid-oxide fuel cell (SOFC) technology)is zirconia ZrO2 stabilized with yttrium andscandium oxides. (Luis M. Gandia, 2013)

5.5.3.2. Other Ways of Production Hydrogen

- Hydrogen Production from Water Splitting Using Photo-Semiconductor Catalysts
- Solar Thermal Water Splitting
- Biomass Sources for Hydrogen Production
- Hydrogen from Bioethanol
- Biological Hydrogen Production

5.5.4. Storage of Hydrogen

Traditionally, hydrogen can be stored as compressed gas or liquid. Beside energy density, the required energy for compression and liquefaction must be calculated. In addition, new technologies are in place and develop. But we will talk about gas and liquid storage in this section.

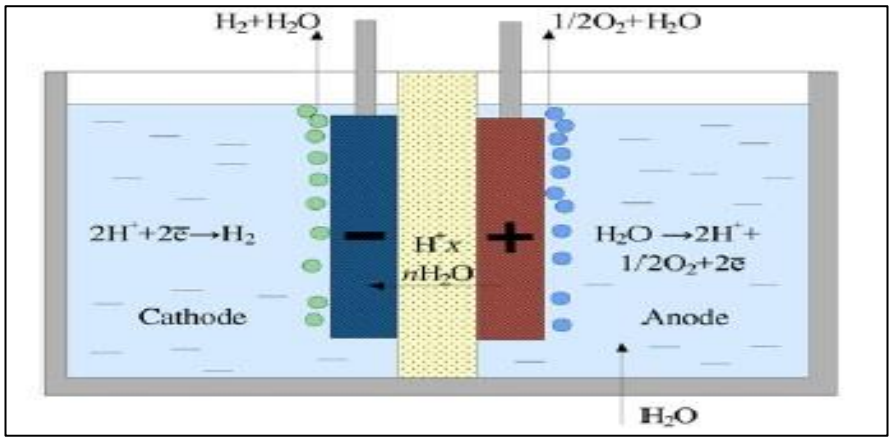


Figure 34. Schematic diagram of solid-oxide electrolysis cell.

5.5.4.1. Gaseous Storage

The storage of gases in pressure vessels is a proven and tested technology. Most gases are available in containers at pressures up to 300 bar (30MPa).

Of thermodynamic interest are, on the one hand, the compression and the work

necessary for it, and, on the other hand, the expansion during the filling process of pressure vessel from a reservoir.

Thermodynamically relevant is the high pressure vessel which is required for compression and work from one side, and, on the other hand, the expansion during the filling process of a pressure vessel from a reservoir (Hirscher, 2010).

- **Compression and Expansion**

Hydrogen gas can be stored by applying compression or expansion processes according to the requirements according to thermodynamic laws.

5.5.4.2. Gas Tank Systems

For storing compressed hydrogen , hydrogen gas compressed between 200 and 350 bar though, last years this pressure amount gets higher to 700 bar and higher (Hirscher, 2010).

Hydrogen tends to adsorb and alienate on material surfaces. Hydrogen diffuses then into the material and causes brittleness and Diffusion. Materials for hydrogen applications are mainly austenitic stainless steel ..

Apart from the container itself, valves for reducing the pressure, pipelines, and sensors to control pressure, temperature and tightness are applied. For certification, tank systems have to undergo extensive tests, there are a number of regulations for pressure vessels and tank systems. Electronic safety systems for monitoring pressure, temperature and tank filling level with leak monitoring and emergency stop measures have been developed.

Type I commercially available pressure containers offer good specification like stongness and safe but too heavy. They are available with net volumes from 2.5 to 50l.. Characteristics in Table 10 show that the pressures vary from 200 to 300 bar.

Table 8. Characteristics of Commercially Obtainable Type I Pressure Containers.Source: Hirscher,2010.

Net volume [dm^3]	2.5	10	20	33	40	50
Nominal pressure [bar]	200	300	200	200	200	200/300
Testing pressure [bar]	300	450	300	300	300	300/450
Tank weight [kg]	3.5	21	31.6	41	58.5	58/94
Tank volume [dm^3]	3.6	14.3	27	41.8	49.8	60.1/64.7
H_2 density [$kg\,m^{-3}$] at 25 °C	14.5	20.6	14.5	14.5	14.5	14.5/20.6
H_2 content [Nm^3]	0.4	2.29	3.22	5.32	6.44	8.05/11.43
H_2 content [kg]	0.04	0.21	0.29	0.48	0.58	0.72/1.03
Grav. H_2 content [$kgH_2\,kg^{-1}$]	0.01	0.009	0.009	0.012	0.011	0.012/0.011
Vol. H_2 content [$kgH_2\,dm^{-3}$]	0.009	0.014	0.011	0.011	0.012	0.012/0.016
Grav. energy density [$kWh\,kg^{-1}$]	0.333	0.300	0.305	0.400	0.367	0.400/0.367
Vol. energy density [$kWh\,dm^{-3}$]	0.300	0.477	0.367	0.367	0.400	0.400/0.533

The systems are quite heavy, the energy densities reach around 0.4kWhkg $^{-1}$ (Hirscher, 2010)..

Other tank types are type II and type III.With adequate material and dimensioning, gaseous hydrogen storage takes placein a closed system and thus hydrogen can be stored without loss for extended periods of time.

5.5.4.3. Liquid Storage

Liquefied gases is used commonly and approved technology. Hydrogen was first liquefied by J. Dewar in 1898. Compared to compressed gases, the density of liquefied gases is considerably higher. On the other hand, liquefaction, storage and handling of the cryogenic boiling liquids require energy input as well as complex tank systems and infrastructure.

After an overview of the liquefaction process, a short thermodynamic analysis of a liquid hydrogen infrastructure with storage tanks and filling processes is presented. (Hirscher, 2010)

Tank systems are customized containers with vacuum insulation and pressure regulation.

- **Liquefaction**

Hydrogen gas can be stored and liquefied according to thermodynamic laws appropriate to the required pressure and capacity conditions.

Figure 35. (a) Reservoir tank and (b) conditioning container at the HyCentA Graz.

5.5.4.4. Liquid Tank Systems

Liquid storage requires highly sophisticated tank systems. Heat transfer into the tank through conduction, convection and radiation has to be minimized. That is why special insulated vessels includes inner tank and outer container also with insulating vacuum layer between both. See Figure 36. The vacuum layer should inhibit heat conduction and heat convection. The no vacuum space between the nested containers, which is filled with multilayer insulation, which has several layers of aluminum foil alternating with glass fiber mats to avoid heat radiation. Due to the inevitable internal heat leakage, the hydrogen evaporates inside the container and the pressure increases. Liquid hydrogen vessels are therefore always equipped with a suitable pressure relief system and safety valve.

Liquid storage occurs in an open system that should be addressed through catalytic combustion, dilution or alternative consumption of the freed hydrogen. Evaporation losses in today's warehouse installations are between 0.3% and 3% per day, but larger tank installations have an advantage over lower surface area/volume ratio (Leon, 2008).

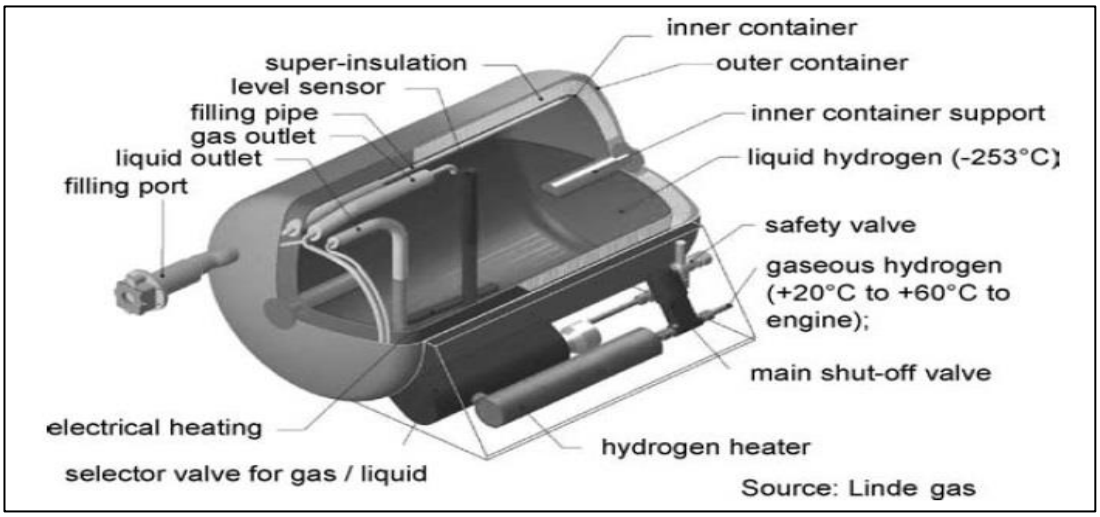


Figure 36. Liquid hydrogen tank Source: Hirscher,2010.

5.5.5. Electricity Generation Using Hydrogen

Electricity production from the stored hydrogen is achieved in two ways.

- Using with fuel cells
- Combustion

5.5.5.1. Combustion

When stored as hydrogen fuel, it is burned in the internal combustion engines and then the kinetic energy generated by the engines is converted to electric energy by means of electric generation systems, or electric energy is obtained by turning the heat in the gas turbines through the necessary equipment.

5.5.5.2. Fuel Cells

A single fuel cell has an electrolyte that stands between two electrodes, an anode and a cathode. The two-pole plates on both sides of the cell help disperse the gases and works as a current collector. In a polymer electrolyte membrane (PEM) fuel cell, which is selected as most potential using for transportation, flows to anode, where a catalyst separates hydrogen molecules into protons and electrons. . The membrane only lets the protons for passing. While protons are transmitted across the membrane to the other side of the cell, the negative charged electron current passes through an external circuit in the cathode. It runs the electron flow engine .

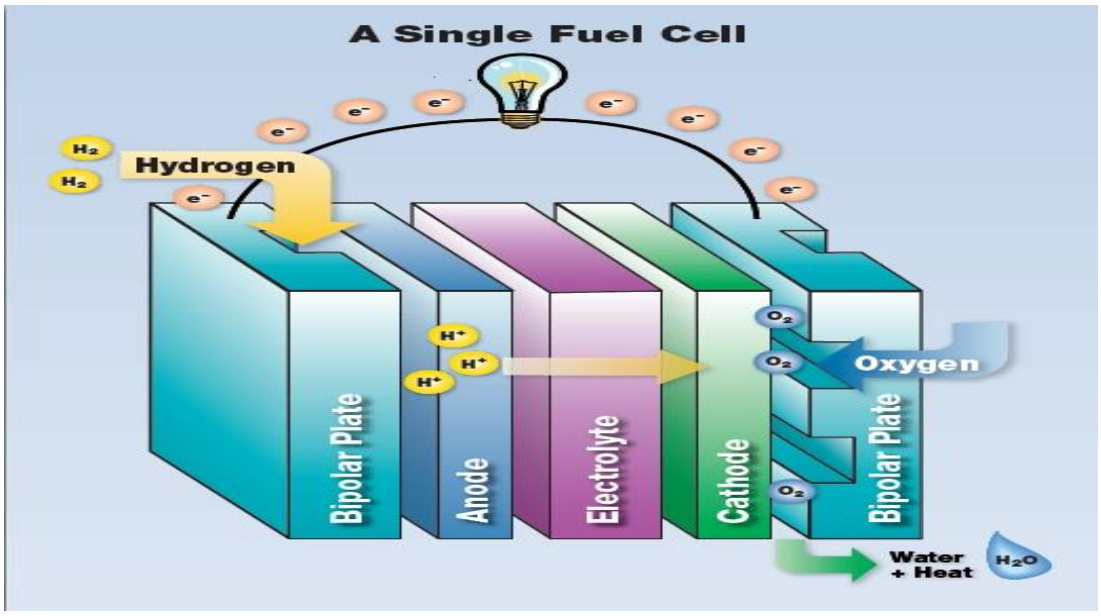


Figure 37. Fuel Cell Working Principle

Oxygen gas typically emits from air, flows to the cathode. After the running of motor the electrons return back the protons starts to a reaction with oxygen, which have moved through the membrane and transforms to a water. During this process exhaust heat and this heat can be also used.(DOE Hydrogen Program, 2006).

Most important facts evaluate the produced power some factors, including the fuel cell type, size, operating temperature and pressure at which gases needed. Potential energy can be generated by fuelcell is 1V, which is enough to produce electricity also using for small applications.

The fuel cells are combined to create stacks to have more voltages. (Although the term "fuel cell" is often used to interpret the request) This thesis can be used as a centralized power generation, which we use also in this thesis but also for small applications like laptop computers (50-100 Watts) or for homes (1-5kW), vehicles (50-125 kW, and central power generation (1-200 MW or more). (DOE Hydrogen Program, 2006).

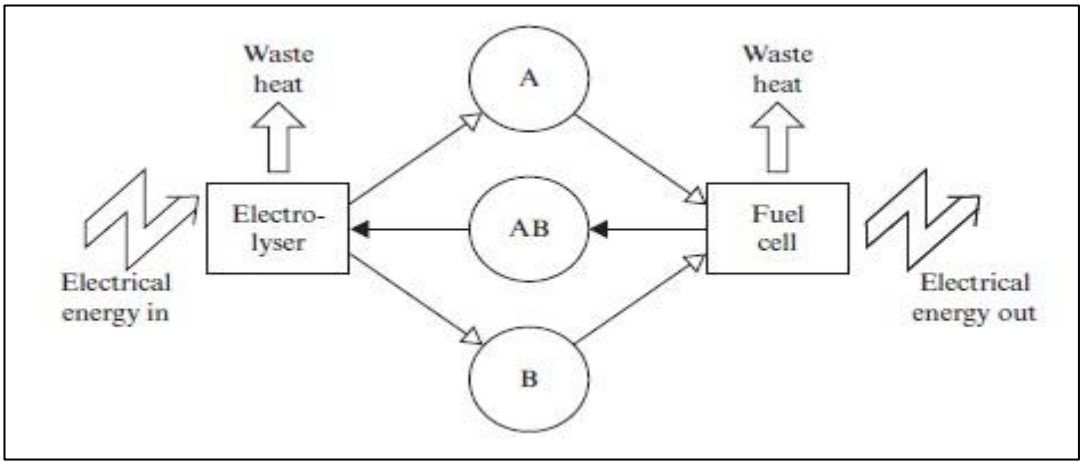


Figure 38. Schematic Diagram of An Electrochemical Fuel Cell

6. Key Study - Base Load Production Facility

In this section, wind, solar ,biomass and hydrogen data, equipment and the results of calculations of renewable energy power plant which are planned to be established in Usak province of Turkey have been examined.

Figure 39 Energy Sources and Usak

6.1. Wind Power Plant

The following data are obtained as a result of one year wind measurements of Usak province. Details of the graphics and selected equipment resulting from the data are discussed in section 5.1.1.

6.1.1. Specifications of Wind Power Plant

E-58 model wind turbine of Enercon company will be used in the wind power plant.

Figure 40 Enercon E-58

6.1.1.1. Enercon E-58

The wind turbine E-58/10.58 is the product of German manufacturer Enercon GmbH,. This manufacturer has been in business since 1984. The rated power of Enercon E-58/10.58 is 1,00 MW. For starting to work, turbine needs a 2,5 m/s wind speed. The cut-out wind speed is 34 m/s. The rotor diameter is 78,6 m. The rotor area is 2.697 m². The wind turbine has 3 rotor blades. The maximum rotor speed is 24 U/min.The Turbine is fittet without. direct drive gearbox. In the generator, Enercon GmbH sets to synchronous. The system has one generator and maximum speed of the generator is also 24 U/min. It produces power up to 440 V and a frequency 50 Hz. Generally manufacturer uses steel tower and for anticorrosion manufacturer uses special painting techniques. Manufacturer of the tower is SAM.Enercon E-58 Datasheet is given Table11 in next page.

Table 9. Enercon E-58 Datasheet Source: ENERCON Product Overview

Enercon E-58 Datasheet							
Power		Rotor		Generator		Tower	
Rated power	1,000.0 kW	Diameter	58.6 m	Type	synchronous	Hub height	59/67/70.5/89 m
Cut-in wind speed	2.5 m/s	Swept area	2,697.0 m²	Number	1	Type	Steel tower
Rated wind speed	12.0 m/s	Number of blades	3	Speed, max	24.0 U/min	Shape	Conical
Cut-out wind speed	34.0 m/s	Rotor speed, max	24.0 U/min	Voltage	440.0 V	Corrosion protection	Painted
Survival wind speed	60.0 m/s	Tipspeed	74 m/s	Grid connection	WR	Manufacturer	SAM
		Type	AERO E-58	Grid frequency	50 Hz		
		Material	GFK / Epoxy	Hersteller	Enercon		
		Manufacturer	Enercon				
		Power density 1	370.8 W/m²				
		Power density 2	2.7 m²/kW				

6.1.1.2. Power Curve

The following table shows the power values of the Enercon-58 model wind turbine at the specified wind speed values, and the wind curve graph is plotted accordingly

Powercurve Enercon E 58	
Wind Speed(m/s)	Power(kW)
0	0
1	0
2	0
3	4,7
4	28,6
5	72,3
6	140,2
7	233,8
8	381,3
9	545,8
10	725,3
11	905
12	987,9
13	1000
14	1000
15	1000
16	1000
17	1000
18	1000
19	1000
20	1000
21	1000
22	1000
23	1000

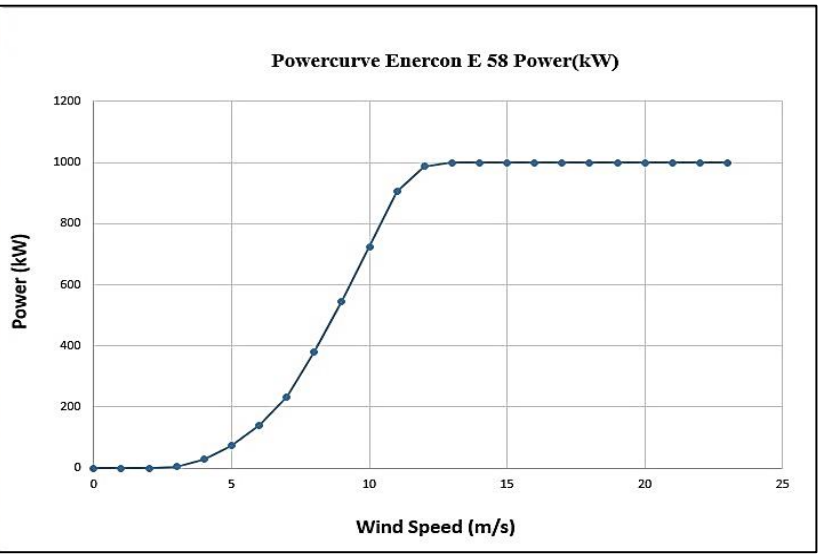


Figure 41 Enercon E-58 Powercurve

6.1.2. Wind Hourly Electrical Output of Wind Power Plant

The amount of electricity generated from the turbine was calculated according to the real met mast wind measurement datas on height 80 meter in Usak. Graph of hourly electricity which is generated from wind energy in Usak is shown in the next figure.

Wind	
Total. MWh	2002,78
Jan	251,046
Feb	243,715
Mar	158,124
Apr.	164,194
May	126,61
Jun	198,988
July	166,548
Aug	153,018
Sep	137,368
Oct	85,5486
Nov	182,702
Dec	134,916

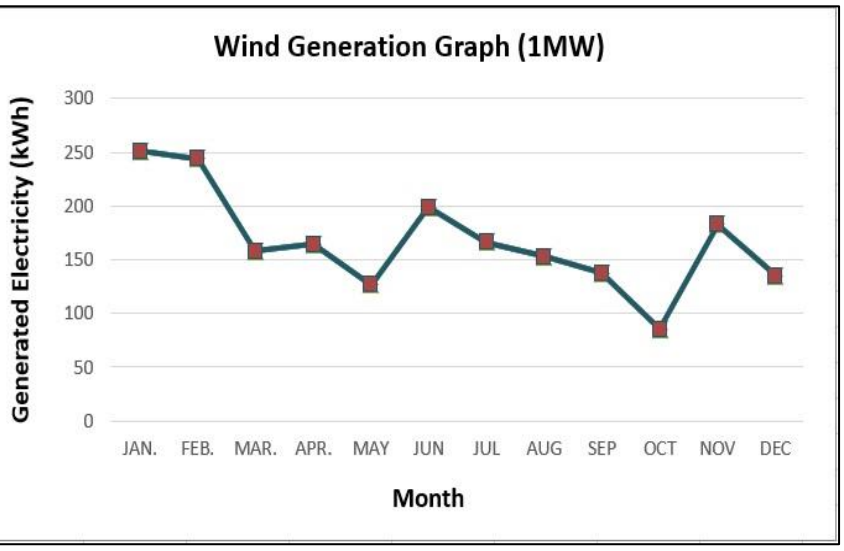


Figure 42. Wind Hourly Electrical Output Graph in Usak

- Wind speed data based on met mast wind measurement data on Height 80m in Usak. Used mast design and equipment are seen from the following figures. The technical details of the used anemometer on met mast are in the appendix A.

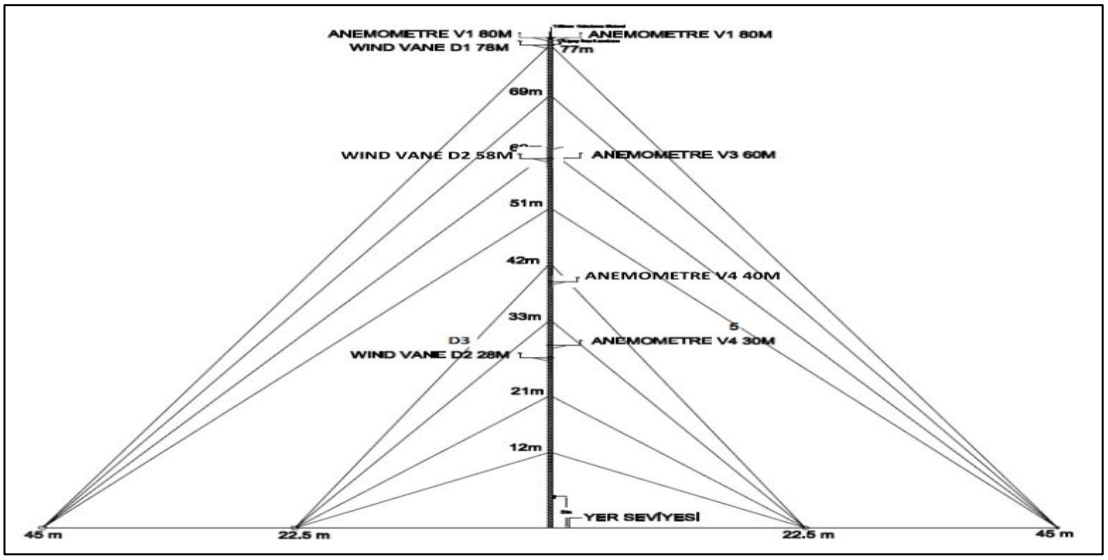


Figure 43. Mast Design for 80 Meter Met Mast

Table 10. Met Mast Equipments

S/N	DEFINITION	UNIT
1	Met Mast	1
2	Ropes and Rope Connection Accessories	1
3	Ground Platform	1
4	Side Connections	7
5	Fixing Platforms	1
6	Ground Rope Fixing Apparatus	1
Additional Equipments		
7	Lightning System	1
8	Steel cabin	0
9	Data Cables (4/6x0.50)	1
10	Design and Engineering	1
Electronic Equipment		
11	Anemometer "Thies First Class Advanced or	5
12	Measnet Calibration for Anemometers	5
13	Directional Sensor "Vector W200P" or Thies First Class	3
14	Galltec KPC 1 / S Temperature & Humidity sensor	1
15	Temperature / Humidity Sensor Radiation Shield	1
16	Temperature / Humidity Sensor Calibration	1
17	Teknam BAP102 Pressure Sensor	1
18	Pressure Sensor Calibration	1
19	Flight Warning Lamp (with built-in solar panel)	
Data Recording System and Components		1
20	Campbell CR1000 or Ammonit Meteo 40	1
21	GSM & GPRS Data Transfer System, antenna, installation equipment	1
22	Quadband modem	1
23	Software	1
Energy System		
24	20 Watt Solar Panel	1
25	12V / 12Ah Battery	1
26	10A Solar Charge Controller	1
Installation		
27	Installation and Commissioning	
28	System Operation and Delivery	1
29	1st year Periodic Maintenance (3 times)	1

- Tables of wind hourly electrical output data based on met mast wind measurement data on height 80m in Usak are in the appendix B.

6.2. Solar Power Plant

The following data are obtained as a result of one year solar energy measurements of Usak province. Details of the graphics and selected equipment resulting from the data are discussed in section 5.2.1.

6.2.1. Specifications of Solar Power Plant

In this section, the equipment considered to be used in accordance with the calculations and the data of these equipment are given.

Figure 44. A Sample Solar Power Plant

6.2.1.1. Solar Panel and Inverter

The panel and the inverter data which are thought to be used in the following table are shown. The number of panels required to be used according to the planned power and the equipment to be supplied is 4167 pieces.

The properties of the selected PV which is name Sharp USA ND-240QCJ element are given on the Table 13.

Table 11. SharpUSA ND-240QCJ Data Sheet

ELECTRICAL CHARACTERISTICS	
Maximum Power (Pmax)*	240 W
Tolerance of Pmax	+5%/-0%
PTC Rating	216.4 W
Type of Cell	Polycrystalline silicon
Cell Configuration	60 in series
Open Circuit Voltage (Voc)	37.5 V
Maximum Power Voltage (Vpm)	29.3 V
Short Circuit Current (Isc)	8.75 A
Maximum Power Current (Ipm)	8.19 A
Module Efficiency (%)	14.7%
Maximum System (DC) Voltage	600 V (UL)/1000V (IEC)
Series Fuse Rating	15 A
NOCT	47.5°C
Temperature Coefficient (Pmax)	-0.485%/°C
Temperature Coefficient (Voc)	-0.36%/°C
Temperature Coefficient (Isc)	0.053%/°C

We used an invertor to transform from D.C electricity is generated by solar panel to A.C. Inverter specifications are shown on the following table. Chosen inverter is SunGrow SG125HV. 8 units of this equipment are required to be used in 1 MW solar system.

Table 12. SunGrow SG125HV Specifications

Nominal AC power (at 50 °C)	125000 W
Max. AC output at PF=1 (at 50 °C)	125000 W
Max. AC apparent power (at 50 °C)	125000 VA
Max. AC output current	120 A
Nominal AC voltage	3 / PE, 600 V
AC voltage range	480 - 690 V
Nominal grid frequency / Grid frequency range	50 Hz / 45 – 55 Hz, 60 Hz / 55 – 65 Hz
THD	< 3 % (at nominal power)
DC current injection	< 0.5 % In
Power factor at nominal powe / Adjustable power factor	> 0.99 / 0.8 leading – 0.8 lagging
Feed-in phases / Connection phases	3 / 3

6.2.2. Solar Hourly Electrical Output Power Plant

Hourly solar energy is based on Akım2 solar power plant data. Akım2 solar power plant is located in Karlık village of Usak province. The used data are based on 1 year measured values.

Figure 45. Akım2 Solar Power Plant in Karlık Village of Usak

The below graph shows a year of solar energy generation in Karlık village of Usak, based on Akım2 data.

Solar	
Total. MWh	1808,03
JAN.	64,2526
FEB.	89,4669
MAR.	135,223
APR.	162,481
MAY	217,193
JUN	243,089
JUL	240,363
AUG	225,566
SEP	189,935
OCT	121,301
NOV	58,5089
DEC	60,6506

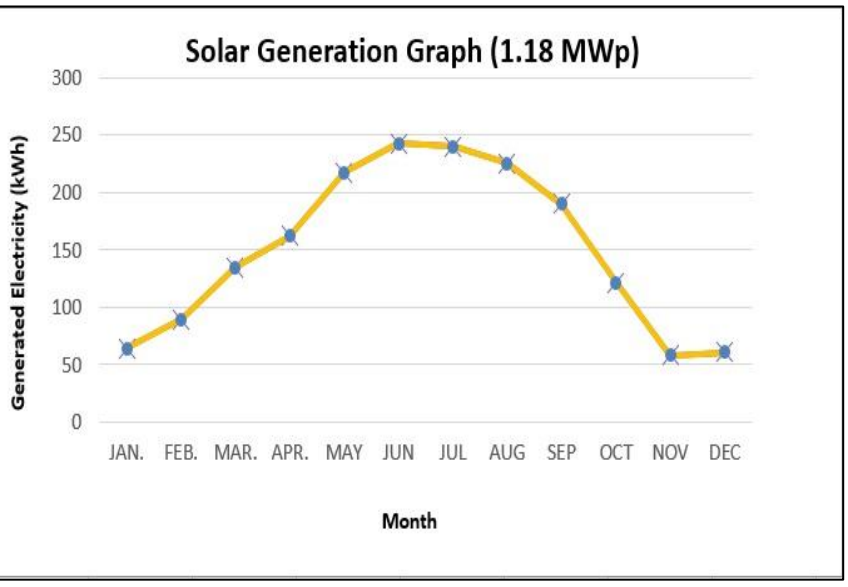


Figure 46. Solar Generation Graph in Karlık Village of Usak

- Tables of solar hourly electrical output data in Usak according to Akım2 solar power plant values are in the appendix C.

6.2.3. Comparison of Produced Solar and Wind Energy

The amounts of electricity generated from solar and wind energy change to depend on months. The following graph shows how the energy generated from the these sources that are depend on months change according to each other.

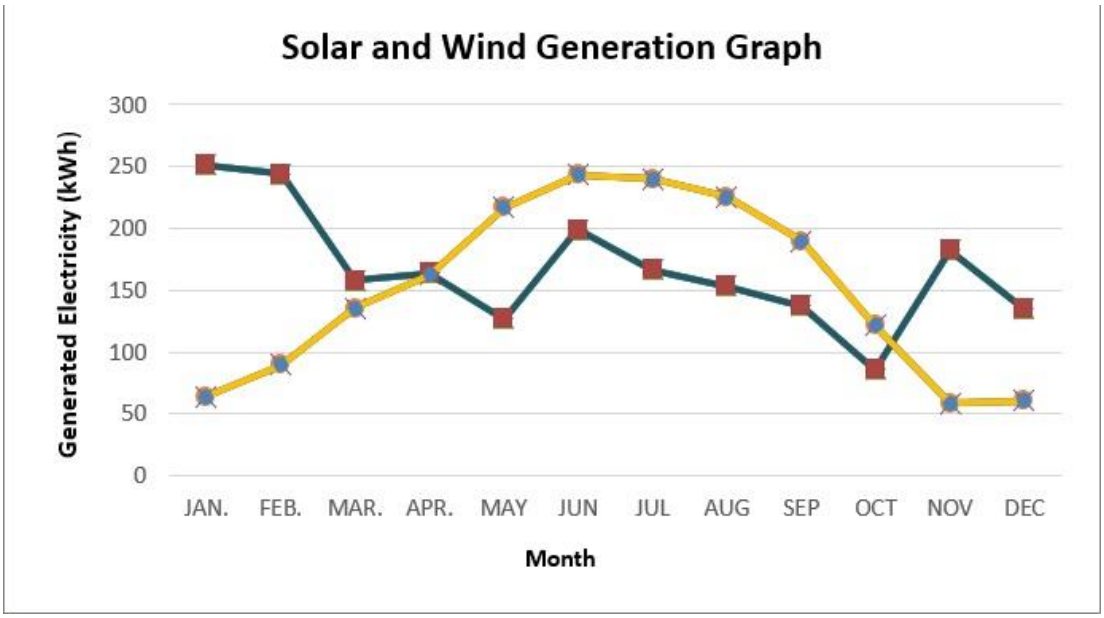


Figure 47. Solar and Wind Genaration Graph in Usak

6.3. Biomass Power Plant

Biomass source will be provided by Usak municipality according to the results of calculations section.

Figure 48. LVHUAN - LHBMG600

6.3.1. Specifications of Biomass Power Plant

The equipment to be used for the energy planned to be produced from the Biomass source is the LHBMG600 product from LVHUAN brand. Two pieces of this equipment have been used to reach sufficient capacity in situations where high energy support is required.

6.3.1.1. LVHUAN - LHBMG600

LHBMG600 model biomass generator working principle :

- Condition: converts biomass with biomass gasifier to biomass gas
- Mixture of gas and the air in the engine's cylinders.
- Mixed gas flows to the cylinder and flaming inside it and the gas energy converts to electrical power
- Power force moves the alternator and the generator generates electric.
- Water moves around the engines and lets the engines cool.
- With the control panel automatically controls all parts of the biomass system

The specific information of the equipment is shown in the table below.

Table 13. LVHUAN - LHBMG600 Specifications

Model Number (Engine Type)	LHBMG600
Brand Name	LVHUAN
Prime Power/Standby Power	450kw/600 KW
Gas mixing type	outside
Rated Speed	1000/1500RPM
Rated Frequency	50/60Hz
Rated Voltage	400V/230V
Phase	AC 3-Phase, 4 wire
Voltage Stability	≤±2%
Voltage transient	≤±10%
Voltage Stable time	≤1
Engine Capacity	71.45 L
Cylinder Number	12 pcs
Cylinder Bore	190mm
Stroke	210mm
Heat consumption	≤11mj/kw.h
Oil consumption	≤1.63g/kw.h
Starting System	DC 24V eclectic motor
Cooling method	water cooler
Lubricant method	Pressure and splash
Isolation class	H
Protection	IP23
Alternator	ENGGA/CN Stamford
Power Factor	0.8 lagging
Exciting method	brushless

6.3.1.2. Wood Pellets

The following table in the next page shows the values of the biomass source considered to be used.

Table 14. Wood Pallet Properties

Property	A1	A2	B
Origin	1.1 and 1.2.1	1.1 and 1.2.1	1.1, 1.2, 1.3
Dimensions	D06, D08 (± 1 mm) 3,15≤ L ≤40 mm Max. 45 mm (1w-%)	D06, D08(± 1 mm) 3,15≤ L ≤40 mm Max. 45 mm (1w-%)	D06, D08(± 1 mm) 3,15≤ L ≤40 mm Max. 45 mm (1w-%)
Moisture, M	≤ 10 w-%	≤ 10 w-%	≤ 10 w-%
Ash content, A dry basis	0.7 w-%	1.5 w-%	3.0 w-%
Bulk density, BD	≥ 600 kg/m³	≥ 600 kg/m³	≥ 600 kg/m³
Mechanical durability, DU	≥ 97.5 w-%	≥ 97.5 w-%	≥ 96.5 w-%
Net calorific value as received, Q	≥ 16.5 MJ/kg [4.6 kWh/kg]	≥ 16.5 MJ/kg [4.6 kWh/kg]	≥ 16.0 MJ/kg [4.4 kWh/kg]
Fines, F (< 3,15 mm)	The amount of fines shall be ≤ 1% leaving the final point of loading for delivery to the end-user. i.e leaving the final storage point or the factory if delivering directly to the end-user. The amount of fines leaving the factory gate shall also be ≤ 1% (unless there is a different agreement between the producer and their customer).		

6.3.2. Biomass Hourly Electrical Output Power Plant

Biomass hourly production will be given in calculations according to system requirements.

6.4. Hydrogen Based Electricity Generation Facility

Since hydrogen storage, generation and electrical systems are still in the process of development, existing ready-to-use systems have been used. Equipment used, characteristics and process diagrams are shown in this section.

Electrolyser

HYSTAT - 15 electrolysis machine was used as the electrolysis equipment. The properties of the equipment are given in the table below.

Table 15. HYSTAT-15 Electrolyser Technical Specifications

MODEL	HySTAT®-10-10	HySTAT®-15-10	HySTAT®-30-10	HySTAT®-45-10	HySTAT®-60-10
Operating Pressure	10 barg				
Nominal hydrogen Flow	10 Nm³/h	15 Nm³/h	30 Nm³/h	45 Nm³/h	60 Nm³/h
Nr. of cell stacks	1	1	2	3	4
Hydrogen flow range	40 - 100% (25 -100% as an option)				
Hydrogen Purity (before HPS)*	99,9%; H2O saturated, O2 < 1,000 ppm				
Hydrogen Purity (after HPS)	99,998% (99,999% as an option); O2 < 2ppm; N2 < 12ppm; Atm. Dew point: -60°C or -76°F (-75°C or -103°F as an option)				
Estimated AC power consumption (all included)	5,4 kWh/Nm³ at full capacity		5,2 kWh/Nm³ at full capacity		
Voltage	3 x 400 VAC ± 3% (3 x 480 or 575 VAC ± 3% as an option)				
Frequency	50 Hz ± 3 % / 60 Hz ± 3 % (option)				
Installed power	100	120	240	120 + 240 + 35KVA	2 x 240 + 35KVA
Max. cooling water temperature (electrolyte)	Closed loop cooling circuit installed				
Design flow cooling water (electrolyte)					
Max. cooling water temperature (gas cooling)	Chiller gas colling circuit installed				
Design flow cooling water (gas cooling)					
Demineralized water consumption	Feed water purification system installed				
Tap water consumption	1,5 - 2 liters/Nm3 H2				
Electrolyte	H2O + 30% wt. KOH				
Electrolyte Quantity	220 L	240 L	360 L	480 L	610 L
Installation area	Outdoor, general purpose area (optional indoor)				
Ambient Temperature Range	-20°C to +40°C (-40°C or +50°C as an option)				
Dimensions (L X W X H)	6,10m x 2,44m x 2,90m (+1,60m with dry cooler)				
Empty weight	Approx. 16 Tons				

Since the power from the sun and wind may be insufficient from time to time, 10 pieces of HYSTER-15 are used instead of 3 pieces of hyster-60.

6.4.1. Storage

Due to energy loss and additional costs resulting from the liquefaction, it has been decided to store the hydrogen as a gas. The hydrogen volumetric values required to calculate the tank volume are given in the Table 24 below.

Table 16. Hydrogen Storage Type Properties

	Weight		Gas		Liquid	
	pounds (lb)	kilograms (kg)	cubic feet (scf)	cu meters (Nm^3)	gallons (gal)	liters (l)
1 pound	1.0	0.4536	192.0	5.047	1.6928	6.408
1 kilogram	2.205	1.0	423.3	11.126	3.377	14.128
1 scf gas	0.00521	0.00236	1.0	0.02628	0.00882	0.03339
1 Nm^3 gas	0.19815	0.08988	38.04	1.0	0.3355	1.2699
1 gallon liquid	0.5906	0.2679	113.4	2.981	1.0	3.785
1 liter liquid	0.15604	0.07078	29.99	0.7881	0.2642	1.0

Scf (standard cubic foot) gas measured at 1 atmosphere and 70°F.
Nm^3 (normal cubic meter) gas measured at 1 atmosphere and 0°C.
Liquid measured at 1 atmosphere and boiling temperature.

The amount of hydrogen that does not go to the fuel cell in the electrolysis unit should be stored in the tank. The tank should be selected according to the hydrogen amount and pressure conditions to be stored. The SEFIC Hydrogen Storage Tank is selected according to the required values. The characteristics of the tank are shown in the Table 25 below.

Table 17. Tank Properties

Model	Water capacity	Working pressure(MPA)	External dimension(mm)	Net weight(kg)	Full-load weight(kg)		
					LOX	LIN	LAr
CFLY05/1.0	5m3	1	2216*4405	4130	9830	8180	11130
CFL-Y05/1.75	5m3	1.75	2216*4405	4400	10100	8450	11400
CFL-Y10/1.0	10m3	1	2216*7098	6250	17920	14620	20520
CFL-Y10/1.75	10m3	1.75	2216*7098	6861	18261	14961	20861
CFL-Y15/0.8	15m3	0.8	2616*6520	7380	24480	22530	28380
CFL-Y15/1.75	15m3	1.75	2616*6520	8501	25601	20651	29501
CFL-Y20/0.8	20m3	0.8	2616*8030	8925	31725	25125	36925
CFL-Y20/1.75	20m3	1.75	2616*8030	10378	33178	26578	38378
CFL-Y30/0.8	30m3	0.8	2616*11070	12166	46366	36466	54166
CFL-Y30/1.75	30m3	1.75	2616*11070	14300	48500	38600	56300
CFL-Y50/0.8	50m3	0.8	3020*12685	19494	76494	59994	89494
CFL-Y50/1.75	50m3	1.75	3020*12685	23050	80050	63550	93050
CFL-Y100/0.8	100m3	0.8	3520*17585	33800	147800	114800	174800
CFL-Y100/1.6	100m3	1.6	3520*17585	40550	154550	121550	181550

By taking advantage of the pressure difference, the hydrogen gas is transferred to the tank by vacuum.

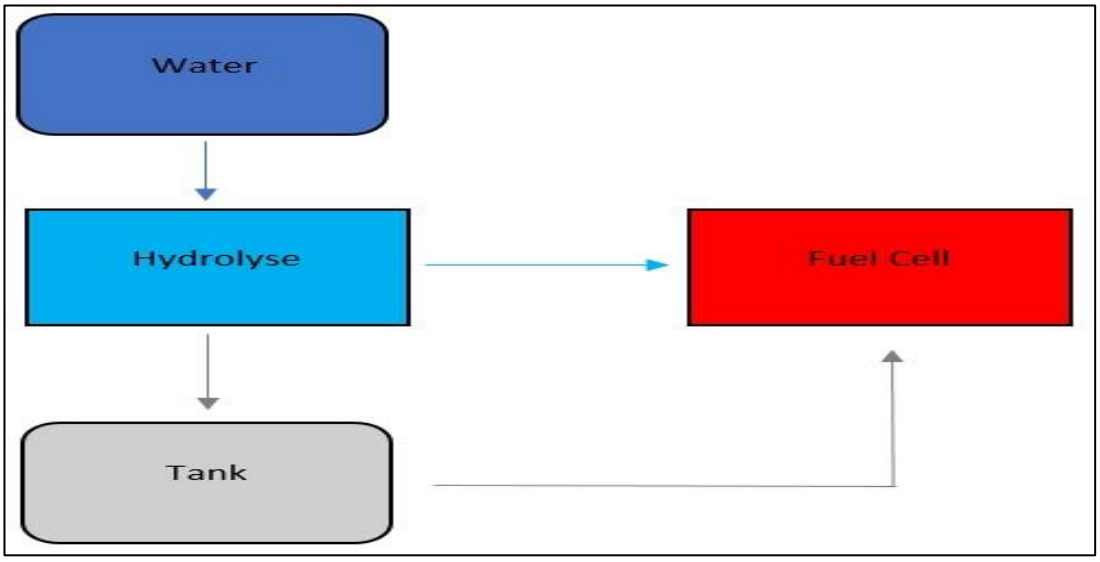


Figure 49. Tank-Hydrolyse Fuel Cell Processes Scheme

6.4.2. Fuel Cell

29 pieces Doosan brand 10 kW fuel cells are used according to the targeted amount of electricity to be produced.

Figure 50. DOOSAN -10 Kw Fuel Cell

6.4.2.1. Why the fuel cell is used ?

-Fuel cells converts the chemical energy to electricity, and as a final product you can have water and heat.

-Hydrogen-powered fuel cells are more efficient than combustion technologies and pollution free.

- A conventional combustion-based power plant has a generation efficiency between 33% to 35% on the other hand hydrogen based fuel cells has an efficiency up to %65 .
- The engine in a conventional car fed up by benzenes has approximately 20 % efficiency. On such engines, the chemical energy in benzene converted into power and also kinetic energy. On Hydrogen fuel cell vehicles used electric motors has an efficiency up to 40-60 percent and converts the fuel's energy to electrical power at the same time such motors has 50% lower fuel consumption, compared to a conventional vehicle .
- The main positive specification of fuel cells are operating quietly and are well useable for lots of small and large application.

6.4.2.2. Doosan 10 kW Fuel Cell

The table below shows the properties of the fuel cell.

Table 18. DOOSAN- 10 kW Fuel Cell Specifications

division	unit	10kW
System output		10kW
fuel		City gas
size	mm	1,500 x 1,600 x 1,520 (W x D x H)
Radiator Size	mm	1,120 x 550 x 850 (W x D x H)
Monthly maximum power generation	kW / month	7,200
Rated heat output	kcal / h	12,000
Gas consumption	Nm^3	2.6
Rated power generation efficiency	% (LHV)	34.4
Rated heat recovery efficiency	% (LHV)	49.5
Rated Total Efficiency	% (LHV)	83.9
Grid connection		Grid-linked operation
power		AC 380V, three-phase four-wire type
System uptime		Within 2 hours

7. Calculations

In this section, the base load is calculated according to the wind, solar energy datas and equipment are given in section 5. The following figure shows the process diagram of the plant. The calculations are made according to the process shown in the following diagram. Following mathematical calculations in this part is designed according to below scheme.Definations are taken in this scheme.

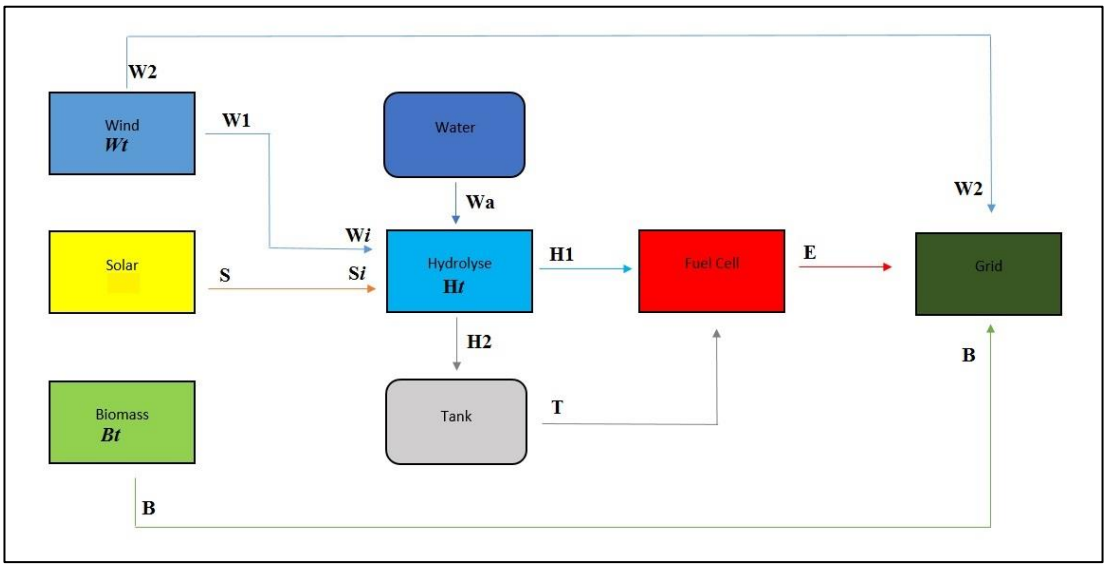


Figure 51. Hyrdogen Storeged Renewable Energy Power Plant Process Scheme

- Hourly electricity production is calculated according to the hourly rates in the 5.1.2 section. There are calculated results in the Excel table B column.

Table 19. Wind Hourly Electrical Output Data Based on Met Mast Wind Measurement Data on Height 80m in Usak on Coloumn B

	A	B	C	D	E	F	G	H	I	J
1	Date/Time	Wind Hourly Generation (AC) Kwh	Solar Hourly Generation (AC) Kwh	Wind Energy Not Stored and Pumped to Grid	Electrolysis Input (kWh)	Hydrogen Content in Tanks Nm3	Hydrogen Fuelcell Output kWh	Pumped Wind + Fuelcell kWh	Biomass Electricity Generation kWh	Base Load
2	1.1.2016 00:00	545,8	0,0	245,8	300,0	33,8	64,5	310,3	664,2	974,5
3	1.1.2016 01:00	140,2	0,0	0,0	140,2	32,6	30,1	30,1	944,4	974,5
4	1.1.2016 02:00	545,8	0,0	245,8	300,0	50,1	64,5	310,3	664,2	974,5
5	1.1.2016 03:00	381,3	0,0	81,3	300,0	58,8	64,5	145,8	828,7	974,5
6	1.1.2016 04:00	381,3	0,0	81,3	300,0	63,1	64,5	145,8	828,7	974,5
7	1.1.2016 05:00	545,8	0,0	245,8	300,0	65,3	64,5	310,3	664,2	974,5
8	1.1.2016 06:00	545,8	0,0	245,8	300,0	66,4	64,5	310,3	664,2	974,5
9	1.1.2016 07:00	381,3	0,0	81,3	300,0	67,0	64,5	145,8	828,7	974,5
10	1.1.2016 08:00	381,3	45,8	81,3	345,8	72,4	74,3	155,6	818,9	974,5
11	1.1.2016 09:00	233,8	92,9	0,0	326,3	72,9	70,2	70,2	904,3	974,5
12	1.1.2016 10:00	233,8	123,6	0,0	357,4	76,7	76,8	76,8	897,6	974,5
13	1.1.2016 11:00	233,8	147,0	0,0	380,8	81,2	81,9	81,9	892,6	974,5
14	1.1.2016 12:00	381,3	155,8	81,3	455,8	91,9	98,0	179,3	795,2	974,5
15	1.1.2016 13:00	233,8	147,0	0,0	380,8	88,8	81,9	81,9	892,6	974,5
16	1.1.2016 14:00	72,3	123,6	0,0	195,9	66,4	42,1	42,1	932,4	974,5
17	1.1.2016 15:00	28,6	92,5	0,0	121,1	46,8	26,0	26,0	948,5	974,5

- Hourly electricity production is calculated according to solar hourly generation data in section 5.2.2 The calculated values are located in column C of the excel chart.

Table 20. Solar Hourly Electrical Output Data in Usak According to Akım2 Solar Power Plant on Coloumn C

	A	B	C	D	E	F	G	H	I	J
1	Date/Time	Wind Hourly Generation (AC) Kwh	Solar Hourly Generation (AC) Kwh	Wind Energy Not Stored and Pumped to Grid	Electrolysis Input (KWh)	Hydrogen Content in Tanks Nm3	Hydrogen Fuelcell Output kWh	Pumped Wind + Fuelcell kWh	Biomass Electricity Generation kWh	Base Load
2	1.1.2016 00:00	545,8	0,0	245,8	300,0	33,8	64,5	310,3	664,2	974,5
3	1.1.2016 01:00	140,2	0,0	0,0	140,2	32,6	30,1	30,1	944,4	974,5
4	1.1.2016 02:00	545,8	0,0	245,8	300,0	90,1	64,5	310,3	664,2	974,5
5	1.1.2016 03:00	381,3	0,0	81,3	300,0	58,8	64,5	145,8	828,7	974,5
6	1.1.2016 04:00	381,3	0,0	81,3	300,0	63,1	64,5	145,8	828,7	974,5
7	1.1.2016 05:00	545,8	0,0	245,8	300,0	65,3	64,5	310,3	664,2	974,5
8	1.1.2016 06:00	545,8	0,0	245,8	300,0	66,4	64,5	310,3	664,2	974,5
9	1.1.2016 07:00	381,3	0,0	81,3	300,0	67,0	64,5	145,8	828,7	974,5
10	1.1.2016 08:00	381,3	45,8	81,3	345,8	72,4	74,3	155,6	818,9	974,5
11	1.1.2016 09:00	233,8	92,5	0,0	326,3	72,9	70,2	70,2	904,3	974,5
12	1.1.2016 10:00	233,8	123,6	0,0	357,4	76,7	76,8	76,8	897,6	974,5
13	1.1.2016 11:00	233,8	147,0	0,0	380,8	81,2	81,9	81,9	892,6	974,5
14	1.1.2016 12:00	381,3	155,8	81,3	455,8	91,9	98,0	179,3	795,2	974,5
15	1.1.2016 13:00	233,8	147,0	0,0	380,8	88,8	81,9	81,9	892,6	974,5
16	1.1.2016 14:00	72,3	123,6	0,0	195,9	66,4	42,1	42,1	932,4	974,5
17	1.1.2016 15:00	28,6	92,5	0,0	121,1	46,8	26,0	26,0	948,5	974,5

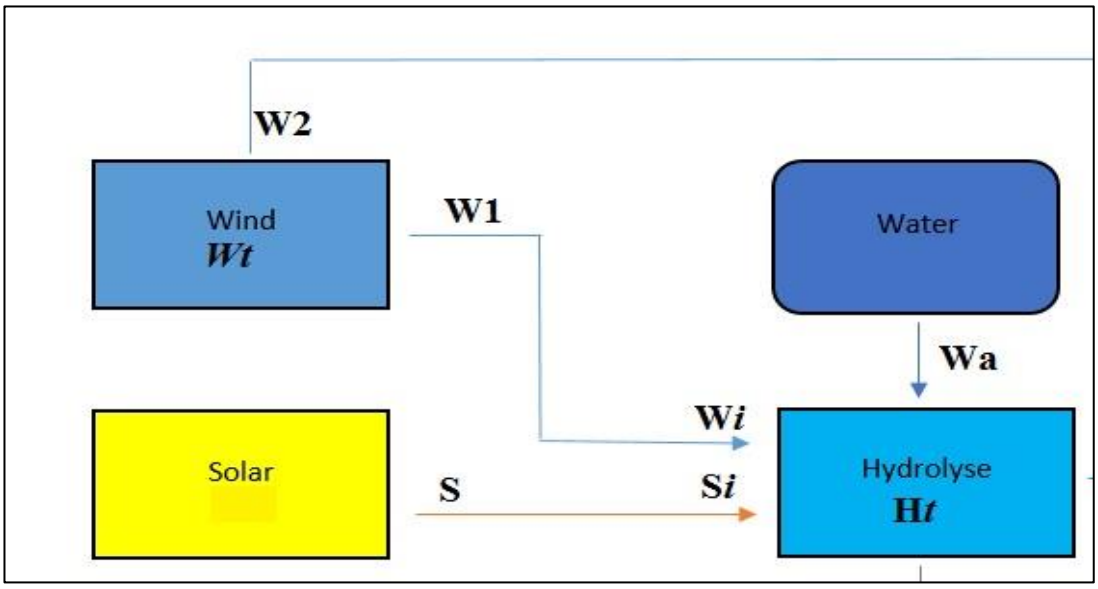


Figure 52. Solar-Wind Prosses Scheme

- We store all energy produced by solar in column C

- $S = Si$ (1)

Table 21. The Excess Electrical Energy Values That Are Not Stored and Transferred to the Grid on Column D

	A	B	C	D	E	F	G	H	I	J
1	Date/Time	Wind Hourly Generation (AC) Kwh	Solar Hourly Generation (AC) Kwh	Wind Energy Not Stored and Pumped to Grid	Electrolysis Input (kWh)	Hydrogen Content in Tanks Nm3	Hydrogen Fuelcell Output kWh	Pumped Wind + Fuelcell kWh	Biomass Electricity Generation kWh	Base Load
2	1.1.2016 00:00	545,8	0,0	245,8	300,0	33,8	64,5	310,3	664,2	974,5
3	1.1.2016 01:00	140,2	0,0	0,0	140,2	32,6	30,1	30,1	944,4	974,5
4	1.1.2016 02:00	545,8	0,0	245,8	300,0	50,1	64,5	310,3	664,2	974,5
5	1.1.2016 03:00	381,3	0,0	81,3	300,0	58,8	64,5	145,8	828,7	974,5
6	1.1.2016 04:00	381,3	0,0	81,3	300,0	63,1	64,5	145,8	828,7	974,5
7	1.1.2016 05:00	545,8	0,0	245,8	300,0	65,3	64,5	310,3	664,2	974,5
8	1.1.2016 06:00	545,8	0,0	245,8	300,0	66,4	64,5	310,3	664,2	974,5
9	1.1.2016 07:00	381,3	0,0	81,3	300,0	67,0	64,5	145,8	828,7	974,5
10	1.1.2016 08:00	381,3	45,8	81,3	345,8	72,4	74,3	155,6	818,9	974,5
11	1.1.2016 09:00	233,8	92,5	0,0	326,3	72,9	70,2	70,2	904,3	974,5
12	1.1.2016 10:00	233,8	123,6	0,0	357,4	76,7	76,8	76,8	897,6	974,5
13	1.1.2016 11:00	233,8	147,0	0,0	380,8	81,2	81,9	81,9	892,6	974,5
14	1.1.2016 12:00	381,3	155,8	81,3	455,8	91,9	98,0	179,3	795,2	974,5
15	1.1.2016 13:00	233,8	147,0	0,0	380,8	88,8	81,9	81,9	892,6	974,5
16	1.1.2016 14:00	72,3	123,6	0,0	195,9	66,4	42,1	42,1	932,4	974,5
17	1.1.2016 15:00	28,6	92,5	0,0	121,1	46,8	26,0	26,0	948,5	974,5

- We store partly wind energy as hydrogen.
- We calculated avarage hourly wind production 229 kWh which will be stored to hydro storage and will be used for generating electiricity by hydro facility
- Rest of the wind energy output will be transferred to main grid transformer station whis is calculated oin coloumn D.

If $$Wt \leq 229 \text{ (kWh)} ; \quad (2)$$

$$Wt = W1 = Wi \quad (3)$$

$$W2 = 0 \quad (4)$$

If $$Wt > 229 \text{ (kWh)}; \quad (5)$$

$$W2 = Wt - 229 \text{ (kWh)} \quad (6)$$

$$W1 = 229 \text{ (kWh)} \quad (7)$$

- For hydro storage, we calculated the sum of generated solar energy and wind energy, which is column E (Electrolysis Input).

$$\text{Electrolysis Input} = Wi + Si \quad (8)$$

Table 22. Electrolysis Input Comes From Wind and Solar Energy's Sum on Column E

	A	B	C	D	E	F	G	H	I	J
1	Date/Time	Wind Hourly Generation (AC) Kwh	Solar Hourly Generation (AC) Kwh	Wind Energy Not Stored and Pumped to Grid	Electrolysis Input (kWh)	Hydrogen Content in Tanks Nm3	Hydrogen Fuelcell Output kWh	Pumped Wind + Fuelcell kWh	Biomass Electricity Generation kWh	Base Load
2	1.1.2016 00:00	545,8	0,0	245,8	300,0	33,8	64,5	310,3	664,2	974,5
3	1.1.2016 01:00	140,2	0,0	0,0	140,2	32,6	30,1	30,1	944,4	974,5
4	1.1.2016 02:00	545,8	0,0	245,8	300,0	50,1	64,5	310,3	664,2	974,5
5	1.1.2016 03:00	381,3	0,0	81,3	300,0	58,8	64,5	145,8	828,7	974,5
6	1.1.2016 04:00	381,3	0,0	81,3	300,0	63,1	64,5	145,8	828,7	974,5
7	1.1.2016 05:00	545,8	0,0	245,8	300,0	65,3	64,5	310,3	664,2	974,5
8	1.1.2016 06:00	545,8	0,0	245,8	300,0	66,4	64,5	310,3	664,2	974,5
9	1.1.2016 07:00	381,3	0,0	81,3	300,0	67,0	64,5	145,8	828,7	974,5
10	1.1.2016 08:00	381,3	45,8	81,3	345,8	72,4	74,3	155,6	818,9	974,5
11	1.1.2016 09:00	233,8	92,5	0,0	326,3	72,9	70,2	70,2	904,3	974,5
12	1.1.2016 10:00	233,8	123,6	0,0	357,4	76,7	76,8	76,8	897,6	974,5
13	1.1.2016 11:00	233,8	147,0	0,0	380,8	81,2	81,9	81,9	892,6	974,5
14	1.1.2016 12:00	381,3	155,8	81,3	455,8	91,9	98,0	179,3	795,2	974,5
15	1.1.2016 13:00	233,8	147,0	0,0	380,8	88,8	81,9	81,9	892,6	974,5
16	1.1.2016 14:00	72,3	123,6	0,0	195,9	66,4	42,1	42,1	932,4	974,5
17	1.1.2016 15:00	28,6	92,5	0,0	121,1	46,8	26,0	26,0	948,5	974,5

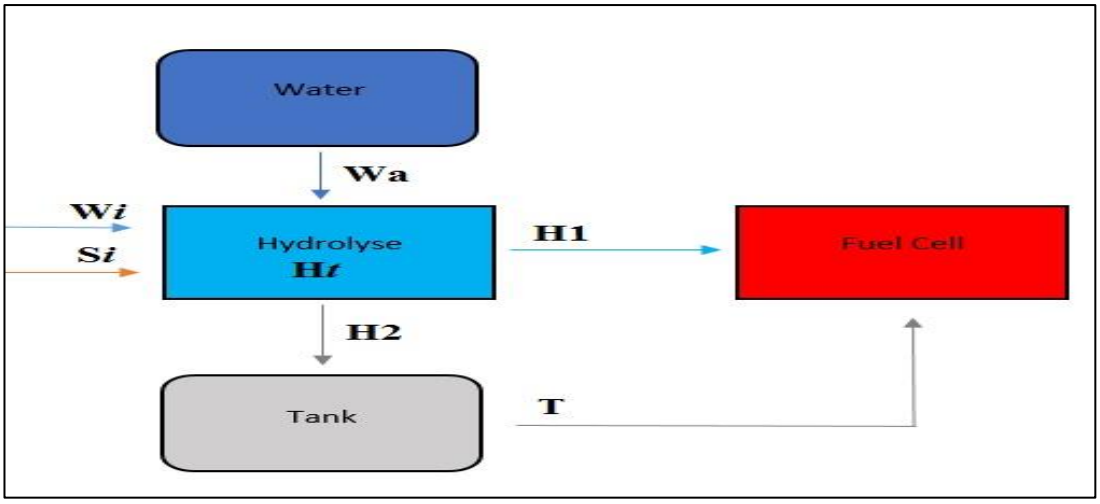


Figure 53. Hydrogen Stored and Fuel Prosses

- In colon F will calculated the hydrogen content in tank with the constant of percentage of wind energy stored, wind energy transferred to transformer. Fuel also in column F.
- According to Table 23 HYSTAT-15 Technical Specifications ;

$$T = (Wi + Si) / (120 * 0.9 * 15) \tag{9}$$

Table 23. Hydrogen Content in Tank on F column

	A	B	C	D	E	F	G	H	I	J
1	Date/Time	Wind Hourly Generation (AC) Kwh	Solar Hourly Generation (AC) Kwh	Wind Energy Not Stored and Pumped to Grid	Electrolysis Input (kWh)	Hydrogen Content in Tanks Nm3	Hydrogen Fuelcell Output kWh	Pumped Wind + Fuelcell kWh	Biomass Electricity Generation kWh	Base Load
2	1.1.2016 00:00	545,8	0,0	245,8	300,0	33,8	64,5	310,3	664,2	974,5
3	1.1.2016 01:00	140,2	0,0	0,0	140,2	32,6	30,1	30,1	944,4	974,5
4	1.1.2016 02:00	545,8	0,0	245,8	300,0	50,1	64,5	310,3	664,2	974,5
5	1.1.2016 03:00	381,3	0,0	81,3	300,0	58,8	64,5	145,8	828,7	974,5
6	1.1.2016 04:00	381,3	0,0	81,3	300,0	63,1	64,5	145,8	828,7	974,5
7	1.1.2016 05:00	545,8	0,0	245,8	300,0	65,3	64,5	310,3	664,2	974,5
8	1.1.2016 06:00	545,8	0,0	245,8	300,0	66,4	64,5	310,3	664,2	974,5
9	1.1.2016 07:00	381,3	0,0	81,3	300,0	67,0	64,5	145,8	828,7	974,5
10	1.1.2016 08:00	381,3	45,8	81,3	345,8	72,4	74,3	155,6	818,9	974,5
11	1.1.2016 09:00	233,8	92,5	0,0	326,3	72,9	70,2	70,2	904,3	974,5
12	1.1.2016 10:00	233,8	123,6	0,0	357,4	76,7	76,8	76,8	897,6	974,5
13	1.1.2016 11:00	233,8	147,0	0,0	380,8	81,2	81,9	81,9	892,6	974,5
14	1.1.2016 12:00	381,3	155,8	81,3	455,8	91,9	98,0	179,3	795,2	974,5
15	1.1.2016 13:00	233,8	147,0	0,0	380,8	88,8	81,9	81,9	892,6	974,5
16	1.1.2016 14:00	72,3	123,6	0,0	195,9	66,4	42,1	42,1	932,4	974,5
17	1.1.2016 15:00	28,6	92,5	0,0	121,1	46,8	26,0	26,0	948,5	974,5

- We can see proportion of saturity for each hour and in F 8787 cell, we found maximum storage capacity we need in excel table using with Large function.

Table 24.Maximum Storage Needed on F 8787 cell

	A	B	C	D	E	F	G	H	I	J
1	Date/Time	Wind Hourly Generation (AC) Kwh	Solar Hourly Generation (AC) Kwh	Wind Energy Not Stored and Pumped to Grid	Electrolysis Input (kWh)	Hydrogen Content in Tanks Nm3	Hydrogen Fuelcell Output kWh	Pumped Wind + Fuelcell kWh	Biomass Electricity Generation kWh	Base Load
8766	31.12.2016 04:00	0,0	0,0	0,0	0,0	0,0	0,0	0,0	974,5	974,5
8767	31.12.2016 05:00	0,0	0,0	0,0	0,0	0,0	0,0	0,0	974,5	974,5
8768	31.12.2016 06:00	0,0	0,0	0,0	0,0	0,0	0,0	0,0	974,5	974,5
8769	31.12.2016 07:00	0,0	0,0	0,0	0,0	0,0	0,0	0,0	974,5	974,5
8770	31.12.2016 08:00	0,0	68,6	0,0	68,6	7,7	14,8	14,8	959,7	974,5
8771	31.12.2016 09:00	0,0	138,7	0,0	138,7	19,5	29,8	29,8	944,7	974,5
8772	31.12.2016 10:00	0,0	185,5	0,0	185,5	30,6	39,9	39,9	934,6	974,5
8773	31.12.2016 11:00	0,0	220,5	0,0	220,5	40,1	47,4	47,4	927,1	974,5
8774	31.12.2016 12:00	0,0	233,6	0,0	233,6	46,3	50,2	50,2	924,3	974,5
8775	31.12.2016 13:00	0,0	220,5	0,0	220,5	48,0	47,4	47,4	927,1	974,5
8776	31.12.2016 14:00	0,0	185,5	0,0	185,5	44,9	39,9	39,9	934,6	974,5
8777	31.12.2016 15:00	0,0	138,7	0,0	138,7	38,0	29,8	29,8	944,7	974,5
8778	31.12.2016 16:00	0,0	68,6	0,0	68,6	26,7	14,8	14,8	959,7	974,5
8779	31.12.2016 17:00	0,0	0,0	0,0	0,0	13,4	0,0	0,0	974,5	974,5
8780	31.12.2016 18:00	0,0	0,0	0,0	0,0	6,7	0,0	0,0	974,5	974,5
8781	31.12.2016 19:00	0,0	0,0	0,0	0,0	3,3	0,0	0,0	974,5	974,5
8782	31.12.2016 20:00	0,0	0,0	0,0	0,0	1,7	0,0	0,0	974,5	974,5
8783	31.12.2016 21:00	0,0	0,0	0,0	0,0	0,8	0,0	0,0	974,5	974,5
8784	31.12.2016 22:00	0,0	0,0	0,0	0,0	0,4	0,0	0,0	974,5	974,5
8785	31.12.2016 23:00	0,0	0,0	0,0	0,0	0,2	0,0	0,0	974,5	974,5
8786										
8787					Storage Miktarı:	285,1	Base Load	974,4985893		
8788										
8789						Fuelcell Max Gen	201,6827957			
8790										
8791										
8792										
8793										

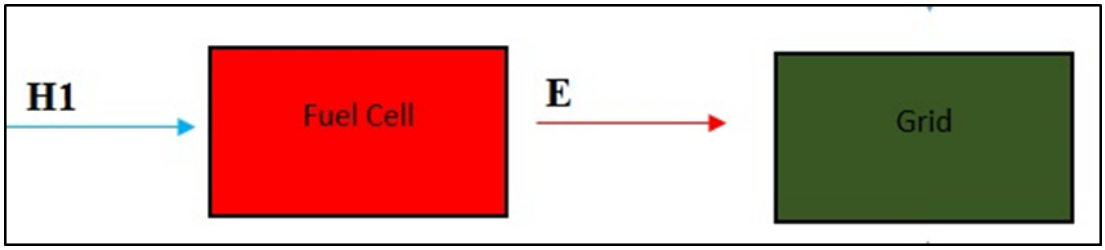


Figure 54 Fuel Cell Output

- We found that the best option %50 of generated wind energy to send transformer and res %50 to store as hydrogen.With this concept,we calculated fuel cell output in coloumn G and for this calculation.
- According to Fuel Cell spesifications and best option on above bullet :

$$E = (Wi + Si) * 0.43 * 0.50 \tag{10}$$

Table 25. Fuel Cell Output on Coloumn G

	A	B	C	D	E	F	G	H	I	J
1	Date/Time	Wind Hourly Generation (AC) Kwh	Solar Hourly Generation (AC) Kwh	Wind Energy Not Stored and Pumped to Grid	Electrolysis Input (kWh)	Hydrogen Content in Tanks Nm3	Hydrogen Fuelcell Output kWh	Pumped Wind + Fuelcell kWh	Biomass Electricity Generation kWh	Base Load
2	1.1.2016 00:00	545,8	0,0	245,8	300,0	35,8	64,5	310,3	664,2	974,5
3	1.1.2016 01:00	140,2	0,0	0,0	140,2	32,6	30,1	30,1	944,4	974,5
4	1.1.2016 02:00	545,8	0,0	245,8	300,0	50,1	64,5	310,3	664,2	974,5
5	1.1.2016 03:00	381,3	0,0	81,3	300,0	58,8	64,5	145,8	828,7	974,5
6	1.1.2016 04:00	381,3	0,0	81,3	300,0	65,1	64,5	145,8	828,7	974,5
7	1.1.2016 05:00	545,8	0,0	245,8	300,0	65,3	64,5	310,3	664,2	974,5
8	1.1.2016 06:00	545,8	0,0	245,8	300,0	66,4	64,5	310,3	664,2	974,5
9	1.1.2016 07:00	381,3	0,0	81,3	300,0	67,0	64,5	145,8	828,7	974,5
10	1.1.2016 08:00	381,3	45,8	81,3	345,8	72,4	74,3	155,6	818,9	974,5
11	1.1.2016 09:00	233,8	92,5	0,0	326,3	72,9	70,2	70,2	904,3	974,5
12	1.1.2016 10:00	233,8	123,6	0,0	357,4	76,7	76,8	76,8	897,6	974,5
13	1.1.2016 11:00	233,8	147,0	0,0	380,8	81,2	81,9	81,9	892,6	974,5
14	1.1.2016 12:00	381,3	155,8	81,3	455,8	91,9	98,0	179,3	795,2	974,5
15	1.1.2016 13:00	233,8	147,0	0,0	380,8	88,8	81,9	81,9	892,6	974,5
16	1.1.2016 14:00	72,3	123,6	0,0	195,9	66,4	42,1	42,1	932,4	974,5
17	1.1.2016 15:00	28,6	92,5	0,0	121,1	46,8	26,0	26,0	948,5	974,5

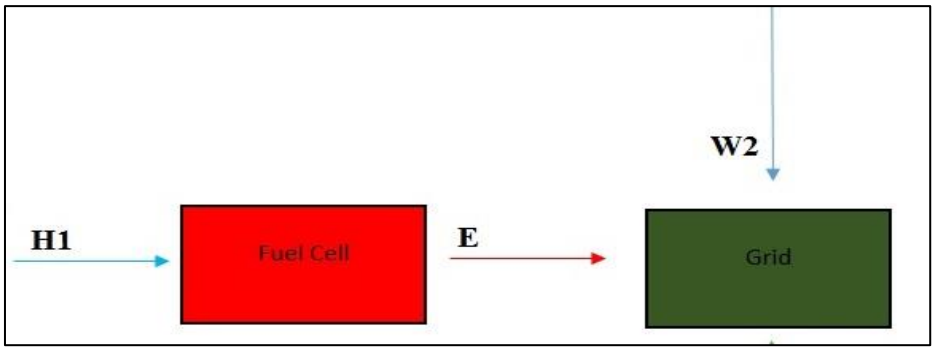


Figure 55. Fuel Cell Plus with Extra Wind Energy Process

- In column H 8787 cell, we calculated the maximum generated power of the sum of wind power not stored plus with power generated by fuel cell with this value. We defined most suitable base load using with Large function in excel table.

$$\text{Base Load} = \text{E} + \text{W2} \tag{11}$$

Table 26. Base Load on H 8787 Cell

	A	B	C	D	E	F	G	H	I	J
1	Date/Time	Wind Hourly Generation (AC) Kwh	Solar Hourly Generation (AC) Kwh	Wind Energy Not Stored and Pumped to Grid	Electrolysis Input (kWh)	Hydrogen Content in Tanks Nm3	Hydrogen Fuelcell Output kWh	Pumped Wind + Fuelcell kWh	Biomass Electricity Generation kWh	Base Load
8756	30.12.2016 18:00	4,7	0,0	0,0	4,7	9,9	1,0	1,0	973,5	974,5
8757	30.12.2016 19:00	0,0	0,0	0,0	0,0	5,0	0,0	0,0	974,5	974,5
8758	30.12.2016 20:00	0,0	0,0	0,0	0,0	2,5	0,0	0,0	974,5	974,5
8759	30.12.2016 21:00	0,0	0,0	0,0	0,0	1,2	0,0	0,0	974,5	974,5
8760	30.12.2016 22:00	0,0	0,0	0,0	0,0	0,6	0,0	0,0	974,5	974,5
8761	30.12.2016 23:00	0,0	0,0	0,0	0,0	0,3	0,0	0,0	974,5	974,5
8762	31.12.2016 00:00	0,0	0,0	0,0	0,0	0,2	0,0	0,0	974,5	974,5
8763	31.12.2016 01:00	0,0	0,0	0,0	0,0	0,1	0,0	0,0	974,5	974,5
8764	31.12.2016 02:00	0,0	0,0	0,0	0,0	0,0	0,0	0,0	974,5	974,5
8765	31.12.2016 03:00	0,0	0,0	0,0	0,0	0,0	0,0	0,0	974,5	974,5
8766	31.12.2016 04:00	0,0	0,0	0,0	0,0	0,0	0,0	0,0	974,5	974,5
8767	31.12.2016 05:00	0,0	0,0	0,0	0,0	0,0	0,0	0,0	974,5	974,5
8768	31.12.2016 06:00	0,0	0,0	0,0	0,0	0,0	0,0	0,0	974,5	974,5
8769	31.12.2016 07:00	0,0	0,0	0,0	0,0	0,0	0,0	0,0	974,5	974,5
8770	31.12.2016 08:00	0,0	68,6	0,0	68,6	7,7	14,8	14,8	959,7	974,5
8771	31.12.2016 09:00	0,0	138,7	0,0	138,7	19,5	29,8	29,8	944,7	974,5
8772	31.12.2016 10:00	0,0	185,5	0,0	185,5	30,6	39,9	39,9	934,6	974,5
8773	31.12.2016 11:00	0,0	220,5	0,0	220,5	40,1	47,4	47,4	927,1	974,5
8774	31.12.2016 12:00	0,0	233,6	0,0	233,6	46,3	50,2	50,2	924,3	974,5
8775	31.12.2016 13:00	0,0	220,5	0,0	220,5	48,0	47,4	47,4	927,1	974,5
8776	31.12.2016 14:00	0,0	185,5	0,0	185,5	44,9	39,9	39,9	934,6	974,5
8777	31.12.2016 15:00	0,0	138,7	0,0	138,7	38,0	29,8	29,8	944,7	974,5
8778	31.12.2016 16:00	0,0	68,6	0,0	68,6	26,7	14,8	14,8	959,7	974,5
8779	31.12.2016 17:00	0,0	0,0	0,0	0,0	13,4	0,0	0,0	974,5	974,5
8780	31.12.2016 18:00	0,0	0,0	0,0	0,0	6,7	0,0	0,0	974,5	974,5
8781	31.12.2016 19:00	0,0	0,0	0,0	0,0	3,3	0,0	0,0	974,5	974,5
8782	31.12.2016 20:00	0,0	0,0	0,0	0,0	1,7	0,0	0,0	974,5	974,5
8783	31.12.2016 21:00	0,0	0,0	0,0	0,0	0,8	0,0	0,0	974,5	974,5
8784	31.12.2016 22:00	0,0	0,0	0,0	0,0	0,4	0,0	0,0	974,5	974,5
8785	31.12.2016 23:00	0,0	0,0	0,0	0,0	0,2	0,0	0,0	974,5	974,5
8786										
8787					Storage Miktarı:	285,1	Base Load:	974,4985893		
8788										
8789						Fuelcell Max Gen	291,6827657			
8790										
8791										
8792										

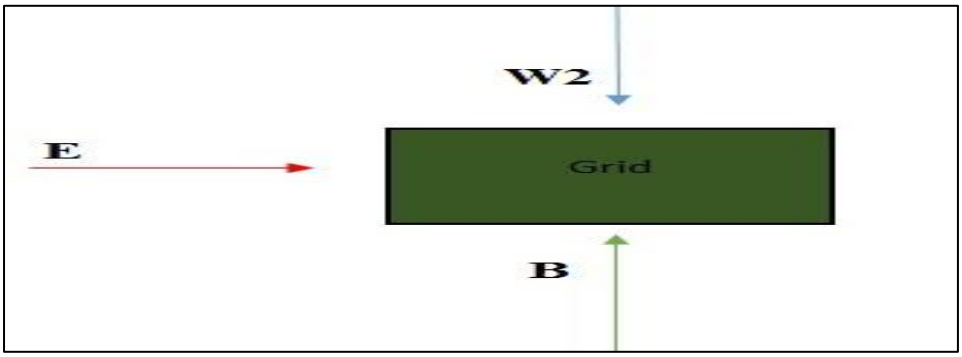


Figure 56. Total Generated Electiricity

- In column I, we calculated needed hourly biomass production. This hourly biomass production values will cover peak load gaps of solar and wind energy production characteristics.

$$B = \text{Base Load} - (W2 + E) \tag{12}$$

Table 27. Biomass Production on Coloumn I

	A	B	C	D	E	F	G	H	I	J
1	Date/Time	Wind Hourly Generation (AC) Kwh	Solar Hourly Generation (AC) Kwh	Wind Energy Not Stored and Pumped to Grid	Electrolysis Input (kWh)	Hydrogen Content in Tanks Nm3	Hydrogen Fuelcell Output kWh	Pumped Wind + Fuelcell kWh	Biomass Electricity Generation kWh	Base Load
2	1.1.2016 00:00	545,8	0,0	245,8	300,0	33,8	64,5	310,3	664,2	974,5
3	1.1.2016 01:00	140,2	0,0	0,0	140,2	32,6	30,1	30,1	944,4	974,5
4	1.1.2016 02:00	545,8	0,0	245,8	300,0	50,1	64,5	310,3	664,2	974,5
5	1.1.2016 03:00	381,3	0,0	81,3	300,0	58,8	64,5	145,8	828,7	974,5
6	1.1.2016 04:00	381,3	0,0	81,3	300,0	63,1	64,5	145,8	828,7	974,5
7	1.1.2016 05:00	545,8	0,0	245,8	300,0	65,3	64,5	310,3	664,2	974,5
8	1.1.2016 06:00	545,8	0,0	245,8	300,0	66,4	64,5	310,3	664,2	974,5
9	1.1.2016 07:00	381,3	0,0	81,3	300,0	67,0	64,5	145,8	828,7	974,5
10	1.1.2016 08:00	381,3	45,8	81,3	345,8	72,4	74,3	155,6	818,9	974,5
11	1.1.2016 09:00	233,8	92,5	0,0	326,3	72,9	70,2	70,2	904,3	974,5
12	1.1.2016 10:00	233,8	123,6	0,0	357,4	76,7	76,8	76,8	897,6	974,5
13	1.1.2016 11:00	233,8	147,0	0,0	380,8	81,2	81,9	81,9	892,6	974,5
14	1.1.2016 12:00	381,3	155,8	81,3	455,8	91,9	98,0	179,3	795,2	974,5
15	1.1.2016 13:00	233,8	147,0	0,0	380,8	88,8	81,9	81,9	892,6	974,5
16	1.1.2016 14:00	72,3	123,6	0,0	195,9	66,4	42,1	42,1	932,4	974,5
17	1.1.2016 15:00	28,6	92,5	0,0	121,1	46,8	26,0	26,0	948,5	974,5

8. Cost Analysis

In this section, cost calculations are made according to the electrical production and hydrogen storage data calculated in Section 6.

8.1. Costs of 1 MW Wind Power Plant

- **Capex & Opex Estimations**

CAPEX and Opex estimations of 1 MW wind power plant are made according to the costs shown in the table below. The results are shown in table 30.

Table 28. Capital Cost Breakdowns for 1 MW Wind Power

Capacity		1.00 MW	
Transmission Line Distance (km)		1	
Investment of Transmission Line per km		$0	
Road Distance (km)		1	
Road Cost per km		$0	
EPC Cost / MW			
Wind Turbine		$974,100	54%
Planning		$162,350	9%
Foundation		$288,622	16%
Grid Connection		$108,233	6%
Logistics		$90,194	5%
Installation		$180,389	10%
PER MWp CAPEX		**$1,803,601**	
	€ 1,699,728.59		
EPC Invesment	**Total**		**Depreciation**
Wind Turbine		$974,100	10
Planning		$162,350	10
Foundation		$288,622	10
Grid Connection		$108,233	10
Logistics		$90,194	10
Installation		$180,389	10
Transmission Line		$0	10
Road Construction		$0	
PROJECT CAPEX		**$1,803,889**	
OPEX	**Per MW / Annum**		
Operation and Management		$7,637	
Personnel		$3,500	
General Expense		$1,500	
Insurance		$1,000	
OPEX	**Total**		
Operation and Management		$7,637	
Personnel		$3,500	
General Expense		$1,500	
Insurance		$1,000	
OPEX		**$13,637**	

8.2. Costs of 1 MW Solar Power Plant

- **Capex & Opex Estimations**

CAPEX and Opex estimations of 1 MW solar power plant are made according to the costs shown in the table below. The results are shown in table 31.

Table 29. Capital Cost Breakdowns for 1 MW Solar Power Plant System

Capacity		1.10 MWp	
Transmission Line Distance (km)		1	
Investment of Transmission Line per km		$0	
Road Distance (km)		1	
Road Cost per km		$0	
EPC Cost / MW			
Solar Panels		$456,278	46%
Invertor		$164,472	16%
Montage Materials		$169,778	17%
Cables		$8,149	1%
Logistics		$21,222	2%
Installation		$180,389	18%
PER MWp CAPEX		**$1,000,000**	
		€ 942,408.59	
EPC Invesment	**Total**		**Depreciation**
Solar Panels		$501,906	10
Invertor		$180,919	10
Montage Materials		$186,756	10
Cables		$8,964	10
Logistics		$23,344	10
Installation		$198,428	10
Transmission Line		$0	10
Road Construction		$0	
PROJECT CAPEX		**$1,100,317**	
OPEX	**Per MW / Annum**		
Operation and Management		$7,637	
Personnel		$3,500	
General Expense		$1,500	
Insurance		$1,000	
OPEX	**Total**		
Operation and Management		$8,400	
Personnel		$3,850	
General Expense		$1,650	
Insurance		$1,100	
OPEX		**$15,000**	

8.3. Costs of Biomass 1MW Power Plant

- **Capex & Opex Estimations**

CAPEX and Opex estimations of 1 MW biomass power plant are made according to the costs shown in the table below. The results are shown in table 32.

Table 30. Capital Cost Breakdowns for 1 MW Biomass Power Plant System

Capacity		1.00 MW	
Transmission Line Distance (km)		1	
Investment of Transmission Line per km		$0	
Road Distance (km)		1	
Road Cost per km		$0	
EPC Cost / MW			
Biomass Engine		$458,400	54%
Planning		$76,400	9%
Foundation		$135,822	16%
Grid Connection		$50,933	6%
Logistics		$42,444	5%
Installation		$84,889	10%
PER MWp CAPEX		$848,601	
		€ 799,728.59	
EPC Invesment	Total		Depreciation
Biomass Engine		$458,400	10
Planning		$76,400	10
Foundation		$135,822	10
Grid Connection		$50,933	10
Logistics		$42,444	10
Installation		$84,889	10
Transmission Line		$0	10
Road Construction		$0	
PROJECT CAPEX		$848,889	
OPEX	Per MW / Annum		
Operation and Management		$11,455	
Personnel		$3,500	
General Expense		$1,500	
Insurance		$1,000	
OPEX	Total		
Operation and Management		$11,455	
Personnel		$3,500	
General Expense		$1,500	
Insurance		$1,000	
WoodChips Cost		$410,000	
OPEX		$427,455	

8.4. Costs of Hydrogen Storage System

- **Capex & Opex Estimations**

CAPEX and OPEX estimations which are based on cost of hydrogen generation,production and storaged equipments that are mentioned in stage 5 and used to energy calculations in Stage 6 are shown in Table 33.

Table 31. Capital Cost Breakdowns for 1 MW Biomass Power Plant System

Hydrogen System Cost			
Electrolyser		$1,220,998	
Hydrogen Storage Tanks		$315,150	
Fuelcell		$495,861	
Planning		$76,400	
Foundation		$135,822	
Logistics		$42,444	
Installation		$84,889	
PER MWp CAPEX		**$2,371,277**	
		€ 2,234,710.89	
EPC Invesment	**Total**		**Depreciation**
Biomass Engine		$1,220,998	10
Planning		$76,400	10
Foundation		$135,822	10
Logistics		$42,444	10
Installation		$84,889	10
Transmission Line		$0	10
Road Construction		$0	
PROJECT CAPEX		**$1,560,554**	
OPEX	**Per MW / Annum**		
Operation and Management		$22,910	
Personnel		$3,500	
General Expense		$1,500	
Insurance		$1,000	
OPEX	**Total**		
Operation and Management		$22,910	
Personnel		$3,500	
General Expense		$1,500	
Insurance		$1,000	
Water Cost			
OPEX		**$28,910**	

8.5. Energy Sales

The amount of electricity which is annually produced is calculated that multiplied by the base load and the total time of one year. Average efficiency loss of solar, wind and biomass was accepted annually %0.5. Net annual generation was calculated that efficiency loss is multiplied by gross annual. Energy sales is calculated that 0,13300 $/kWh value which is accepted that it is feed in tariff was multiplied by net annual generation and system usage fee has been taken away from this. System usage fee is calculated this way; Net annual generation multiplies with 25,6 TL /MWh and divided from USD/TL currency. Feed in tariff remains same during ten years. After the ten years, it is calculated by spot market value. Spot market value was taken constant which is accepted 0,0600 $/kWh.

Table 32. Energy Sales from 1st Year to 6th Year

Energy Sales	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6
Net Annual Generation	8,516,226 kwh	8,473,431 kwh	8,430,636 kwh	8,387,841 kwh	8,345,045 kwh	8,302,250 kwh
Gross Annual Generation	8,559,021 kwh	8,559,021 kwh	8,559,021 kwh	8,559,021 kwh	8,559,021 kwh	8,559,021 kwh
Effeciency Loss	99.5%	99.0%	98.5%	98.0%	97.5%	97.0%
Feed in Tariff	0.13300 $-kwh	0.13300 $-kwh	0.13300 $-kwh	0.13300 $-kwh	0.13300 $-kwh	0.13300 $-kwh
Spot Market	0.06000 $-kwh	0.06000 $-kwh	0.06000 $-kwh	0.06000 $-kwh	0.06000 $-kwh	0.06000 $-kwh
Energy Sales	$1,072,098.22	$1,066,710.79	$1,061,323.36	$1,055,935.93	$1,050,548.50	$1,045,161.07
Carbon Sales						
System Usage Fee	$60,559.83	$60,255.51	$59,951.19	$59,646.87	$59,342.55	$59,038.22

Table 33. Energy Sales from 7th Year to 15th Year

Year 16	Year 17	Year 18	Year 19	Year 20	Year 21	Year 22	Year 23	Year 24	Year 25
7.874.299 kwh	7.831.504 kwh	7.788.709 kwh	7.745.914 kwh	7.703.119 kwh	7.660.324 kwh	7.617.529 kwh	7.574.734 kwh	7.531.938 kwh	7.489.143 kwh
8.559.021 kwh	8.559.021 kwh	8.559.021 kwh	8.559.021 kwh	8.559.021 kwh	8.559.021 kwh	8.559.021 kwh	8.559.021 kwh	8.559.021 kwh	8.559.021 kwh
92,0%	91,5%	91,0%	90,5%	90,0%	89,5%	89,0%	88,5%	88,0%	87,5%
0,06000 $-kwh	0,06000 $-kwh	0,06000 $-kwh	0,06000 $-kwh	0,06000 $-kwh	0,06000 $-kwh	0,06000 $-kwh	0,06000 $-kwh	0,06000 $-kwh	0,06000 $-kwh
$416.462,94	$414.199,56	$411.936,17	$409.672,79	$407.409,40	$405.146,01	$402.882,63	$400.619,24	$398.355,86	$396.092,47
$55.995,02	$55.690,70	$55.386,38	$55.082,06	$54.777,73	$54.473,41	$54.169,09	$53.864,77	$53.560,45	$53.256,13

Table 34. Energy Sales from 16th Year to 25th Year

Year 7	Year 8	Year 9	Year 10	Year 11	Year 12	Year 13	Year 14	Year 15
8,259,455 kwh	8,216,660 kwh	8,173,865 kwh	8,131,070 kwh	8,088,275 kwh	8,045,480 kwh	8,002,685 kwh	7,959,890 kwh	7,917,094 kwh
8,559,021 kwh	8,559,021 kwh	8,559,021 kwh	8,559,021 kwh	8,559,021 kwh	8,559,021 kwh	8,559,021 kwh	8,559,021 kwh	8,559,021 kwh
96.5%	96.0%	95.5%	95.0%	94.5%	94.0%	93.5%	93.0%	92.5%
0.13300 $-kwh	0.13300 $-kwh	0.13300 $-kwh	0.13300 $-kwh					
0.06000 $-kwh	0.06000 $-kwh	0.06000 $-kwh	0.06000 $-kwh	0.06000 $-kwh	0.06000 $-kwh	0.06000 $-kwh	0.06000 $-kwh	0.06000 $-kwh
$1,039,773.65	$1,034,386.22	$1,028,998.79	$1,023,611.36	$427,779.87	$425,516.48	$423,253.10	$420,989.71	$418,726.33
$58,733.90	$58,429.58	$58,125.26	$57,820.94	$57,516.62	$57,212.30	$56,907.98	$56,603.66	$56,299.34

8.6. Cash Flow

A cash flow forecast was calculated according to the results in the previous sections. Values depend on years are shown in the following tables.

Table 35. Cash Flow From 2017 to 2025

		Income Statement	2017	2018	2019	2020	2021	2022	2023	2024	2025
1	+	**Total Revenues**	**$0,00**	**$1.072.098,22**	**$1.066.710,79**	**$1.061.323,36**	**$1.055.935,93**	**$1.050.548,50**	**$1.045.161,07**	**$1.039.773,65**	**$1.034.386,22**
	a	Energy Sales	$0,00	$1.072.098,22	$1.066.710,79	$1.061.323,36	$1.055.935,93	$1.050.548,50	$1.045.161,07	$1.039.773,65	$1.034.386,22
	b	Carbon Credit	$0,00	$0,00	$0,00	$0,00	$0,00	$0,00	$0,00	$0,00	$0,00
2	-	**Operating Costs**	**$0,00**	**$110.705,08**	**$147.606,78**	**$147.606,78**	**$147.606,78**	**$147.606,78**	**$147.606,78**	**$147.606,78**	**$147.606,78**
	a	Opex	$0,00	$110.705,08	$147.606,78	$147.606,78	$147.606,78	$147.606,78	$147.606,78	$147.606,78	$147.606,78
	b	Land Leasing Costs	$0,00	$0,00	$0,00	$0,00	$0,00	$0,00	$0,00	$0,00	$0,00
		EBITDA	$0,00	$961.393,13	$919.104,01	$913.716,58	$908.329,15	$902.941,72	$897.554,30	$892.166,87	$886.779,44
4	-	**Depreciation**	**$0,00**	**$618.855,30**	**$618.855,30**	**$618.855,30**	**$618.855,30**	**$618.855,30**	**$618.855,30**	**$618.855,30**	**$618.855,30**
	a	Solar Panels	$0,00								
	b	Invertor	$0,00								
	c	Montage Materials	$0,00								
	d	Cables	$0,00								
	e	Logistics	$0,00								
	f	Transmission Line	$0,00								
		EBIT	$0,00	$342.537,83	$300.248,71	$294.861,28	$289.473,85	$284.086,42	$278.699,00	$273.311,57	$267.924,14
5	-	**Interests**	**$0,00**	**$213.614,81**	**$213.614,81**	**$186.912,96**	**$160.211,11**	**$133.509,26**	**$106.807,40**	**$80.105,55**	**$53.403,70**
	a	Interest	$0,00	$203.442,68	$203.442,68	$178.012,34	$152.582,01	$127.151,67	$101.721,34	$76.291,00	$50.860,67
	b	BSMV	$0,00	$10.172,13	$10.172,13	$8.900,62	$7.629,10	$6.357,58	$5.086,07	$3.814,55	$2.543,03
6	-	**Expensed CAPEX**									
	a	Licence (Tender) Fee	$0,00	$0,00	$0,00	$0,00					
	b	Project Acquisition Fee	$671.000,00								
	c	Developer's Success Fee	$0,00								
	d	Installation		$0,00	$0,00	$0,00	$0,00	$0,00	$0,00	$0,00	$0,00
	e	Road Construction	$0,00	$0,00	$0,00	$0,00	$0,00	$0,00	$0,00	$0,00	$0,00
		EBT	-$671.000,00	$128.923,02	$86.633,90	$107.948,32	$129.262,75	$150.577,17	$171.891,59	$193.206,01	$214.520,44
7	-	**Tax**	**$0,00**	**$25.784,60**	**$17.326,78**	**$21.589,66**	**$25.852,55**	**$30.115,43**	**$34.378,32**	**$38.641,20**	**$42.904,09**
		EAT	-$671.000,00	$103.138,42	$69.307,12	$86.358,66	$103.410,20	$120.461,73	$137.513,27	$154.564,81	$171.616,35

Cash Flow Statement	2017	2018	2019	2020	2021	2022	2023	2024	2025
Starting Cash (Equity)	**$2.177.982,78**	**$175.698,78**	**$897.692,50**	**$1.020.736,37**	**$1.160.831,79**	**$1.317.978,74**	**$1.492.177,23**	**$1.683.427,26**	**$1.891.728,83**
Net Profit	-$671.000,00	$103.138,42	$69.307,12	$86.358,66	$103.410,20	$120.461,73	$137.513,27	$154.564,81	$171.616,35
Depreciation	$0,00	$618.855,30	$618.855,30	$618.855,30	$618.855,30	$618.855,30	$618.855,30	$618.855,30	$618.855,30
Investment	-$5.852.232,36								
Financing	$4.520.948,35								
Debt Pricipal Repayment	$0,00	$0,00	$565.118,54	$565.118,54	$565.118,54	$565.118,54	$565.118,54	$565.118,54	$565.118,54
Net Cash Generated	-$2.002.284,01	$721.993,72	$123.043,88	$140.095,41	$157.146,95	$174.198,49	$191.250,03	$208.301,57	$225.353,11
Ending Cash	**$175.698,78**	**$897.692,50**	**$1.020.736,37**	**$1.160.831,79**	**$1.317.978,74**	**$1.492.177,23**	**$1.683.427,26**	**$1.891.728,83**	**$2.117.081,93**

Debt Repayment Schedule	2017	2018	2019	2020	2021	2022	2023	2024	2025
Balance:	$4.520.948,35								
Principal Repayment			$565.118,54	$565.118,54	$565.118,54	$565.118,54	$565.118,54	$565.118,54	$565.118,54
Remaining Balance			$3.955.829,81	$3.390.711,26	$2.825.592,72	$2.260.474,18	$1.695.355,63	$1.130.237,09	$565.118,54
Interest Payment		$203.442,68	$203.442,68	$178.012,34	$152.582,01	$127.151,67	$101.721,34	$76.291,00	$50.860,67

IRR Calculation	2017	2018	2019	2020	2021	2022	2023	2024	2025
Project Cash Flow	-$2.002.284,01	$721.993,72	$123.043,88	$140.095,41	$157.146,95	$174.198,49	$191.250,03	$208.301,57	$225.353,11
Cumulative Project Cash Flow	-$2.002.284,01	-$1.280.290,29	-$1.157.246,41	-$1.017.151,00	-$860.004,05	-$685.805,55	-$494.555,53	-$286.253,96	-$60.900,85
Project IRR	**12,97%**								

Table 36. Cash Flow From 2026 to 2033

		Income Statement	2026	2027	2028	2029	2030	2031	2032	2033
1	+	**Total Revenues**	**$1.028.998,79**	**$1.023.611,36**	**$427.779,87**	**$425.516,48**	**$423.253,10**	**$420.989,71**	**$418.726,33**	**$416.462,94**
	a	Energy Sales	$1.028.998,79	$1.023.611,36	$427.779,87	$425.516,48	$423.253,10	$420.989,71	$418.726,33	$416.462,94
	b	Carbon Credit	$0,00	$0,00	$0,00	$0,00	$0,00	$0,00	$0,00	$0,00
2	-	**Operating Costs**	**$147.606,78**	**$147.606,78**	**$147.606,78**	**$147.606,78**	**$147.606,78**	**$147.606,78**	**$147.606,78**	**$147.606,78**
	a	Opex	$147.606,78	$147.606,78	$147.606,78	$147.606,78	$147.606,78	$147.606,78	$147.606,78	$147.606,78
	b	Land Leasing Costs	$0,00	$0,00	$0,00	$0,00	$0,00	$0,00	$0,00	$0,00
		EBITDA	$881.392,01	$876.004,58	$280.173,09	$277.909,71	$275.646,32	$273.382,93	$271.119,55	$268.856,16
4	-	**Depreciation**	**$618.855,30**	**$618.855,30**	**$0,00**	**$0,00**	**$0,00**	**$0,00**	**$0,00**	**$0,00**
	a	Solar Panels								
	b	Invertor								
	c	Montage Materials								
	d	Cables								
	e	Logistics								
	f	Transmission Line								
		EBIT	$262.536,71	$257.149,28	$280.173,09	$277.909,71	$275.646,32	$273.382,93	$271.119,55	$268.856,16
5	-	**Interests**	**$26.701,85**	**$0,00**	**$0,00**	**$0,00**	**$0,00**	**$0,00**	**$0,00**	**$0,00**
	a	Interest	$25.430,33	$0,00						
	b	BSMV	$1.271,52	$0,00						
6	-	**Expensed CAPEX**								
	a	Licence (Tender) Fee								
	b	Project Acquisition Fee								
	c	Developer's Success Fee								
	d	Installation	$0,00	$100.000,00	$0,00	$0,00	$0,00	$0,00	$0,00	$0,00
	e	Road Construction	$0,00	$0,00	$0,00	$0,00	$0,00	$0,00	$0,00	$0,00
		EBT	$235.834,86	$157.149,28	$280.173,09	$277.909,71	$275.646,32	$273.382,93	$271.119,55	$268.856,16
7	-	**Tax**	**$47.166,97**	**$31.429,86**	**$56.034,62**	**$55.581,94**	**$55.129,26**	**$54.676,59**	**$54.223,91**	**$53.771,23**
		EAT	$188.667,89	$125.719,43	$224.138,47	$222.327,76	$220.517,06	$218.706,35	$216.895,64	$215.084,93

Cash Flow Statement	2026	2027	2028	2029	2030	2031	2032	2033
Starting Cash (Equity)	**$2.117.081,93**	**$2.359.486,58**	**$3.104.061,30**	**$3.328.199,78**	**$3.550.527,54**	**$3.771.044,60**	**$3.989.750,95**	**$4.206.646,59**
Net Profit	$188.667,89	$125.719,43	$224.138,47	$222.327,76	$220.517,06	$218.706,35	$216.895,64	$215.084,93
Depreciation	$618.855,30	$618.855,30	$0,00	$0,00	$0,00	$0,00	$0,00	$0,00
Investment								
Financing								
Debt Pricipal Repayment	$565.118,54	$0,00	$0,00	$0,00	$0,00	$0,00	$0,00	$0,00
Net Cash Generated	$242.404,64	$744.574,73	$224.138,47	$222.327,76	$220.517,06	$218.706,35	$216.895,64	$215.084,93
Ending Cash	**$2.359.486,58**	**$3.104.061,30**	**$3.328.199,78**	**$3.550.527,54**	**$3.771.044,60**	**$3.989.750,95**	**$4.206.646,59**	**$4.421.731,52**

Debt Repayment Schedule	2026	2027	2028	2029	2030	2031	2032	2033
Balance:								
Principal Repayment	$565.118,54							
Remaining Balance	$0,00							
Interest Payment	$25.430,33	$0,00						

IRR Calculation	2026	2027	2028	2029	2030	2031	2032	2033
Project Cash Flow	$242.404,64	$744.574,73	$224.138,47	$222.327,76	$220.517,06	$218.706,35	$216.895,64	$215.084,93
Cumulative Project Cash Flow	$181.503,79	$926.078,52	$1.150.216,99	$1.372.544,76	$1.593.061,81	$1.811.768,16	$2.028.663,80	$2.243.748,73
Project IRR								

Table 37. Cash Flow From 2034 to 2042

		Income Statement	2034	2035	2036	2037	2038	2039	2040	2041	2042
1	+	**Total Revenues**	**$414.199,56**	**$411.936,17**	**$409.672,79**	**$407.409,40**	**$405.146,01**	**$402.882,63**	**$400.619,24**	**$398.355,86**	**$396.092,47**
	a	Energy Sales	$414.199,56	$411.936,17	$409.672,79	$407.409,40	$405.146,01	$402.882,63	$400.619,24	$398.355,86	$396.092,47
	b	Carbon Credit	$0,00	$0,00	$0,00	$0,00	$0,00	$0,00	$0,00	$0,00	$0,00
2	-	**Operating Costs**	**$147.606,78**	**$147.606,78**	**$147.606,78**	**$147.606,78**	**$147.606,78**	**$147.606,78**	**$147.606,78**	**$147.606,78**	**$147.606,78**
	a	Opex	$147.606,78	$147.606,78	$147.606,78	$147.606,78	$147.606,78	$147.606,78	$147.606,78	$147.606,78	$147.606,78
	b	Land Leasing Costs	$0,00	$0,00	$0,00	$0,00	$0,00	$0,00	$0,00	$0,00	$0,00
		EBITDA	$266.592,78	$264.329,39	$262.066,01	$259.802,62	$257.539,24	$255.275,85	$253.012,46	$250.749,08	$248.485,69
4	-	**Depreciation**	**$0,00**	**$0,00**	**$0,00**	**$0,00**	**$0,00**	**$0,00**	**$0,00**	**$0,00**	**$0,00**
	a	Solar Panels									
	b	Invertor									
	c	Montage Materials									
	d	Cables									
	e	Logistics									
	f	Transmission Line									
		EBIT	$266.592,78	$264.329,39	$262.066,01	$259.802,62	$257.539,24	$255.275,85	$253.012,46	$250.749,08	$248.485,69
5	-	**Interests**	**$0,00**	**$0,00**	**$0,00**	**$0,00**	**$0,00**	**$0,00**	**$0,00**	**$0,00**	**$0,00**
	a	Interest									
	b	BSMV									
6	-	**Expensed CAPEX**									
	a	Licence (Tender) Fee									
	b	Project Acquisition Fee									
	c	Developer's Success Fee									
	d	Installation	$0,00	$0,00	$0,00	$0,00	$1,00	$2,00	$3,00	$4,00	$5,00
	e	Road Construction	$0,00	$0,00	$0,00	$0,00	$1,00	$2,00	$3,00	$4,00	$5,00
		EBT	$266.592,78	$264.329,39	$262.066,01	$259.802,62	$257.537,24	$255.271,85	$253.006,46	$250.741,08	$248.475,69
7	-	**Tax**	**$53.318,56**	**$52.865,88**	**$52.413,20**	**$51.960,52**	**$51.507,45**	**$51.054,37**	**$50.601,29**	**$50.148,22**	**$49.695,14**
		EAT	$213.274,22	$211.463,51	$209.652,81	$207.842,10	$206.029,79	$204.217,48	$202.405,17	$200.592,86	$198.780,56

Cash Flow Statement	2034	2035	2036	2037	2038	2039	2040	2041	2042
Starting Cash (Equity)	**$4.421.731,52**	**$4.635.005,74**	**$4.846.469,25**	**$5.056.122,06**	**$5.263.964,16**	**$5.469.993,95**	**$5.674.211,43**	**$5.876.616,60**	**$6.077.209,46**
Net Profit	$213.274,22	$211.463,51	$209.652,81	$207.842,10	$206.029,79	$204.217,48	$202.405,17	$200.592,86	$198.780,56
Depreciation	$0,00	$0,00	$0,00	$0,00	$0,00	$0,00	$0,00	$0,00	$0,00
Investment									
Financing									
Debt Pricipal Repayment	$0,00	$0,00	$0,00	$0,00	$0,00	$0,00	$0,00	$0,00	$0,00
Net Cash Generated	$213.274,22	$211.463,51	$209.652,81	$207.842,10	$206.029,79	$204.217,48	$202.405,17	$200.592,86	$198.780,56
Ending Cash	**$4.635.005,74**	**$4.846.469,25**	**$5.056.122,06**	**$5.263.964,16**	**$5.469.993,95**	**$5.674.211,43**	**$5.876.616,60**	**$6.077.209,46**	**$6.275.990,02**

Debt Repayment Schedule	2034	2035	2036	2037	2038	2039	2040	2041	2042
Balance:									
Principal Repayment									
Remaining Balance									
Interest Payment									

IRR Calculation	2034	2035	2036	2037	2038	2039	2040	2041	2042
Project Cash Flow	$213.274,22	$211.463,51	$209.652,81	$207.842,10	$206.029,79	$204.217,48	$202.405,17	$200.592,86	$198.780,56
Cumulative Project Cash Flow	$2.457.022,96	$2.668.486,47	$2.878.139,28	$3.085.981,37	$3.292.011,16	$3.496.228,64	$3.698.633,81	$3.899.226,68	$4.098.007,23
Project IRR									

8.7. LCOE Values Chomperison with Other Baseload Energy Generation Facilites

LCOE estimations was calculated according to the values obtained from the previous calculations. Estimations results which are calculated by LCOE method are shown in Table 40.

Table 38. Values of LCOE Estimation

LCOE Estimation					
n	It	Ft	Mt	Et	r
25	512000	410000	147607	8559021	0,05

- The LCOE value is calculated using with below formula.Necessary parameters that are in formula is based on values where are in Table 40.

$$\frac{\sum_{t=1}^{n} \frac{It + Mt + Ft}{(1+r)^t}}{\sum_{t=1}^{n} \frac{Et}{(1+r)^t}} = 124.9684 \left(\frac{\$}{Mwh}\right)$$

Table 39. LCOE Costs of Other Generation Types Source: Lazard, 2017.

Generation Type	Low($/Mwh)	High($/Mwh)
Fuel Cell	106	167
Geothermal	77	117
Biomass Direct	55	114
Natural Gas Reciprocating Engine	68	106
Nuclear	112	183
Coal	60	143
Gas Combined Cycle	42	78

The LCOE value of our project is higher than other production types. Technological developments in renewable energy equipments and hydrogen storage techniques are expected to decrease LCOE value.

9. Result of the Key Study

The key operation demonstration is suitable for the hydrogen storage renewable energy power plant which is considered to be built. The annual wind and solar capacity is sufficient for the works done for the power plant. Biomass support is a potential for creating Uşak province's biomass source from its own local sources. In addition, it is quite reasonable to establish a plant in Usak, which is one of the regions where the state gives the purchase guarantee for renewable energy resources.

On the other hand, there are some issues that need to be raised from the top. Generally, public awareness about biomass needs to be raised.

The main data above are based on actual measurements. The reason for this is that the progeny and relevance of the project have increased

10.Conclusion and Recomendations

It is possible to make base load with wind load and solar, biomass and hydrogen storage system, but the cost is not very efficient. I expect that the cost of LCOE to drop further due to the development of hydrogen storage systems.

We do not need only fossil fuels to generate energy continuously. We can reach the base load by using renewable energy resources.

Technically, it is possible to obtain different fuel products by reacting the storage excess hydrogen with other gases. In this way, it is possible to further increase the system efficiency.

- **Recomedations**

1 All countries should make academic research about hydrogen production, storage and hydrogen production.

2 Hydrogen-based storage technology has lower operation and maintenance costs than other storage methods. A better hydrogen storage system can reduce storage losses with less loss.

3 Although it has the necessary resources for wind and solar and biomass,government investment incentives are still not enough for this region.This situation should be solved.

4 The feed in tariff given per kWh are calculated assuming cost based on the sun. Additional incentives should be made to hydrogen-based storage systems.

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ABBREVIATIONS

A.C: Alternating Current

A: Ampere

A_T: Area of Rotor

B: Biomass Energy

CAES: Compresses Air Storage

CAPEX: Capital Expenditure

CHP: Combine Heat Power

C_p: Power Efficient

C_T: Torque Efficient

D.C: Direct Current

DOE: Department of Energy

E (in process scheme): Fuel Cell Output

E: Energy

Ej: Exajoule

Et: Electricity Generation in Year t

Ft: Fuel Expenditures in Year t

GW: Gigawatt

h:Hour

H1: Fuel Cell Input

Ht: Amount of Electrolysed Hydrogen

HTF: Heat Transfer Liquid

HTS: High Temperature Coils

IEA: International Energy Agency

It: Investment Expenditures in Year t

J: Inertia

K: Kelvin

KW: Kilowatt

LCOE: Levelized Cost of Energy

LTS: Low Temperature Coils

M:Mass

mA: Milliamp

MEA: Membrane Electrode Assembly

Mj: Megajoule

MLI: Multi Layer Instillation

Mt: Operations and Expenditures in Year t

MW: Megawatt

n:Life of System

N: RPM

NREL: National Renewable Energy Laboratory

OPEX: Operational Expenditures

p_a: Density of Air

PEM: Proton Exchange Membrane

PHS: Pumped Hydro Storage

P_T: Turbine Power

PV: Photovoltaic

r:Discount Rate

R: Radius

REN21: Renewable Energy Policy Network For The 21st Century

S: Solar Energy Output

SMES: Superconducting Magnetic Energy Storage

SOFC: Solid Oxide Fuel Coil

T: Amount Hydrogen in Tank

T: Temperature

T: Torque

T_T: Theoretical Torque

V: Velocity

V: Volt

v:Volume of Air Parcel

W: Rotational Speed

W1: 229kWh and smaller amount of 229 kWh Wind Energy Output

W2: Extra Wind Energy Output

WA: Water

Wt: Total Wind Energy

Z: Elevation

Λ: Speed Ratio

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APPENDIXES

Appendix A. Anemometer Technical Details

Wind Transmitter „First Class“ Advanced

Classified according to IEC 61400-12-1 (2005-12)

4.3351.00.000
4.3351.10.000

7 Technical Data

Characteristic	Description	
Measuring range	0.3...75 m/s	
Accuracy	0.3...50 m/s	1% of meas. value or < 0.2 m/s
Survival speed	80 m/s (min. 30 minutes)	
Permissible Ambient conditions	- 50...+ 80°C, all occurring situations of relative humidity (incl. dew moistening)	
Output signal	**Form**	rectangle, edge steepness < 1µsec
	Frequency	1082 Hz @ 50 m/s
	Amplitude	is supply voltage, max. 15 V
	Push-Pull Output	output resistance: typical 100Ω ≥ 10V, 130Ω @ 5V, 230Ω @ 3.3V Constant power limiting on typical 25mA
	Open Drain Output	Drain resistance typical 50Ω, Pull-Up-voltage max. 30V Constant power limiting on typical 50mA,
	Load	R ≥ 1 kΩ C ≤ 200 nF (corresp. to length typical cable < 1km)
Linearity	Correlation factor r between frequency and wind speed y=0.0462* f +0.21 typical r > 0.999 99 (4...20 m/s)	
Starting velocity	< 0.3 m/s	
Resolution	0.05 m wind run	
Distance constant	< 3 m (acc. to ASTM D 5096 – 96) 3 m acc. to ISO 17713-1	
Turbulent flow	Deviation Δv turbulent compared with stationary horizontal flow -0.5% < Δv < +2% Frequency < 2 Hz	
Classification	According to IEC 61400-12-1 (2005-12) Class A classification index A 0.9 Class B classification index B 3.0 Class S classification index S 0.5	
Wind load	Approx.. 100 N @ 75 m/s	
Heating	Surface temperature of housing neck > 0°C at 20 m/s up to –10°C air temperature, at 10 m/s up to –20°C using the THIES icing standard 012002 on the housing neck. Heating regulated by temperature sensor	
Electrical supply for opto-electronic scanning	Voltage:	3.3...48 V DC (galvanic isolation from housing)
	Current:	130µA typ. 150µA max. @ 3,3V bis 15,0V (w/o external load) 180µA typ. 200µA max. @ 15V bis 48V (w/o external load)
Electrical supply for heating	Voltage:	24 V AC/DC, 54...65Hz (galvanic isolation from housing)
	Idling voltage:	max. 30 V AC, max. 48 V DC
	Capacity:	25 W

Appendix B. Wind Hourly Elecrical Output Data Based on Met Mast Wind Measurement Data on Height 80m in Usak (1 Year)

Total. MWh	2002,8	Jan	251,0	Feb	243,7	Mar	158,1	Apr.	164,2	May	126,6	Jun	199,0	July	166,5	Aug	153,0	Sep	137,4	Oct	85,5	Nov	182,7	Dec	134,9

Wind Generation kWh	Total kWh	00:00 00:59	01:00 01:59	02:00 02:59	03:00 03:59	04:00 04:59	05:00 05:59	06:00 06:59	07:00 07:59	08:00 08:59	09:00 09:59	10:00 10:59	11:00 11:59	12:00 12:59	13:00 13:59	14:00 14:59	15:00 15:59	16:00 16:59	17:00 17:59	18:00 18:59	19:00 19:59	20:00 20:59	21:00 21:59	22:00 22:59	23:00 23:59
1.01.2016	5275	546	140	546	381	381	546	546	381	381	234	234	234	381	234	72	29	0	5	5	0	0	0	0	0
2.01.2016	700	0	0	0	0	0	0	0	0	0	0	0	0	5	29	29	5	29	29	29	29	72	72	234	140
3.01.2016	11803	72	72	140	140	72	29	72	29	72	140	234	381	234	234	905	988	988	1000	1000	1000	1000	1000	1000	1000
4.01.2016	12611	1000	1000	725	546	905	988	988	546	546	140	140	140	72	140	140	72	234	381	234	234	546	1000	905	988
5.01.2016	23879	988	988	1000	1000	988	1000	1000	988	988	1000	1000	1000	1000	1000	988	988	1000	1000	1000	1000	988	988	1000	988
6.01.2016	23180	905	988	988	988	1000	905	988	905	905	1000	1000	1000	1000	905	905	905	905	988	1000	1000	1000	1000	1000	1000
7.01.2016	18009	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000	725	546	725	905	381	140	72	140	140	234
8.01.2016	1701	546	381	234	234	72	29	29	5	5	29	29	72	29	5	5	0	0	0	0	0	0	0	0	0
9.01.2016	520	0	0	0	0	0	5	5	5	0	5	0	0	0	0	29	72	72	72	5	5	5	29	72	140
10.01.2016	16423	140	234	234	381	546	988	988	1000	905	905	546	546	234	546	546	546	546	725	988	988	905	988	1000	1000
11.01.2016	15655	988	905	546	381	234	234	234	234	381	381	381	546	546	381	546	905	988	988	988	905	1000	988	988	988
12.01.2016	23618	725	988	1000	1000	1000	905	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000
13.01.2016	14506	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000	546	381	140	381	0	29	0	29	0	0	0
14.01.2016	394	0	0	0	0	0	0	0	0	0	0	29	72	5	0	29	29	72	72	72	0	5	5	0	5
15.01.2016	11053	72	29	29	140	140	234	234	381	234	140	140	381	381	725	905	725	725	546	546	725	905	905	905	905
16.01.2016	22760	546	905	905	905	1000	1000	1000	988	905	725	1000	1000	1000	1000	988	905	1000	1000	988	1000	1000	1000	1000	1000
17.01.2016	21552	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000	725	725	72	29
18.01.2016	3195	234	381	234	234	234	140	72	140	234	234	234	234	234	140	140	29	0	0	29	5	5	0	5	5
19.01.2016	19	5	0	0	5	5	5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
20.01.2016	5781	0	0	0	0	0	0	0	0	0	29	140	234	234	234	381	234	234	234	381	546	725	725	725	725
21.01.2016	3357	546	546	546	381	381	234	234	234	140	72	29	5	5	5	0	0	0	0	0	0	0	0	0	0
22.01.2016	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
23.01.2016	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
24.01.2016	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
25.01.2016	62	0	29	5	5	5	5	5	5	5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
26.01.2016	100	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	5	0	0	0	5	5	29	29	29
27.01.2016	133	29	29	29	29	5	5	5	5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
28.01.2016	1399	0	0	0	0	5	5	5	5	29	29	72	29	140	234	234	234	72	72	140	29	5	5	29	29
29.01.2016	1024	72	72	72	72	72	29	0	5	29	29	5	5	5	29	29	29	29	29	5	29	29	72	140	140
30.01.2016	1614	72	140	72	29	29	29	0	0	5	5	0	0	5	29	29	72	381	381	140	140	29	29	0	0
31.01.2016	10726	5	29	29	29	29	140	140	234	140	140	381	381	725	725	725	725	725	546	546	905	988	988	725	725
1.02.2016	9786	725	725	905	905	988	725	381	234	234	234	381	234	381	381	234	140	381	234	140	140	234	234	381	234
2.02.2016	4689	140	72	546	234	381	546	546	725	546	546	234	72	72	29	0	0	0	0	0	0	0	0	0	0
3.02.2016	10068	0	5	5	29	140	234	140	234	234	381	381	381	546	546	381	725	546	546	905	988	725	546	725	725
4.02.2016	17949	546	546	725	725	905	725	905	546	725	905	988	988	905	905	725	905	725	381	546	725	725	725	725	725
5.02.2016	13570	725	725	381	381	381	381	546	988	1000	1000	1000	1000	1000	1000	1000	546	234	234	381	72	72	140	0	381
6.02.2016	19237	381	988	905	905	905	905	725	725	905	905	905	905	905	905	905	905	725	725	988	905	725	725	381	381
7.02.2016	410	140	140	72	29	29	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
8.02.2016	481	0	5	5	5	0	0	0	29	5	0	0	0	5	5	5	29	72	5	0	0	29	72	140	72
9.02.2016	1504	72	72	72	72	29	29	72	29	29	29	5	29	72	72	72	29	29	5	29	72	72	140	140	234
10.02.2016	17399	234	234	381	381	546	546	725	725	546	381	546	546	905	1000	905	988	1000	1000	905	905	1000	1000	1000	1000
11.02.2016	19600	1000	1000	1000	1000	1000	988	988	905	905	725	905	905	905	546	381	725	988	905	381	546	725	725	725	725
12.02.2016	14117	546	905	988	905	905	905	725	546	546	381	546	381	234	546	234	234	381	546	381	381	546	725	725	905
13.02.2016	23976	988	988	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000
14.02.2016	19545	1000	988	905	725	905	725	546	546	725	725	546	725	725	546	546	905	905	905	988	1000	988	988	988	1000
15.02.2016	14760	905	725	725	905	905	988	725	546	725	546	725	1000	905	905	546	546	546	381	381	381	234	234	140	140
16.02.2016	1021	140	72	72	72	5	5	0	0	0	0	29	72	72	72	140	72	29	29	29	72	29	5	5	0
17.02.2016	398	0	0	0	0	0	0	0	0	0	0	5	29	0	0	0	5	29	72	72	72	29	29	29	29
18.02.2016	5220	234	5	72	29	5	29	29	72	29	140	381	381	234	140	140	234	381	381	381	234	381	381	381	546
19.02.2016	6176	381	234	381	381	381	234	381	140	234	546	546	381	234	140	72	234	234	234	234	234	234	72	29	5
20.02.2016	235	5	0	0	5	0	0	0	0	0	5	29	5	5	5	29	72	72	0	5	0	0	0	0	0
21.02.2016	9095	0	29	72	234	546	546	546	725	546	381	381	234	234	381	546	546	234	234	234	381	234	381	725	725
22.02.2016	10099	546	546	234	234	234	381	381	381	234	725	546	905	1000	905	546	725	381	234	234	234	140	72	140	140
23.02.2016	1938	72	5	29	140	140	140	140	5	5	0	0	0	0	0	0	0	0	140	140	140	234	234	140	234
24.02.2016	9047	381	546	381	381	381	546	381	381	381	234	72	140	234	546	381	381	72	72	29	140	546	988	725	725
25.02.2016	1621	381	234	234	234	72	140	140	29	29	29	5	0	0	0	0	5	5	0	0	0	0	29	29	29
26.02.2016	5261	29	140	234	234	140	234	381	381	140	140	140	381	381	381	140	140	234	140	140	234	140	140	234	381
27.02.2016	4126	140	72	381	546	546	381	140	234	140	72	72	234	381	234	234	140	72	72	29	5	0	0	0	0
28.02.2016	2388	0	0	0	0	0	29	5	5	29	72	72	72	29	5	29	29	29	140	381	381	234	234	234	381
1.03.2016	19461	1000	1000	1000	988	988	1000	905	905	546	546	988	905	905	988	988	905	725	546	546	546	725	725	546	546
2.03.2016	13760	381	381	234	234	140	234	140	234	234	234	234	381	725	725	725	988	725	905	1000	1000	1000	905	1000	1000
3.03.2016	11588	1000	988	234	140	140	72	72	381	381	234	546	381	546	234	234	381	546	725	725	546	546	725	905	905
4.03.2016	21140	725	725	988	1000	1000	1000	1000	1000	1000	1000	1000	905	905	988	905	905	905	1000	988	988	725	725	381	381
5.03.2016	4626	725	546	546	546	381	546	546	234	72	72	72	29	29	72	72	29	5	5	5	5	29	29	29	5
6.03.2016	2364	29	72	0	0	0	0	0	29	29	140	72	72	72	72	140	140	140	140	140	234	234	234	140	234
7.03.2016	5423	234	381	234	140	140	140	140	140	140	72	140	72	140	72	72	140	140	234	381	234	381	546	381	725
8.03.2016	3859	725	546	381	381	234	381	140	72	72	29	29	72	29	5	5	0	0	0	5	5	234	140	140	234
9.03.2016	8867	234	140	140	140	140	234	140	140	140	234	234	234	381	546	381	140	381	234	546	725	381	1000	1000	1000
10.03.2016	14323	1000	1000	1000	988	381	546	381	381	234	546	546	725	546	546	381	381	725	725	546	381	546	546	725	546
11.03.2016	4105	725	546	234	381	381	381	234	234	72	29	72	72	72	140	140	140	140	29	72	5	5	0	0	0
12.03.2016	159	0	0	0	0	0	0	0	0	0	5	5	0	0	0	5	0	0	0	0	0	0	5	0	140
13.03.2016	978	140	140	234	72	29	72	234	0	0	0	0	0	0	0	0	0	0	29	29	0	0	0	0	0
14.03.2016	90	0	0	0	0	5	5	29	5	5	29	5	0	0	0	0	0	0	0	0	5	5	0	0	0
15.03.2016	29	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	29	0	0	0	0	0	0	0	0
16.03.2016	298	0	0	0	0	0	0	0	0	0	0	0	0	0	0	29	29	72	140	29	0	0	0	0	0
17.03.2016	205	0	0	0	5	5	5	29	5	0	0	0	5	5	0	29	29	29	29	29	5	0	0	0	0
18.03.2016	828	0	0	0	0	0	0	5	29	29	0	0	29	29	5	29	29	5	72	140	72	72	72	72	140
19.03.2016	1498	72	29	72	140	72	140	72	29	5	5	29	29	72	72	72	140	72	72	72	72	72	29	29	29
20.03.2016	196	72	29	5	0	0	0	29	29	5	5	5	5	0	0	0	5	0	0	0	0	0	0	5	5
21.03.2016	9622	29	29	72	72	72	140	140	140	72	140	140	234	234	381	381	381	725	905	988	905	725	905	905	905
22.03.2016	21816	725	725	905	905	725	725	905	988	905	725	988	988	1000	1000	725	905	1000	1000	1000	1000	1000	1000	988	988
23.03.2016	6869	988	988	1000	1000	1000	725	140	5	5	381	140	5	29	0	0	0	0	5	140	140	72	29	5	72
24.03.2016	3648	381	234	234	234	381	381	234	140	234	234	140	140	140	72	140	140	72	29	5	0	72	5	5	0
25.03.2016	19	0	0	0	0	0	0	0	0	0	0	0	5	5	0	0	0	5	0	0	0	0	0	0	5
26.03.2016	1119	0	140	140	140	234	72	29	72	234	0	0	0	0	0	0	0	0	0	0	29	29	0	0	0
27.03.2016	90	0	0	0	0	0	0	5	5	29	5	5	29	5	0	0	0	0	0	0	0	0	5	5	0
28.03.2016	29	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	29	0	0	0	0	0	0
29.03.2016	298	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	29	29	72	140	29	0	0	0
30.03.2016	205	0	0	0	0	0	5	5	5	29	5	0	0	0	5	5	0	29	29	29	29	29	5	0	0
31.03.2016	615	0	0	0	0	0	0	0	0	5	29	29	0	0	29	29	5	29	29	5	72	140	72	72	72
1.04.2016	1653	72	140	72	29	72	140	72	140	72	29	5	5	29	29	72	72	72	140	72	72	72	72	72	29
2.04.2016	244	29	29	72	29	5	0	0	0	29	29	5	5	5	5	0	0	0	5	0	0	0	0	0	0
3.04.2016	7822	5	5	29	29	72	72	72	140	140	140	72	140	140	234	234	381	381	381	725	905	988	905	725	905
4.04.2016	21651	905	905	725	725	905	905	725	725	905	988	905	725	988	988	1000	1000	725	905	1000	1000	1000	1000	1000	1000
5.04.2016	8767	988	988	988	988	1000	1000	1000	725	140	5	5	381	140	5	29	0	0	0	0	5	140	140	72	29
6.04.2016	3643	5	72	381	234	234	234	381	381	234	140	234	234	140	140	140	72	140	140	72	29	5	0	0	0
7.04.2016	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
8.04.2016	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
9.04.2016	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
10.04.2016	105	0	0	0	0	0	0	0	5	5	29	29	5	29	5	0	0	0	0	0	0	0	0	0	0
11.04.2016	4890	0	0	0	0	0	0	29	72	29	72	234	381	381	234	234	381	381	234	546	546	381	140	234	381
12.04.2016	3900	72	29	5	0	29	29	72	72	29	140	140	140	234	234	381	546	381	381	234	234	234	140	72	72
13.04.2016	2678	140	140	72	72	72	29	5	0	0	0	0	5	5	5	29	72	234	381	381	381	234	140	140	140
14.04.2016	1250	140	140	140	140	72	140	72	29	5	29	72	140	29	72	29	0	0	0	0	0	0	0	0	0
15.04.2016	38	0	0	0	5	5	5	5	0	5	5	5	0	0	0	0	0	0	0	0	0	0	0	0	5
16.04.2016	316	29	29	0	5	5	29	29	5	0	5	5	0	0	0	0	0	0	0	0	0	5	72	72	29
17.04.2016	4666	29	29	29	29	72	29	29	5	29	29	5	29	72	72	72	72	140	234	381	381	546	725	725	905
18.04.2016	14331	725	725	725	725	725	905	905	725	725	546	725	905	234	546	234	381	381	381	546	546	546	546	381	546
19.04.2016	14496	988	905	546	381	546	381	546	234	29	72	72	234	381	234	234	725	1000	1000	1000	1000	1000	988	1000	1000
20.04.2016	12927	1000	1000	905	905	988	905	988	725	725	725	725	381	546	546	381	381	381	234	234	140	72	29	5	5
21.04.2016	105	5	5	5	0	0	0	0	0	0	0	0	0	0	0	0	0	5	0	0	0	0	29	29	29
22.04.2016	5036	29	72	72	72	140	234	234	381	234	234	140	234	234	234	381	546	725	381	140	140	72	72	29	5
23.04.2016	9242	5	5	0	5	5	29	29	29	72	234	546	381	381	546	725	546	725	988	905	905	546	546	546	546
24.04.2016	6478	546	725	381	546	725	234	546	725	234	29	72	381	381	234	140	29	72	140	140	29	29	140	0	0
25.04.2016	3767	0	0	0	0	5	0	29	140	140	381	140	140	381	234	234	140	140	140	381	381	381	234	72	72
26.04.2016	1035	72	29	5	0	5	72	140	140	72	29	72	29	5	5	72	29	5	5	5	0	5	72	140	29
27.04.2016	17121	29	29	381	546	725	725	546	381	381	381	546	546	905	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000
28.04.2016	16869	1000	1000	1000	988	1000	1000	1000	725	1000	546	1000	988	546	905	725	725	546	905	381	140	140	234	234	140
29.04.2016	1009	140	72	140	234	140	72	72	29	29	0	29	29	5	0	0	0	0	0	5	5	5	0	5	0
30.04.2016	157	0	0	0	0	0	0	5	5	5	29	5	5	0	0	5	5	5	5	5	72	5	5	0	0

1.05.2016	19	0	0	0	0	0	0	0	0	0	0	5	5	0	0	0	5	0	0	0	0	0	0	5	0
2.05.2016	1119	140	140	140	234	72	29	72	234	0	0	0	0	0	0	0	0	0	0	29	29	0	0	0	0
3.05.2016	90	0	0	0	0	0	5	5	29	5	5	29	5	0	0	0	0	0	0	0	0	5	5	0	0
4.05.2016	29	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	29	0	0	0	0	0	0	0
5.05.2016	298	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	29	29	72	140	29	0	0	0	0
6.05.2016	205	0	0	0	0	5	5	5	29	5	0	0	0	5	5	0	29	29	29	29	29	5	0	0	0
7.05.2016	687	0	0	0	0	0	0	0	5	29	29	0	0	29	29	5	29	29	5	72	140	72	72	72	72
8.05.2016	1609	140	72	29	72	140	72	140	72	29	5	5	29	29	72	72	72	140	72	72	72	72	72	29	29
9.05.2016	220	29	72	29	5	0	0	0	29	29	5	5	5	5	0	0	0	5	0	0	0	0	0	0	5
10.05.2016	8722	5	29	29	72	72	72	140	140	140	72	140	140	234	234	381	381	381	725	905	988	905	725	905	905
11.05.2016	21733	905	725	725	905	905	725	725	905	988	905	725	988	988	1000	1000	725	905	1000	1000	1000	1000	1000	1000	988
12.05.2016	7784	988	988	988	1000	1000	1000	725	140	5	5	381	140	5	29	0	0	0	0	5	140	140	72	29	5
13.05.2016	3638	72	381	234	234	234	381	381	234	140	234	234	140	140	140	72	140	140	72	29	5	0	0	0	0
14.05.2016	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
15.05.2016	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
16.05.2016	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
17.05.2016	105	0	0	0	0	0	0	5	5	29	29	5	29	5	0	0	0	0	0	0	0	0	0	0	0
18.05.2016	4963	0	0	0	0	0	29	72	29	72	234	381	381	234	234	381	381	234	546	546	381	140	234	381	72
19.05.2016	3968	29	5	0	29	29	72	72	29	140	140	140	234	234	381	546	381	381	234	234	234	140	72	72	140
20.05.2016	2678	140	72	72	72	29	5	0	0	0	0	5	5	5	29	72	234	381	381	381	234	140	140	140	140
21.05.2016	1109	140	140	140	72	140	72	29	5	29	72	140	29	72	29	0	0	0	0	0	0	0	0	0	0
22.05.2016	66	0	0	5	5	5	5	0	5	5	5	0	0	0	0	0	0	0	0	0	0	0	0	5	29
23.05.2016	316	29	0	5	5	29	29	5	0	5	5	0	0	0	0	0	0	0	0	0	5	72	72	29	29
24.05.2016	5363	29	29	29	72	29	29	5	29	29	5	29	72	72	72	72	140	234	381	381	546	725	725	905	725
25.05.2016	14593	725	725	725	725	905	905	725	725	546	725	905	234	546	234	381	381	381	546	546	546	546	381	546	988
26.05.2016	14508	905	546	381	546	381	546	234	29	72	72	234	381	234	234	725	1000	1000	1000	1000	1000	988	1000	1000	1000
27.05.2016	11932	1000	905	905	988	905	988	725	725	725	725	381	546	546	381	381	381	234	234	140	72	29	5	5	5
28.05.2016	129	5	5	0	0	0	0	0	0	0	0	0	0	0	0	0	5	0	0	0	0	29	29	29	29
29.05.2016	5012	72	72	72	140	234	234	381	234	234	140	234	234	234	381	546	725	381	140	140	72	72	29	5	5
30.05.2016	9784	5	0	5	5	29	29	29	72	234	546	381	381	546	725	546	725	988	905	905	546	546	546	546	546
31.05.2016	5933	725	381	546	725	234	546	725	234	29	72	381	381	234	140	29	72	140	140	29	29	140	0	0	0
1.06.2016	3840	0	0	0	5	0	29	140	140	381	140	140	381	234	234	140	140	140	381	381	381	234	72	72	72
2.06.2016	991	29	5	0	5	72	140	140	72	29	72	29	5	5	72	29	5	5	5	0	5	72	140	29	29
3.06.2016	18093	29	381	546	725	725	546	381	381	381	546	546	905	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000
4.06.2016	16009	1000	1000	988	1000	1000	1000	725	1000	546	1000	988	546	905	725	725	546	905	381	140	140	234	234	140	140
5.06.2016	869	72	140	234	140	72	72	29	29	0	29	29	5	0	0	0	0	0	5	5	5	0	5	0	0
6.06.2016	254	0	0	0	0	0	5	5	5	29	5	5	0	0	5	5	5	5	5	140	29	0	5	5	0
7.06.2016	2945	5	0	0	0	0	0	0	5	0	0	0	0	29	72	381	234	140	234	234	234	381	381	381	234
8.06.2016	9118	381	381	546	381	546	381	381	381	381	234	234	234	234	546	546	546	546	546	725	381	234	140	140	72
9.06.2016	1982	72	72	72	72	29	72	72	140	72	72	29	29	29	29	29	29	72	72	140	234	234	234	72	5
10.06.2016	166	5	5	5	5	5	0	0	5	5	0	0	5	29	29	5	5	0	0	5	0	0	29	29	0
11.06.2016	504	0	0	0	5	0	0	0	0	0	29	29	29	29	72	29	29	29	140	72	5	5	0	0	5
12.06.2016	1902	5	5	5	5	5	0	5	72	140	234	140	140	140	234	140	234	140	72	72	29	29	29	29	0
13.06.2016	10954	5	29	140	140	140	234	234	234	140	725	725	546	725	905	725	725	725	988	988	905	381	72	140	381
14.06.2016	15771	234	140	234	381	725	905	725	725	905	1000	988	725	988	988	1000	725	725	725	905	546	725	381	140	234
15.06.2016	3588	381	381	381	234	72	140	140	140	72	140	140	234	140	140	140	72	72	140	140	140	140	5	0	0
16.06.2016	4460	0	0	0	0	5	5	5	29	29	29	29	72	72	72	140	234	234	381	546	546	381	381	546	725
17.06.2016	18914	725	725	905	905	905	546	725	905	725	546	546	234	381	546	725	905	1000	1000	988	988	1000	988	1000	1000
18.06.2016	16702	1000	1000	1000	1000	905	725	725	905	905	905	905	546	725	905	905	725	546	381	381	381	381	234	234	381
19.06.2016	5469	140	234	140	234	546	546	234	381	381	381	381	140	140	72	72	72	72	140	140	140	29	72	234	546
20.06.2016	7395	725	140	140	381	381	234	381	546	546	381	381	381	546	546	381	234	234	234	234	234	5	29	72	29
21.06.2016	9860	140	381	905	234	546	546	381	381	546	381	546	546	546	546	546	546	381	546	546	381	72	72	72	72
22.06.2016	9119	29	29	29	140	140	381	725	905	905	725	546	381	381	234	234	234	546	234	234	234	381	381	546	546
23.06.2016	10417	725	546	234	140	140	72	72	140	234	381	546	381	381	381	381	546	725	725	381	381	546	905	725	725
24.06.2016	11318	725	725	905	988	905	234	234	234	140	234	234	234	234	234	234	234	381	546	381	725	725	725	725	381
25.06.2016	7740	546	546	546	725	725	381	234	140	140	72	72	29	5	29	5	29	140	234	546	546	546	546	725	234
26.06.2016	3280	546	381	234	140	5	5	5	29	5	29	29	29	72	140	234	381	546	381	29	0	0	5	29	29
27.06.2016	1544	29	72	72	72	29	29	5	5	29	5	5	29	29	72	140	234	140	72	29	140	140	140	29	0
28.06.2016	1155	0	0	5	72	29	72	140	29	0	0	0	0	0	0	0	0	5	72	140	234	72	72	72	140
29.06.2016	2546	72	29	29	72	29	29	5	5	29	29	5	72	29	140	381	381	725	140	29	72	5	29	72	140
30.06.2016	2087	140	72	72	140	72	140	72	29	72	29	5	5	5	29	29	29	72	140	140	140	140	234	140	140
1.07.2016	6069	140	140	140	140	140	234	546	725	381	234	140	140	234	234	234	234	381	381	381	234	234	140	140	140
2.07.2016	2555	140	140	140	72	29	72	72	72	72	72	29	72	29	29	29	29	140	140	381	234	140	140	140	140
3.07.2016	3884	140	140	140	140	140	72	140	72	29	5	29	5	72	72	140	234	234	381	381	381	234	234	234	234
4.07.2016	11909	381	234	234	140	234	381	234	140	140	140	140	234	234	546	905	988	988	905	905	905	725	725	725	725
5.07.2016	11312	546	546	546	546	381	381	140	381	546	546	546	725	725	725	725	905	988	546	234	140	72	140	140	140
6.07.2016	2359	140	140	546	234	234	72	72	72	72	72	72	29	5	0	0	0	0	5	140	140	140	72	72	29
7.07.2016	6709	29	140	234	29	29	5	29	29	29	72	29	5	5	381	546	546	381	546	725	725	381	546	546	725
8.07.2016	10465	725	725	725	725	546	381	381	381	546	546	381	381	234	234	234	234	381	546	546	381	381	381	234	234
9.07.2016	2334	234	72	140	381	72	5	0	5	5	5	5	0	5	29	72	29	29	140	381	140	234	140	140	72
10.07.2016	8492	72	72	140	140	140	140	140	234	234	381	234	234	234	234	381	546	725	725	725	725	725	546	381	381
11.07.2016	6314	234	381	546	381	381	381	381	381	234	234	140	140	140	140	140	140	234	381	546	234	234	140	29	140
12.07.2016	8425	140	381	905	546	29	72	29	29	140	234	234	140	72	140	140	140	140	381	725	905	905	905	546	546
13.07.2016	2265	381	234	234	72	72	140	140	140	5	5	5	0	0	5	0	29	5	0	234	140	140	140	72	72
14.07.2016	944	29	5	0	0	0	0	0	0	5	72	72	29	29	72	72	72	140	140	72	72	29	29	5	0
15.07.2016	757	5	0	0	0	0	0	0	0	0	0	5	5	29	29	5	5	29	140	234	72	72	72	29	29
16.07.2016	291	5	0	0	5	29	5	29	29	29	72	5	5	0	5	5	0	5	0	0	29	5	29	5	0
17.07.2016	868	0	0	29	29	29	5	0	0	0	29	72	29	140	72	29	5	29	234	140	0	0	0	0	0
18.07.2016	4838	5	5	29	72	72	29	29	72	72	29	29	5	140	72	72	234	546	546	381	381	381	546	546	546
19.07.2016	14924	546	725	725	725	725	546	725	725	725	725	546	546	381	381	725	725	725	725	546	546	546	546	546	546
20.07.2016	6536	546	546	381	381	234	140	140	234	234	140	140	140	234	381	381	234	546	381	140	234	140	140	234	234
21.07.2016	5115	234	234	234	234	234	140	72	72	140	140	72	140	140	234	234	381	381	381	381	381	234	140	140	140
22.07.2016	2190	72	72	140	234	140	29	29	29	5	5	5	0	29	29	29	29	29	72	140	234	234	234	234	140
23.07.2016	3165	29	29	29	72	29	140	29	5	5	29	5	29	72	72	140	140	381	381	381	234	234	234	234	234
24.07.2016	9856	234	546	381	546	234	140	140	381	546	381	381	381	381	546	725	546	725	905	905	381	140	140	29	140
25.07.2016	9269	234	234	234	72	29	234	381	725	725	725	546	234	140	140	140	140	140	381	725	725	725	546	546	546
26.07.2016	5599	546	546	546	381	140	72	72	140	140	140	72	72	72	72	5	5	29	140	140	546	234	381	381	725
27.07.2016	2676	546	140	5	0	0	0	0	0	5	5	0	0	0	0	5	234	381	234	234	234	234	140	140	140
28.07.2016	3119	140	140	140	140	140	29	29	29	29	72	29	0	5	0	0	140	234	234	381	381	234	72	140	381
29.07.2016	3539	234	140	140	234	0	0	0	0	5	5	5	72	5	0	29	140	381	234	381	234	381	546	234	140
30.07.2016	4291	72	140	140	72	29	5	29	72	140	72	72	140	29	140	29	140	381	725	546	381	234	234	234	234
31.07.2016	5480	234	234	234	381	72	72	140	140	140	72	72	72	5	29	29	140	234	234	381	381	546	546	546	546
1.08.2016	1503	546	29	72	140	140	72	5	0	0	5	5	0	0	29	29	29	29	29	72	72	72	72	29	29
2.08.2016	933	29	0	0	0	5	5	0	0	5	29	72	29	72	29	29	72	72	140	140	72	72	29	5	29
3.08.2016	5945	29	5	0	29	72	72	72	72	29	29	72	29	72	140	234	546	546	905	725	725	546	381	234	381
4.08.2016	8820	234	234	234	234	381	381	234	234	234	234	234	140	140	381	725	905	988	725	234	234	140	234	381	725
5.08.2016	4782	546	140	234	234	140	72	72	234	140	72	72	72	140	140	29	72	381	234	725	725	234	72	0	0
6.08.2016	3308	0	29	140	140	140	29	29	140	72	5	5	140	29	5	140	381	234	381	381	234	140	140	234	140
7.08.2016	4864	140	72	140	72	140	140	140	72	72	72	72	72	72	72	140	381	546	546	381	381	381	381	234	140
8.08.2016	4315	140	140	234	234	140	140	29	72	140	140	140	72	29	72	29	29	72	234	546	546	381	381	234	140
9.08.2016	4589	234	234	381	381	546	140	29	72	140	29	29	29	29	29	29	29	72	140	546	725	234	140	234	140
10.08.2016	2755	29	140	234	140	72	29	5	5	0	5	140	72	140	140	234	546	546	140	5	5	0	29	29	72
11.08.2016	1910	29	29	140	234	140	29	72	140	140	140	29	29	0	0	0	0	0	29	140	234	140	72	72	72
12.08.2016	2135	0	0	0	0	0	0	0	0	5	5	29	29	140	140	140	72	72	140	234	234	140	140	234	381
13.08.2016	11207	381	381	381	234	234	381	546	381	546	234	140	234	546	381	546	905	546	905	725	546	381	381	546	725
14.08.2016	15448	905	725	546	725	546	546	546	546	546	725	725	725	725	725	905	725	725	546	725	546	381	546	546	546
15.08.2016	12081	381	381	905	1000	988	988	905	725	725	381	234	234	140	234	234	234	381	725	905	725	234	140	140	140
16.08.2016	7739	72	140	381	234	546	381	381	234	234	140	140	234	140	140	234	381	546	546	546	546	546	381	381	234
17.08.2016	4577	140	234	234	381	381	234	140	234	234	140	140	72	72	72	72	72	234	234	381	381	140	140	140	72
18.08.2016	2981	72	29	29	29	29	5	0	0	5	29	29	5	0	5	5	72	72	29	140	381	381	546	546	546
19.08.2016	1621	140	140	72	72	72	72	5	5	0	5	5	0	0	0	0	0	0	140	234	234	140	140	72	72
20.08.2016	5575	140	72	29	29	72	72	29	29	29	72	29	140	140	72	546	725	905	725	725	725	140	29	72	29
21.08.2016	1248	5	29	29	234	381	140	72	5	29	72	29	0	0	0	29	29	29	72	29	29	5	5	0	0
22.08.2016	842	0	0	0	0	0	0	0	0	0	29	72	29	72	72	72	72	72	140	72	72	29	29	5	5
23.08.2016	2568	0	5	29	72	72	29	29	29	29	72	72	72	29	5	29	72	234	234	234	234	140	234	381	234
24.08.2016	7513	140	234	140	546	381	140	140	381	381	234	140	234	234	234	546	546	546	72	381	381	725	381	234	140
25.08.2016	8545	381	546	381	234	140	381	381	381	381	381	234	140	140	234	381	546	725	546	546	381	234	381	234	234
26.08.2016	7541	234	234	381	381	234	234	234	140	140	72	72	72	140	140	234	546	725	546	546	546	546	381	381	381
27.08.2016	4520	381	234	234	234	234	140	72	140	72	29	72	29	29	72	381	546	546	140	234	140	140	140	140	140
28.08.2016	1927	140	140	140	72	72	29	29	29	5	5	5	5	0	0	0	72	234	381	140	72	140	72	72	72
29.08.2016	924	72	29	5	5	0	0	0	0	5	0	0	29	72	140	72	72	72	72	72	72	72	29	29	5
30.08.2016	1461	5	0	0	0	0	0	0	0	5	0	0	0	0	29	5	72	140	381	234	234	140	72	72	72
31.08.2016	8841	234	234	234	234	381	234	234	381	381	234	234	234	381	381	546	725	725	546	381	381	381	381	381	381

Wind Generation kWh	Total kWh	00:00	01:00	02:00	03:00	04:00	05:00	06:00	07:00	08:00	09:00	10:00	11:00	12:00	13:00	14:00	15:00	16:00	17:00	18:00	19:00	20:00	21:00	22:00	23:00
		00:59	01:59	02:59	03:59	04:59	05:59	06:59	07:59	08:59	09:59	10:59	11:59	12:59	13:59	14:59	15:59	16:59	17:59	18:59	19:59	20:59	21:59	22:59	23:59
1.09.2017	7107	0	0	0	0	0	0	0	242	469	654	810	903	952	903	810	654	469	242	0	0	0	0	0	0
2.09.2017	6620	0	0	0	0	0	0	0	225	437	609	755	841	887	841	755	609	437	225	0	0	0	0	0	0
3.09.2017	6912	0	0	0	0	0	0	0	235	456	636	788	878	926	878	788	636	456	235	0	0	0	0	0	0
4.09.2017	7009	0	0	0	0	0	0	0	238	463	645	799	890	939	890	799	645	463	238	0	0	0	0	0	0
5.09.2017	7009	0	0	0	0	0	0	0	238	463	645	799	890	939	890	799	645	463	238	0	0	0	0	0	0
6.09.2017	6912	0	0	0	0	0	0	0	235	456	636	788	878	926	878	788	636	456	235	0	0	0	0	0	0
7.09.2017	6815	0	0	0	0	0	0	0	232	450	627	777	865	913	865	777	627	450	232	0	0	0	0	0	0
8.09.2017	6523	0	0	0	0	0	0	0	222	430	600	744	828	874	828	744	600	430	222	0	0	0	0	0	0
9.09.2017	6523	0	0	0	0	0	0	0	222	430	600	744	828	874	828	744	600	430	222	0	0	0	0	0	0
10.09.2017	6620	0	0	0	0	0	0	0	225	437	609	755	841	887	841	755	609	437	225	0	0	0	0	0	0
11.09.2017	6620	0	0	0	0	0	0	0	225	437	609	755	841	887	841	755	609	437	225	0	0	0	0	0	0
12.09.2017	6523	0	0	0	0	0	0	0	222	430	600	744	828	874	828	744	600	430	222	0	0	0	0	0	0
13.09.2017	6620	0	0	0	0	0	0	0	225	437	609	755	841	887	841	755	609	437	225	0	0	0	0	0	0
14.09.2017	6425	0	0	0	0	0	0	0	218	424	591	732	816	861	816	732	591	424	218	0	0	0	0	0	0
15.09.2017	6328	0	0	0	0	0	0	0	215	418	582	721	804	848	804	721	582	418	215	0	0	0	0	0	0
16.09.2017	6231	0	0	0	0	0	0	0	212	411	573	710	791	835	791	710	573	411	212	0	0	0	0	0	0
17.09.2017	6425	0	0	0	0	0	0	0	218	424	591	732	816	861	816	732	591	424	218	0	0	0	0	0	0
18.09.2017	6328	0	0	0	0	0	0	0	215	418	582	721	804	848	804	721	582	418	215	0	0	0	0	0	0
19.09.2017	6231	0	0	0	0	0	0	0	212	411	573	710	791	835	791	710	573	411	212	0	0	0	0	0	0
20.09.2017	5646	0	0	0	0	0	0	0	192	373	519	644	717	757	717	644	519	373	192	0	0	0	0	0	0
21.09.2017	5744	0	0	0	0	0	0	0	195	379	528	655	729	770	729	655	528	379	195	0	0	0	0	0	0
22.09.2017	5939	0	0	0	0	0	0	0	202	392	546	677	754	796	754	677	546	392	202	0	0	0	0	0	0
23.09.2017	6133	0	0	0	0	0	0	0	209	405	564	699	779	822	779	699	564	405	209	0	0	0	0	0	0
24.09.2017	6231	0	0	0	0	0	0	0	212	411	573	710	791	835	791	710	573	411	212	0	0	0	0	0	0
25.09.2017	6036	0	0	0	0	0	0	0	205	398	555	688	767	809	767	688	555	398	205	0	0	0	0	0	0
26.09.2017	6036	0	0	0	0	0	0	0	205	398	555	688	767	809	767	688	555	398	205	0	0	0	0	0	0
27.09.2017	5939	0	0	0	0	0	0	0	202	392	546	677	754	796	754	677	546	392	202	0	0	0	0	0	0
28.09.2017	5744	0	0	0	0	0	0	0	195	379	528	655	729	770	729	655	528	379	195	0	0	0	0	0	0
29.09.2017	5452	0	0	0	0	0	0	0	185	360	502	621	692	731	692	621	502	360	185	0	0	0	0	0	0
30.09.2017	5257	0	0	0	0	0	0	0	179	347	484	599	668	704	668	599	484	347	179	0	0	0	0	0	0
1.10.2017	1460	0	0	0	0	0	0	0	50	96	134	166	185	196	185	166	134	96	50	0	0	0	0	0	0
2.10.2017	3699	0	0	0	0	0	0	0	126	244	340	422	470	496	470	422	340	244	126	0	0	0	0	0	0
3.10.2017	4868	0	0	0	0	0	0	0	165	321	448	555	618	652	618	555	448	321	165	0	0	0	0	0	0
4.10.2017	5257	0	0	0	0	0	0	0	179	347	484	599	668	704	668	599	484	347	179	0	0	0	0	0	0
5.10.2017	5062	0	0	0	0	0	0	0	172	334	466	577	643	678	643	577	466	334	172	0	0	0	0	0	0
6.10.2017	4186	0	0	0	0	0	0	0	142	276	385	477	532	561	532	477	385	276	142	0	0	0	0	0	0
7.10.2017	2921	0	0	0	0	0	0	0	99	193	269	333	371	391	371	333	269	193	99	0	0	0	0	0	0
8.10.2017	4965	0	0	0	0	0	0	0	169	328	457	566	631	665	631	566	457	328	169	0	0	0	0	0	0
9.10.2017	2823	0	0	0	0	0	0	0	96	186	260	322	359	378	359	322	260	186	96	0	0	0	0	0	0
10.10.2017	2823	0	0	0	0	0	0	0	96	186	260	322	359	378	359	322	260	186	96	0	0	0	0	0	0
11.10.2017	3407	0	0	0	0	0	0	0	116	225	313	388	433	457	433	388	313	225	116	0	0	0	0	0	0
12.10.2017	5062	0	0	0	0	0	0	0	172	334	466	577	643	678	643	577	466	334	172	0	0	0	0	0	0
13.10.2017	4965	0	0	0	0	0	0	0	169	328	457	566	631	665	631	566	457	328	169	0	0	0	0	0	0
14.10.2017	5160	0	0	0	0	0	0	0	175	341	475	588	655	691	655	588	475	341	175	0	0	0	0	0	0
15.10.2017	4965	0	0	0	0	0	0	0	169	328	457	566	631	665	631	566	457	328	169	0	0	0	0	0	0
16.10.2017	4965	0	0	0	0	0	0	0	169	328	457	566	631	665	631	566	457	328	169	0	0	0	0	0	0
17.10.2017	4770	0	0	0	0	0	0	0	162	315	439	544	606	639	606	544	439	315	162	0	0	0	0	0	0
18.10.2017	4868	0	0	0	0	0	0	0	165	321	448	555	618	652	618	555	448	321	165	0	0	0	0	0	0
19.10.2017	4673	0	0	0	0	0	0	0	159	308	430	533	593	626	593	533	430	308	159	0	0	0	0	0	0
20.10.2017	4576	0	0	0	0	0	0	0	156	302	421	522	581	613	581	522	421	302	156	0	0	0	0	0	0
21.10.2017	2434	0	0	0	0	0	0	0	83	161	224	277	309	326	309	277	224	161	83	0	0	0	0	0	0
22.10.2017	1655	0	0	0	0	0	0	0	56	109	152	189	210	222	210	189	152	109	56	0	0	0	0	0	0
23.10.2017	2629	0	0	0	0	0	0	0	89	173	242	300	334	352	334	300	242	173	89	0	0	0	0	0	0
24.10.2017	3894	0	0	0	0	0	0	0	132	257	358	444	495	522	495	444	358	257	132	0	0	0	0	0	0
25.10.2017	3310	0	0	0	0	0	0	0	113	218	305	377	420	444	420	377	305	218	113	0	0	0	0	0	0
26.10.2017	4089	0	0	0	0	0	0	0	139	270	376	466	519	548	519	466	376	270	139	0	0	0	0	0	0
27.10.2017	4478	0	0	0	0	0	0	0	152	296	412	511	569	600	569	511	412	296	152	0	0	0	0	0	0
28.10.2017	4089	0	0	0	0	0	0	0	139	270	376	466	519	548	519	466	376	270	139	0	0	0	0	0	0
29.10.2017	4186	0	0	0	0	0	0	0	142	276	385	477	532	561	532	477	385	276	142	0	0	0	0	0	0
30.10.2017	2823	0	0	0	0	0	0	0	96	186	260	322	359	378	359	322	260	186	96	0	0	0	0	0	0
31.10.2017	2239	0	0	0	0	0	0	0	76	148	206	255	284	300	284	255	206	148	76	0	0	0	0	0	0
1.11.2017	4186	0	0	0	0	0	0	0	0	197	398	532	632	670	632	532	398	197	0	0	0	0	0	0	0
2.11.2017	2336	0	0	0	0	0	0	0	0	110	222	297	353	374	353	297	222	110	0	0	0	0	0	0	0
3.11.2017	3505	0	0	0	0	0	0	0	0	165	333	445	529	561	529	445	333	165	0	0	0	0	0	0	0
4.11.2017	4089	0	0	0	0	0	0	0	0	192	388	519	617	654	617	519	388	192	0	0	0	0	0	0	0
5.11.2017	3797	0	0	0	0	0	0	0	0	178	361	482	573	607	573	482	361	178	0	0	0	0	0	0	0
6.11.2017	3894	0	0	0	0	0	0	0	0	183	370	495	588	623	588	495	370	183	0	0	0	0	0	0	0
7.11.2017	3407	0	0	0	0	0	0	0	0	160	324	433	515	545	515	433	324	160	0	0	0	0	0	0	0
8.11.2017	487	0	0	0	0	0	0	0	0	23	46	62	74	78	74	62	46	23	0	0	0	0	0	0	0
9.11.2017	681	0	0	0	0	0	0	0	0	32	65	87	103	109	103	87	65	32	0	0	0	0	0	0	0
10.11.2017	876	0	0	0	0	0	0	0	0	41	83	111	132	140	132	111	83	41	0	0	0	0	0	0	0
11.11.2017	487	0	0	0	0	0	0	0	0	23	46	62	74	78	74	62	46	23	0	0	0	0	0	0	0
12.11.2017	1363	0	0	0	0	0	0	0	0	64	129	173	206	218	206	173	129	64	0	0	0	0	0	0	0
13.11.2017	876	0	0	0	0	0	0	0	0	41	83	111	132	140	132	111	83	41	0	0	0	0	0	0	0
14.11.2017	2726	0	0	0	0	0	0	0	0	128	259	346	412	436	412	346	259	128	0	0	0	0	0	0	0
15.11.2017	1558	0	0	0	0	0	0	0	0	73	148	198	235	249	235	198	148	73	0	0	0	0	0	0	0
16.11.2017	1168	0	0	0	0	0	0	0	0	55	111	148	176	187	176	148	111	55	0	0	0	0	0	0	0
17.11.2017	1558	0	0	0	0	0	0	0	0	73	148	198	235	249	235	198	148	73	0	0	0	0	0	0	0
18.11.2017	681	0	0	0	0	0	0	0	0	32	65	87	103	109	103	87	65	32	0	0	0	0	0	0	0
19.11.2017	1168	0	0	0	0	0	0	0	0	55	111	148	176	187	176	148	111	55	0	0	0	0	0	0	0
20.11.2017	876	0	0	0	0	0	0	0	0	41	83	111	132	140	132	111	83	41	0	0	0	0	0	0	0
21.11.2017	779	0	0	0	0	0	0	0	0	37	74	99	118	125	118	99	74	37	0	0	0	0	0	0	0
22.11.2017	487	0	0	0	0	0	0	0	0	23	46	62	74	78	74	62	46	23	0	0	0	0	0	0	0
23.11.2017	584	0	0	0	0	0	0	0	0	27	55	74	88	93	88	74	55	27	0	0	0	0	0	0	0
24.11.2017	1168	0	0	0	0	0	0	0	0	55	111	148	176	187	176	148	111	55	0	0	0	0	0	0	0
25.11.2017	1363	0	0	0	0	0	0	0	0	64	129	173	206	218	206	173	129	64	0	0	0	0	0	0	0
26.11.2017	3407	0	0	0	0	0	0	0	0	160	324	433	515	545	515	433	324	160	0	0	0	0	0	0	0
27.11.2017	3310	0	0	0	0	0	0	0	0	156	314	420	500	530	500	420	314	156	0	0	0	0	0	0	0
28.11.2017	3407	0	0	0	0	0	0	0	0	160	324	433	515	545	515	433	324	160	0	0	0	0	0	0	0
29.11.2017	1460	0	0	0	0	0	0	0	0	69	139	185	221	234	221	185	139	69	0	0	0	0	0	0	0
30.11.2017	2823	0	0	0	0	0	0	0	0	133	268	359	426	452	426	359	268	133	0	0	0	0	0	0	0
1.12.2017	2239	0	0	0	0	0	0	0	0	105	213	284	338	358	338	284	213	105	0	0	0	0	0	0	0
2.12.2017	3115	0	0	0	0	0	0	0	0	146	296	396	470	498	470	396	296	146	0	0	0	0	0	0	0
3.12.2017	2044	0	0	0	0	0	0	0	0	96	194	260	309	327	309	260	194	96	0	0	0	0	0	0	0
4.12.2017	1460	0	0	0	0	0	0	0	0	69	139	185	221	234	221	185	139	69	0	0	0	0	0	0	0
5.12.2017	3213	0	0	0	0	0	0	0	0	151	305	408	485	514	485	408	305	151	0	0	0	0	0	0	0
6.12.2017	2921	0	0	0	0	0	0	0	0	137	277	371	441	467	441	371	277	137	0	0	0	0	0	0	0
7.12.2017	2726	0	0	0	0	0	0	0	0	128	259	346	412	436	412	346	259	128	0	0	0	0	0	0	0
8.12.2017	2239	0	0	0	0	0	0	0	0	105	213	284	338	358	338	284	213	105	0	0	0	0	0	0	0
9.12.2017	2921	0	0	0	0	0	0	0	0	137	277	371	441	467	441	371	277	137	0	0	0	0	0	0	0
10.12.2017	974	0	0	0	0	0	0	0	0	46	92	124	147	156	147	124	92	46	0	0	0	0	0	0	0
11.12.2017	1947	0	0	0	0	0	0	0	0	92	185	247	294	312	294	247	185	92	0	0	0	0	0	0	0
12.12.2017	1168	0	0	0	0	0	0	0	0	55	111	148	176	187	176	148	111	55	0	0	0	0	0	0	0
13.12.2017	1266	0	0	0	0	0	0	0	0	59	120	161	191	202	191	161	120	59	0	0	0	0	0	0	0
14.12.2017	2239	0	0	0	0	0	0	0	0	105	213	284	338	358	338	284	213	105	0	0	0	0	0	0	0
15.12.2017	3407	0	0	0	0	0	0	0	0	160	324	433	515	545	515	433	324	160	0	0	0	0	0	0	0
16.12.2017	1752	0	0	0	0	0	0	0	0	82	166	223	265	280	265	223	166	82	0	0	0	0	0	0	0
17.12.2017	1168	0	0	0	0	0	0	0	0	55	111	148	176	187	176	148	111	55	0	0	0	0	0	0	0
18.12.2017	487	0	0	0	0	0	0	0	0	23	46	62	74	78	74	62	46	23	0	0	0	0	0	0	0
19.12.2017	2434	0	0	0	0	0	0	0	0	114	231	309	368	389	368	309	231	114	0	0	0	0	0	0	0
20.12.2017	974	0	0	0	0	0	0	0	0	46	92	124	147	156	147	124	92	46	0	0	0	0	0	0	0
21.12.2017	584	0	0	0	0	0	0	0	0	27	55	74	88	93	88	74	55	27	0	0	0	0	0	0	0
22.12.2017	2044	0	0	0	0	0	0	0	0	96	194	260	309	327	309	260	194	96	0	0	0	0	0	0	0
23.12.2017	1363	0	0	0	0	0	0	0	0	64	129	173	206	218	206	173	129	64	0	0	0	0	0	0	0
24.12.2017	1752	0	0	0	0	0	0	0	0	82	166	223	265	280	265	223	166	82	0	0	0	0	0	0	0
25.12.2017	1168	0	0	0	0	0	0	0	0	55	111	148	176	187	176	148	111	55	0	0	0	0	0	0	0
26.12.2017	3018	0	0	0	0	0	0	0	0	142	287	383	456	483	456	383	287	142	0	0	0	0	0	0	0
27.12.2017	2921	0	0	0	0	0	0	0	0	137	277	371	441	467	441	371	277	137	0	0	0	0	0	0	0
28.12.2017	2336	0	0	0	0	0	0	0	0	110	222	297	353	374	353	297	222	110	0	0	0	0	0	0	0
29.12.2017	1460	0	0	0	0	0	0	0	0	69	139	185	221	234	221	185	139	69	0	0	0	0	0	0	0
30.12.2017	1850	0	0	0	0	0	0	0	0	87	176	235	279	296	279	235	176	87	0	0	0	0	0	0	0
31.12.2017	1460	0	0	0	0	0	0	0	0	69	139	185	221	234	221	185	139	69	0	0	0	0	0	0	0

Appendix B. Solar Hourly Electrical Output in Usak (1 Year)

Total. MWh	1808,0	JAN.	64,3	FEB.	89,5	MAR.	135,2	APR.	162,5	MAY	217,2	JUN	243,1	JUL	240,4	AUG	225,6	SEP	189,9	OCT	121,3	NOV	58,5	DEC	60,7

Solar Generation kWh	Total Daily Gen.	00:00 00:59	01:00 01:59	02:00 02:59	03:00 03:59	04:00 04:59	05:00 05:59	06:00 06:59	07:00 07:59	08:00 08:59	09:00 09:59	10:00 10:59	11:00 11:59	12:00 12:59	13:00 13:59	14:00 14:59	15:00 15:59	16:00 16:59	17:00 17:59	18:00 18:59	19:00 19:59	20:00 20:59	21:00 21:59	22:00 22:59	23:00 23:59
1.01.2017	974	0	0	0	0	0	0	0	0	46	92	124	147	156	147	124	92	46	0	0	0	0	0	0	0
2.01.2017	1655	0	0	0	0	0	0	0	0	78	157	210	250	265	250	210	157	78	0	0	0	0	0	0	0
3.01.2017	681	0	0	0	0	0	0	0	0	32	65	87	103	109	103	87	65	32	0	0	0	0	0	0	0
4.01.2017	779	0	0	0	0	0	0	0	0	37	74	99	118	125	118	99	74	37	0	0	0	0	0	0	0
5.01.2017	1168	0	0	0	0	0	0	0	0	55	111	148	176	187	176	148	111	55	0	0	0	0	0	0	0
6.01.2017	681	0	0	0	0	0	0	0	0	32	65	87	103	109	103	87	65	32	0	0	0	0	0	0	0
7.01.2017	1168	0	0	0	0	0	0	0	0	55	111	148	176	187	176	148	111	55	0	0	0	0	0	0	0
8.01.2017	1655	0	0	0	0	0	0	0	0	78	157	210	250	265	250	210	157	78	0	0	0	0	0	0	0
9.01.2017	1947	0	0	0	0	0	0	0	0	92	185	247	294	312	294	247	185	92	0	0	0	0	0	0	0
10.01.2017	3310	0	0	0	0	0	0	0	0	156	314	420	500	530	500	420	314	156	0	0	0	0	0	0	0
11.01.2017	2434	0	0	0	0	0	0	0	0	114	231	309	368	389	368	309	231	114	0	0	0	0	0	0	0
12.01.2017	2142	0	0	0	0	0	0	0	0	101	203	272	323	343	323	272	203	101	0	0	0	0	0	0	0
13.01.2017	1460	0	0	0	0	0	0	0	0	69	139	185	221	234	221	185	139	69	0	0	0	0	0	0	0
14.01.2017	3018	0	0	0	0	0	0	0	0	142	287	383	456	483	456	383	287	142	0	0	0	0	0	0	0
15.01.2017	1947	0	0	0	0	0	0	0	0	92	185	247	294	312	294	247	185	92	0	0	0	0	0	0	0
16.01.2017	3213	0	0	0	0	0	0	0	0	151	305	408	485	514	485	408	305	151	0	0	0	0	0	0	0
17.01.2017	3115	0	0	0	0	0	0	0	0	146	296	396	470	498	470	396	296	146	0	0	0	0	0	0	0
18.01.2017	2336	0	0	0	0	0	0	0	0	110	222	297	353	374	353	297	222	110	0	0	0	0	0	0	0
19.01.2017	2142	0	0	0	0	0	0	0	0	101	203	272	323	343	323	272	203	101	0	0	0	0	0	0	0
20.01.2017	3213	0	0	0	0	0	0	0	0	151	305	408	485	514	485	408	305	151	0	0	0	0	0	0	0
21.01.2017	3407	0	0	0	0	0	0	0	0	160	324	433	515	545	515	433	324	160	0	0	0	0	0	0	0
22.01.2017	3213	0	0	0	0	0	0	0	0	151	305	408	485	514	485	408	305	151	0	0	0	0	0	0	0
23.01.2017	2142	0	0	0	0	0	0	0	0	101	203	272	323	343	323	272	203	101	0	0	0	0	0	0	0
24.01.2017	2823	0	0	0	0	0	0	0	0	133	268	359	426	452	426	359	268	133	0	0	0	0	0	0	0
25.01.2017	3018	0	0	0	0	0	0	0	0	142	287	383	456	483	456	383	287	142	0	0	0	0	0	0	0
26.01.2017	2726	0	0	0	0	0	0	0	0	128	259	346	412	436	412	346	259	128	0	0	0	0	0	0	0
27.01.2017	1947	0	0	0	0	0	0	0	0	92	185	247	294	312	294	247	185	92	0	0	0	0	0	0	0
28.01.2017	1460	0	0	0	0	0	0	0	0	69	139	185	221	234	221	185	139	69	0	0	0	0	0	0	0
29.01.2017	1558	0	0	0	0	0	0	0	0	73	148	198	235	249	235	198	148	73	0	0	0	0	0	0	0
30.01.2017	1460	0	0	0	0	0	0	0	0	69	139	185	221	234	221	185	139	69	0	0	0	0	0	0	0
31.01.2017	1460	0	0	0	0	0	0	0	0	69	139	185	221	234	221	185	139	69	0	0	0	0	0	0	0
1.02.2017	1363	0	0	0	0	0	0	0	46	90	125	155	173	183	173	155	125	90	46	0	0	0	0	0	0
2.02.2017	3894	0	0	0	0	0	0	0	132	257	358	444	495	522	495	444	358	257	132	0	0	0	0	0	0
3.02.2017	3991	0	0	0	0	0	0	0	136	263	367	455	507	535	507	455	367	263	136	0	0	0	0	0	0
4.02.2017	3310	0	0	0	0	0	0	0	113	218	305	377	420	444	420	377	305	218	113	0	0	0	0	0	0
5.02.2017	3991	0	0	0	0	0	0	0	136	263	367	455	507	535	507	455	367	263	136	0	0	0	0	0	0
6.02.2017	1850	0	0	0	0	0	0	0	63	122	170	211	235	248	235	211	170	122	63	0	0	0	0	0	0
7.02.2017	2531	0	0	0	0	0	0	0	86	167	233	289	321	339	321	289	233	167	86	0	0	0	0	0	0
8.02.2017	2629	0	0	0	0	0	0	0	89	173	242	300	334	352	334	300	242	173	89	0	0	0	0	0	0
9.02.2017	3602	0	0	0	0	0	0	0	122	238	331	411	457	483	457	411	331	238	122	0	0	0	0	0	0
10.02.2017	3602	0	0	0	0	0	0	0	122	238	331	411	457	483	457	411	331	238	122	0	0	0	0	0	0
11.02.2017	2629	0	0	0	0	0	0	0	89	173	242	300	334	352	334	300	242	173	89	0	0	0	0	0	0
12.02.2017	3797	0	0	0	0	0	0	0	129	251	349	433	482	509	482	433	349	251	129	0	0	0	0	0	0
13.02.2017	4576	0	0	0	0	0	0	0	156	302	421	522	581	613	581	522	421	302	156	0	0	0	0	0	0
14.02.2017	4284	0	0	0	0	0	0	0	146	283	394	488	544	574	544	488	394	283	146	0	0	0	0	0	0
15.02.2017	2531	0	0	0	0	0	0	0	86	167	233	289	321	339	321	289	233	167	86	0	0	0	0	0	0
16.02.2017	2142	0	0	0	0	0	0	0	73	141	197	244	272	287	272	244	197	141	73	0	0	0	0	0	0
17.02.2017	3407	0	0	0	0	0	0	0	116	225	313	388	433	457	433	388	313	225	116	0	0	0	0	0	0
18.02.2017	1363	0	0	0	0	0	0	0	46	90	125	155	173	183	173	155	125	90	46	0	0	0	0	0	0
19.02.2017	3991	0	0	0	0	0	0	0	136	263	367	455	507	535	507	455	367	263	136	0	0	0	0	0	0
20.02.2017	2044	0	0	0	0	0	0	0	70	135	188	233	260	274	260	233	188	135	70	0	0	0	0	0	0
21.02.2017	3407	0	0	0	0	0	0	0	116	225	313	388	433	457	433	388	313	225	116	0	0	0	0	0	0
22.02.2017	779	0	0	0	0	0	0	0	26	51	72	89	99	104	99	89	72	51	26	0	0	0	0	0	0
23.02.2017	3407	0	0	0	0	0	0	0	116	225	313	388	433	457	433	388	313	225	116	0	0	0	0	0	0
24.02.2017	4770	0	0	0	0	0	0	0	162	315	439	544	606	639	606	544	439	315	162	0	0	0	0	0	0
25.02.2017	4284	0	0	0	0	0	0	0	146	283	394	488	544	574	544	488	394	283	146	0	0	0	0	0	0
26.02.2017	4965	0	0	0	0	0	0	0	169	328	457	566	631	665	631	566	457	328	169	0	0	0	0	0	0
27.02.2017	4965	0	0	0	0	0	0	0	169	328	457	566	631	665	631	566	457	328	169	0	0	0	0	0	0
28.02.2017	1363	0	0	0	0	0	0	0	46	90	125	155	173	183	173	155	125	90	46	0	0	0	0	0	0
1.03.2017	2434	0	0	0	0	0	0	0	83	161	224	277	309	326	309	277	224	161	83	0	0	0	0	0	0
2.03.2017	5549	0	0	0	0	0	0	0	189	366	511	633	705	744	705	633	511	366	189	0	0	0	0	0	0
3.03.2017	3407	0	0	0	0	0	0	0	116	225	313	388	433	457	433	388	313	225	116	0	0	0	0	0	0
4.03.2017	1850	0	0	0	0	0	0	0	63	122	170	211	235	248	235	211	170	122	63	0	0	0	0	0	0
5.03.2017	4381	0	0	0	0	0	0	0	149	289	403	499	556	587	556	499	403	289	149	0	0	0	0	0	0
6.03.2017	5646	0	0	0	0	0	0	0	192	373	519	644	717	757	717	644	519	373	192	0	0	0	0	0	0
7.03.2017	4284	0	0	0	0	0	0	0	146	283	394	488	544	574	544	488	394	283	146	0	0	0	0	0	0
8.03.2017	2629	0	0	0	0	0	0	0	89	173	242	300	334	352	334	300	242	173	89	0	0	0	0	0	0
9.03.2017	4089	0	0	0	0	0	0	0	139	270	376	466	519	548	519	466	376	270	139	0	0	0	0	0	0
10.03.2017	4868	0	0	0	0	0	0	0	165	321	448	555	618	652	618	555	448	321	165	0	0	0	0	0	0
11.03.2017	4186	0	0	0	0	0	0	0	142	276	385	477	532	561	532	477	385	276	142	0	0	0	0	0	0
12.03.2017	3213	0	0	0	0	0	0	0	109	212	296	366	408	430	408	366	296	212	109	0	0	0	0	0	0
13.03.2017	5160	0	0	0	0	0	0	0	175	341	475	588	655	691	655	588	475	341	175	0	0	0	0	0	0
14.03.2017	4868	0	0	0	0	0	0	0	165	321	448	555	618	652	618	555	448	321	165	0	0	0	0	0	0
15.03.2017	3699	0	0	0	0	0	0	0	126	244	340	422	470	496	470	422	340	244	126	0	0	0	0	0	0
16.03.2017	5062	0	0	0	0	0	0	0	172	334	466	577	643	678	643	577	466	334	172	0	0	0	0	0	0
17.03.2017	3797	0	0	0	0	0	0	0	129	251	349	433	482	509	482	433	349	251	129	0	0	0	0	0	0
18.03.2017	6133	0	0	0	0	0	0	0	209	405	564	699	779	822	779	699	564	405	209	0	0	0	0	0	0
19.03.2017	4576	0	0	0	0	0	0	0	156	302	421	522	581	613	581	522	421	302	156	0	0	0	0	0	0
20.03.2017	5939	0	0	0	0	0	0	0	202	392	546	677	754	796	754	677	546	392	202	0	0	0	0	0	0
21.03.2017	5062	0	0	0	0	0	0	0	172	334	466	577	643	678	643	577	466	334	172	0	0	0	0	0	0
22.03.2017	2726	0	0	0	0	0	0	0	93	180	251	311	346	365	346	311	251	180	93	0	0	0	0	0	0
23.03.2017	3213	0	0	0	0	0	0	0	109	212	296	366	408	430	408	366	296	212	109	0	0	0	0	0	0
24.03.2017	6620	0	0	0	0	0	0	0	225	437	609	755	841	887	841	755	609	437	225	0	0	0	0	0	0
25.03.2017	5354	0	0	0	0	0	0	0	182	353	493	610	680	717	680	610	493	353	182	0	0	0	0	0	0
26.03.2017	3018	0	0	0	0	0	0	0	103	199	278	344	383	404	383	344	278	199	103	0	0	0	0	0	0
27.03.2017	5549	0	0	0	0	0	0	0	189	366	511	633	705	744	705	633	511	366	189	0	0	0	0	0	0
28.03.2017	3797	0	0	0	0	0	0	0	129	251	349	433	482	509	482	433	349	251	129	0	0	0	0	0	0
29.03.2017	5257	0	0	0	0	0	0	0	179	347	484	599	668	704	668	599	484	347	179	0	0	0	0	0	0
30.03.2017	5354	0	0	0	0	0	0	0	182	353	493	610	680	717	680	610	493	353	182	0	0	0	0	0	0
31.03.2017	3505	0	0	0	0	0	0	0	119	231	322	400	445	470	445	400	322	231	119	0	0	0	0	0	0
1.04.2017	4478	0	0	0	0	0	0	0	152	296	412	511	569	600	569	511	412	296	152	0	0	0	0	0	0
2.04.2017	5452	0	0	0	0	0	0	0	185	360	502	621	692	731	692	621	502	360	185	0	0	0	0	0	0
3.04.2017	2239	0	0	0	0	0	0	0	76	148	206	255	284	300	284	255	206	148	76	0	0	0	0	0	0
4.04.2017	1850	0	0	0	0	0	0	0	63	122	170	211	235	248	235	211	170	122	63	0	0	0	0	0	0
5.04.2017	6036	0	0	0	0	0	0	0	205	398	555	688	767	809	767	688	555	398	205	0	0	0	0	0	0
6.04.2017	6717	0	0	0	0	0	0	0	228	443	618	766	853	900	853	766	618	443	228	0	0	0	0	0	0
7.04.2017	6133	0	0	0	0	0	0	0	209	405	564	699	779	822	779	699	564	405	209	0	0	0	0	0	0
8.04.2017	5160	0	0	0	0	0	0	0	175	341	475	588	655	691	655	588	475	341	175	0	0	0	0	0	0
9.04.2017	4673	0	0	0	0	0	0	0	159	308	430	533	593	626	593	533	430	308	159	0	0	0	0	0	0
10.04.2017	6328	0	0	0	0	0	0	0	215	418	582	721	804	848	804	721	582	418	215	0	0	0	0	0	0
11.04.2017	6523	0	0	0	0	0	0	0	222	430	600	744	828	874	828	744	600	430	222	0	0	0	0	0	0
12.04.2017	6523	0	0	0	0	0	0	0	222	430	600	744	828	874	828	744	600	430	222	0	0	0	0	0	0
13.04.2017	7009	0	0	0	0	0	0	0	238	463	645	799	890	939	890	799	645	463	238	0	0	0	0	0	0
14.04.2017	6523	0	0	0	0	0	0	0	222	430	600	744	828	874	828	744	600	430	222	0	0	0	0	0	0
15.04.2017	4478	0	0	0	0	0	0	0	152	296	412	511	569	600	569	511	412	296	152	0	0	0	0	0	0
16.04.2017	2336	0	0	0	0	0	0	0	79	154	215	266	297	313	297	266	215	154	79	0	0	0	0	0	0
17.04.2017	2044	0	0	0	0	0	0	0	70	135	188	233	260	274	260	233	188	135	70	0	0	0	0	0	0
18.04.2017	2336	0	0	0	0	0	0	0	79	154	215	266	297	313	297	266	215	154	79	0	0	0	0	0	0
19.04.2017	3894	0	0	0	0	0	0	0	132	257	358	444	495	522	495	444	358	257	132	0	0	0	0	0	0
20.04.2017	3407	0	0	0	0	0	0	0	116	225	313	388	433	457	433	388	313	225	116	0	0	0	0	0	0
21.04.2017	4673	0	0	0	0	0	0	0	159	308	430	533	593	626	593	533	430	308	159	0	0	0	0	0	0
22.04.2017	3115	0	0	0	0	0	0	0	106	206	287	355	396	417	396	355	287	206	106	0	0	0	0	0	0
23.04.2017	6620	0	0	0	0	0	0	0	225	437	609	755	841	887	841	755	609	437	225	0	0	0	0	0	0
24.04.2017	7691	0	0	0	0	0	0	0	261	508	708	877	977	1031	977	877	708	508	261	0	0	0	0	0	0
25.04.2017	7886	0	0	0	0	0	0	0	268	520	725	899	1001	1057	1001	899	725	520	268	0	0	0	0	0	0
26.04.2017	7691	0	0	0	0	0	0	0	261	508	708	877	977	1031	977	877	708	508	261	0	0	0	0	0	0
27.04.2017	7691	0	0	0	0	0	0	0	261	508	708	877	977	1031	977	877	708	508	261	0	0	0	0	0	0
28.04.2017	7788	0	0	0	0	0	0	0	265	514	717	888	989	1044	989	888	717	514	265	0	0	0	0	0	0
29.04.2017	7691	0	0	0	0	0	0	0	261	508	708	877	977	1031	977	877	708	508	261	0	0	0	0	0	0
30.04.2017	7496	0	0	0	0	0	0	0	255	495	690	855	952	1004	952	855	690	495	255	0	0	0	0	0	0

Total. MWh	1808,0	JAN.	64,3	FEB.	89,5	MAR.	135,2	APR.	162,5	MAY	217,2	JUN	243,1	JUL	240,4	AUG	225,6	SEP	189,9	OCT	121,3	NOV	58,5	DEC	60,7

Solar Generation kWh	Total Daily Gen.	00:00 00:59	01:00 01:59	02:00 02:59	03:00 03:59	04:00 04:59	05:00 05:59	06:00 06:59	07:00 07:59	08:00 08:59	09:00 09:59	10:00 10:59	11:00 11:59	12:00 12:59	13:00 13:59	14:00 14:59	15:00 15:59	16:00 16:59	17:00 17:59	18:00 18:59	19:00 19:59	20:00 20:59	21:00 21:59	22:00 22:59	23:00 23:59
1.05.2017	7691	0	0	0	0	0	0	192	377	546	684	777	838	861	838	777	684	546	377	192	0	0	0	0	0
2.05.2017	7593	0	0	0	0	0	0	190	372	539	676	767	828	850	828	767	676	539	372	190	0	0	0	0	0
3.05.2017	6912	0	0	0	0	0	0	173	339	491	615	698	753	774	753	698	615	491	339	173	0	0	0	0	0
4.05.2017	7496	0	0	0	0	0	0	187	367	532	667	757	817	840	817	757	667	532	367	187	0	0	0	0	0
5.05.2017	6912	0	0	0	0	0	0	173	339	491	615	698	753	774	753	698	615	491	339	173	0	0	0	0	0
6.05.2017	7691	0	0	0	0	0	0	192	377	546	684	777	838	861	838	777	684	546	377	192	0	0	0	0	0
7.05.2017	7788	0	0	0	0	0	0	195	382	553	693	787	849	872	849	787	693	553	382	195	0	0	0	0	0
8.05.2017	7399	0	0	0	0	0	0	185	363	525	658	747	806	829	806	747	658	525	363	185	0	0	0	0	0
9.05.2017	5160	0	0	0	0	0	0	129	253	366	459	521	562	578	562	521	459	366	253	129	0	0	0	0	0
10.05.2017	5939	0	0	0	0	0	0	148	291	422	529	600	647	665	647	600	529	422	291	148	0	0	0	0	0
11.05.2017	5549	0	0	0	0	0	0	139	272	394	494	560	605	621	605	560	494	394	272	139	0	0	0	0	0
12.05.2017	5354	0	0	0	0	0	0	134	262	380	477	541	584	600	584	541	477	380	262	134	0	0	0	0	0
13.05.2017	6815	0	0	0	0	0	0	170	334	484	607	688	743	763	743	688	607	484	334	170	0	0	0	0	0
14.05.2017	6328	0	0	0	0	0	0	158	310	449	563	639	690	709	690	639	563	449	310	158	0	0	0	0	0
15.05.2017	8372	0	0	0	0	0	0	209	410	594	745	846	913	938	913	846	745	594	410	209	0	0	0	0	0
16.05.2017	2726	0	0	0	0	0	0	68	134	194	243	275	297	305	297	275	243	194	134	68	0	0	0	0	0
17.05.2017	8762	0	0	0	0	0	0	219	429	622	780	885	955	981	955	885	780	622	429	219	0	0	0	0	0
18.05.2017	8664	0	0	0	0	0	0	217	425	615	771	875	944	970	944	875	771	615	425	217	0	0	0	0	0
19.05.2017	7301	0	0	0	0	0	0	183	358	518	650	737	796	818	796	737	650	518	358	183	0	0	0	0	0
20.05.2017	7399	0	0	0	0	0	0	185	363	525	658	747	806	829	806	747	658	525	363	185	0	0	0	0	0
21.05.2017	5939	0	0	0	0	0	0	148	291	422	529	600	647	665	647	600	529	422	291	148	0	0	0	0	0
22.05.2017	6912	0	0	0	0	0	0	173	339	491	615	698	753	774	753	698	615	491	339	173	0	0	0	0	0
23.05.2017	8178	0	0	0	0	0	0	204	401	581	728	826	891	916	891	826	728	581	401	204	0	0	0	0	0
24.05.2017	6912	0	0	0	0	0	0	173	339	491	615	698	753	774	753	698	615	491	339	173	0	0	0	0	0
25.05.2017	6425	0	0	0	0	0	0	161	315	456	572	649	700	720	700	649	572	456	315	161	0	0	0	0	0
26.05.2017	7593	0	0	0	0	0	0	190	372	539	676	767	828	850	828	767	676	539	372	190	0	0	0	0	0
27.05.2017	7399	0	0	0	0	0	0	185	363	525	658	747	806	829	806	747	658	525	363	185	0	0	0	0	0
28.05.2017	6523	0	0	0	0	0	0	163	320	463	581	659	711	731	711	659	581	463	320	163	0	0	0	0	0
29.05.2017	7788	0	0	0	0	0	0	195	382	553	693	787	849	872	849	787	693	553	382	195	0	0	0	0	0
30.05.2017	8080	0	0	0	0	0	0	202	396	574	719	816	881	905	881	816	719	574	396	202	0	0	0	0	0
31.05.2017	7593	0	0	0	0	0	0	190	372	539	676	767	828	850	828	767	676	539	372	190	0	0	0	0	0
1.06.2017	8080	0	0	0	0	0	0	202	396	574	719	816	881	905	881	816	719	574	396	202	0	0	0	0	0
2.06.2017	8664	0	0	0	0	0	0	217	425	615	771	875	944	970	944	875	771	615	425	217	0	0	0	0	0
3.06.2017	7788	0	0	0	0	0	0	195	382	553	693	787	849	872	849	787	693	553	382	195	0	0	0	0	0
4.06.2017	6620	0	0	0	0	0	0	165	324	470	589	669	722	741	722	669	589	470	324	165	0	0	0	0	0
5.06.2017	8567	0	0	0	0	0	0	214	420	608	762	865	934	960	934	865	762	608	420	214	0	0	0	0	0
6.06.2017	8859	0	0	0	0	0	0	221	434	629	788	895	966	992	966	895	788	629	434	221	0	0	0	0	0
7.06.2017	7399	0	0	0	0	0	0	185	363	525	658	747	806	829	806	747	658	525	363	185	0	0	0	0	0
8.06.2017	8859	0	0	0	0	0	0	221	434	629	788	895	966	992	966	895	788	629	434	221	0	0	0	0	0
9.06.2017	8956	0	0	0	0	0	0	224	439	636	797	905	976	1003	976	905	797	636	439	224	0	0	0	0	0
10.06.2017	8859	0	0	0	0	0	0	221	434	629	788	895	966	992	966	895	788	629	434	221	0	0	0	0	0
11.06.2017	8664	0	0	0	0	0	0	217	425	615	771	875	944	970	944	875	771	615	425	217	0	0	0	0	0
12.06.2017	8664	0	0	0	0	0	0	217	425	615	771	875	944	970	944	875	771	615	425	217	0	0	0	0	0
13.06.2017	8664	0	0	0	0	0	0	217	425	615	771	875	944	970	944	875	771	615	425	217	0	0	0	0	0
14.06.2017	8567	0	0	0	0	0	0	214	420	608	762	865	934	960	934	865	762	608	420	214	0	0	0	0	0
15.06.2017	8275	0	0	0	0	0	0	207	405	588	736	836	902	927	902	836	736	588	405	207	0	0	0	0	0
16.06.2017	7691	0	0	0	0	0	0	192	377	546	684	777	838	861	838	777	684	546	377	192	0	0	0	0	0
17.06.2017	8372	0	0	0	0	0	0	209	410	594	745	846	913	938	913	846	745	594	410	209	0	0	0	0	0
18.06.2017	8956	0	0	0	0	0	0	224	439	636	797	905	976	1003	976	905	797	636	439	224	0	0	0	0	0
19.06.2017	8859	0	0	0	0	0	0	221	434	629	788	895	966	992	966	895	788	629	434	221	0	0	0	0	0
20.06.2017	8567	0	0	0	0	0	0	214	420	608	762	865	934	960	934	865	762	608	420	214	0	0	0	0	0
21.06.2017	6523	0	0	0	0	0	0	163	320	463	581	659	711	731	711	659	581	463	320	163	0	0	0	0	0
22.06.2017	6425	0	0	0	0	0	0	161	315	456	572	649	700	720	700	649	572	456	315	161	0	0	0	0	0
23.06.2017	7496	0	0	0	0	0	0	187	367	532	667	757	817	840	817	757	667	532	367	187	0	0	0	0	0
24.06.2017	8178	0	0	0	0	0	0	204	401	581	728	826	891	916	891	826	728	581	401	204	0	0	0	0	0
25.06.2017	7788	0	0	0	0	0	0	195	382	553	693	787	849	872	849	787	693	553	382	195	0	0	0	0	0
26.06.2017	7496	0	0	0	0	0	0	187	367	532	667	757	817	840	817	757	667	532	367	187	0	0	0	0	0
27.06.2017	7107	0	0	0	0	0	0	178	348	505	632	718	775	796	775	718	632	505	348	178	0	0	0	0	0
28.06.2017	6425	0	0	0	0	0	0	161	315	456	572	649	700	720	700	649	572	456	315	161	0	0	0	0	0
29.06.2017	8859	0	0	0	0	0	0	221	434	629	788	895	966	992	966	895	788	629	434	221	0	0	0	0	0
30.06.2017	8859	0	0	0	0	0	0	221	434	629	788	895	966	992	966	895	788	629	434	221	0	0	0	0	0
1.07.2017	8956	0	0	0	0	0	0	224	439	636	797	905	976	1003	976	905	797	636	439	224	0	0	0	0	0
2.07.2017	8567	0	0	0	0	0	0	214	420	608	762	865	934	960	934	865	762	608	420	214	0	0	0	0	0
3.07.2017	6328	0	0	0	0	0	0	158	310	449	563	639	690	709	690	639	563	449	310	158	0	0	0	0	0
4.07.2017	8664	0	0	0	0	0	0	217	425	615	771	875	944	970	944	875	771	615	425	217	0	0	0	0	0
5.07.2017	8372	0	0	0	0	0	0	209	410	594	745	846	913	938	913	846	745	594	410	209	0	0	0	0	0
6.07.2017	8372	0	0	0	0	0	0	209	410	594	745	846	913	938	913	846	745	594	410	209	0	0	0	0	0
7.07.2017	7399	0	0	0	0	0	0	185	363	525	658	747	806	829	806	747	658	525	363	185	0	0	0	0	0
8.07.2017	7691	0	0	0	0	0	0	192	377	546	684	777	838	861	838	777	684	546	377	192	0	0	0	0	0
9.07.2017	5841	0	0	0	0	0	0	146	286	415	520	590	637	654	637	590	520	415	286	146	0	0	0	0	0
10.07.2017	7301	0	0	0	0	0	0	183	358	518	650	737	796	818	796	737	650	518	358	183	0	0	0	0	0
11.07.2017	8470	0	0	0	0	0	0	212	415	601	754	855	923	949	923	855	754	601	415	212	0	0	0	0	0
12.07.2017	8470	0	0	0	0	0	0	212	415	601	754	855	923	949	923	855	754	601	415	212	0	0	0	0	0
13.07.2017	8372	0	0	0	0	0	0	209	410	594	745	846	913	938	913	846	745	594	410	209	0	0	0	0	0
14.07.2017	8275	0	0	0	0	0	0	207	405	588	736	836	902	927	902	836	736	588	405	207	0	0	0	0	0
15.07.2017	8567	0	0	0	0	0	0	214	420	608	762	865	934	960	934	865	762	608	420	214	0	0	0	0	0
16.07.2017	8567	0	0	0	0	0	0	214	420	608	762	865	934	960	934	865	762	608	420	214	0	0	0	0	0
17.07.2017	8275	0	0	0	0	0	0	207	405	588	736	836	902	927	902	836	736	588	405	207	0	0	0	0	0
18.07.2017	7983	0	0	0	0	0	0	200	391	567	710	806	870	894	870	806	710	567	391	200	0	0	0	0	0
19.07.2017	7983	0	0	0	0	0	0	200	391	567	710	806	870	894	870	806	710	567	391	200	0	0	0	0	0
20.07.2017	7593	0	0	0	0	0	0	190	372	539	676	767	828	850	828	767	676	539	372	190	0	0	0	0	0
21.07.2017	6620	0	0	0	0	0	0	165	324	470	589	669	722	741	722	669	589	470	324	165	0	0	0	0	0
22.07.2017	7788	0	0	0	0	0	0	195	382	553	693	787	849	872	849	787	693	553	382	195	0	0	0	0	0
23.07.2017	7983	0	0	0	0	0	0	200	391	567	710	806	870	894	870	806	710	567	391	200	0	0	0	0	0
24.07.2017	7691	0	0	0	0	0	0	192	377	546	684	777	838	861	838	777	684	546	377	192	0	0	0	0	0
25.07.2017	7691	0	0	0	0	0	0	192	377	546	684	777	838	861	838	777	684	546	377	192	0	0	0	0	0
26.07.2017	7691	0	0	0	0	0	0	192	377	546	684	777	838	861	838	777	684	546	377	192	0	0	0	0	0
27.07.2017	7496	0	0	0	0	0	0	187	367	532	667	757	817	840	817	757	667	532	367	187	0	0	0	0	0
28.07.2017	6133	0	0	0	0	0	0	153	301	435	546	619	669	687	669	619	546	435	301	153	0	0	0	0	0
29.07.2017	7593	0	0	0	0	0	0	190	372	539	676	767	828	850	828	767	676	539	372	190	0	0	0	0	0
30.07.2017	7301	0	0	0	0	0	0	183	358	518	650	737	796	818	796	737	650	518	358	183	0	0	0	0	0
31.07.2017	6328	0	0	0	0	0	0	158	310	449	563	639	690	709	690	639	563	449	310	158	0	0	0	0	0
1.08.2017	6717	0	0	0	0	0	0	0	228	443	618	766	853	900	853	766	618	443	228	0	0	0	0	0	0
2.08.2017	6912	0	0	0	0	0	0	0	235	456	636	788	878	926	878	788	636	456	235	0	0	0	0	0	0
3.08.2017	8080	0	0	0	0	0	0	0	275	533	743	921	1026	1083	1026	921	743	533	275	0	0	0	0	0	0
4.08.2017	7788	0	0	0	0	0	0	0	265	514	717	888	989	1044	989	888	717	514	265	0	0	0	0	0	0
5.08.2017	7496	0	0	0	0	0	0	0	255	495	690	855	952	1004	952	855	690	495	255	0	0	0	0	0	0
6.08.2017	6815	0	0	0	0	0	0	0	232	450	627	777	865	913	865	777	627	450	232	0	0	0	0	0	0
7.08.2017	7399	0	0	0	0	0	0	0	252	488	681	843	940	991	940	843	681	488	252	0	0	0	0	0	0
8.08.2017	6523	0	0	0	0	0	0	0	222	430	600	744	828	874	828	744	600	430	222	0	0	0	0	0	0
9.08.2017	7204	0	0	0	0	0	0	0	245	475	663	821	915	965	915	821	663	475	245	0	0	0	0	0	0
10.08.2017	7593	0	0	0	0	0	0	0	258	501	699	866	964	1018	964	866	699	501	258	0	0	0	0	0	0
11.08.2017	7593	0	0	0	0	0	0	0	258	501	699	866	964	1018	964	866	699	501	258	0	0	0	0	0	0
12.08.2017	7496	0	0	0	0	0	0	0	255	495	690	855	952	1004	952	855	690	495	255	0	0	0	0	0	0
13.08.2017	7593	0	0	0	0	0	0	0	258	501	699	866	964	1018	964	866	699	501	258	0	0	0	0	0	0
14.08.2017	7496	0	0	0	0	0	0	0	255	495	690	855	952	1004	952	855	690	495	255	0	0	0	0	0	0
15.08.2017	7399	0	0	0	0	0	0	0	252	488	681	843	940	991	940	843	681	488	252	0	0	0	0	0	0
16.08.2017	7496	0	0	0	0	0	0	0	255	495	690	855	952	1004	952	855	690	495	255	0	0	0	0	0	0
17.08.2017	7593	0	0	0	0	0	0	0	258	501	699	866	964	1018	964	866	699	501	258	0	0	0	0	0	0
18.08.2017	7691	0	0	0	0	0	0	0	261	508	708	877	977	1031	977	877	708	508	261	0	0	0	0	0	0
19.08.2017	7496	0	0	0	0	0	0	0	255	495	690	855	952	1004	952	855	690	495	255	0	0	0	0	0	0
20.08.2017	7593	0	0	0	0	0	0	0	258	501	699	866	964	1018	964	866	699	501	258	0	0	0	0	0	0
21.08.2017	7691	0	0	0	0	0	0	0	261	508	708	877	977	1031	977	877	708	508	261	0	0	0	0	0	0
22.08.2017	7496	0	0	0	0	0	0	0	255	495	690	855	952	1004	952	855	690	495	255	0	0	0	0	0	0
23.08.2017	7496	0	0	0	0	0	0	0	255	495	690	855	952	1004	952	855	690	495	255	0	0	0	0	0	0
24.08.2017	7691	0	0	0	0	0	0	0	261	508	708	877	977	1031	977	877	708	508	261	0	0	0	0	0	0
25.08.2017	7496	0	0	0	0	0	0	0	255	495	690	855	952	1004	952	855	690	495	255	0	0	0	0	0	0
26.08.2017	7204	0	0	0	0	0	0	0	245	475	663	821	915	965	915	821	663	475	245	0	0	0	0	0	0
27.08.2017	6912	0	0	0	0	0	0	0	235	456	636	788	878	926	878	788	636	456	235	0	0	0	0	0	0
28.08.2017	6425	0	0	0	0	0	0	0	218	424	591	732	816	861	816	732	591	424	218	0	0	0	0	0	0
29.08.2017	4770	0	0	0	0	0	0	0	162	315	439	544	606	639	606	544	439	315	162	0	0	0	0	0	0
30.08.2017	7204	0	0	0	0	0	0	0	245	475	663	821	915	965	915	821	663	475	245	0	0	0	0	0	0
31.08.2017	7204	0	0	0	0	0	0	0	245	475	663	821	915	965	915	821	663	475	245	0	0	0	0	0	0

Total. MWh	1808,0	JAN.	64,3	FEB.	89,5	MAR.	135,2	APR.	162,5	MAY	217,2	JUN	243,1	JUL	240,4	AUG	225,6	SEP	189,9	OCT	121,3	NOV	58,5	DEC	60,7

Solar Generation kWh	Total Daily Gen.	00:00 00:59	01:00 01:59	02:00 02:59	03:00 03:59	04:00 04:59	05:00 05:59	06:00 06:59	07:00 07:59	08:00 08:59	09:00 09:59	10:00 10:59	11:00 11:59	12:00 12:59	13:00 13:59	14:00 14:59	15:00 15:59	16:00 16:59	17:00 17:59	18:00 18:59	19:00 19:59	20:00 20:59	21:00 21:59	22:00 22:59	23:00 23:59
1.09.2017	7107	0	0	0	0	0	0	0	242	469	654	810	903	952	903	810	654	469	242	0	0	0	0	0	0
2.09.2017	6620	0	0	0	0	0	0	0	225	437	609	755	841	887	841	755	609	437	225	0	0	0	0	0	0
3.09.2017	6912	0	0	0	0	0	0	0	235	456	636	788	878	926	878	788	636	456	235	0	0	0	0	0	0
4.09.2017	7009	0	0	0	0	0	0	0	238	463	645	799	890	939	890	799	645	463	238	0	0	0	0	0	0
5.09.2017	7009	0	0	0	0	0	0	0	238	463	645	799	890	939	890	799	645	463	238	0	0	0	0	0	0
6.09.2017	6912	0	0	0	0	0	0	0	235	456	636	788	878	926	878	788	636	456	235	0	0	0	0	0	0
7.09.2017	6815	0	0	0	0	0	0	0	232	450	627	777	865	913	865	777	627	450	232	0	0	0	0	0	0
8.09.2017	6523	0	0	0	0	0	0	0	222	430	600	744	828	874	828	744	600	430	222	0	0	0	0	0	0
9.09.2017	6523	0	0	0	0	0	0	0	222	430	600	744	828	874	828	744	600	430	222	0	0	0	0	0	0
10.09.2017	6620	0	0	0	0	0	0	0	225	437	609	755	841	887	841	755	609	437	225	0	0	0	0	0	0
11.09.2017	6620	0	0	0	0	0	0	0	225	437	609	755	841	887	841	755	609	437	225	0	0	0	0	0	0
12.09.2017	6523	0	0	0	0	0	0	0	222	430	600	744	828	874	828	744	600	430	222	0	0	0	0	0	0
13.09.2017	6620	0	0	0	0	0	0	0	225	437	609	755	841	887	841	755	609	437	225	0	0	0	0	0	0
14.09.2017	6425	0	0	0	0	0	0	0	218	424	591	732	816	861	816	732	591	424	218	0	0	0	0	0	0
15.09.2017	6328	0	0	0	0	0	0	0	215	418	582	721	804	848	804	721	582	418	215	0	0	0	0	0	0
16.09.2017	6231	0	0	0	0	0	0	0	212	411	573	710	791	835	791	710	573	411	212	0	0	0	0	0	0
17.09.2017	6425	0	0	0	0	0	0	0	218	424	591	732	816	861	816	732	591	424	218	0	0	0	0	0	0
18.09.2017	6328	0	0	0	0	0	0	0	215	418	582	721	804	848	804	721	582	418	215	0	0	0	0	0	0
19.09.2017	6231	0	0	0	0	0	0	0	212	411	573	710	791	835	791	710	573	411	212	0	0	0	0	0	0
20.09.2017	5646	0	0	0	0	0	0	0	192	373	519	644	717	757	717	644	519	373	192	0	0	0	0	0	0
21.09.2017	5744	0	0	0	0	0	0	0	195	379	528	655	729	770	729	655	528	379	195	0	0	0	0	0	0
22.09.2017	5939	0	0	0	0	0	0	0	202	392	546	677	754	796	754	677	546	392	202	0	0	0	0	0	0
23.09.2017	6133	0	0	0	0	0	0	0	209	405	564	699	779	822	779	699	564	405	209	0	0	0	0	0	0
24.09.2017	6231	0	0	0	0	0	0	0	212	411	573	710	791	835	791	710	573	411	212	0	0	0	0	0	0
25.09.2017	6036	0	0	0	0	0	0	0	205	398	555	688	767	809	767	688	555	398	205	0	0	0	0	0	0
26.09.2017	6036	0	0	0	0	0	0	0	205	398	555	688	767	809	767	688	555	398	205	0	0	0	0	0	0
27.09.2017	5939	0	0	0	0	0	0	0	202	392	546	677	754	796	754	677	546	392	202	0	0	0	0	0	0
28.09.2017	5744	0	0	0	0	0	0	0	195	379	528	655	729	770	729	655	528	379	195	0	0	0	0	0	0
29.09.2017	5452	0	0	0	0	0	0	0	185	360	502	621	692	731	692	621	502	360	185	0	0	0	0	0	0
30.09.2017	5257	0	0	0	0	0	0	0	179	347	484	599	668	704	668	599	484	347	179	0	0	0	0	0	0
1.10.2017	1460	0	0	0	0	0	0	0	50	96	134	166	185	196	185	166	134	96	50	0	0	0	0	0	0
2.10.2017	3699	0	0	0	0	0	0	0	126	244	340	422	470	496	470	422	340	244	126	0	0	0	0	0	0
3.10.2017	4868	0	0	0	0	0	0	0	165	321	448	555	618	652	618	555	448	321	165	0	0	0	0	0	0
4.10.2017	5257	0	0	0	0	0	0	0	179	347	484	599	668	704	668	599	484	347	179	0	0	0	0	0	0
5.10.2017	5062	0	0	0	0	0	0	0	172	334	466	577	643	678	643	577	466	334	172	0	0	0	0	0	0
6.10.2017	4186	0	0	0	0	0	0	0	142	276	385	477	532	561	532	477	385	276	142	0	0	0	0	0	0
7.10.2017	2921	0	0	0	0	0	0	0	99	193	269	333	371	391	371	333	269	193	99	0	0	0	0	0	0
8.10.2017	4965	0	0	0	0	0	0	0	169	328	457	566	631	665	631	566	457	328	169	0	0	0	0	0	0
9.10.2017	2823	0	0	0	0	0	0	0	96	186	260	322	359	378	359	322	260	186	96	0	0	0	0	0	0
10.10.2017	2823	0	0	0	0	0	0	0	96	186	260	322	359	378	359	322	260	186	96	0	0	0	0	0	0
11.10.2017	3407	0	0	0	0	0	0	0	116	225	313	388	433	457	433	388	313	225	116	0	0	0	0	0	0
12.10.2017	5062	0	0	0	0	0	0	0	172	334	466	577	643	678	643	577	466	334	172	0	0	0	0	0	0
13.10.2017	4965	0	0	0	0	0	0	0	169	328	457	566	631	665	631	566	457	328	169	0	0	0	0	0	0
14.10.2017	5160	0	0	0	0	0	0	0	175	341	475	588	655	691	655	588	475	341	175	0	0	0	0	0	0
15.10.2017	4965	0	0	0	0	0	0	0	169	328	457	566	631	665	631	566	457	328	169	0	0	0	0	0	0
16.10.2017	4965	0	0	0	0	0	0	0	169	328	457	566	631	665	631	566	457	328	169	0	0	0	0	0	0
17.10.2017	4770	0	0	0	0	0	0	0	162	315	439	544	606	639	606	544	439	315	162	0	0	0	0	0	0
18.10.2017	4868	0	0	0	0	0	0	0	165	321	448	555	618	652	618	555	448	321	165	0	0	0	0	0	0
19.10.2017	4673	0	0	0	0	0	0	0	159	308	430	533	593	626	593	533	430	308	159	0	0	0	0	0	0
20.10.2017	4576	0	0	0	0	0	0	0	156	302	421	522	581	613	581	522	421	302	156	0	0	0	0	0	0
21.10.2017	2434	0	0	0	0	0	0	0	83	161	224	277	309	326	309	277	224	161	83	0	0	0	0	0	0
22.10.2017	1655	0	0	0	0	0	0	0	56	109	152	189	210	222	210	189	152	109	56	0	0	0	0	0	0
23.10.2017	2629	0	0	0	0	0	0	0	89	173	242	300	334	352	334	300	242	173	89	0	0	0	0	0	0
24.10.2017	3894	0	0	0	0	0	0	0	132	257	358	444	495	522	495	444	358	257	132	0	0	0	0	0	0
25.10.2017	3310	0	0	0	0	0	0	0	113	218	305	377	420	444	420	377	305	218	113	0	0	0	0	0	0
26.10.2017	4089	0	0	0	0	0	0	0	139	270	376	466	519	548	519	466	376	270	139	0	0	0	0	0	0
27.10.2017	4478	0	0	0	0	0	0	0	152	296	412	511	569	600	569	511	412	296	152	0	0	0	0	0	0
28.10.2017	4089	0	0	0	0	0	0	0	139	270	376	466	519	548	519	466	376	270	139	0	0	0	0	0	0
29.10.2017	4186	0	0	0	0	0	0	0	142	276	385	477	532	561	532	477	385	276	142	0	0	0	0	0	0
30.10.2017	2823	0	0	0	0	0	0	0	96	186	260	322	359	378	359	322	260	186	96	0	0	0	0	0	0
31.10.2017	2239	0	0	0	0	0	0	0	76	148	206	255	284	300	284	255	206	148	76	0	0	0	0	0	0
1.11.2017	4186	0	0	0	0	0	0	0	0	197	398	532	632	670	632	532	398	197	0	0	0	0	0	0	0
2.11.2017	2336	0	0	0	0	0	0	0	0	110	222	297	353	374	353	297	222	110	0	0	0	0	0	0	0
3.11.2017	3505	0	0	0	0	0	0	0	0	165	333	445	529	561	529	445	333	165	0	0	0	0	0	0	0
4.11.2017	4089	0	0	0	0	0	0	0	0	192	388	519	617	654	617	519	388	192	0	0	0	0	0	0	0
5.11.2017	3797	0	0	0	0	0	0	0	0	178	361	482	573	607	573	482	361	178	0	0	0	0	0	0	0
6.11.2017	3894	0	0	0	0	0	0	0	0	183	370	495	588	623	588	495	370	183	0	0	0	0	0	0	0
7.11.2017	3407	0	0	0	0	0	0	0	0	160	324	433	515	545	515	433	324	160	0	0	0	0	0	0	0
8.11.2017	487	0	0	0	0	0	0	0	0	23	46	62	74	78	74	62	46	23	0	0	0	0	0	0	0
9.11.2017	681	0	0	0	0	0	0	0	0	32	65	87	103	109	103	87	65	32	0	0	0	0	0	0	0
10.11.2017	876	0	0	0	0	0	0	0	0	41	83	111	132	140	132	111	83	41	0	0	0	0	0	0	0
11.11.2017	487	0	0	0	0	0	0	0	0	23	46	62	74	78	74	62	46	23	0	0	0	0	0	0	0
12.11.2017	1363	0	0	0	0	0	0	0	0	64	129	173	206	218	206	173	129	64	0	0	0	0	0	0	0
13.11.2017	876	0	0	0	0	0	0	0	0	41	83	111	132	140	132	111	83	41	0	0	0	0	0	0	0
14.11.2017	2726	0	0	0	0	0	0	0	0	128	259	346	412	436	412	346	259	128	0	0	0	0	0	0	0
15.11.2017	1558	0	0	0	0	0	0	0	0	73	148	198	235	249	235	198	148	73	0	0	0	0	0	0	0
16.11.2017	1168	0	0	0	0	0	0	0	0	55	111	148	176	187	176	148	111	55	0	0	0	0	0	0	0
17.11.2017	1558	0	0	0	0	0	0	0	0	73	148	198	235	249	235	198	148	73	0	0	0	0	0	0	0
18.11.2017	681	0	0	0	0	0	0	0	0	32	65	87	103	109	103	87	65	32	0	0	0	0	0	0	0
19.11.2017	1168	0	0	0	0	0	0	0	0	55	111	148	176	187	176	148	111	55	0	0	0	0	0	0	0
20.11.2017	876	0	0	0	0	0	0	0	0	41	83	111	132	140	132	111	83	41	0	0	0	0	0	0	0
21.11.2017	779	0	0	0	0	0	0	0	0	37	74	99	118	125	118	99	74	37	0	0	0	0	0	0	0
22.11.2017	487	0	0	0	0	0	0	0	0	23	46	62	74	78	74	62	46	23	0	0	0	0	0	0	0
23.11.2017	584	0	0	0	0	0	0	0	0	27	55	74	88	93	88	74	55	27	0	0	0	0	0	0	0
24.11.2017	1168	0	0	0	0	0	0	0	0	55	111	148	176	187	176	148	111	55	0	0	0	0	0	0	0
25.11.2017	1363	0	0	0	0	0	0	0	0	64	129	173	206	218	206	173	129	64	0	0	0	0	0	0	0
26.11.2017	3407	0	0	0	0	0	0	0	0	160	324	433	515	545	515	433	324	160	0	0	0	0	0	0	0
27.11.2017	3310	0	0	0	0	0	0	0	0	156	314	420	500	530	500	420	314	156	0	0	0	0	0	0	0
28.11.2017	3407	0	0	0	0	0	0	0	0	160	324	433	515	545	515	433	324	160	0	0	0	0	0	0	0
29.11.2017	1460	0	0	0	0	0	0	0	0	69	139	185	221	234	221	185	139	69	0	0	0	0	0	0	0
30.11.2017	2823	0	0	0	0	0	0	0	0	133	268	359	426	452	426	359	268	133	0	0	0	0	0	0	0
1.12.2017	2239	0	0	0	0	0	0	0	0	105	213	284	338	358	338	284	213	105	0	0	0	0	0	0	0
2.12.2017	3115	0	0	0	0	0	0	0	0	146	296	396	470	498	470	396	296	146	0	0	0	0	0	0	0
3.12.2017	2044	0	0	0	0	0	0	0	0	96	194	260	309	327	309	260	194	96	0	0	0	0	0	0	0
4.12.2017	1460	0	0	0	0	0	0	0	0	69	139	185	221	234	221	185	139	69	0	0	0	0	0	0	0
5.12.2017	3213	0	0	0	0	0	0	0	0	151	305	408	485	514	485	408	305	151	0	0	0	0	0	0	0
6.12.2017	2921	0	0	0	0	0	0	0	0	137	277	371	441	467	441	371	277	137	0	0	0	0	0	0	0
7.12.2017	2726	0	0	0	0	0	0	0	0	128	259	346	412	436	412	346	259	128	0	0	0	0	0	0	0
8.12.2017	2239	0	0	0	0	0	0	0	0	105	213	284	338	358	338	284	213	105	0	0	0	0	0	0	0
9.12.2017	2921	0	0	0	0	0	0	0	0	137	277	371	441	467	441	371	277	137	0	0	0	0	0	0	0
10.12.2017	974	0	0	0	0	0	0	0	0	46	92	124	147	156	147	124	92	46	0	0	0	0	0	0	0
11.12.2017	1947	0	0	0	0	0	0	0	0	92	185	247	294	312	294	247	185	92	0	0	0	0	0	0	0
12.12.2017	1168	0	0	0	0	0	0	0	0	55	111	148	176	187	176	148	111	55	0	0	0	0	0	0	0
13.12.2017	1266	0	0	0	0	0	0	0	0	59	120	161	191	202	191	161	120	59	0	0	0	0	0	0	0
14.12.2017	2239	0	0	0	0	0	0	0	0	105	213	284	338	358	338	284	213	105	0	0	0	0	0	0	0
15.12.2017	3407	0	0	0	0	0	0	0	0	160	324	433	515	545	515	433	324	160	0	0	0	0	0	0	0
16.12.2017	1752	0	0	0	0	0	0	0	0	82	166	223	265	280	265	223	166	82	0	0	0	0	0	0	0
17.12.2017	1168	0	0	0	0	0	0	0	0	55	111	148	176	187	176	148	111	55	0	0	0	0	0	0	0
18.12.2017	487	0	0	0	0	0	0	0	0	23	46	62	74	78	74	62	46	23	0	0	0	0	0	0	0
19.12.2017	2434	0	0	0	0	0	0	0	0	114	231	309	368	389	368	309	231	114	0	0	0	0	0	0	0
20.12.2017	974	0	0	0	0	0	0	0	0	46	92	124	147	156	147	124	92	46	0	0	0	0	0	0	0
21.12.2017	584	0	0	0	0	0	0	0	0	27	55	74	88	93	88	74	55	27	0	0	0	0	0	0	0
22.12.2017	2044	0	0	0	0	0	0	0	0	96	194	260	309	327	309	260	194	96	0	0	0	0	0	0	0
23.12.2017	1363	0	0	0	0	0	0	0	0	64	129	173	206	218	206	173	129	64	0	0	0	0	0	0	0
24.12.2017	1752	0	0	0	0	0	0	0	0	82	166	223	265	280	265	223	166	82	0	0	0	0	0	0	0
25.12.2017	1168	0	0	0	0	0	0	0	0	55	111	148	176	187	176	148	111	55	0	0	0	0	0	0	0
26.12.2017	3018	0	0	0	0	0	0	0	0	142	287	383	456	483	456	383	287	142	0	0	0	0	0	0	0
27.12.2017	2921	0	0	0	0	0	0	0	0	137	277	371	441	467	441	371	277	137	0	0	0	0	0	0	0
28.12.2017	2336	0	0	0	0	0	0	0	0	110	222	297	353	374	353	297	222	110	0	0	0	0	0	0	0
29.12.2017	1460	0	0	0	0	0	0	0	0	69	139	185	221	234	221	185	139	69	0	0	0	0	0	0	0
30.12.2017	1850	0	0	0	0	0	0	0	0	87	176	235	279	296	279	235	176	87	0	0	0	0	0	0	0
31.12.2017	1460	0	0	0	0	0	0	0	0	69	139	185	221	234	221	185	139	69	0	0	0	0	0	0	0