Norwegian University of
Science and Technology

Analysis of the Albanian Power System and its potential to become a green battery for Balkan Peninsula

Mariona Zhuri

Master's Thesis
Submission date:

June 2019

Supervisor: Alemayehu Gebremedhin

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Abstract

Living in a world with so many given resources from nature, we can change our way of living and improve the current situation that we have set ourselves. The delicate situation we are in, with climate change and global warming, requires immediate intervention from all over the world to reduce the release of greenhouse gases. Since carbon dioxide is one of these main gases, the emissions of which we can control, many environmentalists and politics focus on taking measures to reduce its release from human activities. That is why this master thesis is focused into renewable energy potential for improving the existing system of Albania, using modelling and optimization, through MODEST-model.

This Master thesis presents the status of the Albanian energy system, focused on electricity production and its potential to exploit new sources of energy to follow a sustainable future by fulfilling its domestic demand for energy and by increasing the chances to export. This paper points out the problems of the energy system in the

Republic of Albania and at the same time analyzes the potentials of possible developments in the energy sector. Analyzing and proposing energy models and scenarios are at the core of this thesis, proposing possible solutions to optimize the system. All the results are done with the help of the MODEST model, which is an energy-system optimization.

New scenarios are proposed to be added into the Albanian Power System. By using the system analysis method, and the quantitative methodology, a reference scenario was created, based on the existing power system of the country. A model was set up by considering an appropriate time division, all the generating capacities in the power system, the annual power production for 2017, the efficiency of the plants and many other necessary data. All of the new model proposals were focused on the unexploited potential of renewable energy sources of Albania, with the purpose to create a new stable and green power system.

Acknowledgments

I wish to express my deep appreciation to my supervisor,

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List of Abbreviations (or Symbols)

EU	Europe Union
DPI	Dots per inches
NTNU	The Norwegian University of Science and Technology
PDF	Portable Document Format
IEA	International Energy Agency
ERE	Energy Regulatory Agency (Albania)
KESH	Albanian Electro-energetic Corporation
IRENA	International Renewable Energy Agency
BP	British Petroleum
MTOE	Million Tons of Oil Equivalent
PV	Photo Voltaic
OST	Transmission System Operator (Albania)
OSSHE	Electricity Distribution Operator (Albania)
RES	Renewable Energy Sources
MEUR	Million Euro
HVDC	High-voltage, direct current
HPP	Hydro Power Plant
SEEPEX	South East European Power Exchange
ENTSO-E	European Network of Transmission System Operators for Electricity
GEC	General Electric Company
NEA	National Energy Action
CO2	Carbon Dioxide
GHG	Greenhouse gases
KT	Kiloton
MT	Million Tons
MTE	Million Ton Equivalent
AC	Alternating Current
W	Watt
kW	Kilowatt
kWh	Kilowatt hour
TW	Terawatt
TWH	Terawatt hour
GW	Gigawatt
GWH	Gigawatt hour
MVA	Mega Volt Amp
KV	Kilo volt

1 Introduction

1.1 Background

One of the basic points that determines and points out the strategic importance of a country or region is energy. On the other hand, the energy sector occupies a special place in the growth and economic development of any country. One of the basic conditions to keep the economic engine moving constantly is the constant energy security. However, diversified production and energy security policies are one of the country's key security points. The most important challenges faced by the economic development of the countries today and the energy sector in particular are the increase in the consumption of energy per capita and at the same time a relatively lower level of energy intensity, which require the promotion of an efficient and competitive economy. All countries develop national energy strategies to meet their energy needs, as the economic development of a country depends directly on the development of its energy system. In the report “Energy the oxygen of the economy”, the author Peter Voser presents the importance of heat, light and power, in building and running the factories and cities to provide all the goods that we need. Surrounded by various available energy systems, the most popular form is electrical energy, because of the fact that it is easy to transport at high efficiency and reasonable cost from one place to the other.

The production of electricity in the world was 2.9% higher in 2016 than in 2015 (Agency, 2019) and it has grown stably since 1974. Its production comes from combustible fuels (63%), and renewable energy sources. According to IEA, in 2016 the major sector that consumed electricity was industry with a consumption of 8684 TWh, followed by transport and residential sector, respectively with 357 TWh and 5681 TWh. Electricity trade between neighboring countries has also increased in recent years with an average growth rate of 4% (Agency, 2019).

To provide a stable power system, it is important to carry out a detailed analysis of that system. The analysis of energy systems, especially in countries with low economic development is essential to ensure sustainability in one of the most important sectors of a society. Also, the concept of sustainability in the energy sector should be the main priority of a country's energy policies. Western Balkan countries, including Albania, facing great challenges, but at the same time with a tremendous potential for renewable energy exploitation, have the potential to improve their energy production situation, increasing the chances of securing a sustainable development for their countries (IRENA, 2017).

1.2 Problem description

Given the problems of the Albanian energy system, especially during certain periods of the year, this master thesis aims to analyze and provide possible optimization options for this system. Based on the ERE's annual report, in 2017 Albania could not yet meet the domestic electricity needs by importing a considerable amount of power. During 2017, the available electricity increased by 4.9%.Domestic electricity production during 2017 is 4.525 GWh, from 7.136 GWh of electricity produced in 2016, marking a decline of 36.6% (INSTAT, 2017).

With the decline in electricity production for 2017, all energy producers, such as public hydropower plants (-42.7%) and private and concessional power plants (-21.3%), have resulted. The fall in electricity production in 2017 has affected import growth and declining electricity exports. Gross imports (energy intake) increased by 86.3%, while the amount of gross exports (supply energy) decreased by 73.9% compared to 2016.

The main issue of this system, which makes it an unstable system, is the dependence on hydropower. This makes it dependent on hydrological conditions, thus endangering unpredictable electricity purchases, especially in dry periods of the year (summer-autumn), because of the limited generation capacities.

Another issue includes the location of the main hydropower plants, which generate the majority part of electricity. Fierza, Komani and Vau I Dejes are three biggest hydropower plants of the system, located in the north part of the country, while the largest consumption comes from the central and southern parts of the country.

The Albanian Market Model, broadly understood, is characterized by bilateral electricity contracts between market participants, where contracts and tariffs between different market participants are regulated, at their starting point (ERE). The larger producer of electricity in Albania is the state-owned company; Korporata Elektro-Energjitike Shqiptare, KESH. KESH cannot sell electricity in an open market. The price of imported and exported electricity is determined through auctions. The prices of power sold by KESH are very low and this makes it difficult for KESH to profit, or to make new investments to improve the power system.

1.3 Purpose

The aim of this master thesis is to evaluate, through system analysis, whether Albania has the potential and possibilities to cover its domestic demand for electricity and to be a green battery for Balkan. For this purpose, is used MODEST, which is an energy system optimization model, that formulates a linear programing model with objective and boundary functions, which later on will be solved by using CPLEX.

With a surface of 28748 km^2, a very favorable geographical position and natural sources, Albania has a high potential to exploit many renewable energy sources (CORDIS, 2016). The energy sources that can be exploited include bioenergy, with a total reserve of fuel wood that results to be 6Mtoe (CORDIS, 2016). Other bioenergy sources that can be used are animal residues, agricultural residues, and urban wastes, to produce bio fuels or electricity.

According to IRENA, from their "Cost-competitive renewable power generation; Potential across South East Europe", two other renewable energy sources with a very high potential are wind and solar energy, which in 2030 are estimated to have respectively a technical potential of 13653.9 GWh and 3706.3 GWh, while for biomass, the potential is estimated to be 11195 GWh.

Based on this unexploited potential, and on annual data gathered and analyzed, an existing reference scenario was created from the optimization for the existing system. Based on the existing system, new scenarios were proposed, including the expansion of generating capacities in the system, by adding new systems, which use renewable energy sources. The purpose of these new proposals is done to diversify the generating sources of electricity in the system, so that maybe it will not be dependent on imports. The question is whether the introduction of renewable energy sources will help to avoid unpredictable situations and dependence on imports, as well as to create a sustainable system with a potential to be a green battery for the area where it is located.

2 Review of the situation of energy sources and energy technologies in the world

2.1 Reserves of fossil fuels

We live in a world dependent on energy. Every action, process, production line and every important activity for mankind requires energy in order to take place, which is why the energy sector is considered to be the basis of the economic development of each country. To increase the security of supply with energy and optimize energy resources to meet the needs, with having sustainable development as the main goal of the whole economy for the future, countries develop energy policies. Restructuring energy systems requires significant measures to be taken, given that changes in the energy sector do not occur either spontaneously or for short periods.
More and more leaders from world politics, the business sector, media and civil society are reviewing the views of conventional experts about the world's energy future, as well as their common scenarios, and have begun serious quest for a more realistic approach. Their explanations are clear: the minimization of the impact on climate change requires a significant reduction in emissions of gases globally, as early as possible. Oil and gas companies are drilling deeper and deeper, demanding alternative sources, causing ecological and social damage. Coal is still easy to find, but its use is harmful due to the emission of gases that affect the climate. The future of the world cannot rely on fossil fuels anymore.

According to Knoema Corporation , from the latest BP Statistical Review of World Energy, global reserves of fossil fuels are respectively: 1,139 billion tons of coal, 187 trillion cubic meters of natural gas and 1,707 billion barrels of crude oil (KNOEMA, 2018). In their article "Review of fossil fuels and future energy technologies", the authors discuss the peaking of fossil fuels, which has become an unconventional academic debate so far. Based on two different views from the optimists and the pessimists, the first ones stand for the argument that oil will rise to peak in 2100 at the production rate of about 105 million barrels per day and then decline to 40 million barrels per day in 2400.

On the other hand, according to the pessimists, oil has already reached his peak in 2009 with a rate of 86 million barrels per day and by 2050 its global production will decrease to 40 million barrels per day. Other views from many scientists still argue that the world oil production has either reached its peak, or will reach it soon in the coming years, but experts are not clued in to the exact date yet. As the second, most popular fossil fuel, natural gas is also disposed to peak and depletion, and experts predict it will be within the same decade as of oil. As for coal, it is probable to reach its peak by 2035 at a rate of 3650 MTOE and then start declining to 1350 MTOE in 2070 (N.Khan, 2015).

On the other hand, the establishment of Sustainable Development in the center of the national policies and development strategies of many countries has led even more to the proliferation of technologies that use renewable resources for energy production.

2.2 Hydropower

According to the Energy Council, hydropower is supplying 71% of all renewable electricity and is the leading renewable source for the generation of electricity in the world.
The annual technical capacity of hydropower production is 14,576 TWh, but its total capacity potential is estimated to be 3,721 GW; currently the installed global hydropower capacity is much smaller than the potential, reaching 1,064 GW. China stands on top of the hydropower producing countries with an annual production of 96.9 Mtoe and it is followed by Brazil with 32.9 Mtoe per year and Canada with 32.3 Mtoe per year (Council, 2016). On top of the regions with the most hydropower installed capacity stands Asia with 511 GW and East Asia with 381 GW. Europe is the next region with a total installed capacity of 293 GW, followed by North America with 193 GW (Council, 2016).
Based on the International Hydropower Association, there are four hydropower typologies:

2.2.1 Run-of-river hydropower:

This typology is based on a structure that directs flowing water from a river through a canal that will then spin a turbine. Usually these types of hydropower do not have storage facilities, provide ongoing supply of electricity and flexible operations for daily demand variations (Association). The capacity factor of run-of-river hydropower varies between 0.4 and 0.8 and the main factor that affects it is the absence of a major reservoir. This may cause problems when it comes to running such systems, because in some cases may occur that the river's are depleted, usually because of drought and because of the absence of a dam that can store the water, there is no stored power (Farris, 2017). Differently, the absence of a reservoir in these systems, has a smaller impact on the environment, avoiding the inundates of dry land, changes of the water quality, effects on local communities, plants and animals (Farris, 2017).

2.2.2 Storage hydropower:

This typology of hydropower includes large systems that use dams to store water in a reservoir. The water released from the reservoir through a turbine, activates then a generator that produces electricity. The storage capacity offers the possibility to operate for many weeks independently of the hydrological flux. These systems can be also shut down and started up in a short notice period conforming to the change in demand (Association). Some additional benefits that these systems provide include also water supply, recreation, flood control, irrigation and navigation, making them multifunctional systems. They can also be used to store energy from other renewables like solar power and wind (Ånund Killingtveit, 2019).

2.2.3 Pumped-storage hydropower:

These systems generate energy by moving water between two reservoirs at different heights. At times of low demand for electricity, water is pumped to the upper reservoir, using energy from the system and during periods of high demands for electricity, it is released from the upper reservoir into the lower one, through turbines to produce electricity. Pumped-storage hydropower plants are one of the most cost-effective plants for grid energy storage, knowing as key providers of ancillary services (NHA).

2.2.4 Offshore hydropower:

The technologies of offshore hydropower systems use the power of waves or tidal currents to produce electricity from seawater. These are one of the less exploited group of hydropower systems, which is growing recently (Association). A common method used in these systems is called the barrage method and involves trapping water levels inside a basin, creating tidal lagoons and the difference into the water levels inside and outside of the lagoon creates a head, which then drives the turbines (Hydro).

2.3 Solar energy

2.3.1 Review of solar energy and solar energy technologies in the world

The increasing demand for energy and the reduction of non-renewable sources of energy has led to the development of renewable energy technologies to help increasing the energy production. One of the most potential sources of energy on planet Earth is solar energy. The average amount of solar energy received at Earth's atmosphere is around 342 W m^{-2}, of which ca. 30% is scattered or reflected to space, leaving ca. 70% (239 W m^{-2}) available for harvesting and capture.(Ki-HyunKim, 2018)

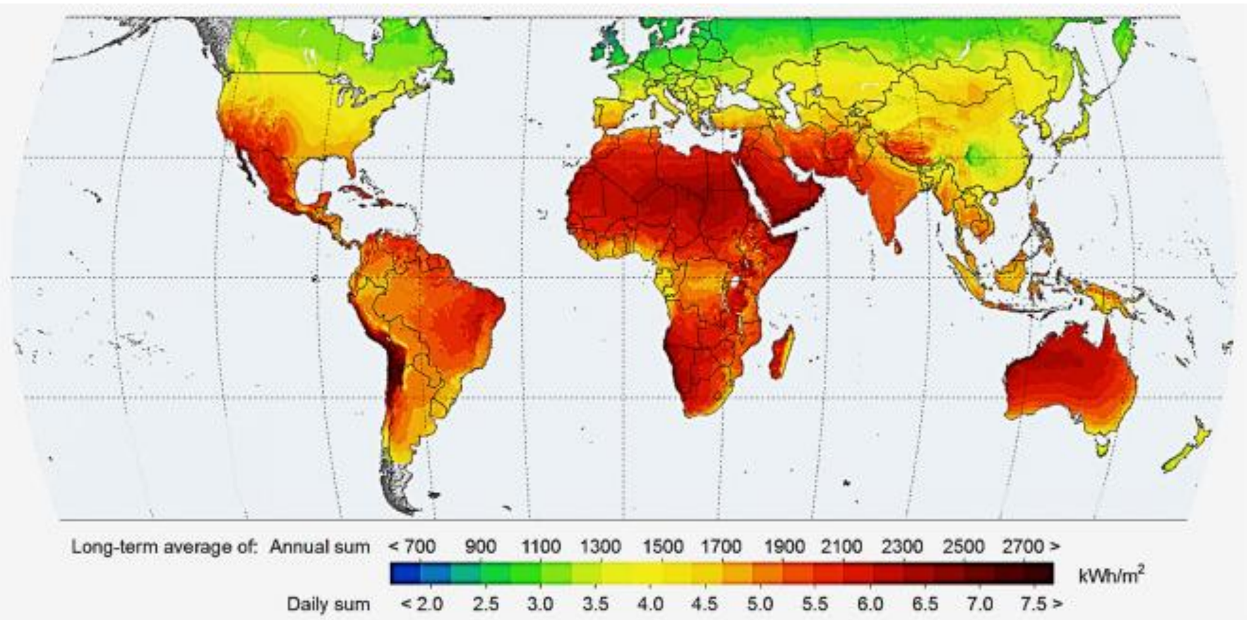


Figure 1: Global horizontal irradiation Source:(Ki-HyunKim, 2018)

Solar energy is a free source of energy, it is with endless possibilities of exploitation and it does not have any harmful impact on the environment or different ecosystems. This has led to the increased use of technologies that use the sun as the primary source of energy. Solar energy technologies use the energy from the sun and convert it into electricity by using Photo Voltaic systems, or into heat for water heating, by using Solar Water Heating Systems.

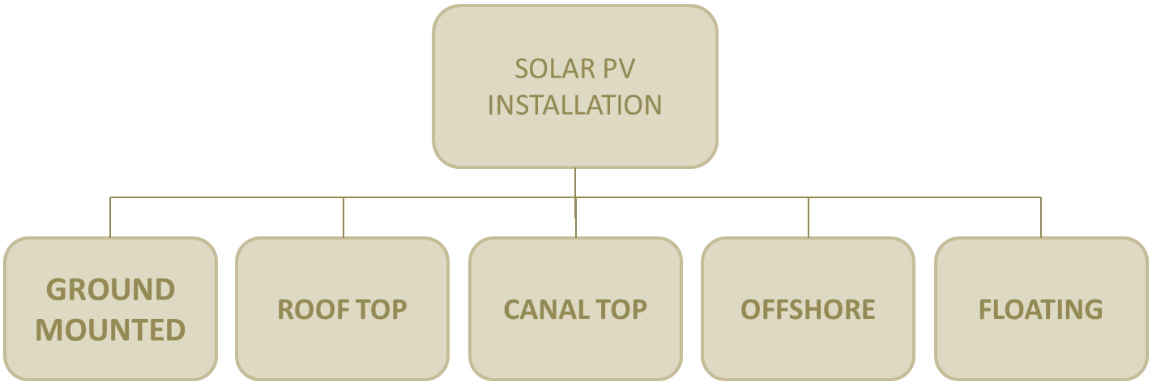


Figure 2:Types of solar PV installations; Source:(K.Sudhakar, 2016)

2.3.2 Ground mounted systems:

In cases when roof is not suitable to install solar panels, the solar PV system is mounted on the ground. In such systems, a frame out of galvanized steel or aluminum is built to tilt the solar cells up to an optimal angle. This frame is attached to the ground via a concrete foundation. These types of systems allow their installation in a larger area of land, have a lower cost when it comes to installing a sun tracking system and are easier to clean and maintain. However, they are limited when it comes to the space of land available, and the costs of installations are high owing to solid foundations and footings that must be built to resist during storms (Ramsdale, 2016).

2.3.3 Rooftop solar PV installations:

These systems (SWH or PV) are installed on the roof of the buildings when it is in a favorable position to catch the sunlight. They are smaller in size than the ground mounted systems and help the buildings to meet their electricity needs by producing electric power within an existing distribution network, allowing you to reduce the costs of the electric bills, however their installation costs are considerable (Doshi, 2017). They can be installed on residential buildings or commercial and industrial buildings, with a capacity ranging from 5 kWp-2MWp (ENERRAY, 2017). Solar panels can also be mounted on roof re-orientation brackets with mechanical solar tracking systems, to increase efficiency (Tonkin, 2019).

2.3.4 Canal top systems:

In canal top systems, the photovoltaic panels are placed above the water canal, by saving this way the installation area. These systems do not require additional cooling, because of the presence of the water in the canal. The evaporation of water in such installations and the use of large areas of land are also reduced. In order to improve the solar radiation and the optimum temperature of the panels, plane reflectors are often used (Deethumol Augustin, 2016). Some of their disadvantages include the high cost of construction and high maintenance difficulties.

2.3.5 Offshore PV Systems

include the installation solar photovoltaic panels on the sea surfaces to solve the problem of limited land usage (Dana, 2018). These systems do not require additional cooling as well, due to the presence of sea water, but the way directions have an influence on the system’s efficiency (C. Diendorfer, 2014). Such systems have a better performance, because of the lower PV cells temperature.

2.3.6 Floating Photo Voltaic Systems

Floating solar systems are systems that can be installed in water surfaces like reservoirs, oceans, lakes, dams, ponds etc. The idea behind these systems arises from the demand for solar panel installation from countries like Japan, Korea, Australia, USA and others, which do not have enough space for solar panel installations.(K.Sudhakar, 2016). The existing floating PV projects include conventional PV arrays, as well as concentrated PV arrays that benefit from the surrounding water body to prevent overheating of the solar cells.(Santafé, 2014).

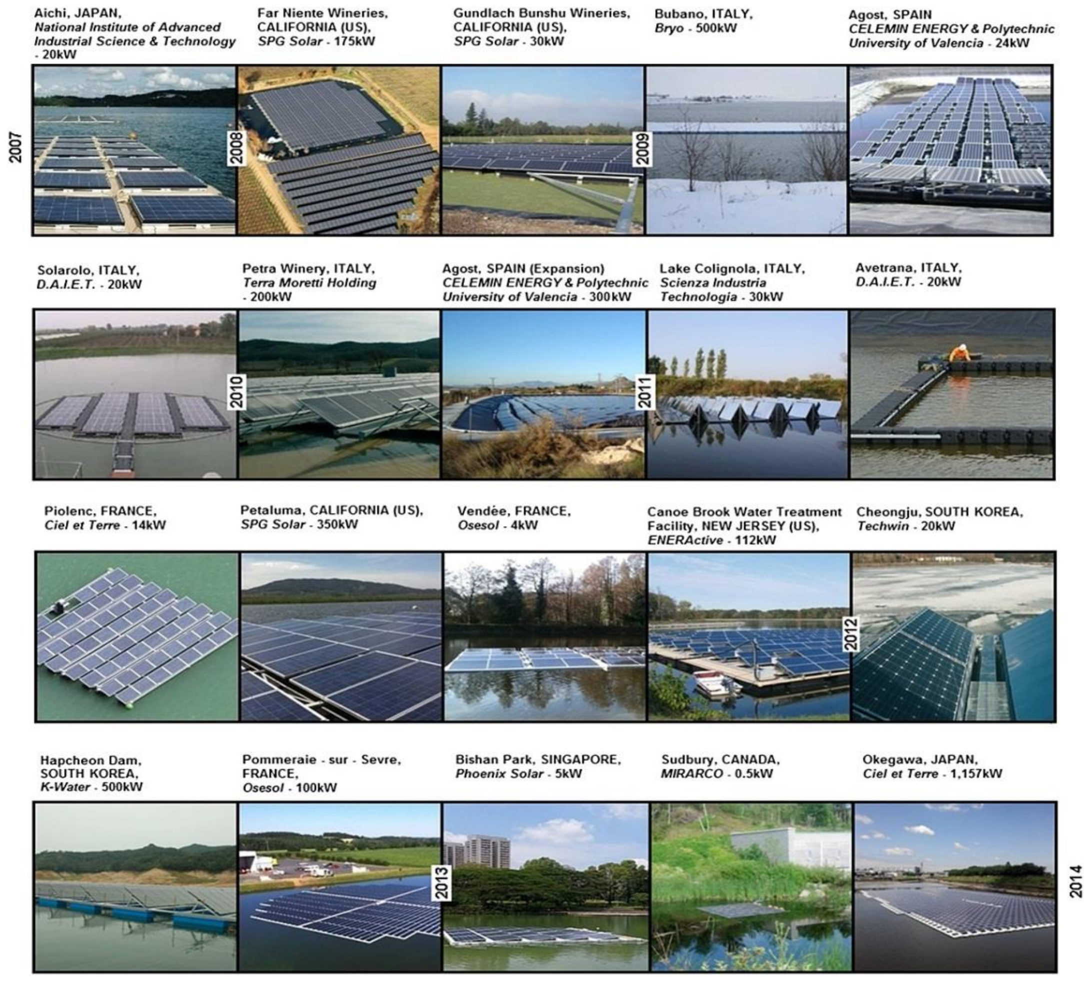


Figure 3:Floating PV projects around the world; Source: (Santafé, 2014)

Based on Figure nr.3, the first floating photovoltaic project in the world, is installed in Aichi, Japan. Then they started to spread in other countries like Italy, Spain, France, California, New Jersey, South Korea, Singapore, and Canada, starting from 0.5 kW installed capacity, until 1157 kW. Compared to other photovoltaic systems, floating photovoltaics have a higher efficiency of energy generation because of the fact the the ambient temperature in water is relatively low and the evaporation from the water surface may be reduced when installed in a reservoir.(Yoon, 2014)

2.3.6.1 Benefits from floating fotovoltaic systems

One of the main features of a floating photovoltaic system is to reduce the evaporation of water, while generating renewable electrical energy. Such systems consist of:

- A floating platform, which assurances the solidity of the system that generates the electricity.
- Supporting structure, which should be able to resist the weight of the PV modules and transmit the wind forces where needed.
- Metal chains or cables to link the pantoons together.
- Ropes, used to tie the outside moduls with the sides of the reservoir
- Flexible couplings ,which allow the system to adapt in different levels of water.
- The anchoring system, used to anchore the floating cover.(Miguel Redón Santafé, 2014)

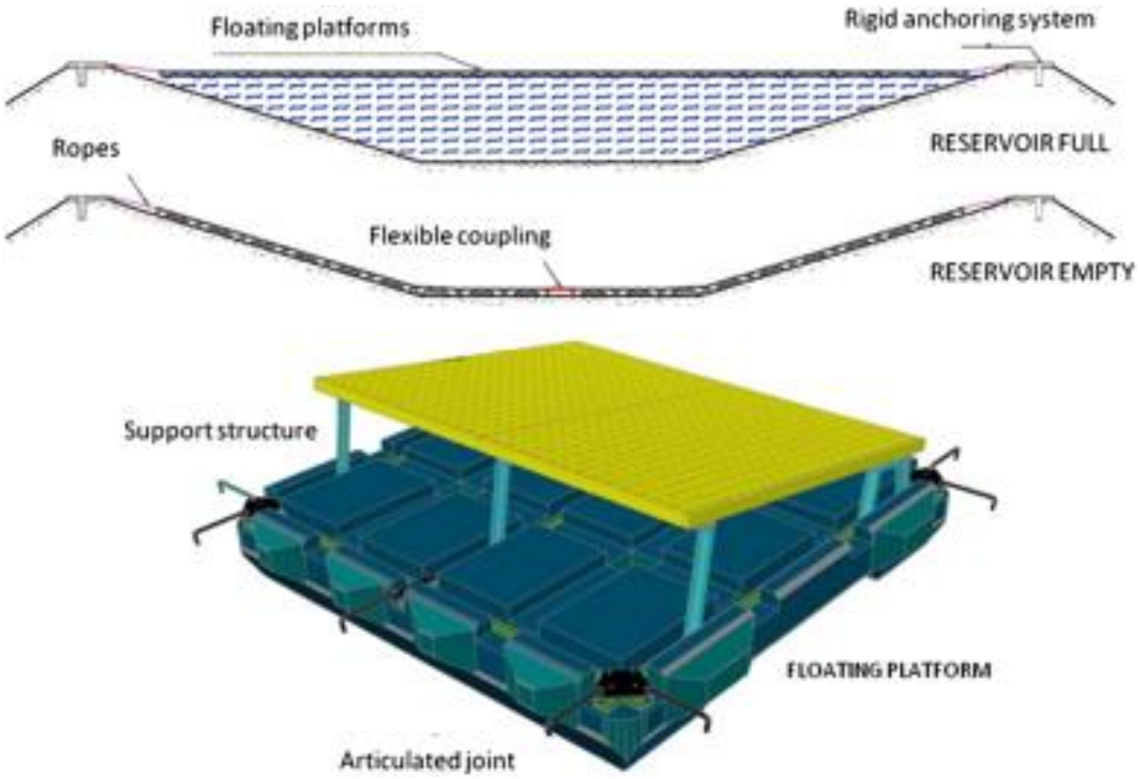


Figure 4: The components of a Floating PV system. Source: Miguel Redón Santafé, 2014

Results gathered by a prototype of this system, installed over a reservoir in Agost, Spain, show that the water saved in a year, due to the coverage of the reservoir is 25% of the reservoir's storage capacity.(Miguel Redón Santafé, 2014)

2.4 Bioenergy

Bioenergy, had the largest growth in consumption of renewable energy sources, over the period 2018 to 2023 (Agency, I. E., 2018). During this period, it accounts for 30% of renewable consumption in all of its forms of fuels, including liquid fuels, gaseous fuels and solid fuels. Bioenergy is mostly used in the sectors of heat and transport and it is expected that in 2023, it will stand as one of the greatest importance sources of renewable energy, even though its share of total renewable energy sources will decline because of the growth and improvement of solar and wind technologies.

Bioenergy's production requires different technology lines, starting from the production of biomass, to its use in another process, to produce electricity, heat, biofuel or combined heat and power. In the power generation of bioenergy, biomass plays a very important role (Emission, 2019).

2.4.1 Technologies of bioenergy

Technologies used to produce bioenergy are based into the conversion of biomass into heat and electricity, by thermo-chemical processes and biochemical processes. The thermos-chemical processes include combustion, gasification and pyrolysis, while biochemical processes include digestion and fermentation (Emission, 2019). Bioenergy can be generated from wood, agricultural waste, wood industry residues, solid waste, sewage sludge, energy grasses, paper industry residues and food industry residues. One of the most cost-effective technologies for generating energy from biomass is co-firing, where 15% of coal is replaced with biomass. This technology allows the deployment of biomass in large amounts, because of the possibility to use the existing plants and have minor investment costs.

The production of heat and electricity from biomass is made through several conversions like:

Thermal conversion, that converts biomass into heat or electricity through a thermal combustion process. One form of combustion is co-firing. This term describes a facility where the combustion of biomass is done along with coal or other feedstocks (Helene Cser, 2015) For electricity production, combined heat and power facilities are more efficient than direct and co-firing combustion.Pyrolysis technologies use another form of thermal conversion. These technologies involve heating biomass in the absence of oxygen, through varied thermal temperatures and converting it into gas, bio-oil or biochar.

Thermochemical conversion, that includes the processes of gasification and synthesis. Thermochemical processes use heat and chemicals to convert biomass into syngas or a gas mixture that contains carbon monoxide and hydrogen. To accelerate the chemical reaction of syngas into a liquid fuel is used a catalyst. The type of catalyst used determines the type of the fuel, whether it will be a hydrocarbon product or an alcohol. Through gasification, solid fuels are converted into gas in the presence of steam, which later can be used to produce heat and electricity. When used with heat recovery systems and advanced turbine designs, this technology is more than 40% efficient than direct combustion (Helene Cser, 2015).

As the industry of bioenergy moves toward building facilities of a commercial scale, that use advanced bioenergy crops, research for biomass production technologies is still underway. The increase of the bioenergy market is difficult and challenging, because the prices of the fuels in the market are very volatile. Anyway, new investments in the research for new technologies that produce bioenergy, as one of the renewable energy forms, are increasing. This because society is underway to demand cleaner renewable sources of energy. According to IRENA, the installed capacities in 2018 for bioenergy production were 83063 MW for solid biomass, 17692 MW for biogas, 2352 MW for liquid biofuels and 12624 MW for renewable waste. If continued research, technological innovations and sufficient policy support are given, the use of biomass for electricity will continue to meet our energy needs.

2.5 Geothermal energy

Geothermal energy is the energy that can be used by the exploitation of the heat from the Earth. Geothermal resources can be found beneath the Earth's surface, or deep to extreme temperatures of magma (World, 2019). Geothermal energy can be used for heating, cooling or to produce electricity. For electricity production, the use of geothermal energy becomes challenging, because sources of high or medium temperature are needed and their location usually is close to tectonically active regions (World, 2019). Countries that produce electricity from this renewable energy source are Iceland, New Zealand, Salvador, Philippines and Kenya. In Iceland, this resource is used to cover more than 90% of heating demand. The main advantages of using geothermal energy, according to IRENA, are that it has very high capacity factors and is not depending on weather conditions. According to IRENA, the total installed capacities in 2018 in the world were 13329 MW.

2.5.1 Technologies of geothermal energy

Technologies that produce electricity: These technologies produce electricity from hydrothermal reservoirs and have been operating since 1913 (World, 2019). Types of power plants that operate today are flash plants, which can be single, double and triple and dry steam plants. These plants use temperatures higher than 180 degree Celsius. The production of electricity or combined heat and power from medium temperature fields is also used more and more, as the binary cycle technology that uses geothermal fluid via heat exchangers for heating process fluids in a closed loop, has developed a lot.

Binary cycle power plants operate on water temperatures at 107-180 degree Celsius. The heat from the hot water is used from these plants, to vaporize a working fluid in a heat exchanger, which then runs a turbine. Later, the water is injected back into the ground, so that it can be reheated again.

Dry steam power plants pipe up the steam from underground wells to the turbine of the plant.

Flash steam power plants are the mostly used types of plants that use geothermal energy. They use water of very high temperatures, which is brought up through the wells by itself, because of the high pressure. By flowing up in the well, the pressure is decreased and is vaporized into steam, which is then separated to run a turbine.

Small-scale geothermal power plants are usually used in rural areas. Their installed capacities are usually under 5MW and are usually used to improve the electricity delivery system of the areas where they are implemented.

Technologies for geothermal direct use: These technologies provide direct uses of geothermal energy like district heating. To provide direct heat, can be used geothermal reservoirs of hot water. These technologies include the use of a well, that is drilled into the reservoir to provide hot water, which is raised up through the well. The heat is delivered directly through a mechanical system that includes piping, controls and a heat exchanger. Then, the water is injected underground, or is disposed on the surface, through a disposal system. Direct use of geothermal includes different industrial processes, heating water for fish farms, drying crops etc. (World, 2019).

Geothermal Heat Pumps: These technologies consist of the heat pump unit, the heat exchanger in the ground, and the delivery system of air. The heat exchanger is put in the ground and is made of a system of pipes, where a fluid mixture circulates to absorb the heat within the ground. During summer, the heat pump moves the air from indoor into the heat exchanger, while during winter it removes the heat from the heat exchangers to the air delivery system indoor (World, 2019).

2.6 Wind energy

Wind presents one of the fastest growing technologies of renewable energies. According to IRENA, its installed capacity has increased by a factor of 75 in the last decades. In 2018, their installed capacity was 564 GW, including here onshore and offshore systems. As a source of energy, wind can be used to produce electricity by using the kinetic energy of the air in motion. Using wind turbines, or wind energy conversion systems, wind power systems transform the kinetic energy of the air into electricity, by changing it to rotational energy. The generated power from wind depends on the size of the wind turbine, together with the length of the blades (IRENA, 2018).

2.6.1 Technologies of wind energy

Onshore wind turbines: These technologies include wind farms located on the ground. Their turbine blades and hubs are supported on a steel column. A turbine installation consists of foundations, access road, turbine base and switchgear house. Individually, these turbines are connected with a power system in a voltage of usually 34.5 kV, by cables located underground (Hollaway, 2013).

Offshore wind turbines: These technologies are still are still under development and they include the installation of wind farms on water. A lot of research is focused into these types of technologies, to reduce the levelised cost of energy by 50% by 2030 (SINTEF, 2017). Offshore wind technologies include floating technology, which allows the installation, maintenance and intervention of wind turbines, by eliminating the need of offshore vessels. They can meet large quantities of power requirements and can be transported at favorable costs (Offshore Wind Solutions).

3 Challenges of the today's energy production

3.1 Situation in the world today

The main challenges of production of energy nowadays are related to the consumption of non-renewable resources. Given that these resources are limited and their inadequate use will cover the exhaustion of them, mankind has had to find other alternatives to produce energy.

These other alternative sources such as wind, water, sun etc. are found in nature and are inexhaustible and renewable. Today, we face the challenge of increasing and improving the efficiency of excisting technologies, in order to increase productivity, but every research means more time and costs. Besides that, because of so many environmental issues, these technologies have to be environmental friendly, as well.

Oil consumption in the world today reaches almost 100.8 million barrels per day.(portal, 2019) The global energy consumption in 2017 was mostly influenced by China, the largest energy consumer in the world since 2009. It grew in most of Asian countries, also in Japan and Europe, driven by the economic growth.This consumption remained stable in the United States, thanks to energy efficiency improvements. Brazil also notes an increasing energy consumption in 2017, while in countries such as Mexico and Argentina this consumption decreased during 2017.(2018, 2019)

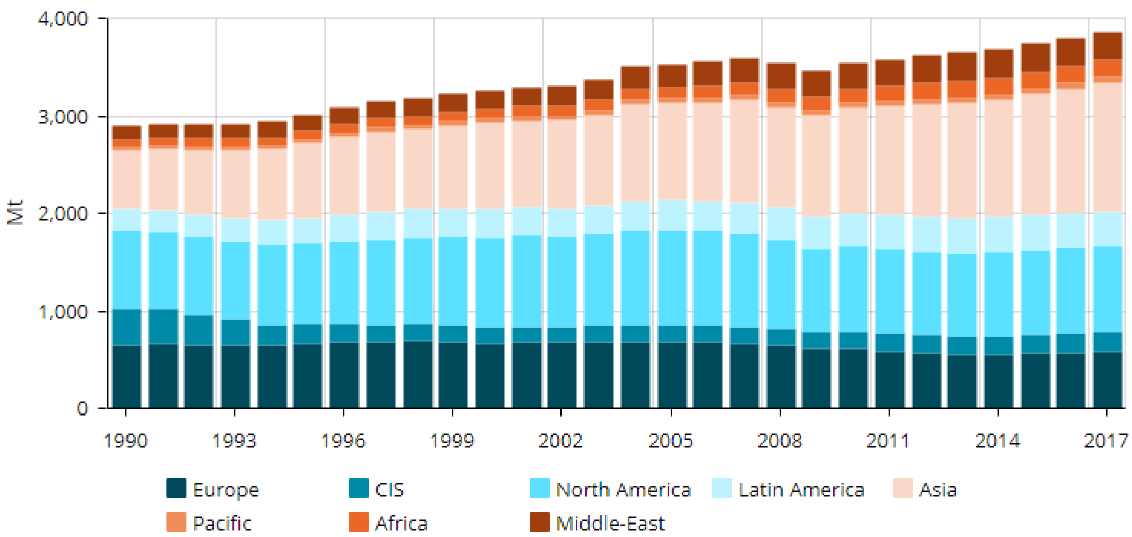


Figure 5: Oil consumption in the world; Source: Enerdata

While energy consumption continues growing all over the world, the CO_2 emissions keep growing as well. In 2017 they grew by 2.1%.Fossil fuel emissions that also include cement production, were about 91% of total CO2 emissions from human sources in 2014.

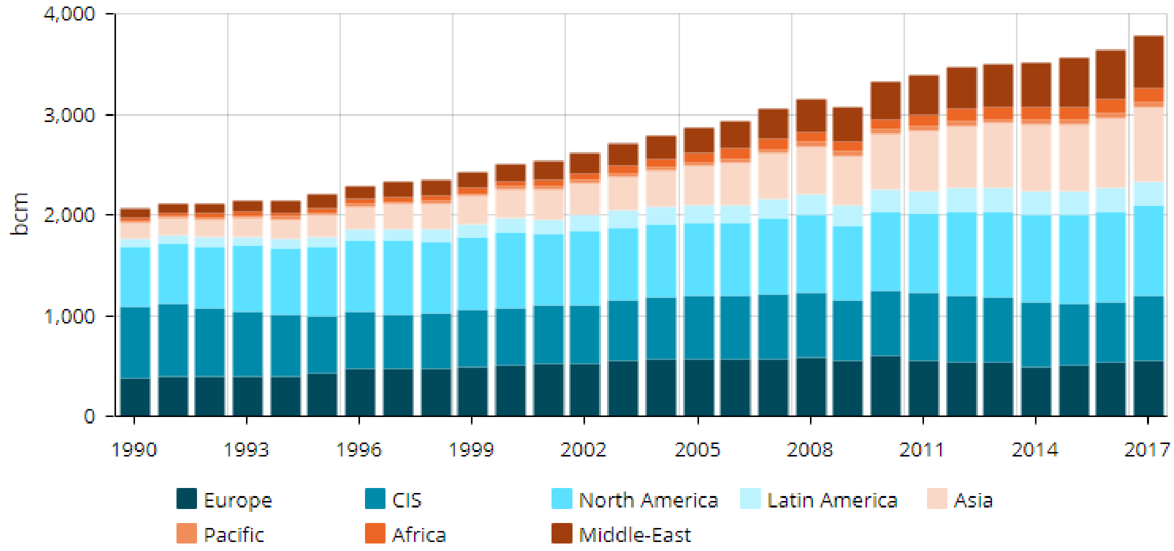


Figure 6: Natural gas consumption in the world. Source: Enerdata

This portion of emissions came from the use of coal (42%), oil (33%), gas (19%), cement (6%) and gas flaring (1%).(CO2.earth, 2019) Carbon dioxide is the main greenhouse gas, whose emissions humans can control, that contributes to global worming.

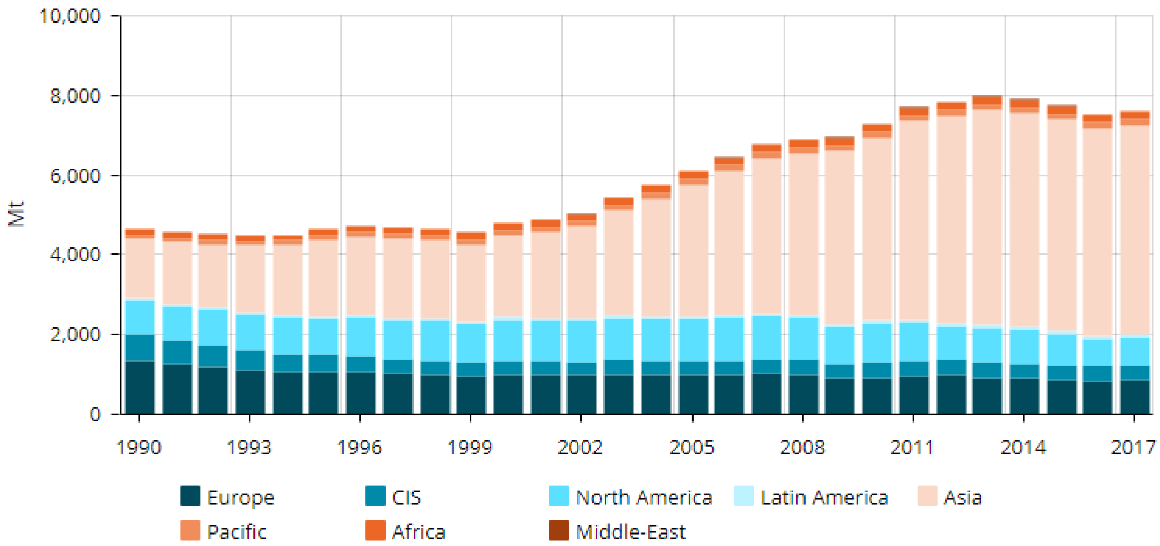


Figure 7: Coal consumption in the world. Source: Enerdata

Energy security is a topic where every country in the world is focusing more and more every day. Energy security includes; oil security, natural gas security, electricity security, and every other energy source used for energy supply. The growing demand for oil, natural gas and other non renewable sources is risking their security in the world, that is why the focus is pointed more and more to renewable energy sources. The question that raises is: Can these renewable energy sources replace oil, natural gas or coil? According to the Global Energy Statistical Yearbook 2018, the use of renewable energy sources increased in 2017 by nearly one percentage point within the global power generation mix. Renewables now cover 1/3 of the power mix in Europe, 1/4 in China and 1/6 in the United States, India and Japan.(2018, 2018) Anyway, 93% of the world’s energy resources is supplyed by fossil fuels and nuclear energy. (Pyke, 2017)

Given that many of the new technologies that make use of renewable resources are costly and their development requires time, switching from fossil fuels to renewables becomes difficult. In addition, many of these resources are intermittent and this complicates even more this transition. This means that when there is not enough wind or sun, the need of fossil fuels is required in these operating plants as backup. Renewable energy technologies require the use of large areas of land, resulting in escalation and storage problems (Pyke, 2017).

Since the diffusion of technologies that exploit renewable resources is difficult and there are some disadvantages, the key would be to exploit a mix of these resources, distributed over a wide area. These disadvantages have led to the creation of newer technologies, such as floating pv, combining resilient resources for more effective productivity. The more developed countries today that have a sustainable energy system have found the solution to the diversification of resources that they use for energy production. If we do this today, with renewable energy sources, we increase the chances for a stable energy system.

3.2 Situation in Europe

Primary energy consumption in the European Countries, in 2016 was 1 543 million tons of oil equivalent, which is 4% above the target of 2020 (Agency, E. E., 2018b). According to European Environment Agency, owing to the energy efficiency improvements, the increase of using renewable energy sources, climate change and economic decline, the primary energy consumption in the European Countries decreased by 10%, between 2005-2016, while in 2017 it increased by 1.3%. This primary energy consumption was dominated by fossil fuels, but their share from 2005-2016 declined by 6%, accompanied by a 1% drop of nuclear energy, as well. In the meantime, the share of renewable energy sources during these years increased from 7% to 14%.

Over this period of time, the imports of fossil fuels were increased by 2%(Agency, E. E., 2018b). The primary production of crude oil in the EU had a peak production in 1999, which was 165.8 Mtoe and a minimum of 64.5 Mtoe in 2014. In 2016 this production was 68 Mtoe (Explained, e. S., 2018a). According to Eurostat, the top countries that produced crude oil in 2016 were United Kingdom with 45.6 Mtoe, Denmark with 7 Mtoe, Romania with 3.8 Mtoe, Italy with 3.8 Mtoe, while the non-European Country of Norway, one of the key producers in Europe reached a production of 80.5 Mtoe. Other countries which are EU candidate, like Albania, Serbia, and Turkey, have a 4.6 Mtoe crude oil production in total. Meanwhile, the consumption of bituminous coal in 2017, in the European Countries reached 236 Mt (Explained, e. S., 2018b). From the online statistics of Eurostat, the decrease of the hard coal consumption from 2013 until 2017 is obvious. Accompanying the decline in consumption, the production of hard coal in the European Union has also decreased starting from 1990.

On the other hand, the consumption of brown coal reached 384 Mt in 2017 following the same trend of decrease in as hard coal. Both, hard and brown coal are mainly used for electricity and heat production. In 2017, the delivery of bituminous coal to main activity power producers reached an amount of 127 Mt, while brown coal reached an amount of 318 Mt, showing a noticeable downward trend since 2016 (Explained, e. S., 2018b). The demand of natural gas in 2017, in Europe, reached 548 billion cubic meters (Honore, 2018). Its consumption increased by 5% in 2017, following an increasing trend from 2015, while the production in EU countries fell by 0.6% in 2017 (eurostat, 2018). According to Eurostat, the countries with the most noticeable increase were Portugal, with an increase of 22.2%, Greece with 20.5%, Croatia with 13.1 % and the Netherlands with 9.7%. While the countries with a decrease in consumption of natural gas, in the same year, were Sweden, with 17.7%, Finland with 6.8%, Latvia with 9.6% and Estonia with a decrease of 5%. The increase in consumption of natural gas is explained with the economic recovery, cold temperatures in January and the increase of its use in the power sector (Honore, 2018).

On the other hand, the greenhouse gas emissions in 2017, in the European Union countries increased by 0.6% compared to 2016, but compared to 1990 the greenhouse gas emission levels correlate to a reduction of 22% (Agency, E. E., 2018a). Based on the data taken from the European Environment Agency, the GHG emissions coming from the main sectors in 2015 were: from energy supply 1331272 kt CO_2 equivalent, from the Industry 857340 kt CO2 equivalent, from transport 905888 kt CO2 equivalent, and from the residential sector 551616 kt CO2 equivalent. In the majority of the EU countries, the main producers of GHG emissions in 2016 were businesses which supply electricity, steam, gas and air conditioning (Explained, S., 2018). In order to decrease the GHG emissions, many countries have taken measures and will continue to do so in the coming years. Due to economic or political reasons, many nuclear plants in some countries may be shut down, followed by many coal plants, due to emissions limits set by the Industrial Emissions Directive or EU standards (Honore, 2018). Furthermore, the GHG emissions in the EU, compared to the levels of 1990, are expected to decrease further to 26% by 2020 and to 32% by 2030 (Agency, E. E., 2018a). This means that these measures will include even more the expansion of the use of renewable resources, in various sectors of the economy, in order to achieve the common goal of GHG emissions reduction.

In the face of greenhouse gas emission reduction targets of 80–95% by 2050 and with some sectors like agriculture, which are GHG emitting and face difficulties in achieving such targets the energy sector will have to reduce its GHG emissions to zero (Olav H. Hohmeyer, 2014). According to a study conducted by Olav H. and Hohmeyer, for the case of electricity production in Germany, was showed that it is possible to have a 100% renewable electricity supply system.

3.3 Situation in Balkan

Most of the Balkan countries are engaged in trading in the energy sector. All of the countries are engaged to meet all demands for energy and depending on production capacities some countries try to export and some others are larger importers.

Countries such as Bulgaria, Bosnia and Romania are the largest exporters and Albania, Croatia, Macedonia, Kosovo, Serbia and Montenegro are countries who import more energy. The access to the transmission network in the Balkan countries is independent of energy trading.

All companies who are looking to import or export electricity should definitively purchase capacity on the transmission lines in order to transfer the energy in the relevant countries. Serbia still holds an important and the central position in the Balkans as it was the transmission hub years ago in Yugoslav days. Due to the high infrastructure cost of building new transmission lines and small investments, little has changed since that period of time.

New transmission projects for example between Kosovo and Albania, are slowly reducing export dominance of some countries in the Balkan region.

The Western Balkan countries, which are poor in the aspect of fossil energy sources, try to meet the needs of electricity by hydropower. So 40% of the electricity production capacity is provided by the hydropower plants. For example, 90% of electricity generation in Albania is provided by hydropower plants. For this reason Albania during the low precipitation periods also experiences difficulties with regard to electricity. Meanwhile, electricity reductions that live in Kosovo since 1999 continue today.

Unlike the Western Balkan countries, Bulgaria and Romania have a strategic position on the Black Sea coast. These two countries have a convenient position for gas and oil pipeline networks from Russia and the Caspian Sea region. In addition, Romania in the Balkans maintains the country's quality of oil and natural gas. While Bulgaria fulfills approximately 45% of the electricity needs of the Balkan countries.

However, Sofia, which tries to become the Balkan energy center, from the aspect of oil and natural gas is heavily dependent on the outside. Since Bulgaria imports 60% of Russia's fossil fuel resources from Russia, it is greatly influenced by the waves of oil and natural gas prices (European Network of Transmission System Operators for Electricity).

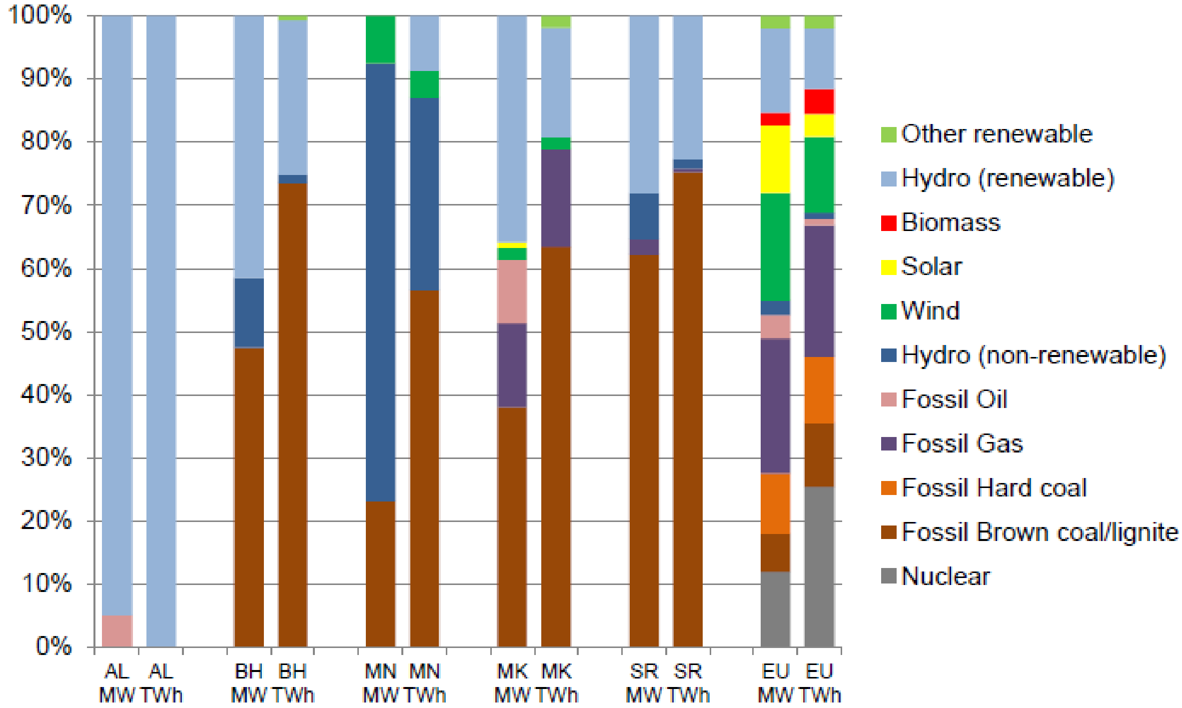


Figure 8: The comparison of energy production sources between Albania, Bosnia and Herzegovina, Montenegro, Serbia and Europe Union. Source: European Network of Transmission System Operators for Electricity

Power generation in the Western Balkans and in all the region in general is at a critical juncture. All six countries in the western region – Albania, Kosovo, Montenegro, Bosnia and Herzegovina, FYR Macedonia, and Serbia – are facing the challenge of building new energy capacity to replace the old and existing infrastructure but also are faceing the serve growing demand while meeting targets on climate change mitigation and carbon reduction. Addressing on this challenge successfully will require a new strategy on energy sector, focusing on renewable sources, decarbonisation, combined with a significant increase on internal and external regional cooperation (Electricity).

4 Energy sectors in Albania

4.1 Albanian energy situation overview

Figure 9: Albanian Man on the Balkan region. Source: Network, 2017

The total energy consumption in Albania has increased over the years, although in some cases this increase is modest. The source of primary energy in Albania is oil with its byproducts, where the most important one in terms of consumption is Diesel.

Albania is the largest exporter of crude oil in the Western Balkans (872 000 tonnes in 2016), and a total crude oil production of 1.06 million tonnes in the same year.(Network, 2017) All Albanian oil assets and deposits are inherited by Albpetrol company, which is owned by the state. Nowadays this company is active in the development, production and trade of crude oil. (Network,2017). Another company operating in Albania is Bankers Petrolium, which in the same time is the largest oil producer.

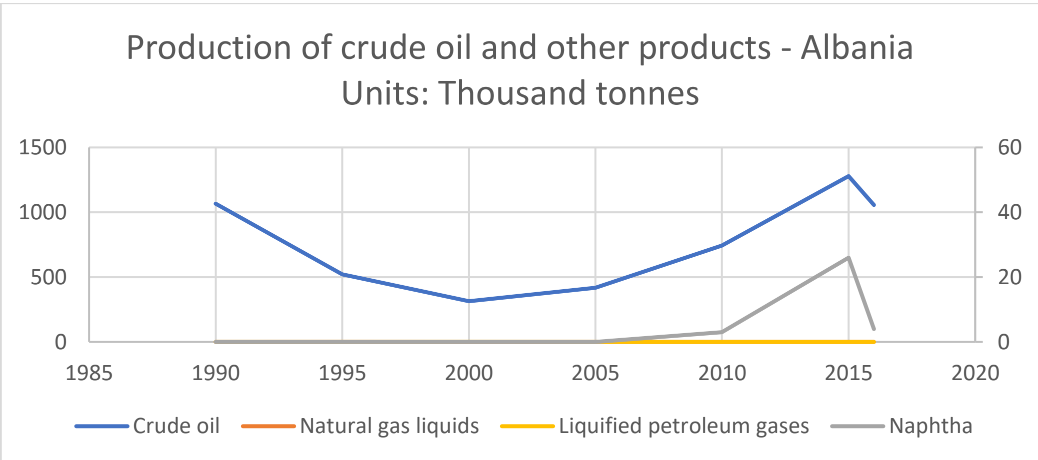


Figure 10: Production of crude oil in Albania 1985-2015

The transport sector and the residential sector are the sectors with the highest specific weight in the energy consumption in Albania.

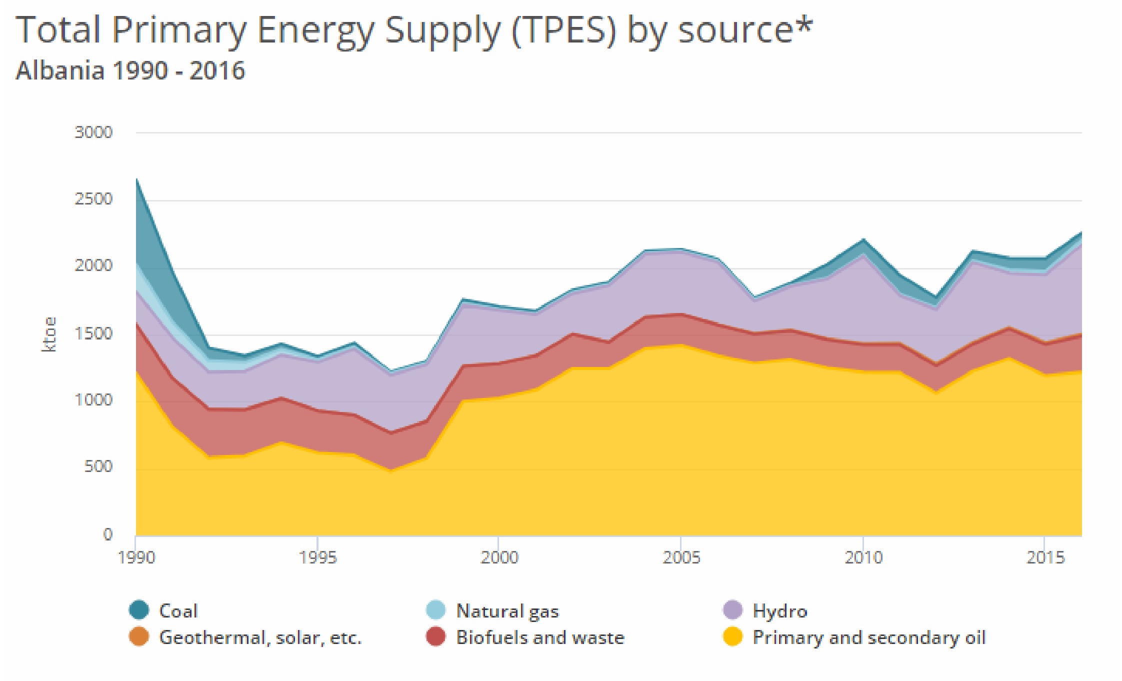


Figure 11 Total Primary Energy Supply. Source IEA

Other sources of energy in Albania include also; coal with a primary energy supply of 51ktoe in 2016, natural gas with a total energy supply of 35 ktoe, geothermal energy with a supply of 13ktoe, and primary and secondary oil with 1220 ktoe.(IEA)

Table 1 Total Primary Energy Supply (TPES) by source IEA

Year	Coal	Natural gas	Nuclear	Hydro	Geothermal, solar, etc.	Biofuels and waste	Primary and secondary oil
1990	630	203	0	245	0	363	1214
1995	19	23	0	361	0	316	617
2000	17	9	0	395	1	258	1027
2005	13	9	0	462	2	230	1419
2010	111	12	0	651	7	205	1221
2015	95	27	0	507	12	234	1193
2016	51	35	0	669	13	269	1220

Albania's mineral deposits include chrome, copper, iron-nickel, limestone, sand, asphalt and natural bitumen, ornamental limestone and ornamental sandstone. The mining industry focuses mainly on producing chromium, copper, iron, nickel, bitumen and inert minerals serving as raw materials in the construction industry.From the geographic point of view there are 36.9 million tons of geological reserves and three main regions where the chromium ore is located: Northeastern region, central region and southeastern region.(aida.gov.al) The mining of copper ore and its processing in Albania has been partly developed, due to low reserves on deposits, low copper content and unfavorable operating conditions. Iron-nickel and nickel-silicate minerals are considered as deposits with the largest mining stocks in Albania. The geological reserves are estimated at about 364 million tons (AIDA).

According to AIDA, in 2016 The main share of total exports consists of: "Textiles and footwear" with 43.8%, "Minerals, fuels and electricity" by 19.1% and "Construction materials and metals" by 13%.

4.2 The potential of renewable energy in Albania

The benefits of being a country with 2,400 hours of sunshine a year and an average of 240-300 sunny days, with 152 small streams, and 8 large rivers, wind power on the coastline, show a remarkable potential by listing Albania on the list of five countries with greatest potential in renewable energy in the world, together with China, Costa Rica, Afghanistan and India. This, referred to an analysis published by "The Guardian", when international experts evaluate the Albanian's potential for clean energy.

4.2.1 The potential for solar energy utility in Albania

With a favorable geographic position in the Mediterranean Sea Basin, it has very favorable climate conditions for using solar energy. The high intensity of solar radiation, the duration of this radiation, the temperature and humidity of the air, mild and wet winters and hot and dry summers, set a greater energy potential than the average energy potential for solar energy utilization. Solar energy is a highly promising source of energy for the future and its use is potential as it is a natural resource of inexhaustible energy, is the largest natural resource reserve that is distributed anywhere in the world in quantities greater than our energy needs, is clean, does not require any additional costs and poses no big risk to environmental pollution.

The above arguments lead us to the conclusion that the use of solar energy to produce hot water for the sanitary and technological needs and for the production of electricity, replacing electricity, is a chance that nature offers us and which we should use it carefully.

The territory of the Republic of Albania is divided into four main climatic zones, where fluctuations of climatic elements within them are relatively small. These areas are named as follows:

- Field Mediterranean Area
- Hilly Mediterranean Area
- Pre-mountainous Mediterranean Area
- Mountainous Mediterranean Area (Alban Kuriqi 2014)

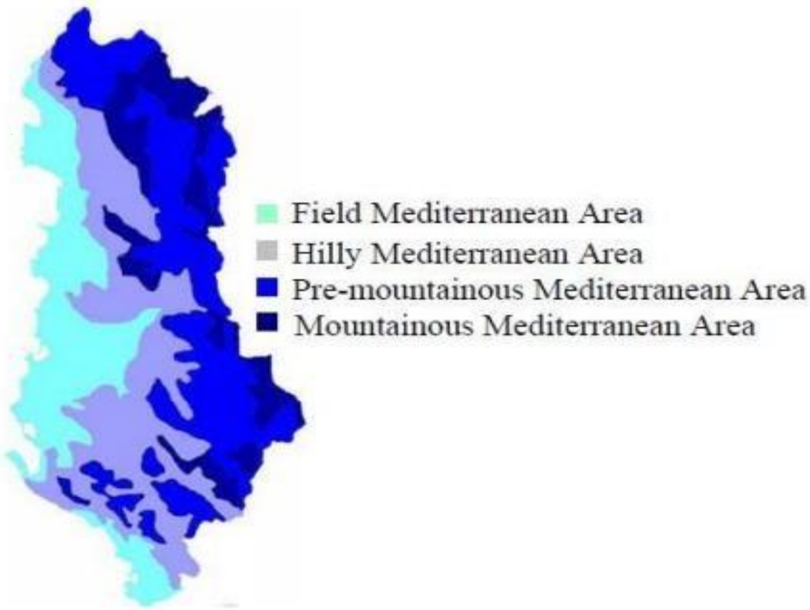


Figure 12: Climate areas in Albania. Source: "Climate and climate change data for Albania", Report 2014

In the Albanian territory there is a considerable solar energy potential, where many of its areas are exposed to a radiation ranging from 1185 kWh / m^2 per year up to 1700 kWh / m^2 per year. The number of sunny days varies from an average of 240-260 days per year to a maximum of 280-300 days per year in the southwestern part. The average daily value of solar energy potential in the regions of Albania varies from 4.05 kWh / m^2 / d to 5.94 kWh / m^2 / d. (A.Halili, 2016)

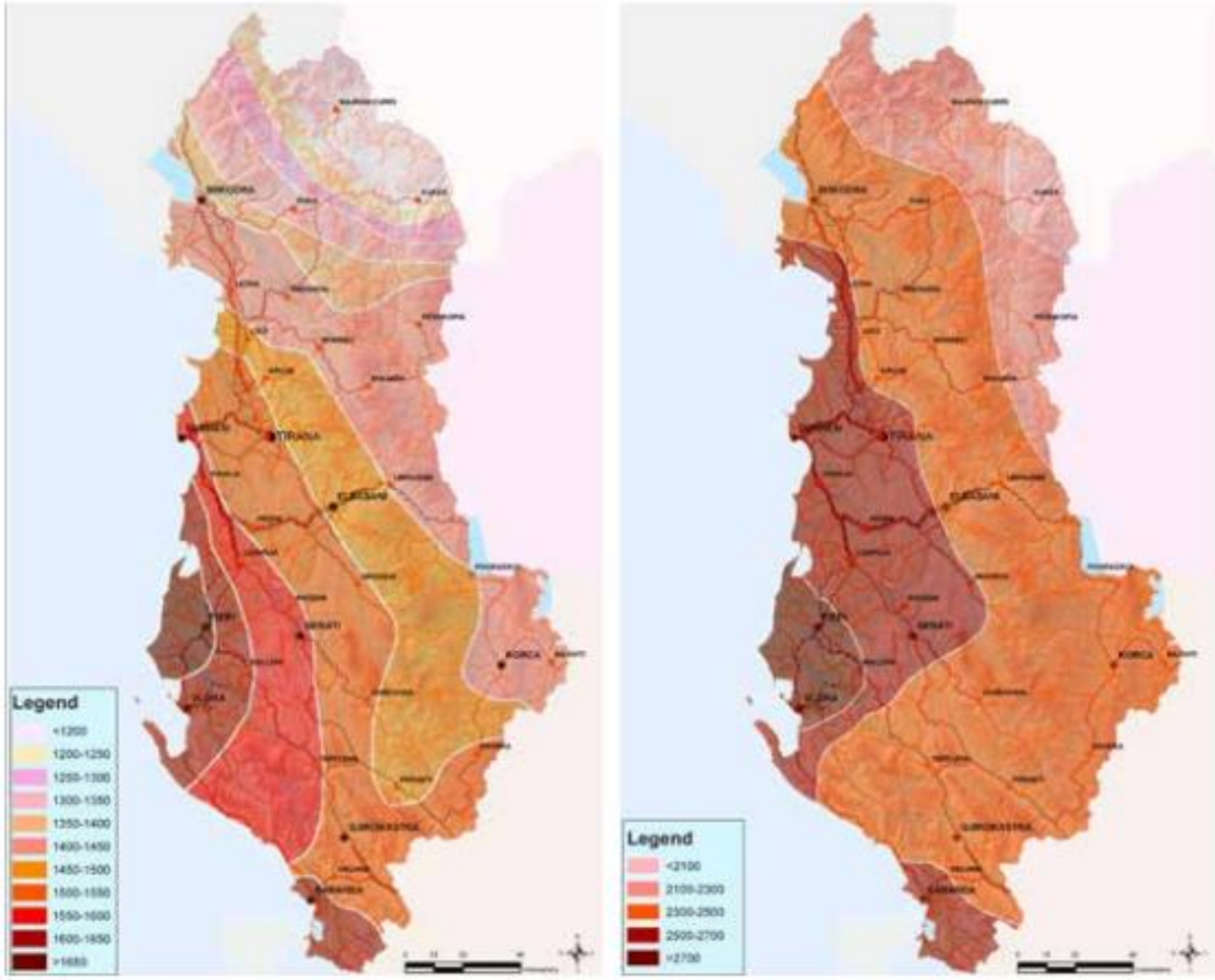


Figure 17: Solar Irradiation (kWh/m2/year) and Sunshine Hours (hours/year) in Albania. Source: UNDP

4.2.2 Wind energy potential

Albania has a mountain relief in 2/3 of its territory. Its coastline has a length of 345 km in the north-south direction, where a part is the coastal lowland and the rest very close to the southern mountainous coast. The main directions of the wind in this country are northwestern-southeast and southwestern-northeast, with a dominant direction towards the land. Within the territory, the direction and intensity of the wind from one area to another varies greatly with time. The climatic analysis carried out for the assessment of the natural potential of the wind in the Albanian territory has taken into consideration the observations in 22 meteorological stations spread all over the country. Observations show that in the coastal zone dominate the west winds that change the course in the depths of the territory. The annual average wind speed fluctuates between 0.8 and 6.6 m / s.The highest wind speeds have been recorded especially during the winter period when cyclone activity prevails. Analyzing the results in high-flow areas it is noted that the average speed of> 3 m / s is present throughout the year and it is> 5 m / s at noon (IRENA, 2017).

The need to study the potential use of wind for Albania today, is paramount and necessary. The meteorological stations are built in representative areas based on climatological aspects of the exhibition, not for the use of wind energy. Consequently, the natural wind potential is expected to be higher. The measured speed at the top of the hills, places these preferred for installing wind turbines, has resulted about 1.5 times higher than in the field or flat places where measuring stations are often located. It should be noted here that potentially exploitable wind power sites are also hilly areas or special hillsides along the coast, places where the wind is a constant phenomenon due to the contrast of the seaside temperatures. Moreover, all wind speed measurements in Albania are made at wind speeds up to 10 m above the surface of the earth. This means that researchers of its potential need to consider the fact that wind speed is higher at higher altitudes, consequently, so does its power.

4.2.3 Geothermal resources in Albania

The geothermal situation provides two directions for the use of geothermal energy, broken down as follows:

- Thermal sources with low enthalpy and maximum temperature up to 80 ° C. These are natural resources or wells located in a wide territory of Albania, from the south near the Albanian-Greek border to the northeastern area.
- Use of deep vertical wells for geothermal energy, where a large number of abandoned oil and gas cans can be used for heating purposes.

Until today, temperatures in 145 deep wells and heavy drilling have been measured, as well as in various mine sites in different levels of hypsometric. The temperature in these wells is recorded at regular intervals measured by resistances and thermosets thermos. Northeast and southeast are studied about 25 drilling along with 8 thermal water sources that have been subjected to chemical analysis. Despite their study to date, this energy has not been exploited as a result of high costs of exploitation. The geothermal regime of geological structures in the Albanian territory is conditioned by the density of the heat flow, the geothermal gradient and the diffusion of the temperature field at different depths of these sources, closely related to the lithology and the tectonics of the geological structures as well as the hydrodynamics of underground water (IRENA, 2017).

Temperature estimates by depth show that in the depths of 100 m the temperatures are above 5°C to about 19°C, while in the West and the southwest of Albania the temperatures are in the order of 16°C to 18.8°C. In the western extreme, as in the south-west area, the temperature reaches 32.9°C, in depths of 1000 m, at depths of 2000 m the temperature reaches 54°C and in the depth of 3000 m they are 71.8°C. At deeper levels, the temperature gradually increases, reaching 105.8°C in the depth of 6000 m, measured in the Ardenica structure. Experimental energy estimates for the four largest sources: Elbasan, Peshkopi, Kozani-8 and Ishmi-1 / b, resulted that the total thermal water supply is 44.8 l / sec, the geothermal capacity 6.64 MWt and the possible power that can be installed is 7084 kW. These data are quite promising to start energy projects to utilize this renewable energy source.

4.2.4 Bioenergy potential in Albania

Another energy source that is estimated is biomass, which is closely related to firewood. From the data of the Ministry of Energy, it results that 93 percent of firewood is consumed for heating and cooking and only 7 percent is used for other services. Biomass contributes through the firewood to the energy balance of the country by 10 percent. From the data provided it is clear that the use of bioenergy is at very low and almost inexistent levels. From these facts we can say that Albania has an untapped potential of this sector (IRENA, 2017).

In the table below we can spot the different biomass potential categories

Biomass categories	Theoretical Potential	Share in country energy balance (%)	Technical energy potential - heat	Technical energy potential - electricity
Forests	263.6	1.07	234.4	70.3
Agriculture	1521	6.17	979.8	293.9
Urban waste	1576.4	6.39	1276	382.8
Waste -orchards	168	0.68	142.9	42.9
Waste-livestock	585.25	2.37	521.6	156.5
Energy plants	62.34	0.25	57.1	17.1
Total	4176	16.9	3212	963.6

Table 2: Source: Albanian National Renewable Energy Action Plan

4.3 A historic review of the energy policies undertaken up to the present in Albania

The electrification process in Albania has started about 30 years compared to other countries. The energy production industry dates to the middle of the third decade of the twentieth century and had great natural opportunities to develop in relation to the territory and the population. The hydro resources that could be used for power generation were spread all over the country and can be mentioned: Rivers Drin, Mat, Vjosa, Bistrica, Shkumbin, Kir, etc. that constituted a powerful base where dozens of large and small hydropower plants could be built. The establishment of the first factories on the one hand, and the growth of the cities, on the other hand, encouraged the creation and development of the electricity production industry both for production and lighting.

The first concessions for the production and construction of the electrical industry have begun to be released in the mid-20th century. In 1925, the production and distribution concession was granted to the General Electric Company (GEC), which created the first hydropower plant in Albania in Vithkuq. The need for electricity that was the greatest innovation of the time had in the country in few years the birth and development of the first companies of production and distribution of energy. They were investments of Albanian entrepreneurs but also of foreign capital, especially the Italian one, who in a few years became the owner of this market.

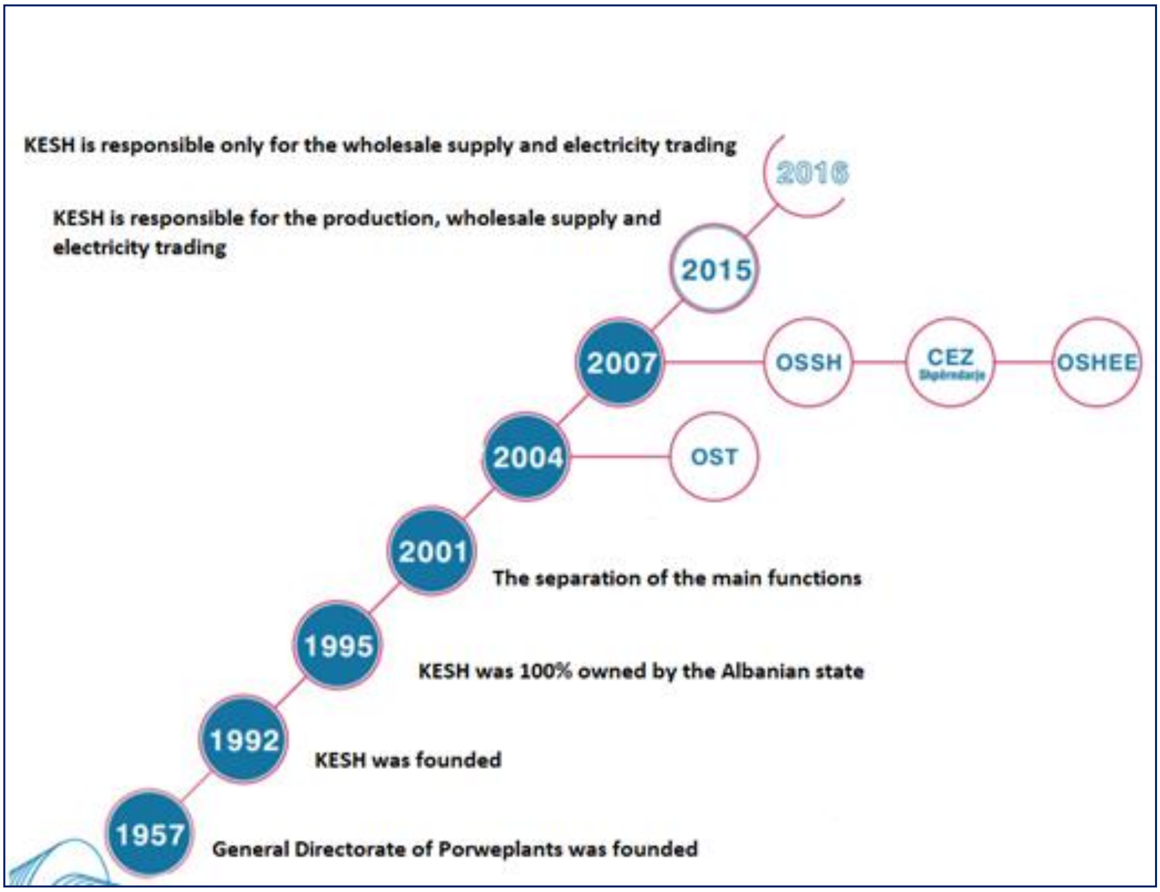


Figure 13. Transformation of the electro-energetic system of Albania
Source: KESH.al

In 1957, the General Directorate of Electric Power Generation is established as a State Enterprise and in 1992 this enterprise is transformed from a State Enterprise to KESH. In 1995 KESH acquires the status of an anonymous Company owned 100% by the Albanian State. In 2001, the current Statute of KESH comes into power, by separating the function of transmission and distribution of electricity, leaving in power only the generating function. In 2004, the transmission function is removed from KESH, leading to the creation of OST and in 2007, the function of distribution is removed, by leading to the creation of the distributing operator of electricity OSSH, nowadays known as OSHEE.

In 2015, KESH carries on the activity of Production, Public Supply with Wholesale and Trading of Electricity and the Shares of the Company are owned 100% by the Albanian State. In 2016 until now KESH is "released" from the Public Wholesale function and focuses on production and trading of electricity as well as maintenance and development of the power plants as well.

Responding to the dynamics of the development of the national legal framework, which aims to harmonize with the European Union energy legislate ion, KESH has undergone a number of fundamental transformations since 2000, transforming from a vertically integrated company into a company today focused on the trading and the production of electricity (KESH, 2015).

The process for electricity rates in Albania

If one of the companies, KESH, OSHEE, and OST wishes to change the tariff of the price of electricity, it should apply to the energy regulatory body ERE. The Energy Regulatory Entity in the respective articles of energy after considering the applications submitted by these companies sets the start of procedures for determining the respective tariffs of electricity activities, which are published in the Official Journal. Calculation of the electricity production tariff is based on the relevant methodology approved by the ERE and based on the forecast of domestic net hydro production and includes all operational and capital expenditures.

4.3.1.1 The Environmental Protection Law in Albania

As the hydropower plants have a major impact on the environment by changing it and affecting the use of land, houses and natural habitats in the areas around the dam that will be built hydropower, The National Environmental Agency operates under the Law on Environmental Protection. Most hydropower plants have a dam and reservoir that bring migration to fish and affect their population. Hydropower operation can also affect water temperatures and increase river currents. These changes have adverse effects on the surrounding flora and fauna. According to NEA, if KESH or other private companies decide to construct new hydropower plants, they must be equipped with environmental permits issued by NEA, which is a central public institution under the Ministry of Environment. The law on environmental protection aims at preserving and improving the environment, preventing and reducing the risks to human life, ensuring and improving the quality of life.

5 Methodology

The method used for understanding the Albanian energy system is system analysis, which helps to show how resources of this system may be better used to meet certain targets. This methodology is generally used in industrial projects, to provide a solution that meets the requirements of the users. Author Henrik Lund, in its book "Renewable Energy Systems", describes the three implementation phases of the energy system analysis tools (Lund, 2014). According to the book, the need for these tools depends on renewable energy in the energy system and the implementation of renewable energy technologies is defined in three phases.

The introduction phase, which appears for a situation where there is no share of renewable energy in the system, or only a small share of it. This phase is distinguished by proposals that introduce a small share of renewable energy, that allows the system to respond in the same way during the year, and easily permits the identification of the technical influence of the incorporation of the share of renewables on the system.

The large-scale integration phase, which appears for a situation where a large share of renewables in the energy system already exists. In this phase, new proposals involve the increase of renewable energy in the system and their influence will vary from hour to hour, depending on the electricity demand, or the electricity supply. This phase includes complex calculations, which usually requires the use of simulation models.

The 100 percent renewable energy phase, which appears for a situation where the energy system is transformed into a system based 100 percent on renewable energy. This phase includes proposals based on new renewable energy technologies that conserve the energy, improve the efficiency, storage energy, use smart grids, gas and district heating. Given that the influence on the system is complex, this phase requires the use of complex models, as well.

Based on the System Analysis method, the Energy System of Albania is analyzed. This quanitative research required the possesion of the latest data, their observation and interpretation. The analysis is focused on the production of electrical energy.All the existing plants, that contribute into the system, by producing electricity are taken into consideration, together with their hourly values of electricity production for one year, production costs, storage capacity, efficiencies of the plants, taxes, fuel prices, imported and exported energy. The year taken into consideration is year 2017. Based on all these data, the idea of an existing scenario of the Albanian Energy System is created and based on the existing scenario, new scenarios are proposed to be considered, in order to optimize the system and to see if there is a possibility for Albania to be a green battery for the Balkan area. New proposed scenarios involve the installation of new renewable energy capacities, including floating photovoltaics, wind energy, bioenergy and also changes into the existing electricity market.

5.1 Model description

In this case, the model used is known as MODEST and it is an energy system optimisation model. This model is based on linear programming and stands for Model for Optimisation of Dynamic Energy Systems with Time-dependent components and boundary conditions (Alemayehu Gebremedhin, 2012). It can be used for different kinds of energy systems, made up of various kinds of energy forms, demand and equipment (MODEST). This model can consider data on energy supply, energy conservation, energy costs in short and logn-term variations, energy demand, energy prices, plant capacities, emission limits etc. It formulates a linear programing model, with objective function and boundory functions, which later on will be solved using CPLEX, for improving efficiency, increasing profitability and reducing costs.

So far, this model has been used for analyzing the electricity and district-heating supply for more than 50 Sweedish utilities, and except for electricity production, it is also used for the analysis of of heat, biogas, cooling, and steam production (http://www.optensys.se/index-filer/Page677.htm). It can be used to help in decision making when it comes to choosing which investments to be made, to decide the operation of all the components of a system and also the dimensioning of new installations (MODEST).

An energy system in MODEST is seen as a network of components, which are called nodes, and energy flows. For each component, may be defined several characteristics that can be combined arbitrarily. Then, by linear programming is calculated the best way, in order to satisfy the energy demand with existing and new added equipment's. The objective is to minimize the capital costs of all the new installations, during an arbitrary number of years, together with all operation costs (DagHenning).

5.2 Situation of electricity production in Albania- Current system

For electricity generation Albania is nearly 100 percent dependent on hydropower. The public net electricity production in 2017 was realized by 100% of hydropower stations. The main three hydropower stations are located in the north part of the country; Fierzë (500 MW), Komani (600 MW) and Vau I Dejës. This cascade covers 90 per cent of domestic electricity production. The public production of electricity is carried out by the KESH company sh.a. Which is 100% owned by the state.

According to ERE the total installed capacity is 1448 MW, from which the installed capacity of hydropower plants is 1350 MW and the installed capacity of the power plant in Vlora is 98 MW. The total installed power capacity in Albania is 2145 MW, of which 1448 MW are owned by KESH and 697 MW is the installed capacity of the independent hydropower plants, which are not owned by the state. In 2017 the net production of electricity was covered 100% by hydropower plants and it was 4,525,173 MWh where:

2,916,989 MWh was produced by hydropower plants owned by KESH sh.a

1608184 MWh was produced by the independent hydropower plants.(ERE, 2018a)

From the country's energy production history analysis, the year 2017 marked a lower output than the 2008-2017 average of domestic sources. The maximum monthly output for 2017 was recorded in December with 608,803 MWh. This production was carried out mainly by hydropower plants under the management of KESH sh.a. Minimal monthly production during 2017 was recorded in September with 86,075 MWh. (ERE)

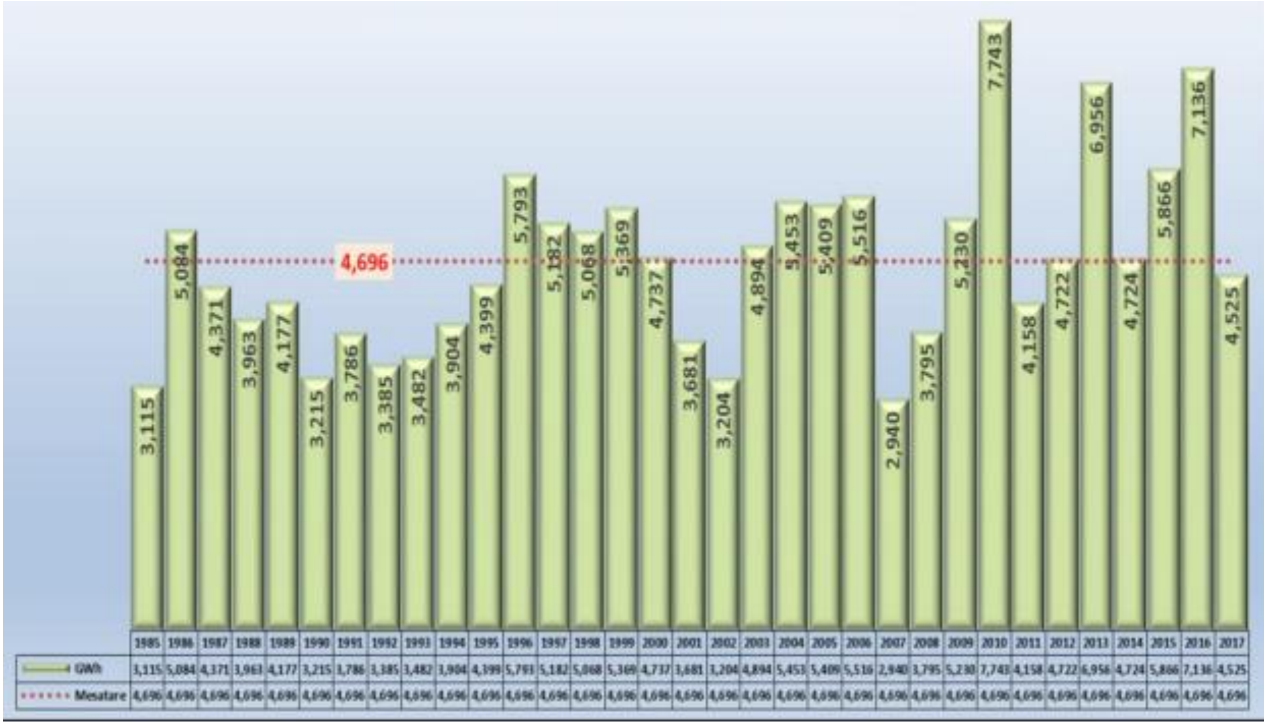


Figure 14 Production of Electric Energy in Albania 1985-2017. Source OST

Based nearly 100 percent only on hydropower, the Power System of Albania is an unstable system, dependent on hydrological conditions, creating this way a high degree of risk in the stability of electricity production.

According to ERE, the characteristic feature of the electricity consumption is almost a complete symmetry in winter and in summer. During winter the power system of the country can fill the electricity demand, but during summer the need for import arises. During summer, in July and August, the tendency of peak load is increasing, and this is getting more evident year by year. This is happening due to the increasing use of the cooling systems. During winter the temperature changes are reflected immediately in the daily consumption of electricity, because in Albania residential consumers use electricity for space heating.

The rapidly increasing power demand has resulted in a need for improvement in production and use of electricity, the increasing of the international connections and exchanges, and more extensive justification of new system facilities.

The largest consumers of electricity in Albania are represented by the residential sector. The load location of consumption is in the center and the south of the country, while the generation of electricity comes from the north. This means a considerable part of energy is lost during the transmission in the grid. On the other hand, Albanian generation system is mainly based in hydro-generation and productive capacity varies in accordance with hydrologic year.(Bualoti Rajmonda and Marialis, 2001)

As mentioned previously, the main problems that lead to an unstable Power System, which does not cover the internal demand for electricity are:

- The electricity losses in the grid
- The generation of electricity based only on hydropower

Recently, KESH has received prior approval from the Ministry of Infrastructure and Energy for: "Construction of a Solar Power Plants Generating Plant and Subsidiary Works on the Surface of HEC Vau i Dejes, Shkodër District", where a floating photovoltaic plant, is thought to be 12,902 kWp, the Albanian Power Corporation is working intensively:

1. To complete study of technical, economic, financial, environmental and social feasibility, based on actual data and measurements, carried out in project implementation areas,

2. With the business plan of the project,

3.With the project implementation chart, the approval of the TSO or DSO for the point of connection to the transmission or distribution network, according to the transmission or distribution requirements,

4. With environmental permits, licenses and preliminary authorizations by the responsible national institutions

5. With legal documentation, in accordance with the provisions of the Civil Code, which proves the long-term relationship with the land to be used for the construction of the generating source (KESH, 2015).

5.3 Transmission System Operator

The Electricity Transmission Activity is performed by the “Transmission System Operator-OST”, a public corporation with 100% state shares. The lengths of the transmission system lines, according to the voltage level are:

400 kV transmission lines- 445.091 km

220 kV transmission lines- 1159.6 km

150 kV transmission lines- 34.4 km

110 kV transmission lines- 1658 km

The above lines also include interconnection lines with neighboring countries:

Interconnection line 400 kV Zemblak (Albania) - Kardia (Greece) (1 line – Map)

Interconnection line 400 kV Tirana (Albania) - Podgorica (Montenegro) (2 line – Map)

Interconnection Line Tirana400 kV (Albania) - Prishtina (Kosovo) (3 line – Map)

Interconnection Line Fierzë 220 kV (Albania) - Prizren (Kosovo) (4 line – Map)

Interconnection Line Kopli 220 kV k (Albania) - Podgorica (Montenegro) (5 line – Map)

Interconnection line 150 kV Bistrica (Albania) - Myrtos (Greece).(ERE, 2018) (6 line – Map)

Future projects include the construction of the new 400 kV airline, Elbasan2 - Bitola, approximately 151 km, between the Albanian and the Macedonian territory.

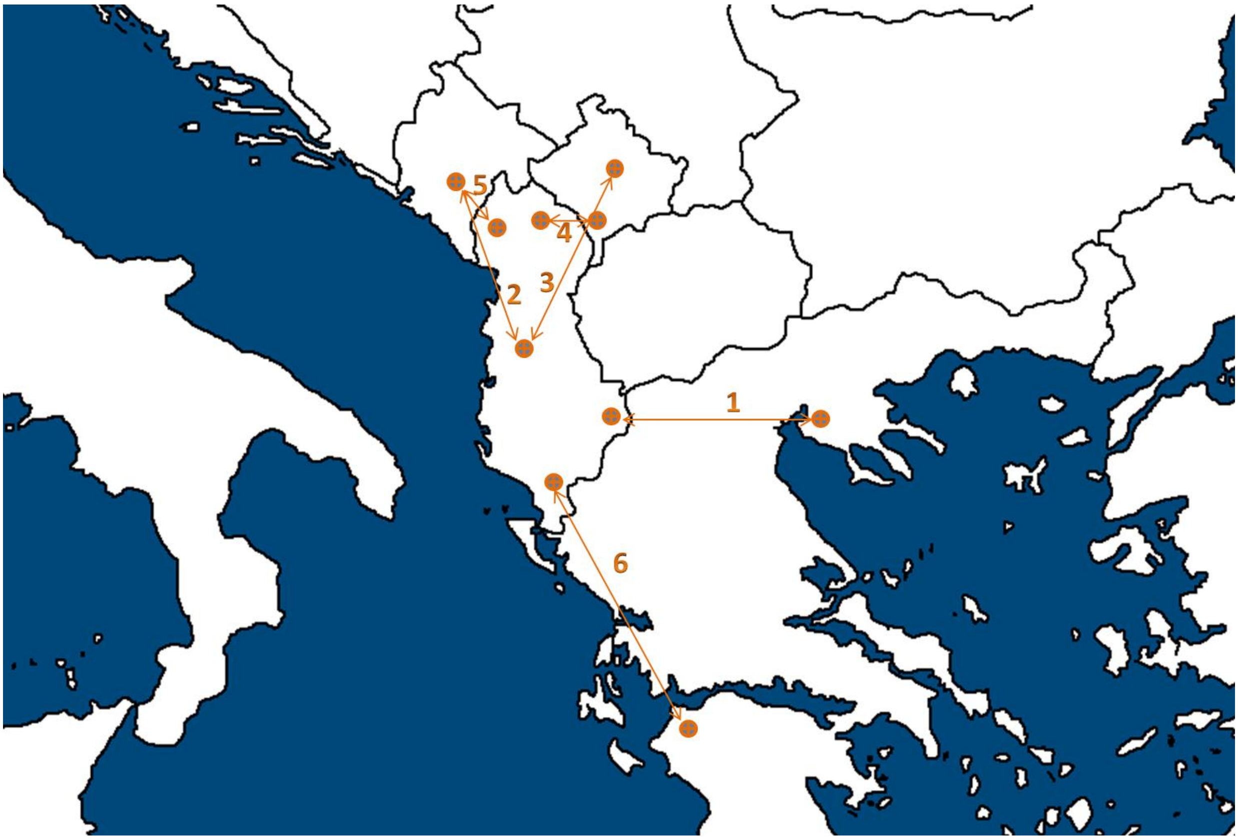


Figure 15: The interconnection lines with other countries

According to ERE, the total energy in the transmission system in 2017 was 7577 GWh, from which 4174 GWh comes from domestic production and 3403 GWh from imported energy. The lossis of energy in the transission system for 2017 were 2.08%, or 158 GWh.

5.4 Distribution System Operator

Distribution of electricity is carried out by the Distribution System Operator- OSHEE, licensed by ERE.

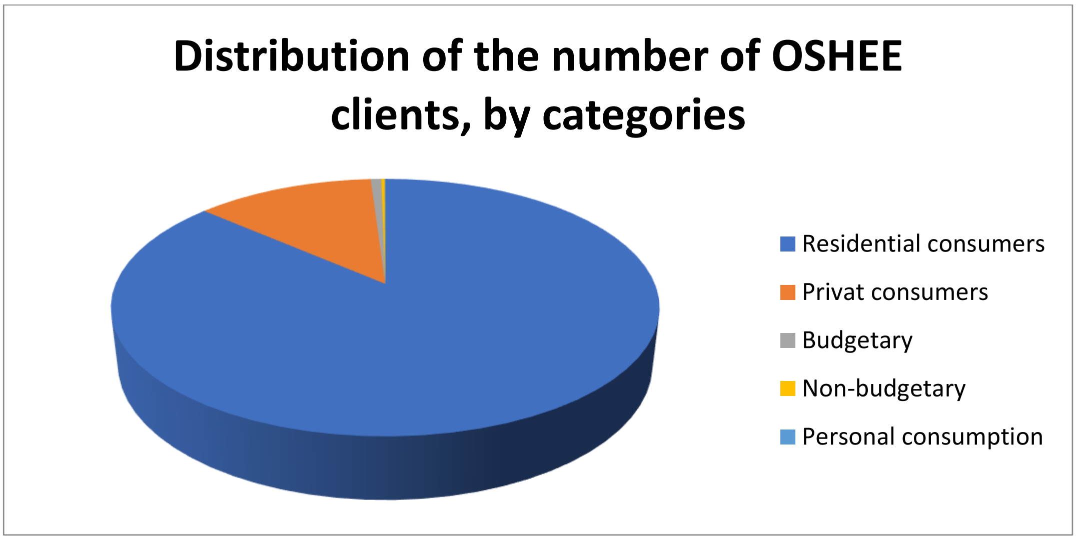


Figure 16: OSHEE's clients in 2017;(ERE, 2018)

The total consumption of electricity in 2017, according to ERE was 7439800 MWh. Losses of electricity raported by OSHEE are marked to be 26.41% and the total losses versus the energy introduced into the system are 25.2%.

The history of the power system in Albania started in 1923, with a diesel facility that operated at 0.4, 3.6 and 16 kV voltage. This facility supplied with electricity the residential and industrial sector. After the establishment of the Hydropower System in 1957 the power supply of Albania started to operate at a voltage up to 110 kV. Nowadays the Albanian Hydropower Systems operates at high voltage lines of 220 kV and 400 kV. The total installed capacity of Albania until 1990 was 1,670 MW, divided into 20 generation units of which 11 were hydro plants (1446 MW) and 9 thermal plants (224 MW). In 2017 the total installed capacity in Albania is 2145 MW, of which 1448 MW are owned by KESH (the thermal power plant of Vlora with 98 MW installed capacity is non-functional) and 697 MW is the capacity of the independent hydropower plant.

During a very slow increase of the generation installed capacity from 1990 (1,670 MW) to 2017 (2145 MW) the electricity demand has increased more than double from around 3.7 GWh in 1990 into around 7,5 GWh in 2017. Albania was a net exporter of electricity until 1998 but nowadays it is a net importer except of 2010 which was a very good hydric year. While in 1986 2.138 GWh was exported in 2017 the imported electricity was 2.915 GWh. As described above actually, the Albanian Energy System is unable to provide customers with quality service without imports, and in the rural areas, time after time may still have outages. In other words, the increased demand for electricity over the years has led to an unstable Energy System, which does not cover the internal demand for electricity. This is nowadays the main problem of the Energy System of Albania. This is a problem because it has led to the import of electricity from other countries.

In 2017 the balance import/export was -2915 GWh (ERE, 2018b). Even during the winter time, when generation is high, there are two types of import. The import that we predict and the import that we can’t predict that comes as a result of not having the planned production. This type of import is more expensive and more difficult to achieve. In some cases, the country faces the risk of not meeting the need for electricity, leading to main problems related to business and more, if unpredicted import agreements are not reached. So, not meeting the need for electricity in a country like Albania, where almost every sector, except of the transport sector, is dependent on electricity, will lead to negative impact of the economy of the country and the welfare of the population. Therefore, that is a main problem in the electricity power system that is part of the energy industry.

For 2015, Electricity Market has operated on the basis of Ministerial Council Decision No.338, of 19.03.2008, which has approved the Albanian Electricity Market Model. (ERE, 2015)This market model has defined the participants in the electricity market in Albania, the role and responsibilities of each participant of the market. Concrete steps have been taken for the liberalization of the Electricity Market in terms of creating technical conditions, a regulatory and sub-legal framework for creating opportunities of participation it the open market.

The electricity market in Albania is a regulated market. It is characterized by bilateral electricity contracts between market participants. Electricity purchases in the unregulated market, including imports, are carried out by OSHEE sh.a. and KESH sh.a in fulfilling the public service obligation for tariff customers and portfolio optimization. KESH sells electricity and auxiliary services to OST to cover technical losses on transmission. It sells excess energy in the domestic or export market in accordance with the rules and procedures for the sale of electricity approved by ERE. KESH sells to the Furnizuesit Publik me Shumicë (Wholesale Public Suppliers) according to its priced requirements approved by the ERE. The sale is made according to annual agreements or for other periods approved by ERE. KESH also buys electricity to meet its contractual obligations. Based on Law no. 43/2015 "On the Electricity Sector", ERE is responsible for defining the rights and obligations of market participants and for ensuring regulatory control in the Albanian Electricity Market (ERE, 2018b).

5.5 Types of electricity market

Countries but also private traders buy and sell energy throught different contracts. Types of contracts could be annual, monthly or intra-day. The mechanism used for purchase of power to cover the consumer demand are the annual and monthly contracts which are awarded after competitive tenders and deals are awarded through negotiations.

Based on ERE, types of electricity market in Albania are:

5.5.1 Cross-border agreements through bilateral contracts:

In this type of market, market participants will make cross-border agreements with negotiated prices based on purchased and nominated capacities in open auctions organized for any relevant time period, equal to one hour. Schedule notifications in OST, in relation to these agreements will be made on the day before submission. Details of this section will be described in the Balancing Rules.

5.5.2 The one day in advance organized market:

Market participants registered for participating in the one day in advance organized market and the market within the daytime will conclude electricity deals on the organized market in accordance with the requirements set by the Market Operator. Market participants that have current electricity purchase agreements, or any other contract for the sale or purchase of electricity at the time these rules will enter into force, have to register their contracts with the relevant network operator for participation in the organized daytime and in the daytime market, in accordance with the requirements determined by the Albanian Market Operator. Arrangements will be completed at a reflection price determined at any time by the Albanian Stock Exchange, licensed for the administration of the organized market.

5.5.3 The organized dayily market:

The organized daily market is a market for continuous trading of products within the time intervals, where the deals are automatically linked, when competing orders are recorded in the trading system. Transactions can be performed an hour before bidding. (ERE, 2018b)

5.6 Power production in Kosovo, Montenegro and Greece

- **Kosovo power market description**

Structure of the electricity market: Since 2006 in Kosovo has started the restructuring of the electricity sector. The Electricity Market Operator in Kosovo is KOSTT and is responsible for the organization and administration of the electricity market and for the management of the final reconciliation process. At the end of 2012, is completed the process of privatization of distribution and supply, which is now managed by KEDS and KESCO. The electricity sector of Kosovo mostly relies on coal-fired power plants (97%) and also is considered one of the sectors with the greatest potential of development. The only major power station outside of KEK is Ujmani(Gazivoda) hydroelectric power plant which is administrated by the Hydro-economic Enterprise "Iber-Lepenc".

According to the electricity balance 2017-2020, hydroelectric power generation in this country is mainly provided by Ujmani power station with a total capacity of 70MW. Kosovo's transmission network has developed over the last 60 years in several stages of construction, expansion, consolidation and consolidation. The transmission network consists of 1324.4 km long lines, including 279.5 km at 400 kV voltage level, 231.8 km at 220 kV voltage level and 841.8 km at 110 kV voltage level. In addition to this, in the system are installed capacities of 1200 MVA transformation at voltage levels 400/220 kV, 1200 MVA at voltage levels 400/110 kV and 1350 MVA at voltage levels 220/110 kV.

Recent developments in the electricity sector (privatization of the distribution and supply network, encouragement of private investments in the project of the Kosova e Re power plant etc.) have presented the need to change the current market model and designing a market that will encourage investment in the energy sector and which would ensure compliance with the provisions of the Energy Community Treaty, respectively with the requirements of the Acquis Communautaire. Since 2016, the Electricity Market in Kosovo operates as an independent trading zone. In this way, the Market Operator operates the electricity market in accordance with primary and secondary legislation as a trading area on its own.

The electricity market in Kosovo is a regulated market, with only one customer that is called Ferronickel NewCo, which has the right to choose suppliers (KOSTT, 2019). The electricity market in Kosovo is dominated by the monopoly. In the field of generation, the Kosovo Energy Corporation (KEK) keeps control of about 97% of all produced energy. While the transmission and distribution network, which includes the supply, is under the full monopoly of the Transmission, System and Market Operator (KOSTT), respectively the Limak-Çalik consortium. One of the features of the monopoly is the swollen price, which in terms of competition would be lower (KOSTT, 2019).

In terms of market development, commitment will continue on the project to create a common Kosovo-Albania market. Bearing in mind the market characteristics in Kosovo and Albania and targets of two governments for safe electricity supply KOSTT, ERO, ERE and OST have discussed and analyzed the idea of merging two markets into a common market (a trading area).

The common market would provide the right signals for investments in new generating capacities, investments in the transmission and distribution network and the common market would benefit customers from both countries. The joint Kosovo-Albania market would also enable the opening of the electricity market and create conditions for a competitive market. The establishment of a common market for all time frames is in line with the EU and Energy Community objectives and WB 6 (West Balkan) initiative, which can be considered as a step towards integration into the regional market of South-Eastern Europe.

- **Montenegro power market description**

The generation, transmission and distribution of electricity in Montenegro is responsibility of the state-owned Electrical Power Company, EPCG. The major plants that generate electricity in Montenegro are Pljevlja coal-fired Thermal Power Plant with 218.5 MW installed capacity, the Perucica, and the Piva Hydro Plants and it has an annually demand of around 3400 GWh and 285000 costumers (export.gov). The energy system of Montenegro cannot fulfill the internal demand of the country, for electrical energy. It has the potential to develop new hydropower plants, as it only uses around 20 percent of its hydro potential, thermal power plants, and renewable energy power plants including sources like wind, biomass and solar.

Structure of the electricity market: The electricity market in Montenegro incorporates wholesale markets, where producers, suppliers, retail markets and end users participate (export.gov). One of the most important segments of the wholesale electricity market in Montenegro is the allotment of transmission capacities on the interconnection lines. This segment happens through auctions arranged by the Southeast Europe Coordination Auction Office.

The Energy law of Montenegro, has the intention to integrate the electricity market in Montenegro into the Balkan and European markets. The Energy Development Strategy of Montenegro, based on the planning of electricity development, assumes a complete opening of electricity market in Montenegro by 2030. This is important to create a secure energy system and to attract new investments in the network of electricity generation, transmission and distribution.

There were 36 active traders in the wholesale electricity market of Montenegro, in 2016 (export.gov). One of the most important segments of this market is the allocation of transmission capacities in the interconnection lines. This market takes place through auctions organized by the Southeast Europe Coordination Auction Office, operating for many years in the South-East Europe. These auctions can be carried out daily, monthly and annual and involve cross border capacities between Montenegro with Albania and Bosnia and Herzegovina. Allocation of available capacities on borders with Serbia are carried out through auctions organized by CGES, since 2013.

- **Greece power market description**

As a member of the European Network of Transmission System Operators for Electricity (ENTSO-E) and is interconnected through overhead AC lines with Albania, FYROM, and Bulgaria, in the Northern borders, and through an HVDC cable with Italy, in the North-West; a new interconnection (overhead AC line) with Turkey is activated in September 2010. Most of the Aegean islands are not connected with the mainland, but have autonomous oil-based production systems, complemented with some wind plants and other Renewable Energy Sources (RES).

The main fuel used in the Greek electricity sector is lignite. Apart from lignite units, the production mix also includes combined-cycle and open-cycle gas-fired units, oil units, large hydro plants, and RES, mainly wind parks, small hydros, biomass, photovoltaics, and small cogeneration plants. The total installed production capacity in country is approximately 13,300 MW (including about 1,200 MW RES). The thermal units' installed capacity amounts to about 9,100 MW, whereas for hydro units it is approximately 3,000 MW. In 2009, the system hourly minimum and maximum loads were 3,238 MWh and 9,761 MWh, respectively.

The historical peak load is 10,421 MW and was recorded on 23 July 2007. Currently, most conventional generation units (not RES) belong to the Public Power Corporation (PPC). Private producers possess only five thermal units with a total installed power of approximately 1,700 MW, but another two privately owned CCGTs (each having 420 MW installed capacity) are under construction. Hence, by the end of 2011, private producers are expected to have a market share of 19.4%. This share is expected to further increase, as the European Commission is pressuring the Greek government to privatize as much as 40% of PPC's lignite and hydro plants over the next few years or take measures that have an equivalent effect (Andrianesis, 2011).

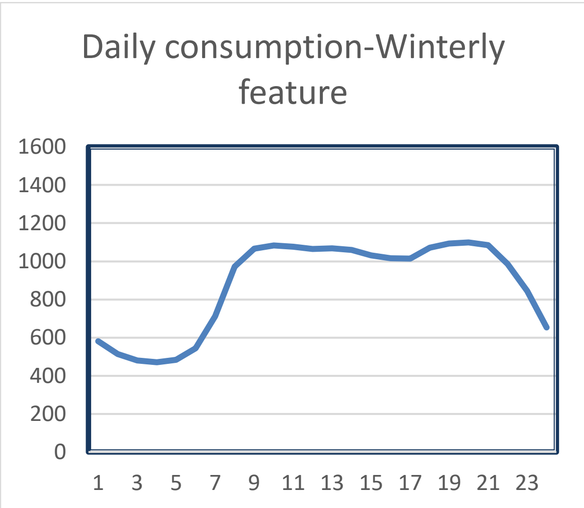
6 Scenarios

Given that Albania has considerable potential for the exploitation of other renewable sources, a number of scenarios are proposed, considering also energy conservation measures under divers conditions and changes in the electricity market.

6.1 Scenarios description

To create a clear idea of the current situation of the Albanian power system, based on the quantitative methodology, a large number of data from official sources were gathered. These data include the production of electricity from all existing systems in the system for the whole year of 2017. After processing these data in excel, following the resulting graphs, the idea of how demand varied at different time periods was created. Seeing the variation of electricity demand every day and its change in every month, during winter and summer, a time segment was set, divided into 10 units to take the energy limit that the system can produce, and to create a reference scenario model, based on the excisting one.

The graphs show an example of the electricity variation during the day in winter and summer. From the graph, we see that during the day, in winter there are two main peaks, one at 9:00 in the morning and the other one around 21:00. This may be explained maybe, with the fact that in winter, a lot of electricity in Albania is used for heating in the interiar surfaces, like homes, offices etc. , or for cooking. One of the main consumers of electricity in the country, according to ERE, is the residential sector. The first peak is around 9 am in the morning, because then is when the daily activities usually start, and the other one is around 8-9 pm, because then is when most of the albanians are back home, cooking and using electricity for heating.



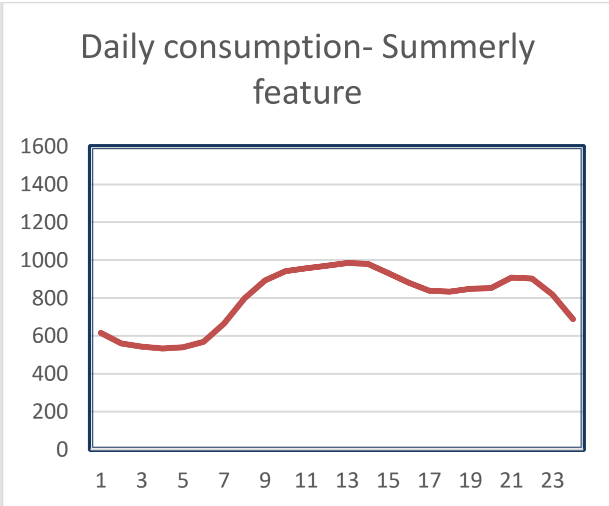


Figure 17: Daily consumption in winter and summer

While in summer, the main peak is around 1-2 pm, when the highest temperatures are indicated. This is explained with the fact that during summer, electricity is mostly use for cooling.

Regarding the monthly variation of the production curve, it is different in different times of the year. Based on the gathered data, the production was higher during february, march and november, when there were a lot of rainfalls and it was lower during summer, as mostly the country is obliged to import . As already said, Albania is dependent on imports, especially during dry periods in summer, because of not enough generating capacities and diversified sources of energy.

Table 3: List of scenarios

Scenario	Description of scenario
1	The Existing Energy System-Reference Scenario
2	Electricity market change-Deregulated electricity market scenario
3	New installed capacities of solar and floating photovoltaics are added to the reference scenario-Solar scenario
4	New wind farms added to the reference scenario-Wind scenario
5	Combined solar and wind scenario
6	Bioenergy scenario
7	Optimisation results for combined solar and wind scenario with the increased demand due to EV

6.2 The Existing Energy System-Reference Scenario

To create the reference scenario, a model was set up by taking into consideration an appropriate time division, all the installed capacities in the Energy system of Albania and the annual power production.

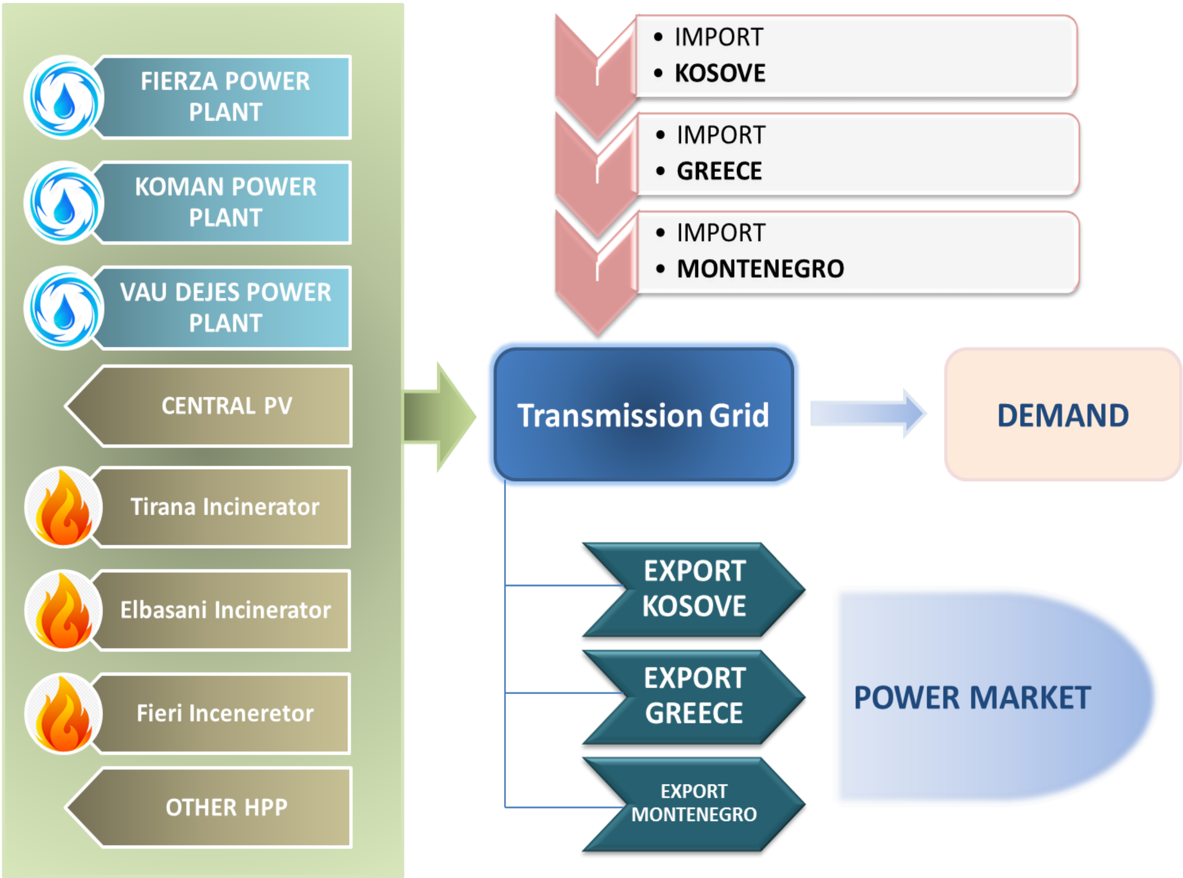


Figure 18: The structure of the existing system

The figure above shows the structure of the existing system, where all the plants that produce electricity, including hydropower plants, solar photovoltaics and incinerators are connected to the transmission grid, which then transmits the electricity to the distribution grid, which then distributes it to the final consumers.

The time division chosen to reflect the demand variation over the year consists of 10 hourly values during 24 hours, for each month of the year. Based on this, the production of every plant was added into the model, together with their efficiency, output and energy price. According to the annual report from ERE, the efficiency of the hydropower plants varies from 0.80-0.90. From the introduction of this data, the model generates the results presented in the graph below, figure number… The demand of electricity varies from year to year, but the total demand used in this study, including the imports was 12.47 TWh.

6.3 Electricity market change-Deregulated electricity market scenario

Electricity market change-Deregulated electricity market scenario the reference system was changed by changing the import and export prices, based on the prices of the electricity market in the South-Eastern Europe , operated by SEEPEX market operator. This is an organized electricity market, where exchange members send their orders of the electricity that will be sold or purchased (supply and demand). These orders are matched at a transparent and fair price, according to the public market rules, which report the priorities and methods used when matching them. SEEPEEX is also responsible to finalize the delivery and payment of all the concluded transactions.

This scenario was thought, because it is a disadvantage for Albania that the electricity is not sold in an open market. The prices of import and export are very low, resulting in low income for the producing companies, making the existing market non profitable, especially for the large producing company, KESH. This situation affects also new incentives and investments to further develop the Energy System by adding new power production. Given that two power plants owned by the Norwegian company Statkraft, operating in Albania, are not operating in the same market as the state-owned power plants, but sold on the open market instead, the idea for the deregulated market scenario was raised. According to Statkraft, European Countries will invest a lot in renewable energy in the coming years and Balkan Countries that aim to be part of this Union, must meet some certain climate targets and this may lead to a great market of wind and sun power in the Balkan region. This may come if firstly, the Balkan countries, including Albania, liberalize their energy markets.

6.4 New installed capacities of solar and floating photovoltaics are added to the reference scenario-Solar scenario

The solar scenario is based on the deregulated market scenario. In this case, the reference system is expanded by adding new installed capacities of solar and floating photovoltaic panels into the system. The investment costs taken into consideration for this scenario are shown in the table below and are based on the calculations from IRENA, in the Danish report. Based on these calculations, the investment cost of large utility-scale PV plant is estimated to be 830 thousand Euro/MW (IRENA).

The new installed capacities involve onshore and offshore plants. With only 1MW central Photovoltaic Plant, Albania has considerable land area that can be used for the installation of new PV plants. The potential of solar energy in 2016, was 3001.1 GWh and in 2030 is expected to be 3706.3 GWh. Floating photovoltaics can be installed on existing hydropower plants and reservoirs, as it has already started developing.

The high potential for exploitation of solar power has made two of the power generation companies in Albania, to take the first steps towards implementing floating photovolaic systems. The state-owned power corporation KESH, has already taken the permition from the Ministry of Transport and Infrastructure for the construction of a 12.9 MW floating PV plant (KESH, 2018). According to the company, this plant will be installed at the water reservoir of the Drin River, in the northwestern part of the country. The project has not started yet, because the company is waiting for an approval for construction from the Council of Ministers.

On the other hand, Norway's state-owned company, Statkraft is planning to implement a 2 MW floating PV plant in the district of Elbasan in Albania, at the Banja Hydropower reservoir in the Devoll's river cascade. A project proposel is submitted to the Albanian Ministry of Energy and Industry in December 2018, as part of the company's strategy on the diversification of the renewable energy sources (Bellini, 2019). Banja Hydropower plant is located in the southeastern part of the country and it is operational since 2016 and it has an installed capacity of 73 MW (Jonuzaj, 2018). In addition to Banja, Statkraft is also constructing Moglica Hydropower plant, which is scheduled to start working in 2019 with a capacity of 184 MW(Bellini, 2019). According to Statkraft, in total these two HPP will have an annual output of 700 GWh, by increasing with 17 percent the total power production in Albania (Statkraft, 2016).

With a water surface of the reservoir of 72.6 km^2 (kesh.al), Fierza has still a lot of available area for exploitation from these new technologies and that is the same for other bigger hydropower plants like Komani, with a surface of 12km^2 and Vau I Dejes, 25km^2 (Statkraft, 2016)

6.5 New wind farms added to the reference scenario-Wind scenario

Based on scenario 1, a new scenario expanded by new wind farms added to the existing system was created. This wind scenario was based on the total potential of wind energy in Albania, which in 2016 was 2885.7-5397.3 GWh and in 2030 is calculated to be 10672.8-13160.4 GWh (IRENA, 2017). The investment cost of these new installed capacities, calculated from IRENA, in Albania is estimated to be approximately 1 MEUR/MW.

6.6 Combined solar and wind scenario

Another model scenario, combines the third and the fourth scenarios, proposing new added generating capacities that include wind and solar energy. This combination refers to the considerable potential of both existing sources of wind and solar energy. It proposes the installation of both these resources, by adding new installed capacities, like onshore wind farms and also photovoltaic systems and floating photovoltaic systems, as well.

6.7 Bioenergy scenario

Another proposed model scenario, is based on bioenergy potential in Albania, coming from the existence of residues from agriculture, urban waste and forest, for power generation. In this scenario, new biomass plants for power generation were added into the system. Their technical lifetime taken into consideration is 15 years and the investment costs are 3.3 MEUR/MWh. According to IRENA, Albania has a technical biomass potential of 11195 GWh. Based on applied data, the optimization, seeking for an optimal solution that leads to the minimum costs, suggests not to invest into these biomass plants, as they result to be expensive and non-cost-effective.

In the existing system, only one plant is actually using this potential. This waste treatment plant is located in the city of Elbasan, and its efficiency is very low. The waste that are treated in this plant, according to internal information, continue a lot of humidity. Two other incinerator plants, in Fieri and Tirana are under construction, according to KESH and they are expected to start functioning next year. Waste treatment is not the only source of bioenergy that Albania represents potential from, that is why this model scenario was proposed to the model.

6.8 Combined solar and wind scenario with the increased demand due to the electrical cars

Based on the combined solar and wind scenario, another scenario was proposed to the model, with the increase demand in this case, for the usage of electrical cars. According to INSTAT- the number of cars in Albania (for passengers) was 500891 cars in 2018 and the average driven kilometers per year that by each single car is 10-12000 km/year, according to Lorenc Malka, in his PHD research, at UPT.

Based on this considerable number of cars, a proposal was made to increase the number of electrical cars used in the country, to reduce this way the CO_2 emissions. Having the number of cars, the average kilometers driven by each car and the average consumption from an electrical car, that is 10 kWh/100 km (energuide.be), some calculations were made to estimate the increased demand, coming from the use of the electrical cars. This demand was increased by about 300 GWh.

7 Results

The results presented in this section are the optimisation results from the model, of the studied scenarios.

7.1 Optimisation results for reference scenario

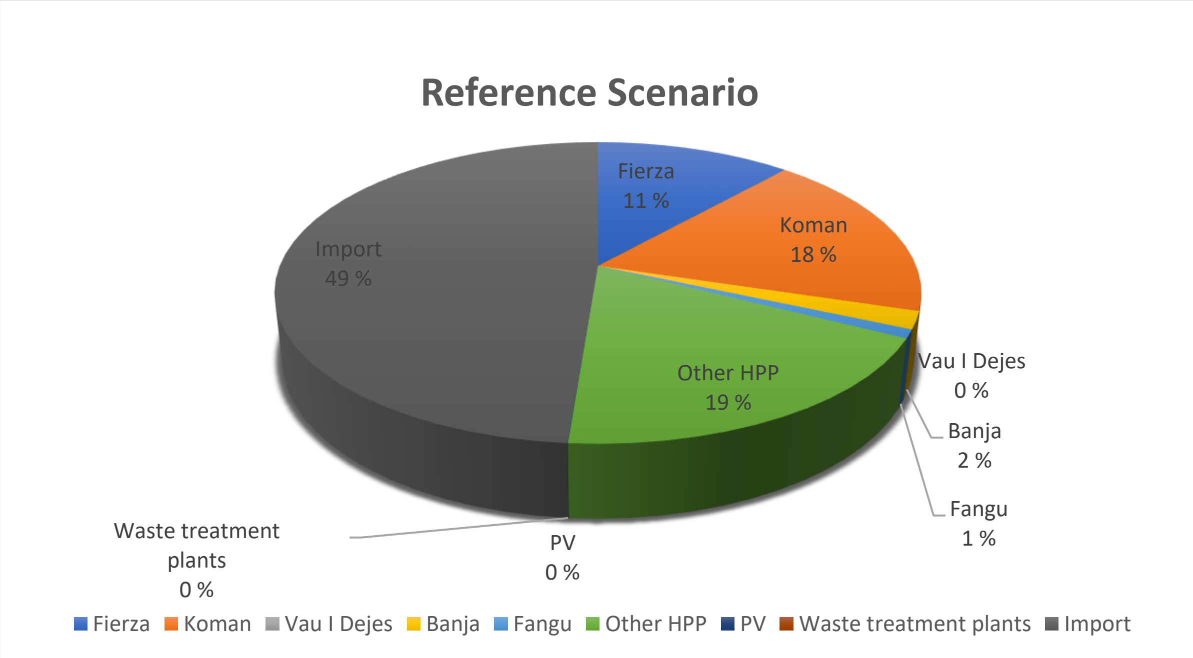


Figure 19: Reference Scenario Pie Chart

Based on the generating results from the optimization, the reference scenario reflects also the situation of the existing power system of Albania. As seen from the graph, the results from the reference scenario show that the three main hydropower plants; Fierza, Komani and Vau I Dejes, play a very important role in the electricity production during the year and a considerable part of energy demand is covered by electricity import. Given that the country is dependent on hydropower, imports cover a considerable part of the total demand, because the system is dependent on hydrological conditions and when there are dry periods, it becomes challenging, because of the large power shortages in the country.

This, in some cases leads to new, unpredictable electricity purchase agreements, which are even more expensive than the predictable ones. Based on these results, it is very important for the Albanian Energy System to diversify its generating sources of electricity. Based on the applied data, the import in the reference scenario covers 49% of the electricity demand, which compared to the existing power system is very similar. From the annual report from ERE, in 2017 the amount of imported electricity was almost as much as the half amount of the total production.

7.2 Optimisation results for deregulated market scenario

The diversification of the generating sources taken into account in other scenarios includes renewable energy sources, for which Albania presents a great potential and also the change in the electricity market, proposing the participation in an open market of electricity, like some other South-Eastern European countries. The demand is kept the same as in the reference scenario. Based on this proposal, for the second scenario with the deregulated market assumption, the model generates the results as shown in the graph below. The system in this case is dependent on import again. This could be because the demand for electricity is the same and no new installed capacities were added into the system. So, the actual generating plants cannot cover the internal demand for electricity.

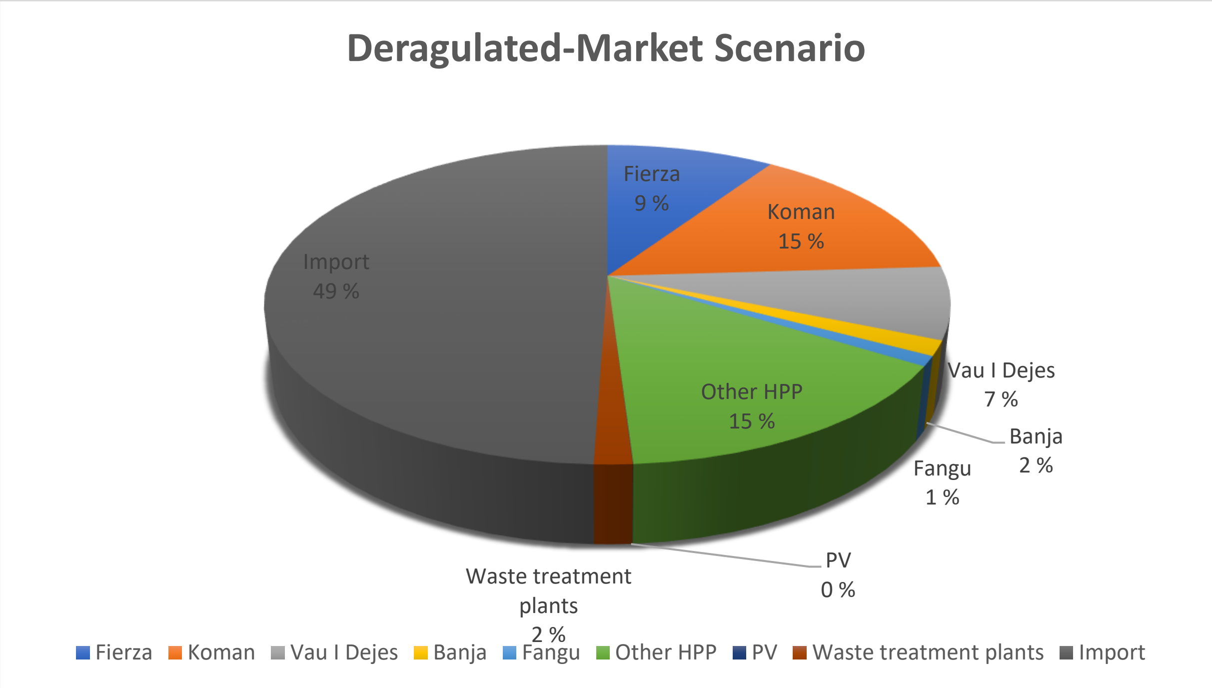


Figure 20: Deragulated-Market Scenario Pie Chart

Even though the prices of imported and exported power were changed in accordance to the prices of an open market, the results do not show a noticeable difference, and this is because of the lack of accurate and missing data, which made it very difficult to analyze the power system of the country.

7.3 Optimisation results for solar scenario

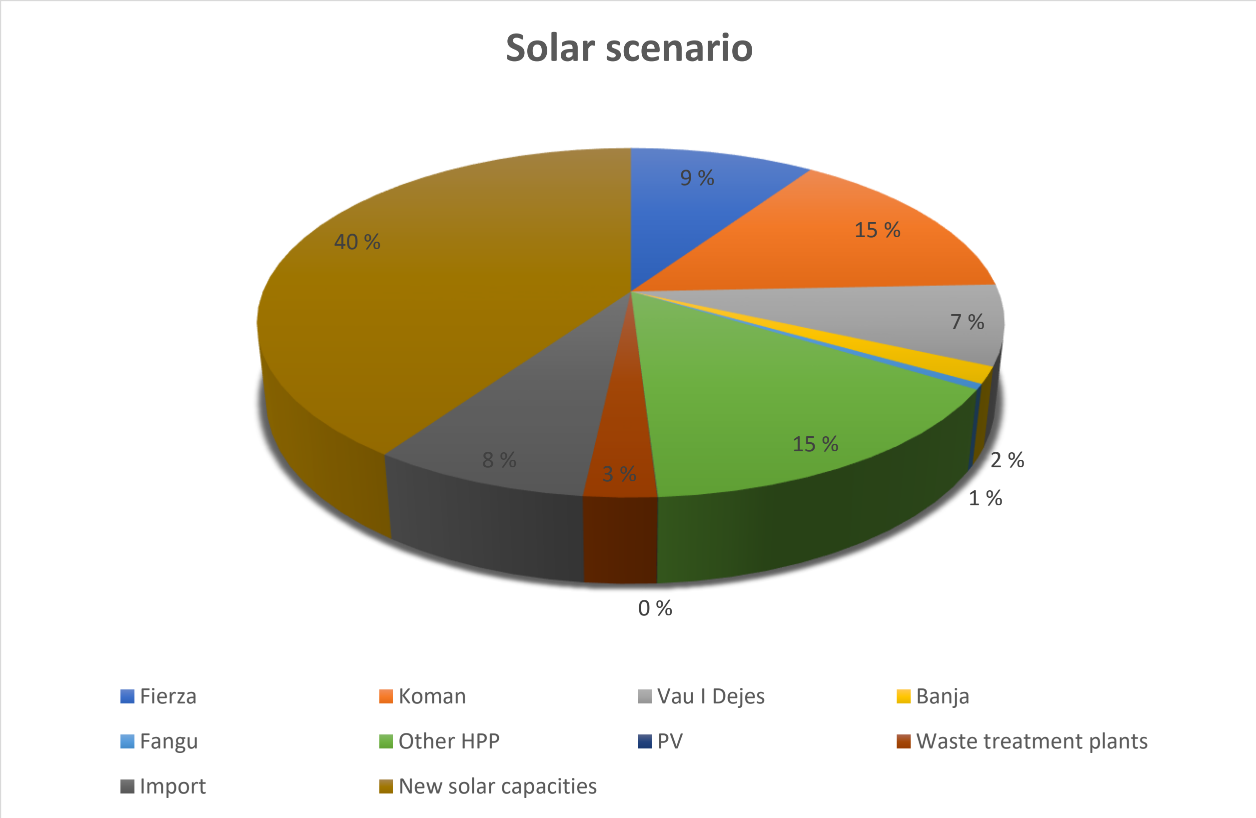


Figure 21: Solar Scenario Pie Chart

As seen from the graph, the optimization suggests considerable investments in new solar capacities into the system. Based on the applied data, taken from the calculations and studies form IRENA, that show a high potential of solar energy exploitation, the results show a share of 40% in the total production. What is very obvious in this case, is the decline of imports in 8%.

The optimization seeks to find the optimal solution, which leads to the minimum total costs for the system. This scenario is based on the deregulated market scenario. Energy limits, investment costs, efficiency and prices were added as applied data. The doubt about the accuracy of the data of import and export prices of electricity, along with the cost of electricity production, which are assumed to be 2 euro / MWh, leave room for discussion in this graph.

7.4 Optimisation results for wind scenario

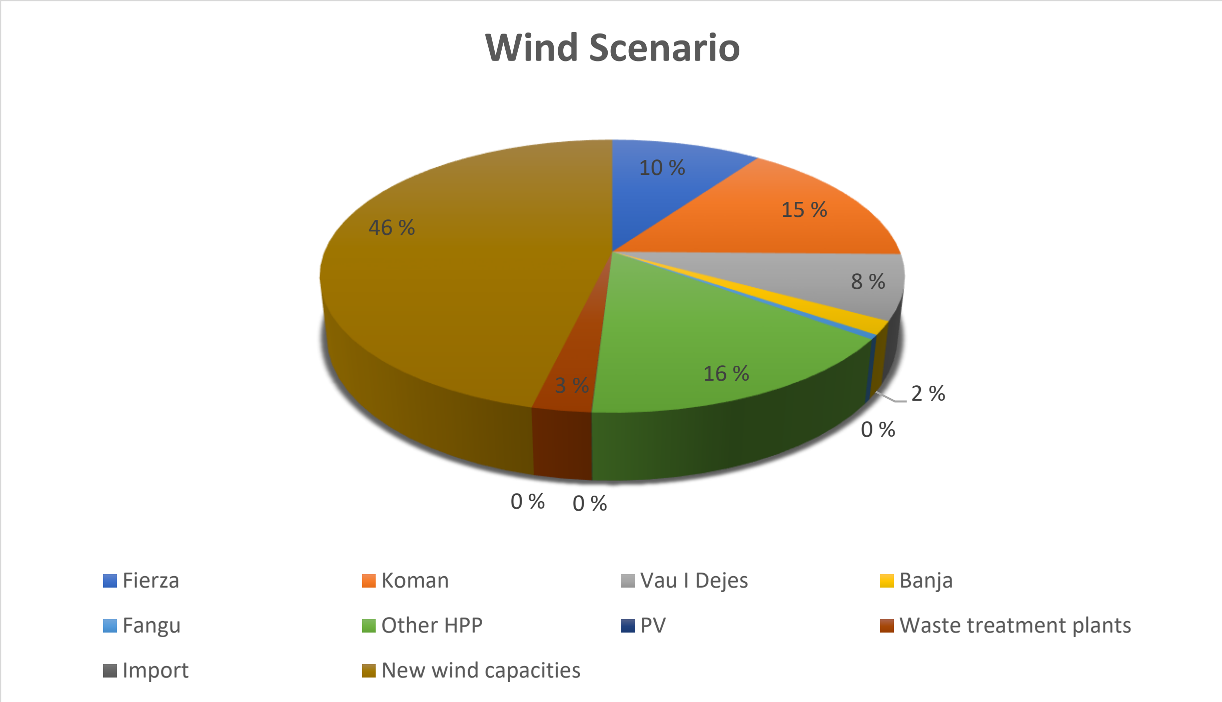


Figure 22: Wind Scenario Pie Chart

In the proposed wind scenario, the new invested capacities in onshore wind farms were proposed and the results generated from the optimization show a share of 46% of new wind capacities in the total electricity production. The import in this case is still remaining 8%, while hydropower plants do not present many changes.

According to the optimization, this scenario would be profitable, and this is acceptable, as the potential seems to be promising, but discussion can be made when interpreting the resulted power system. It is known that new investment costs of wind power are considerable expensive and according to the optimization, the generation of electricity from wind would cover a demand nearly 46 percent.

7.5 Optimisation results for combined solar and wind scenario

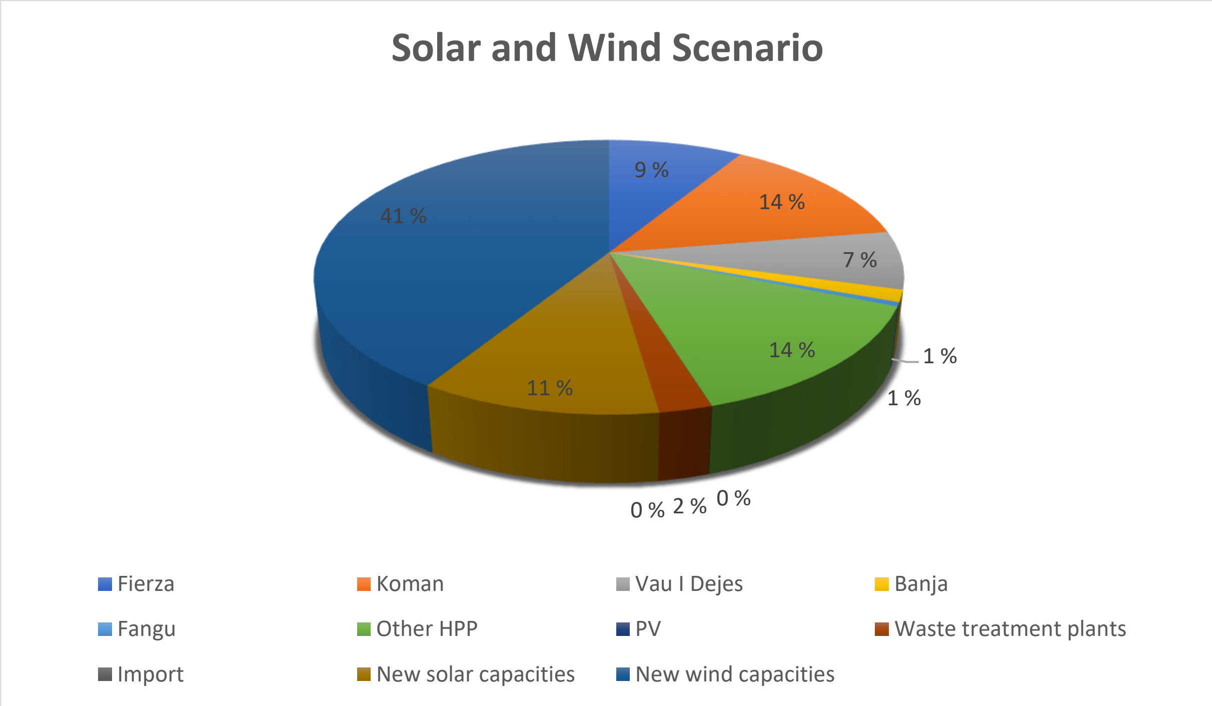


Figure 23: Solar and Wind Scanario Pie Chart

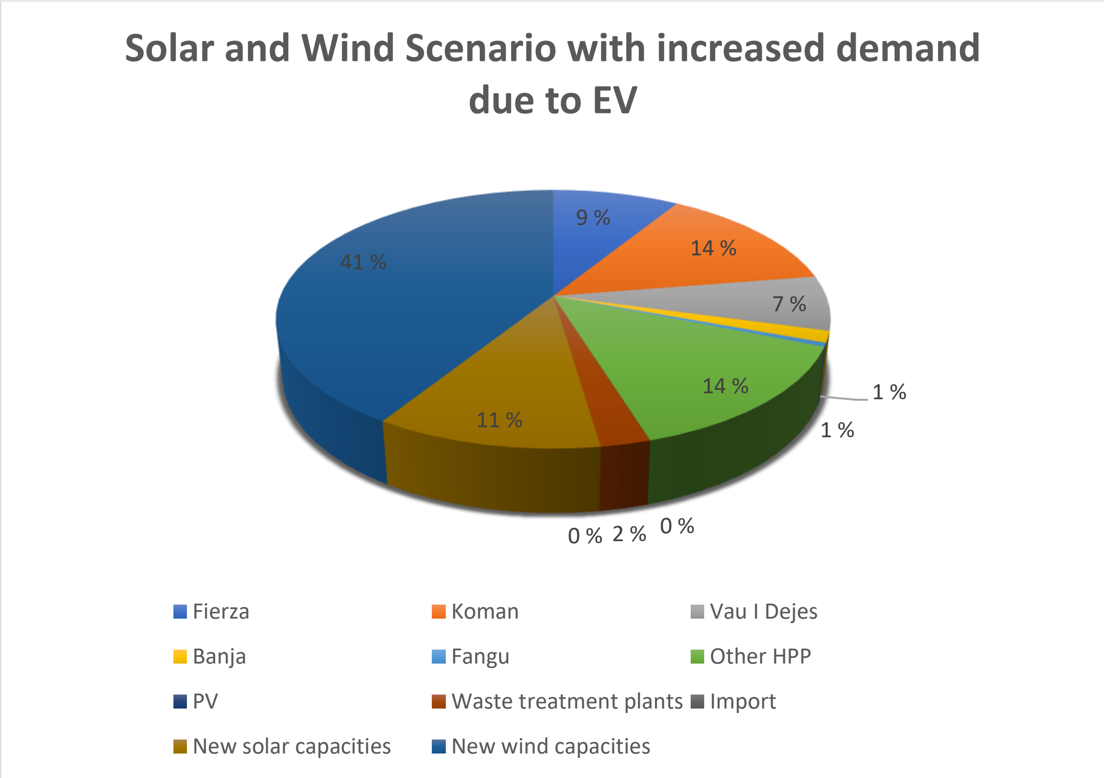
The proposed scenario of combined solar and wind energy, seems to also be profitable and worthy to invest, according to the optimization. In this case, the share of new wind capacities is proposed to be 41% in the total production and new solar capacities have a share of 11%, while the dependence on imports seems almost gone. As in the wind scenario case, these results leave also room for discussion, as the share of wind production in this case is also more than 40%.

7.6 Optimisation results for bioenergy scenario

Based on applied data, the optimization, seeking for an optimal solution that leads to the minimum costs, suggests not to invest into these biomass plants, as they result to be expensive and non-cost-effective.

This may also be affected by the data added in the reference scenario, where some specific information regarding the costs of electricity production was hard to find. However, because of the great attention paid to research in the improvement of technologies at the end, with regard to the reduction of installation costs and the improvement of efficiency, perhaps in the future this investment will be of great interest to Albania, as resources which can be exploited in this field, represent considerable potential.

7.7 Optimisation results for combined solar and wind scenario with the increased demand due to EV



The generated results from the optimization in this case, does not give a new solution for the combined scenario. What will happen is the export amount will be less accordingly, which is understandable, because that amount of electricity, which would go for export is needed for domestic consumption, which in this case is grown from the increased consumption due to electric cars.

8 Concluding discussion

As a country dependent on imports, producing mainly by hydropower only, with the location of the bigger plants in the north part of the country, while the main consumption is concentrated in the central and south part of it, Albania has a lot of challenges when it comes to fulfilling its domestic needs for electricty. Electricity, is one of the main energy types consumed in Albania. (Raporti I ERES), that is why it is neccesary to intervent into the excisting power system, and provide solutions for all the challenges mentioned before.

Based on applied data, the Albanian power system seems to have the possibility to become a green battery for the Balkan area. With an existing power system, based complitely on hydropower the system is highly dependent on imports. The country is facing many challenges in fulfilling its domestic demand for electricity, because of the dependence on hidrological conditions and the absence of enough production installed capacities into the system. As a lot of hydropower potential is actually exploited, attention is directed to other alternative sources, that represent potential. In this direction, Albania represents a lot of potential for renewable energy sources like solar, wind and bioenergy.

By using the system analysis method, and the quantitative methodology, a reference scenario was created, based on the existing power system of the country. A model was set up by considering an appropriate time division, all the generating capacities in the power system, the annual power production for 2017, the efficiency of the plants and many other necessary data.

By adding these data, Modest generated a big equation, that has the objective to minimize the total costs of the power system, by trying to find the optimal solution, which leads to the minimum costs. The reference scenario that resulted from the optimization reflects somehow the situation of the existing power system of Albania. This reflection is not 100% the same, given that many factors affected these results. This case required very specific and accurate data, the possession of which was very difficult. Very few of these data are published and their possession required a great deal of time. This means that this diploma theme requires further work, because of accurate and missing data.

Anyway, a general idea is created based on the results from the proposed model scenarios. These results show that the model, trying to minimize the costs, supports new investments in new solar and wind capacities. By adding these new capacities into the system, the import seems to decrease sensibly, almost disappearing and the power system is converted into a green one, based only on renewable energy sources. These results leave room for discussion, especially in the last case scenario, that combines wind and solar capacities. According to the optimization, the share of wind power is more than 40%.

These results can be explained because changes were made when applying the data into the model. It could not be forced to reflect the reality. The prices of imported and exported electricity were very low, so that the model could not find find a solution for the generated equation to be solved. That is why a new scenario with a deregulated market was proposed.

In conclussion, Albania as a small country, with a favorable location, has a lot of unexploited potential and all of these new proposed investments are attractive, but further studies must be done in the area, so that more data will be available, and new solutions will be found to help creating a sustainable power system for the country, contributing also in the Balkan area.

9 References

2018, G. E. S. Y. (2018) *Share of renewables in electricity production*. Available at: https://yearbook.enerdata.net/renewables/renewable-in-electricity-production-share.html.

A.Halili, D. (2016) *Studimi i potencialeve rajonale te energjise diellore. Mbledhesit diellore, ndikimi i parametrave fizike e teknologjike ne efektivitetin e perdorimit te tyre ne rajone te ndryshme te Shqiperise*. Available at: https://www.upt.al/images/stories/phd/Disertacion_Daniela%20Halili.pdf.

Agency, E. E. (2018a) *Total greenhouse gas emission trends and projections*. Available at: https://www.eea.europa.eu/data-and-maps/indicators/greenhouse-gas-emission-trends-6/assessment-2

Agency, E. E. (2018b) *Primary energy consumption by fuel*. Available at: https://www.eea.europa.eu/data-and-maps/indicators/primary-energy-consumption-by-fuel-6/assessment-2.

Agency, I. E. (2018) *Renewables 2018*. Available at: https://www.iea.org/renewables2018/ (Accessed: 04.06 2019).

AIDA *Burimet energjitike ne Shqiperi*. Available at: http://aida.gov.al/home (Accessed: 04.06 2019).

Alemayehu Gebremedhin, J. D. O. G. (2012) Is there a space for additional renewable energy in the Norwegian power system? Potential for reduced global emission, *ELSEVIER*.

Andrianesis, P. (2011) Greece's electricity market. Available at: https://www.researchgate.net/publication/232173115_An_overview_of_Greece's_wholesale_electricity_market_with_emphasis_on_ancillary_services.

Ånund Killingtveit, i. M. G. W. (2019) Storage hydropower. Available at: https://www.sciencedirect.com/topics/engineering/storage-hydropower.

Association, I. H. *Types of hydropower*. Available at: https://www.hydropower.org/types-of-hydropower (Accessed: 04.06 2019).

Bellini, E. (2019) Statkraft plans its first floating solar plant in Albania, *Pv Magazine*.

Bualoti Rajmonda and Marialis, Ç. (2001) *THE SITUATION AND DEVELOPMENT OF ALBANIAN ELECTRIC POWER SYSTEM IN INTERNATIONAL CONNECTION AND EXCHANGES*.

C. Diendorfer, M. H., M. Lauermann (2014) Performance analysis of offshore solar power plants, *Science Direct*. Available at: https://www.sciencedirect.com/science/article/pii/S1876610214007152.

CORDIS (2016) *Renewable energy potentials of Albania*. Available at: https://cordis.europa.eu/news/rcn/130474/en (Accessed: 04.06 2019).

Council, W. E. (2016) *World Energy Sources*. Available at: https://www.worldenergy.org/data/resources/resource/hydropower/ (Accessed: 04.06 2019).

DagHenning MODEST—An energy-system optimisation model applicable to local utilities and countries, *ELSEVIER*. Available at: https://www.sciencedirect.com/science/article/pii/S0360544297000522.

Dana, R. (2018) Offshore Solar: A New Energy Opportunity For Coastal Communities, *Solar Tribune*. Available at: https://solartribune.com/offshore-solar-new-energy-opportunity-coastal-communities/.

Deethumol Augustin, R. C., Joffie Jacob (2016) Canal Top Solar Energy Harvesting using

Reflector, *GRD Journals*. Available at: https://pdfs.semanticscholar.org/6b6d/9b0af02716ec0379dfc74685b0b892cd7a58.pdf.
Doshi, Y. (2017) *Rooftop Solar Photovoltaic (PV) Installation Market Overview*. Available at: https://www.alliedmarketresearch.com/rooftop-solar-photovoltaic-PV-installation-market.
Electricity, E. N. o. T. S. O. f. Available at: https://docstore.entsoe.eu/Pages/default.aspx (Accessed: 04.06 2019).
Emission, E. (2019) Bioenergy, *SETIS*. Available at: https://setis.ec.europa.eu/system/files/Technology_Information_Sheet_Bioenergy.pdf.
ENERRAY (2017) *The advantages of rooftop solar systems*. Available at: https://www.enerray.com/blog/advantages-rooftop-solar-systems.
ERE (2015) *Power Sector Situation and ERE Activity during 2015*. Available at: http://www.ere.gov.al/doc/Annual_Report__2015.pdf.
ERE (2018a) *Annual Report*. Available at: http://ere.gov.al/doc/2018-07-16-Raporti_Vjetor_2017-v2.pdf.
ERE (2018b) *ere.gov.al* Available at: http://www.ere.gov.al/.
eurostat (2018) *Natural gas supply statistics*. Available at: https://ec.europa.eu/eurostat/statistics-explained/index.php?title=Natural_gas_consumption_statistics&oldid=88292#Consumption_trends.
Explained, e. S. (2018a) Oil and petroleum products - a statistical overview. Available at: https://ec.europa.eu/eurostat/statistics-explained/index.php/Oil_and_petroleum_products_-_a_statistical_overview#Production_of_crude_oil.
Explained, e. S. (2018b) Coal production and consumption statistics. Available at: https://ec.europa.eu/eurostat/statistics-explained/index.php?title=Coal_production_and_consumption_statistics#Consumption_and_production_of_hard_coal.
Explained, S. (2018) Greenhouse gas emission statistics - emission inventories *Statistics Explained*. Available at: https://ec.europa.eu/eurostat/statistics-explained/pdfscache/1180.pdf.
export.gov *Montenegro - Energy Sector*. Available at: https://www.export.gov/article?id=Montenegro-energy-sector.
Farris, C. H. a. A. (2017) Run of River Power, *Energy BC*. Available at: http://www.energybc.ca/runofriver.html.
Helene Cser, L. B. (2015) Technologies that produce electricity, heat, and fuel from biomass feedstocks, *IBSS*. Available at: https://forestry.ces.ncsu.edu/wp-content/uploads/2016/05/IBSS-Bioenergy-Technology_1508.pdf?fwd=no.
Hollaway, L. C. (2013) *Advanced Fibre-Reinforced Polymer (FRP) Composites for Structural Applications,*.
Honore, A. (2018) Natural gas demand in Europe in 2017 and short term expetations, *Oxford Energy Insight*. Available at: https://www.oxfordenergy.org/wpcms/wp-content/uploads/2018/04/Natural-gas-demand-in-Europe-in-2017-and-short-term-expectations-Insight-35.pdf.
Hydro, B. Available at: http://www.british-hydro.org/tidal-range-off-shore/ (Accessed: 04.06 2019).
IRENA (2017) *COST-COMPETITIVE RENEWABLE POWER GENERATION:Potential across South East Europe*.
IRENA (2018) *Wind Energy*. Available at: https://www.irena.org/wind (Accessed: 04.06 2019).
Jonuzaj, K. (2018) Statkraft seeks building permit for floating solar park in Albania, *Renewables now*.
K.Sudhakar, A. S. N. Y. (2016) *Floating photovoltaic power plant: A review*.
KESH (2015) *Korporata ElektroEnergjitike Shqiptare*. Available at: http://kesh.al/Files/KESH%20infoset%20and%20cover%20shqip.pdf?fbclid=IwAR0qt4t8Dq4iJ_Yv6csdQXRqqf7jks89QfYH5Bp_7_c3I7tqjLGQqp33hH0.

KESH (2018) *KESH sh.a merr nga MIE miratimin paraprak për zhvillimin me tej të projektit për ndërtimin e impiantit fotovoltaik lundrues*. Available at: http://www.kesh.al/Njoftim.aspx?_NKatID=1709.

Ki-HyunKim, E. K. P. K. S. K. A. A. A. (2018) *Solar energy: Potential and future prospects*.

KNOEMA (2018) *BP: World Reserves of Fossil Fuels*. Available at: https://knoema.com/infographics/smsfgud/bp-world-reserves-of-fossil-fuels (Accessed: 04.06 2019).

KOSTT (2019). Available at: http://kostt.com/website/index.php/component/content/article/205.html (Accessed: 04.06 2019).

Lund, H. (2014) Energy System Analysis. Available at: https://www.sciencedirect.com/topics/engineering/energy-system-analysis.

MODEST *MODEST*. Available at: http://www.optensys.se/index-filer/Page677.htm (Accessed: 04.06 2019).

N.Khan, N. A. A. K. (2015) Review of fossil fuels and future energy technologies. Available at: https://www.sciencedirect.com/science/article/pii/S0016328715000397.

Network, B. (2017) The Energy Sector in Albania, *Bankwatch Network*. Available at: https://bankwatch.org/beyond-coal/energy-sector-in-albania.

NHA *PUMPED STORAGE*. Available at: https://www.hydro.org/policy/technology/pumped-storage/ (Accessed: 04.06 2019).

Offshore Wind Solutions. Available at: https://akersolutions.com/what-we-do/products-and-services/offshore-wind-solutions/ (Accessed: 04.06 2019).

Olav H. Hohmeyer, S. B. (2014) Trends toward 100% renewable electricity supply in Germany and Europe: a paradigm shift in energy policies. Available at: https://onlinelibrary.wiley.com/doi/full/10.1002/wene.128.

Pyke, T. (2017) The energy debate: Renewable energy cannot replace fossil fuels, *Development Education*. Available at: https://developmenteducation.ie/feature/the-energy-debate-renewable-energy-cannot-replace-fossil-fuels/.

Ramsdale, J. (2016) *What are the pros and cons of a ground-based solar PV system?* Available at: http://www.yougen.co.uk/blog-entry/2709/What+are+the+pros+and+cons+of+a+ground-based+solar+PV+system'3F+/.

Santafé, K. T. M. R. (2014) A review of floating photovoltaic installations: 2007–2013, *Progress in Photovoltaics*. Available at: https://onlinelibrary.wiley.com/doi/abs/10.1002/pip.2466.

SINTEF (2017) *Offshore wind*. Available at: https://www.sintef.no/en/wind_power/ (Accessed: 04.06 2019).

Statkraft (2016) *Banja*. Available at: https://www.statkraft.no/Energikilder/vaare-kraftverk/Albania/banja/.

Tonkin, B. (2019) The Truth About The Disadvantages Of Solar Energy Is About To Be Revealed, *SunPowerSource*. Available at: https://www.sunpowersource.com/disadvantages-of-solar-energy/.

World, R. E. (2019) *Geothermal Energy*. Available at: https://www.renewableenergyworld.com/geothermal-energy/tech.html) (Accessed: 04.06 2019).

Yoon, Y.-G. H.-J. J. S.-J. (2014) Design and installation of floating type photovoltaic energy generation system using FRP members, *ELSEVIER*, 108. Available at: https://www.sciencedirect.com/science/article/pii/S0038092X14003326?via%3Dihub.

10 Appendix

10.1 Appendix A: MODEST data reference scenario

Period of analysis 10 years.

Real discount rate 6.0 % if not otherwise indicated.

Time periods

Name of month	Name of the time division	Nr of hours
January	1 to 6	186
January	7	31
January	8	31
January	9	31
January	10	31
January	11 to 17	217
January	18 to 21	124
January	22	31
January	23	31
January	24	31
February	1 to 6	168
February	7	28
February	8	28
February	9	28
February	10	28
February	11 to 17	196
February	18 to 21	112
February	22	28
February	23	28
February	24	28
March	1 to 6	186
March	7	31
March	8	31
March	9	31
March	10	31
March	11 to 17	217
March	18 to 21	124
March	22	31
March	23	31
March	24	31

April	1 to 6	180
April	7	30
April	8	30
April	9	30
April	10	30
April	11 to 17	210
April	18 to 21	120
April	22	30
April	23	30
April	24	30
May	1 to 6	186
May	7	31
May	8	31
May	9	31
May	10	31
May	11 to 17	217
May	18 to 21	124
May	22	31
May	23	31
May	24	31
June	1 to 6	180
June	7	30
June	8	30
June	9	30
June	10	30
June	11 to 17	210
June	18 to 21	120
June	22	30
June	23	30
June	24	30
July	1 to 6	186
July	7	31
July	8	31
July	9	31
July	10	31
July	11 to 17	217
July	18 to 21	124
July	22	31
July	23	31
July	24	31
August	1 to 6	186
August	7	31
August	8	31
August	9	31
August	10	31

August	11 to 17	217
August	18 to 21	124
August	22	31
August	23	31
August	24	31
September	1 to 6	180
September	7	30
September	8	30
September	9	30
September	10	30
September	11 to 17	210
September	18 to 21	120
September	22	30
September	23	30
September	24	30
October	1 to 6	186
October	7	31
October	8	31
October	9	31
October	10	31
October	11 to 17	217
October	18 to 21	124
October	22	31
October	23	31
October	24	31
November	1 to 6	180
November	7	30
November	8	30
November	9	30
November	10	30
November	11 to 17	210
November	18 to 21	120
November	22	30
November	23	30
November	24	30
December	1 to 6	186
December	7	31
December	8	31
December	9	31
December	10	31
December	11 to 17	217
December	18 to 21	124
December	22	31
December	23	31
December	24	31

10.2 Appendix B: Energy demand load

```
Nodes

ED  Power demand
    energy demand (load)
     Energy demand [MW] time period
      532.06            010101
      710.23            010102
      938.33            010103
      1060.25           010104
      1089.64           010105
      1053.53           010106
      1189.34           010107
      1065.77           010108
      918.44            010109
      734.41            010110
      561.52            010201
      756.83            010202
      984.50            010203
      1086.19           010204
      1098.95           010205
      1073.49           010206
      1185.16           010207
      1070.49           010208
      947.92            010209
      769.54            010210
      556.67            010301
      736.20            010302
      934.37            010303
      1021.86           010304
      1042.66           010305
      976.67            010306
      1069.25           010307
      1010.13           010308
      897.82            010309
      738.20            010310
      511.25            010401
      655.00            010402
      806.55            010403
      870.51            010404
      881.17            010405
      815.71            010406
      847.98            010407
      879.09            010408
      782.09            010409
      652.18            010410
      501.51            010501
      632.87            010502
      762.76            010503
      826.67            010504
      840.58            010505
      805.79            010506
      810.95            010507
      841.24            010508
      750.79            010509
      627.03            010510
      518.73            010601
      624.78            010602
      745.45            010603
```

825.22	010604
858.87	010605
844.65	010606
822.28	010607
868.22	010608
786.50	010609
655.31	010610
537.75	010701
643.39	010702
770.59	010703
862.35	010704
904.72	010705
901.90	010706
871.71	010707
921.30	010708
831.29	010709
694.50	010710
585.50	010801
676.87	010802
806.12	010803
907.50	010804
952.23	010805
970.42	010806
957.79	010807
958.79	010808
859.40	010809
741.22	010810
519.94	010901
643.30	010902
782.61	010903
850.22	010904
866.65	010905
855.24	010906
883.48	010907
830.26	010908
732.71	010909
626.39	010910
514.92	011001
673.83	011002
826.39	011003
874.91	011004
867.95	011005
830.16	011006
903.56	011007
807.15	011008
717.69	011009
612.74	011010
536.77	011101
728.08	011102
901.19	011103
958.10	011104
951.68	011105
929.96	011106
1025.55	011107
890.72	011108
786.91	011109
661.14	011110
607.46	011201
800.46	011202
1030.87	011203
1164.37	011204

```
      1190.19           011205
      1147.62           011206
      1265.94           011207
      1140.56           011208
      1009.28           011209
      833.21            011210
    Energy demand [MWh]   season
    677084.68           01
    625480.83           02
    645884.24           03
    530879.04           04
    532434.28           05
    530352.11           06
    578298.57           07
    621216.06           08
    539172.08           09
    554761.27           10
    591310.94           11
    741234.68           12
    7168108.77          all
FZ  FIERZA PP
    start node

    Energy price
      follow(s) inflation
    Annual costs totalled (present value) by multiplying with
      7.36
    maximum 500.0 MW output to TG
    Outflow to TG may be maximum
    season               MWh
       01             182915.0
       02              69205.0
       03              85127.0
       04             119101.0
       05              60156.0
       06             151376.0
       07              46680.0
       08              40094.0
       09               7323.0
       10              87526.0
       11              15024.0
       12               7945.0
    The efficiency of the outflow is 0.900 in TG
    Node TG is/are assumed to be conversion node(s)
KM  KOMAN PP
    start node

    Energy price
      follow(s) inflation
    Annual costs totalled (present value) by multiplying with
      7.36
    maximum 600.0 MW output to TG
    Outflow to TG may be maximum
    season               MWh
       01             198777.0
       02             146029.0
       03             141547.0
       04             161869.0
       05              94175.0
       06             168615.0
       07              73258.0
```

```
       08               40196.0
       09               30097.0
       10              100520.0
       11               52578.0
       12              156098.0
    The efficiency of the outflow is 0.830 in TG
    Node TG is/are assumed to be conversion node(s)
VD  VAU I DEJES PP
    start node

    Energy price
      follow(s) inflation
    Annual costs totalled (present value) by multiplying with
      7.36
    maximum 250.0 MW output to TG
    Outflow to TG may be maximum
    season               MWh
       01               96292.0
       02               76990.0
       03               71419.0
       04               82564.0
       05               45693.0
       06               79233.0
       07               31970.0
       08               16805.0
       09               13271.0
       10               47505.0
       11               23767.0
       12               95250.0
    The efficiency of the outflow is 0.820 in TG
    Node TG is/are assumed to be conversion node(s)
TG  TRANSMISSION GRID
    conversion node
    The efficiency of the outflow is 0.950 in ED EK EG EM
    Node ED is/are assumed to be energy demand

    Node EK EG EM is/are assumed to be conversion node(s)
HD  Plants connected to the distribution grid
    start node

    Energy price
      follow(s) inflation
    Annual costs totalled (present value) by multiplying with
      7.36
    maximum 223.4 MW output to TG
    Outflow to TG may be maximum
    season               MWh
       01               22495.0
       02               49077.0
       03               73302.0
       04               59927.0
       05               51480.0
       06               26088.0
       07                9063.0
       08                5296.0
       09                8812.0
       10               11565.0
       11               35828.0
       12               87120.0
    The efficiency of the outflow is 0.850 in TG
    Node TG is/are assumed to be conversion node(s)
```

```
HT  Plants connected to the  transmission grid
    start node

    Energy price
      follow(s) inflation
    Annual costs totalled (present value) by multiplying with
      7.36
    maximum 266.4 MW output to TG
    Outflow to TG may be maximum
    season               MWh
       01              18405.0
       02              44938.0
       03              63759.0
       04              57382.0
       05              50316.0
       06              20030.0
       07               7380.0
       08               2892.0
       09               4897.0
       10              10658.0
       11              25852.0
       12              82250.0
    The efficiency of the outflow is 0.850 in TG
    Node TG is/are assumed to be conversion node(s)
AS  Ashta
    start node

    Energy price
      follow(s) inflation
    Annual costs totalled (present value) by multiplying with
      7.36
    maximum  48.2 MW output to TG
    Outflow to TG may be maximum
    season               MWh
       01              24792.0
       02              20138.0
       03              18974.0
       04              21156.0
       05              12011.0
       06              19584.0
       07               7406.0
       08               3572.0
       09               3402.0
       10              12590.0
       11               6731.0
       12              24170.0
    The efficiency of the outflow is 0.870 in TG
    Node TG is/are assumed to be conversion node(s)
LB  Lanabregas PP
    start node

    Energy price
      follow(s) inflation
    Annual costs totalled (present value) by multiplying with
      7.36
    maximum   5.0 MW output to TG
    Outflow to TG may be maximum
    season               MWh
       01               2622.0
       02               2897.0
       03               3303.0
```

```
       04                3120.0
       05                3037.0
       06                2830.0
       07                2397.0
       08                1937.0
       09                1737.0
       10                1816.0
       11                2294.0
       12                3736.0
    The efficiency of the outflow is 0.860 in TG
    Node TG is/are assumed to be conversion node(s)
UB  Ulez Shkopet Bistrica1 Bistrica2
    start node

    Energy price
      follow(s) inflation
    Annual costs totalled (present value) by multiplying with
      7.36
    maximum  76.7 MW output to TG
    Outflow to TG may be maximum
    season               MWh
       01               21378.0
       02               28017.0
       03               43116.0
       04               38597.0
       05               25991.0
       06               18026.0
       07               12908.0
       08               11367.0
       09               10678.0
       10               11159.0
       11               15316.0
       12               50026.0
    The efficiency of the outflow is 0.850 in TG
    Node TG is/are assumed to be conversion node(s)
PS  Peshqesh PP
    start node

    Energy price
      follow(s) inflation
    Annual costs totalled (present value) by multiplying with
      7.36
    maximum  27.9 MW output to TG
    Outflow to TG may be maximum
    season               MWh
       01                5980.0
       02               13496.0
       03               13238.0
       04                8529.0
       05                5688.0
       06                2791.0
       07                1571.0
       08                 800.0
       09                1568.0
       10                3238.0
       11                4204.0
       12               18475.0
    The efficiency of the outflow is 0.850 in TG
    Node TG is/are assumed to be conversion node(s)
FG  Fangu PP
    start node
```

```
    Energy price
      follow(s) inflation
    Annual costs totalled (present value) by multiplying with
      7.36
    maximum  74.6 MW output to TG
    Outflow to TG may be maximum
    season               MWh
       01                   0.0
       02                   0.0
       03                   0.0
       04                   0.0
       05                   0.0
       06                   0.0
       07                   0.0
       08                   0.0
       09                   0.0
       10                   0.0
       11                 181.0
       12               46867.0
    The efficiency of the outflow is 0.850 in TG
    Node TG is/are assumed to be conversion node(s)
BN  Banja PP
    start node

    Energy price
      follow(s) inflation
    Annual costs totalled (present value) by multiplying with
      7.36
    maximum  73.0 MW output to TG
    Outflow to TG may be maximum
    season               MWh
       01               20359.0
       02                6332.0
       03               16690.0
       04                8096.0
       05                9297.0
       06                9452.0
       07               11931.0
       08                4159.0
       09                4013.0
       10                7524.0
       11                8711.0
       12               34303.0
    The efficiency of the outflow is 0.850 in TG
    Node TG is/are assumed to be conversion node(s)
PV  Central Photovoltaic
    start node

    Energy price
      follow(s) inflation
    Annual costs totalled (present value) by multiplying with
      7.36
    maximum   1.0 MW output to TG
    The efficiency of the outflow is 0.200 in TG
    Node TG is/are assumed to be conversion node(s)
TI  Tirana's Incenerator
    start node

    Energy price
      follow(s) inflation
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```
    Annual costs totalled (present value) by multiplying with
      7.36
    maximum  12.0 MW output to TG
    The efficiency of the outflow is 0.210 in TG
    Node TG is/are assumed to be conversion node(s)
EI  Elbasani's Incenerator
    start node

    Energy price
      follow(s) inflation
    Annual costs totalled (present value) by multiplying with
      7.36
    maximum  12.0 MW output to TG
    The efficiency of the outflow is 0.210 in TG
    Node TG is/are assumed to be conversion node(s)
FI  Fieri's Incenerator
    start node

    Energy price
      follow(s) inflation
    Annual costs totalled (present value) by multiplying with
      7.36
    maximum   3.9 MW output to TG
    The efficiency of the outflow is 0.210 in TG
    Node TG is/are assumed to be conversion node(s)
IK  Import Kosovo
    start node

    Energy price
      follow(s) inflation
    Annual costs totalled (present value) by multiplying with
      7.36
    maximum 460.0 MW output to TG
    Outflow to TG may be maximum
    season              MWh
       01            110549.0
       02             48252.0
       03             47772.0
       04             11373.0
       05             55926.0
       06            100479.0
       07            126145.0
       08             94431.0
       09             84722.0
       10            146619.0
       11            165582.0
       12            163652.0
    The efficiency of the outflow is 0.950 in TG
    Node TG is/are assumed to be conversion node(s)
IG  Import Greece
    start node

    Energy price
      follow(s) inflation
    Annual costs totalled (present value) by multiplying with
      7.36
    maximum 1489.0 MW output to TG
    Outflow to TG may be maximum
    season              MWh
       01              6964.0
       02              8984.0
```

```
       03                8673.0
       04                  72.0
       05               56251.0
       06              112429.0
       07               24273.0
       08              106291.0
       09              224418.0
       10              168687.0
       11              195964.0
       12              143660.0
    The efficiency of the outflow is 0.950 in TG
    Node TG is/are assumed to be conversion node(s)
EK  Export Kosovo
    conversion node

    Energy price
      follow(s) inflation
    Annual costs totalled (present value) by multiplying with
      7.36
    maximum 460.0 MW output to WN
    Outflow to WN may be maximum
    season              MWh
       01               26175.0
       02              124255.0
       03              199858.0
       04              140301.0
       05               39829.0
       06               27172.0
       07               24723.0
       08               40935.0
       09               40122.0
       10               34126.0
       11               52631.0
       12               47310.0
    The efficiency of the outflow is 0.950 in WN
    Node WN is/are assumed to be waste node
EG  Export Greece
    conversion node

    Energy price
      follow(s) inflation
    Annual costs totalled (present value) by multiplying with
      7.36
    maximum 1489.0 MW output to WN
    Outflow to WN may be maximum
    season              MWh
       01              191220.0
       02              162033.0
       03              167594.0
       04              179668.0
       05              288413.0
       06              194189.0
       07              202557.0
       08              116103.0
       09              170963.0
       10              121364.0
       11              153032.0
       12              150477.0
    The efficiency of the outflow is 0.950 in WN
    Node WN is/are assumed to be waste node
EM  Export Montenegro
```

```
    conversion node

    Energy price
      follow(s) inflation
    Annual costs totalled (present value) by multiplying with
      7.36
    maximum 1628.0 MW output to WN
    Outflow to WN may be maximum
    season               MWh
       01             109195.0
       02             201441.0
       03             360941.0
       04             302036.0
       05              81009.0
       06              55833.0
       07              29584.0
       08              64745.0
       09              89438.0
       10              45775.0
       11              30797.0
       12             236193.0
    The efficiency of the outflow is 0.950 in WN
    Node WN is/are assumed to be waste node
IM  Import Montenegro
    start node

    Energy price
      follow(s) inflation
    Annual costs totalled (present value) by multiplying with
      7.36
    maximum 1628.0 MW output to TG
    Outflow to TG may be maximum
    season               MWh
       01              62237.0
       02              57391.0
       03             109248.0
       04              20546.0
       05             155396.0
       06             103977.0
       07             151938.0
       08              88034.0
       09              61160.0
       10             176602.0
       11             230106.0
       12             236193.0
    The efficiency of the outflow is 0.950 in TG
    Node TG is/are assumed to be conversion node(s)
WN  West Node
    waste node
```