KOSOVA ACADEMY OF SCIENCES AND ARTS
ACADEMIA SCIENTIARUM ET ARTIUM KOSOVIENSIS

REPORT ON GENERATION OF ELECTRIC ENERGY IN KOSOVA

PRISHTINA
2020

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Publisher:
KOSOVA ACADEMY OF SCIENCES AND ARTS

Technical editor:
KASA

Computer design:
KASA

Size: 11.5 book blocks
Amount of copies: 100 pcs
Format: 23x28 cm

Cataloging in Publication- (CIP)
National Library of Kosova "Pjetër Bogdani"

621.31(496.51)(048.8)

Report on generation of electric energy in Kosova / Isuf Krasniqi...[et al.].- Prishtina : Kosova Academy of Sciences and Arts : Natural Sciences Section,
2020.- 45 f. : ilustr. ; 28 cm.

The title and the text of the book in two languages.

1.Krasniqi, Isuf

ISBN 978-9951-26-024-4

978-9951-26-024-4

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NATURAL SCIENCES SECTION

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The working group was established at the initiative of KASA President, Academician Mehmet Kraja, based on the proposal of November 13, 2019, of the KASA Natural Sciences Section, and by decision of the KASA Presidency of February 21, 2020.

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CONTENT

1. INTRODUCTION

20 years after the war, and despite visible improvements and stability in power supply compared to the first post-war years when power outages, systematic reductions, and the buzzing of individual diesel generators were part of ordinary daily life, Kosova's Electric Energy System is still confronted with formidable problems. A series of undertaken actions, such as: maintenance and regular repair of Kosova A TPP and Kosova B TPP units, investments in the transmission and distribution network, direct investments in the opening of the Sibovc southwest mine, re-functionalization of existing small hydropower plants, privatization of the distribution and supply network, the reduction of technical and non-technical losses, most favorable prices in the regional electricity market, and enhancement of the legal and regulatory framework, have had a direct impact in the improvement of this situation.

Despite conspicuous investments in this sector and the improvement of the overall situation in the Electric Energy System, Kosova still imports around 10% of its electricity demand and faces major problems from the point of view of securing the necessary capacities to cover the maximum energy demand (peak), which is especially pronounced during the winter season. A separate problem is meeting the requirements for necessary reserve capacities and the regulation of stability (balancing) of the Electric Energy System as a whole.

For sustainable economic and social development of the country, and based on current demand for electric power, uninterrupted supply of sufficient and high-quality electric power is indispensable. For this reason, the regular supply of consumers in Kosova (individual, commercial and industrial) with high-quality and abundant electric power, is a great challenge for all parties involved in this issue. There is no simple, fast, and easy solution to this complex problem, because it depends on many multidisciplinary factors.

The Academy of Sciences and Arts of Kosova, with the working group, has prepared a document for analysis, evaluation and suggestions for future developments in the energy sector in Kosova, analyzing the existing supply, increasing future demand, and possible, realistic options for stable and reasonably-priced supply for consumers.

This document analyzes the alternatives and realistic possibilities for Kosova to meet the demand for electricity, including the environmental aspects of each alternative. Previous studies conducted by the European Commission, the World Bank, and other donors, have concluded that in Kosova, electricity generation from coal is the least costly option compared to other options, in order for the whole country to meet its demand for power supply. This report also highlights that the most sustainable and low-cost solution is the construction of new generation capacities based on local lignite reserves, followed by the construction of modest capacities in renewable energy sources (RES).

LIST OF ACRONYMS

BAT	Best Available Techniques
RES	Renewable Energy Sources
IED	Industrial Emissions Directive
ENTSO-E	European Network of Transmission System Operators for Electricity
CG	ControurGlobal
CO2	Carbon Dioxide
HPP	Hydroelectric Power Plant
IED/BAT	Industrial Emissions Directive/Best Available Techniques
HIK	Hydrometeorological Institute of Kosova
GWh	Gigawatt hours
KEDS	Kosova Energy Distribution Services
KESCO	Kosova Company for Supply of Energy
KEK	Kosova Energy Corporation
KOSTT	Transmission, System and Market Operator
kV	Kilovolt
MW	Megawatt
MWh	Megawatt hour
MED	Ministry of Economic Development
NOx	Nitrogen Oxides
SA	Substation
PM2.5	Particulate matter up to 2.5 μm
PM10	Particulate matter up to 10 μm.
HPST	High-pressure Steam Turbine
MPST	Medium-pressure Steam Turbine
LPST	Low-pressure Steam Turbine
EES	Electric Energy System
SO2	Sulfur Dioxide
TPP	Thermal Power Plant
Kosova A TPP	Kosova A Thermal Power Plant
Kosova B TPP	Kosova B Thermal Power Plant
KRTPP	Kosova e Re Thermal Power Plant
ELV	Emission Limit Value
MAV	Maximum Allowed Value
ERO	Energy Regulatory Office

2. KOSOVA'S ELECTRIC ENERGY SYSTEM (EES)

In each Electric Energy System, a number of generators are designed to supply different parts of the daily load (energy market or consumer demand), others are designed to operate continuously for around-the-clock power supply (basic supply), while some are designed to operate at short intervals, usually at peak demand. Kosova A and B TPPs use lignite as primary input, Ujmani HPP, Lumbardhi Deçan HPP, Radavc HPP, Burimi HPP use water, Wind Power and Air Energy-Kitka use wind. As of late, a wind farm with a capacity of 105 MW is under construction, which is a German investment, while PV Onix-Spa, PV Birra Peja and PV Frigo Food Kosova use solar energy [1].

The Zhur hydropower plant is designed, but not realized, and it was expected to generate 305 MW of electricity in a time interval of only 1-2 months.

Recently constructed RES generation is mainly connected to the distribution network for direct supply to individual consumers (commercial and industrial) to meet their needs, and do not directly contribute to the overall transmission system.

Each Electric Energy System must have a reserve amount of electric power. In some Electric Energy Systems, which mainly have hydropower-based generation, the required energy reserve should be approximately 12%, while in systems where the generation is based on gas, oil, coal or nuclear power, the required reserve should be approximately 16-24% of electric power, but in Kosova this amount of energy is completely lacking.

2.1. Transmission and distribution system

Overhead power lines, underground cable lines, etc., serve to transmit and distribute electricity from generating units to consumers. In some countries, this distribution system is divided into several parts, such as: transmission that includes voltages from 115 kV, 138 kV, 230 kV, 380 kV, 500 kV and 750 kV, then the 10 kV, 20 kV primary distribution, and finally the 0.4 kV secondary distribution (end consumers).

In Kosova, the energy system is divided into the transmission system that includes 110 kV, 220 kV and 400 kV voltage levels, which is handled by the Kosova System, Transmission and Market Operator (KOSTT, figure 1), and the distribution system that includes 35 kV, 20 kV, 10 kV and 0.4 kV voltage levels, a sector which has been privatized and is now owned by KEDS.

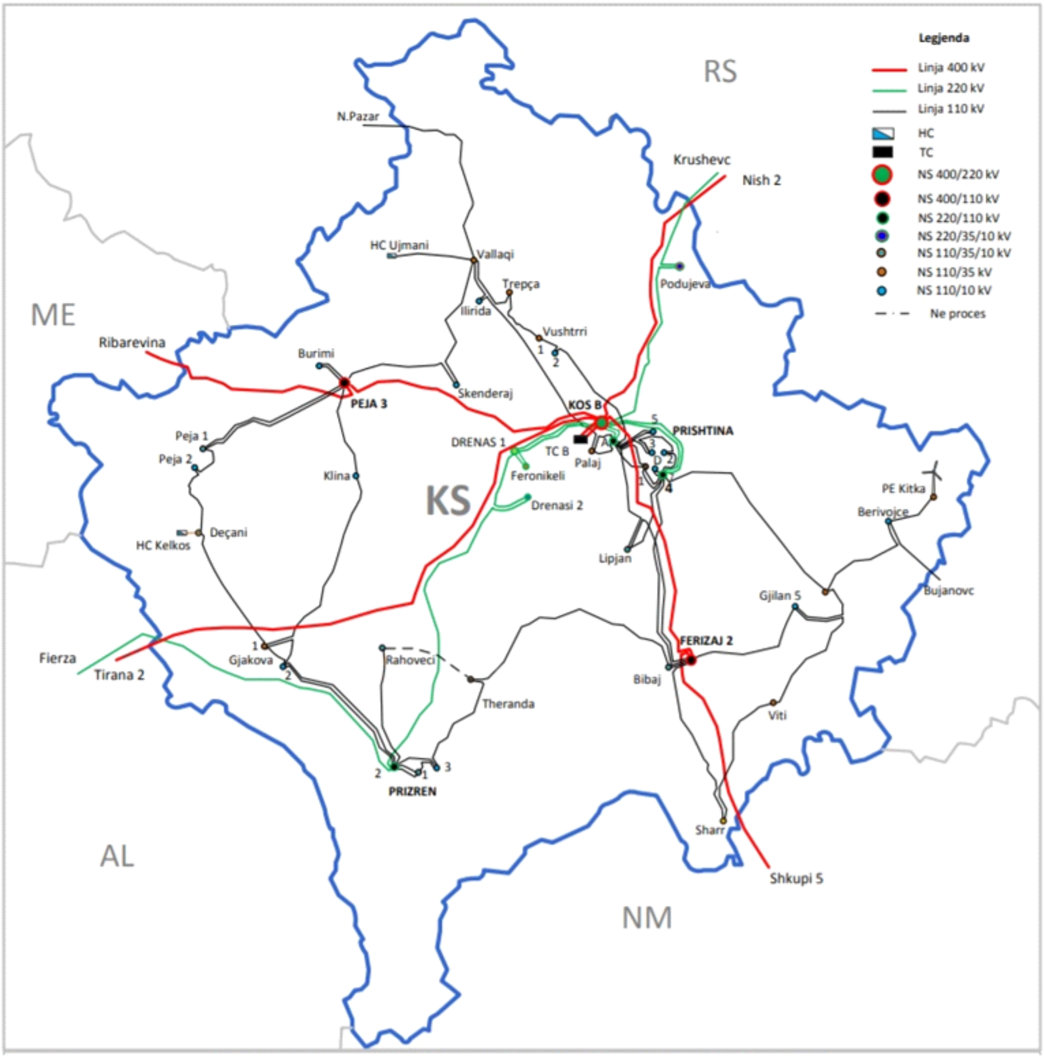

Figure 1. Electricity transmission system of the Republic of Kosova

The electricity transmission system in Kosova is operated by KOSTT, which is responsible for the safety and reliability of the operation of the Electric Energy System. The transmission network has sufficient capacity to withstand power flows from generators or external interconnections in the system, to the distribution. The transmission network of the Kosova Electric Energy System is well connected to the regional and European system through interconnection lines with:

- Albania, Macedonia, Montenegro and Serbia - with 400 kV lines;
- Albania and Serbia - with 220 kV lines, and
- Serbia - with two 110 kV lines.

The 400 kV interconnection line SS Kosova B - SS Kashar (Tirana) was finalized and successfully released for testing in 2016, but for political reasons was not put into regular operation. The main obstacles are presented by Serbia, which opposes the independence of Kosova's Electric Energy System from that of Serbia.

The Agreement signed for the secondary frequency/power regulation between KOSTT and the OST of Albania also remains unenforceable, as KOSTT has not yet started operating as a regulatory area/block within ENTSO-E (European Network of Transmission System Operators for Electricity), although on June 30, 2020, an Agreement was signed between KOSTT and this institution, however the regulation and stability of Kosova's Electric Energy System is still dependent on Serbia.

The transmission network of the Kosova Electric Energy System meets the local transmission needs. There may be considerable energy flows through the transmission network to meet consumer demand with domestic generation and imports, but also for eventual exports of surplus electricity and for transiting energy from other countries. The transit of electricity through Kosova's network in 2018 was about 32% compared to consumption, and this energy burdens the network with increasing losses, network depreciation, and the need for maintenance of the transmission network.

The following diagram shows the demand, generation and exchange of electricity for 2018, which shows that generation is higher than demand during night hours, while demand rises visibly and is higher than generation during daytime. Thus, within the same day, during daytime (high tariff) generation does not cover the demand and electricity has to be imported, while during nighttime (low tariff) there is surplus energy which should be exported, or the generation of electricity should be reduced. (Figure 2).

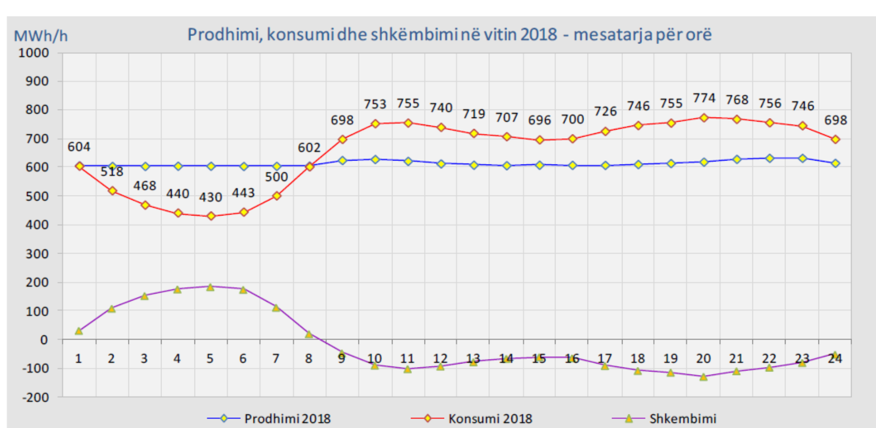

Figure 2. Daily diagram given as annual average for 24 hours of generation, consumption and exchange for 2018

Due to the missing electricity in the system, i.e. demand is greater than current generation capacities, occasional reductions are still present in specific cases.

Long-term planning of electricity consumption for a country requires forecasting the level of demand and consumption structure, maximum load (peak load), optimal structure of sources for electricity generation so that the supply of consumers is done reliably (with guaranteed quality and with sufficient energy), based on the principles of economic efficiency, at the lowest possible cost [2].

The optimal structure of new energy sources (Kosova e Re TPP, wind energy, hydropower and solar energy), which are proposed for generation at reasonable costs, is in line with the objectives of the Kosova Energy Strategy for the 2017-2026 period and the need for operation according to technical requirements from ENTSO.

It is also necessary to compare the data for the maximum installed load and in the use for electricity, predicting the reserve electricity required for emergencies (in cases where a generating unit falls out of the system). It is worth mentioning that Kosova's Electric Energy System (EES) operates without reserve capacities. For operation according to the standards, Kosova's EES should have about 1,300 MW of operating capacities and about 300 MW of reserves of available electricity. With the decommissioning of Kosova A TPP, the need for electricity will become more pronounced until the construction of new generation capacities, which are expected to be completed with the construction of the Kosova e Re TPP [1].

On the other hand, a number of studies have identified that wind energy potential is around 318 MW. But in most of the geographical locations identified in Kosova, wind speed is below 6 m/s, which is not sufficient and favorable for energy generation for commercial operation of these capacities.

2.2. Kosova A Thermal Power Plant

The Kosova A Thermal Power Plant (Kosova A TPP) consists of five independent generation units (blocks) with characteristics shown in Table 2. Blocks Kosova A1 and Kosova A2 are obsolete, and from 2000 are out of operation without any specific status. The annual generation of electricity from Kosova A TPP is about 1,500 GWh. The water supplied to these blocks comes from the Llap river site, while in drought conditions a quantity of water from the Iber-Lepenc system is used. A power plant with a power of 200 MW consumes about 300 t/h of coal with a heat of combustion of about 7,500 kJ/kg, respectively 1,800,000 tons of coal/year if it is estimated that the unit operates around 6,000 h/year. Thus, the three active units of Kosova A TPP consume about 5,400,000 tons of coal/year.

2.3. Kosova B Thermal Power Plant

The Kosova B Thermal Power Plant (Kosova B TPP) consists of two independent generation units (blocks). The annual generation of electricity from Kosova B TPP is about 3,650 GWh. The water supply of Kosova B TPP come from the Ujman Lake through the Iber-Lepenc system.

Water consumption for the three units of the Kosova A TPP is about 3,000 m3/h, while for the two units of the Kosova B TPP is about 2x1,410 m3/h = 2,820 m3/h. Thus, when all the blocks are in operation, they consume about 5,820 m3 of water/h. A quantity of water must also be provided for the hydraulic transport of ash and slag. For this purpose, only in one block of 200 MW about 500 m3 of water/h are consumed. In the Kosova A TPP and Kosova B TPP, ash and slag are removed via the hydraulic system, and once the hydro-mixture is shaped (ash, slag and water) it is sent via special pumps to the Sitnica landfill.

One block of a thermal power plant has a lifespan of about 40 years assuming that a general overhaul is performed once that block has been in operation for about 25 years. It follows that all units of Kosova A TPP should have been out of use, while the units of Kosova B TPP are at the end of their operations.

2.4. Cogeneration

Cogeneration means the combined generation of electricity and thermal energy in a power plant using a certain amount of steam, which after initially producing mechanical work (electricity) in the high-pressure steam turbine (HPST) and the medium-pressure steam turbine (MPST) for the heating needs of the city of Prishtina; for this purpose, from the pipeline between HPST and MPST are taken about 100 tons/hour = 27.715 kg/s of water vapor with the following parameters: pressure 2.405 bar and temperature about 191.80 C. This steam is sent to the surface heat exchanger, which is located near the thermal power plant, and thus generates about 70 MW of energy for thermal consumers.

Cogeneration from the Kosova B thermal power plant has started to be applied in the 2014/2015 heating season, and for this reason the city heating has consumed significantly less heavy oil. Now the cogeneration system operates from both units of the Kosova B thermal power plant.

3. ENERGY RESOURCES IN THE REPUBLIC OF KOSOVA

The variety of resources for electricity generation in Kosova is limited, except for coal, whose reserves are estimated to be 12.5 billion tons, of which 10.9 billion tons are exploitable. Lignite-type coal is the only local fuel for electricity generation.

The Sibovc mine (in the Kosova basin) is considered as the most acceptable option from an economic, social and environmental perspective, and it has enough lignite to supply the existing generating capacities until the end of their operational life, as well as to supply new generation capacities of 600 - 700 MW for around forty years.

3.1. Coal

Coal is the most important energy resource of Kosova, as it is used to generate around 97% of electricity in Kosova. According to the quality, Kosova has lignite coal with low combustion heat (5,860-8,360) kJ/kg. It is distinguished by its brown, dark brown to black color. Coal with combustion heat lower than 5,860 kJ/kg is not counted in coal reserves [1]. In Kosova coal is found in three basins: in the Kosova Plain, Dukagjini Plain and Drenica Plain. In the Kosova Plain, coal has been extracted since the 1960s in the villages: Mirash (Dobrosellë), Bardhi i Madh, Hade and Sibovc [3].

The Kosova Plain lignite contains: moisture (38 -48)%, ash (9.84-21.32)%, hydrogen (2.01 - 2.25)%, sulfur (0.68 - 1.51)% of which only (0.07-0.49)% is combustible sulfur, as well as about 38% combustible matter [4,5].

The combustible elements of solid fuels are: carbon C, hydrogen H and sulfur S. Non-combustible elements, components of fuel are: Nitrogen N, oxygen O, ash A and moisture W. Their elemental content is determined experimentally. In the whole basin of the Kosova Plain the waste/coal ratio is 1.5/1, while in the more profitable northern areas of the basin this ratio reaches 1/1.

The annual consumption of coal for the generation of 800MWh of electricity (approximately how much is currently generated by all power plants) with an efficiency of about $\eta TEC = 30\%$, is about 8 million tons/year [6].

3.2. Natural gas

Kosova has no natural gas resources or connection to any pipeline network for the gas supply system. Importing gas for electricity generation requires extending existing pipelines from Skopje (Northern Macedonia) or Nis (Serbia) to connect Prishtina and the Obiliq power plant locations. The operation of the gas-fired power plant requires the purchase, transport of gas, namely additional costs. This is not impossible, but it is hardly the case due to the relatively low demand and the seasonal nature of the demand. The study on the gasification of Southeast Europe conducted by the World Bank (October 2007) also analyzed the economic aspect of gas supply in Kosova. The study had concluded that from a financial point of view the establishment of the gas transmission line is not reasonable for any country in the region, except Romania, due to small markets. From this aspect, the option of building new generation capacities based on natural gas, would be much higher cost than the option with lignite as fuel, therefore the construction of new generation capacities based on natural gas is considered economically unreasonable for local circumstances.

3.3. Oil

Kosova has no identified oil resources. All fuels in liquid form in Kosova are imported by rail or land routes from Northern Macedonia and Albania. The construction of an oil-fired power plant, as a possible option, would depend on the import of inputs and oil price variations in the international market. As with the option of building a natural gas-fired power plant, buying oil would require additional substantial costs that would make the operation expensive and unsuitable for Kosova's conditions.

3.4. Hydropower potentials

Kosova has modest hydro capacities for electricity generation, given that the rivers in our country have mainly small water flows and short streams, which reduces the geographical options of building water reservoirs for hydropower plants.

The most serious plan for a medium-sized hydropower plant in Kosova has been the Zhur hydropower plant project, located southwest of Prizren in the Sharr region. The designed capacity of the hydropower plant was projected to be 305 MW to generate approximately 400 GWh of electricity per year in average hydrological conditions. It would function as complementary energy in the period of maximum consumption. This project has been considered since the 1980s, but it has been abandoned due to lack of investment and uncertainties about water storage capacity for this installed power.

Other studies conducted by various international institutions have identified 18-20 locations for smaller hydropower plants with a total capacity of about 70 MW, which can generate about 300 GWh per year in average hydrological conditions. Some of these small HPPs have already been built with investments from the private sector and are in operation. For a period of time, the Government has supported (subsidized) these capacities with incentivizing tariffs. But during the issuance of construction permits and licensing of these capacities by the local authorities, very little attention has been paid to the protection of the environment, meaning that the construction of these hydropower plants has caused significant damage to the environment due to diversion of streams and rivers and reduction of the free amount of water for use by local residents, with serious consequences for agriculture and the flora of construction sites. These constructions have often been accompanied by objections and protests from local residents, but without any effect on the authorities' awareness of environmental issues and irreparable consequences. Therefore, in the future this issue should be clearly addressed and regulated by relevant laws, so that environmental protection is a priority when issuing permits and licensing new facilities.

3.5. Wind potentials

Although wind resource maps are not yet complete for the geographical extent of Kosova, private investors have done some monitoring of locations with relevant wind values. So far, less than 34 MW have been installed. The "Mercados Energy" international company, for the needs of the World Bank, based on the assessment of resource availability, has calculated that the potential for wind energy generation in Kosova is about 2,000 GWh per year, which is equal to 1,000 MW of installed capacity with a capacity factor of 25%. This is also a rather optimistic and controversial assessment in public opinion. A 2010 study funded by the Swiss organization entitled "Promotion of renewable energy and energy savings in international cooperation", conducted by consultants of "NEC Technologies", has concluded that wind resources in our country are substantially more modest, and that there are very few areas where wind speed exceeds 6 m/s, which is the minimum required for commercial potential in the region. The report also concluded that winds in Kosova mostly reach average levels. More rigorous identification of wind speed and duration may indicate areas where winds are strongest in more complex terrains, but the utilization of those resources may be hampered by space and access problems. Furthermore, Kosova's small Electric Energy System most likely cannot absorb more than a quarter of the total technical wind potential given the requirements for reliable operation of the Electric Energy System.

3.6. Photovoltaic capacities

Kosova's geographical position conditions the climate features to be of Mediterranean and continental character. In Kosova's latitudes (42º-43º) the annual insolation (sunny weather) should last 4,450-4,460 h/year (or 12.2 h/day on average). But the insolation in Kosova lasts 2,079 h/year or 5.7 h/day, which is 47% of the possible insolation. Although accurate solar maps for our country have not yet been drawn up, a few measurements have been made for some cities. According to the accounts of a foreign company interested in investing in photovoltaic potentials for electricity generation, Kosova has a solar photovoltaic potential of about 160 GW h/year on average, which means about 77 MW of installed capacity, with 22 -25% utilization factor [6]. Studies conducted in recent years show the climatic conditions and sunny days for some locations in Kosova and confirm the limited capacity of economically reasonable use of this potential for the generation of electricity that meets the standards for connection to Kosova's transmission system.

The largest amount of global solar radiation energy in Kosova arrives in the March - September period, at an inclination of 30º to the south. Whereas in the October-February period, the greatest amount of global solar radiation energy falls at an inclination of 60º also to the south.

Figure 3 shows the average monthly global solar radiation during 2009 from the data obtained from the Hydrometeorological Institute of Kosova (HIK), from the respective metering stations in Prishtina, Peja and Prizren.

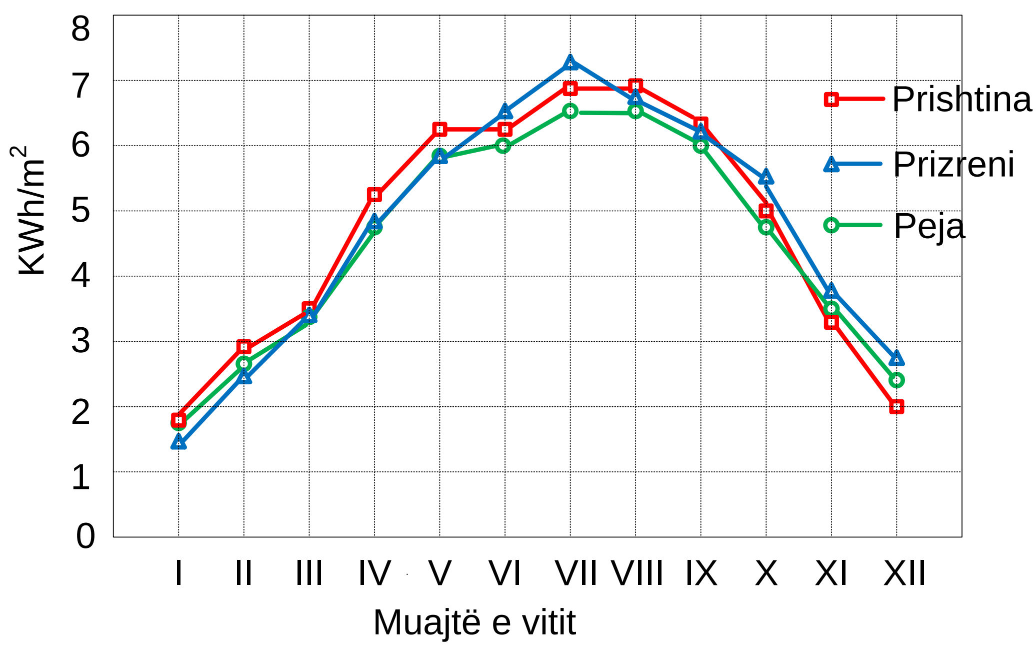

Figure 3. Average daily global radiation on the horizontal plain in the cities of Prishtina, Peja and Prizren for 2009

The average daily and annual values of global solar radiation energy in Kosova during the year are approximate and have the values as in Table 1 [7].

Table 1. Average daily and annual value of global solar radiation energy

Location	Average daily value kWh/m^2	Average annual value kWh/m^2
Prizren	4.14	1512.25
Peja	4.24	1546.25
Prishtina	4.32	1578.25

Sunny weather and cloudy skies in Kosova vary according to the months of the year. Based on HIK observations of sunshine in four meteorological stations (Prishtina, Ferizaj, Prizren, Peja), Kosova has an average of 2,066 hours of sunshine during the year, or about 5.7 hours a day. Within the year, July has the sunniest weather (during summer over 250 hours per month or 8.3 hours/day), while December has the least (about 54 hours in total or 1.7 hours/day). On average, December has around 5.3 times less sunny hours than July.

From the presented data, although modest, it can be concluded that the solar energy capacities in Kosova are modest in terms of meeting the requirements for the construction of solar plants that generate electricity with sufficient quality and quantity to connect to the transmission system. But this energy can be used in small plants for individual needs by connecting to the electricity supply system, and for thermal energy for the heating of domestic water.

For the construction of photovoltaic capacities with significant contribution for the EES system, very large areas are needed for the installation of solar-photovoltaic panels, and the price per MWh still remains high.

3.7. Biogas and biomass

In Kosova, biogas based on organic livestock manure is found in many parts of the country, but in small quantities, and has little potential to be converted to gas for the movement of turbines of electricity generators. On the other hand, most of the raw material for biomass comes from wood, and a small amount also from agricultural, waste which can be converted into biogas. Kosova’s wealth of timber is considerable, but using wood for electricity generation would have very high costs and cause irreparable degradation of forest regions. Projects funded by various international organizations have estimated the share of biogas for electricity generation to be significant at around 13% (according to the data presented in Figure 4), moreover in this study this share is projected to be even higher than the hydropower potential, which is estimated at 11%. In our assessment, this forecast for electricity generation from biogas and biomass is overestimated and does not represent a realistic and economically favorable option for implementation in practice.

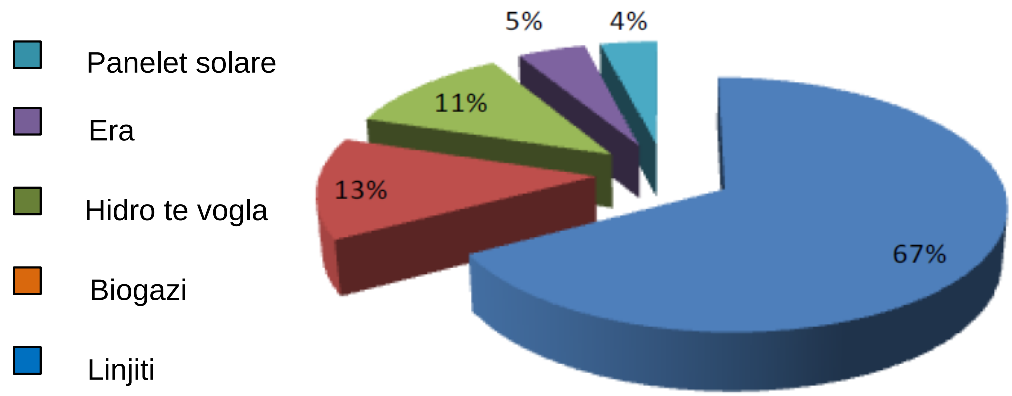

Figure 4. Forecast of electricity generation potentials by 2020 (According to Mercado Energy estimates [8])

4. CURRENT BALANCE OF CONSUMPTION AND SUPPLY IN KOSOVA

This section provides a brief overview of the equilibrium between market demand and supply for electricity supply, based on the characteristics of existing generating capacities for electricity generation, as well as the transmission and distribution lines available to cover the energy market demand.

4.1 Consumption (demand for electricity)

In Kosova, electricity consumption and maximum demand periods increased by more than 90% between 2000 and 2010, and this energy consumption increased by an average annual rate of 6.7%, while maximum demand by an average annual rate of close to 6%. The trend of electricity demand and consumption is presented in Figure 5.

Frequent reductions and unplanned power outages also have a major impact on the energy situation in Kosova, and these outages limit the increase in demand and reduce the large difference in demand manifested according to the seasons of the year. The System, Transmission and Market Operator - KOSTT controls energy reductions during periods of maximum load in situations when domestic generation and energy imports are not sufficient to cover the grid demand for energy. According to an estimate by KOSST, during the years 2001-2007 if the reductions had not been implemented, the annual demand for electricity would have been 300-700 GWh higher. In 2009 and 2010 the reductions are estimated to be 373 and 205 MW [9]. Unplanned power outages are the result of failures of all network segments: generation, transmission and distribution [10].

The regulator sets regulated tariffs for consumers who enjoy the right to supply in terms of universal service. The table below presents the structure of retail tariffs and, according to ERO, with the application of these tariffs it is expected that the supplier will invoice the allowed level of maximum allowed revenues. This tariff structure is being applied from November 1, 2018.

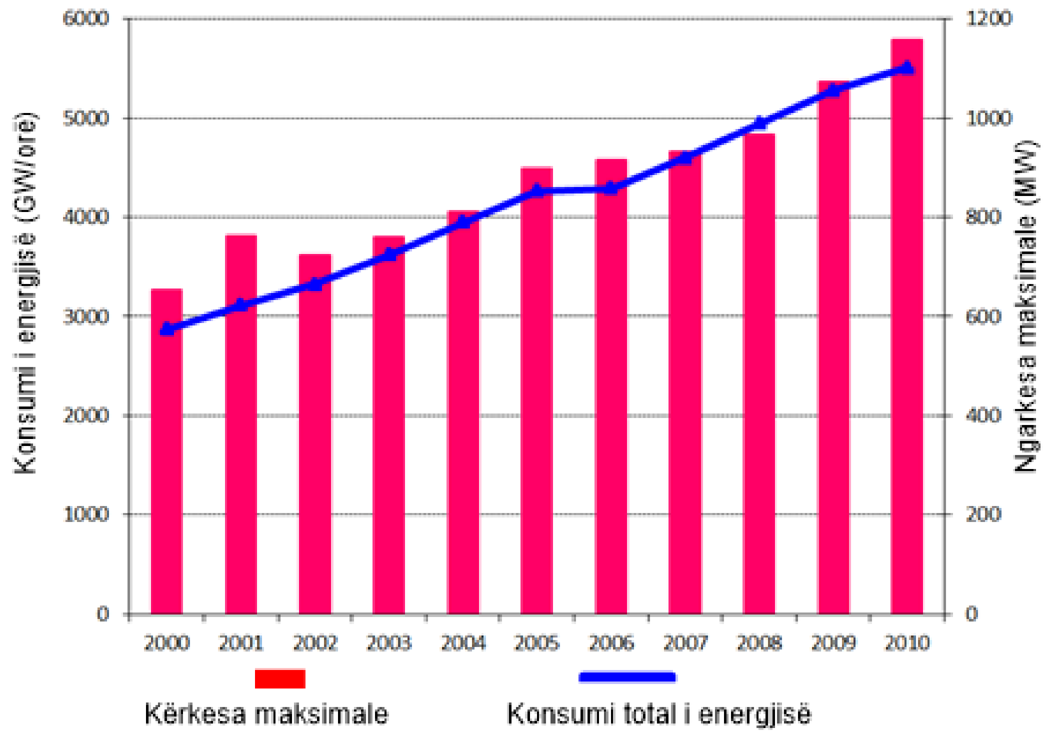

Figure 5. Consumption and maximum demand curve in Kosova in the 2000-2010 period [11].

Current consumer tariffs do not reflect the real cost charged to household consumers. Household tariffs are generally estimated to be approximately 20-30% below the supplier's total cost, while some industrial tariffs significantly exceed the cost level. The price increase towards tariffs that reflect the real cost will have a significant impact on the demand of different categories of consumers, so this impact will largely depend on the conditions in which the construction of new generation capacities is planned.

Kosova currently has eight tariff groups that reflect different operating voltages and consumption power. Tariffs for high voltage consumers, whose meters apply mostly a dual tariff (in other words they have a fixed and variable component). Tariffs for all consumers whose meters are measured, and which vary according to the season and by day (for high voltage consumers and for some settlements) that have dual tariff meters.

Tariffs for household consumers follow a cost-increasing schedule, i.e. higher tariffs for higher levels of consumption. Household consumers, whose meters are not measured, pay a fixed monthly amount, based on their estimated monthly consumption. Electricity consumption in Kosova tends to reach the maximum load in the winter season. For the category of household consumers, the average price of electricity is 5.65cent/kWh, and compared to 2017 there is a price reduction of 6.4%, while for industrial and commercial consumers the average price is 7.94 cents/kWh.

4.2. Existing electricity generation capacities in Kosova

Kosova's Electric Energy System is designed mainly for the generation of electricity based on significant reserves of lignite as a raw material, but not to cover the maximum loads and balance the system. Balancing the system remains a major challenge for all participants in the sector, as it depends on Serbia's Electric Energy System. The balance of installed generation capacities in 2018 was 1,409 MW, including generating capacities from RES. The TPP installation capacity was 1,288 MW (91.41%) of the total installed capacity, while RES installation capacity was 121 MW (8.59%).

The net capacity is considered to be 1,075 MW, of which TPPs constituted 960 MW (89.29%), while RES the rest with a total of 115 MW (about 10.71%). This includes Ujmani HPP with 32 MW (2.98%), other HPPs and solar panels with 83.17 MW (7.74%), including the generation of Kitka wind farm with a capacity of 32.4 MW, which has started commercial operation in October 2018.

From the above notes it appears that all types of renewable electricity sources connected to the EES and those connected to distribution account for only 115.17 MW (10.71%). Kosova has installed generation capacities of 1,409 MW, including generation capacities from RES. These capacities in most of the year would be enough to cover the demand of the domestic market, as well as a quantity of electricity that would be available for export, but due to the age of the power plants and insufficient flexibility to adapt to the demand in different periods and especially at the peak time (maximum demand), then imports are needed, but sometimes also exports to balance the system. The introduction of generators by RES increases the operating capacity of the generation, but in most cases they are unpredictable and are in the priority mode of dispatch, so they have no impact on improving the balance of the Electric Energy System, and sometimes even increase imbalances. The figure below shows the generation, import, export and demand of electricity over the last ten years.

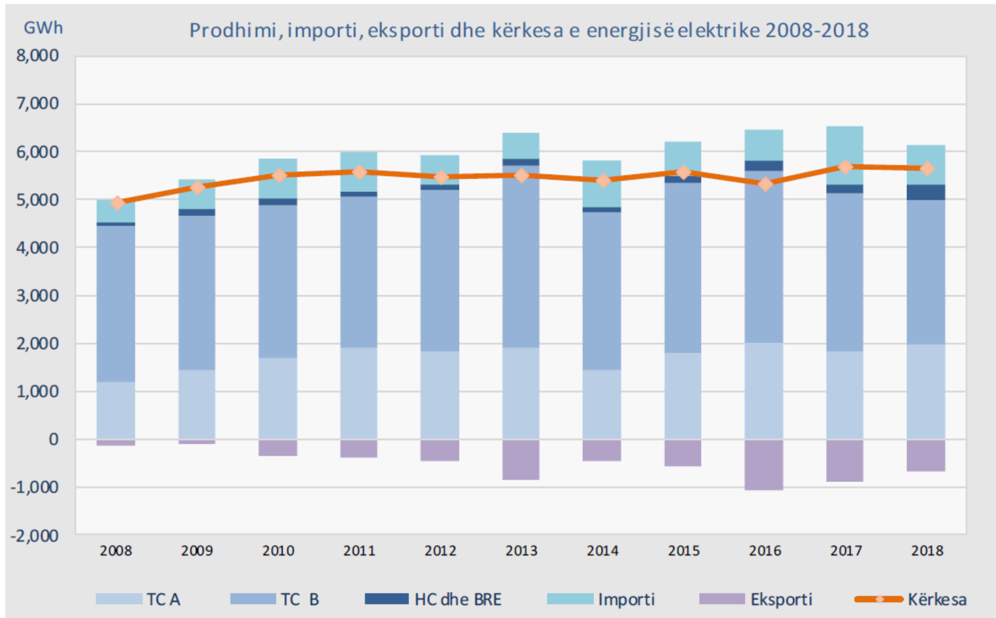

Figure 6. Generation, demand, export and import of electricity in Kosova in the 2008-2018 period [12].

As shown in the diagram above, in recent years, electricity generation has been almost sufficient to cover consumption, and in two of these years Kosova has been an exporter of a quantity of electricity, but over the years it has predominantly been an importer. The maximum load in the energy system of Kosova is almost twice as high as the minimum load, and these changes cannot be followed by local generation, so it is necessary to contract import or export within the same day.

The largest share of metered electricity demand comes from households (approximately 63%), which is followed by industry demand. Technical and non-technical distribution losses together represent 40% of the total electricity generated. Technical and non-technical losses have decreased in recent years, and recently are at the level of approximately 23% recorded in 2018. Reductions in non-technical losses will reduce electricity consumption, because non-metered households have been shown to use significantly larger amounts of electricity (in some cases close to twice the amount utilized by metered households). [13]. Theft and non-payment of consumed energy has significantly decreased and thus has reduced the demand for energy (because a large part of non-technical 'losses' is actually related to electricity consumed, but that has not been paid).

The share of household consumers in the total consumption billed in distribution still remains dominant with about 59.01%, followed by commercial consumption at 22.89%, then by industrial consumption at 17.51%, and finally by consumption in public lighting at 0.59 %. While gross consumption is approximately at the same level as the previous year, household consumption has increased by about 3.6%, commercial consumer consumption has also increased by 6.5%, while industrial consumption in 2018 has decreased by 15.2% compared to the previous year. The figure below shows the share in percentage of consumption categories compared to total consumption (presented with loss and no loss in distribution).

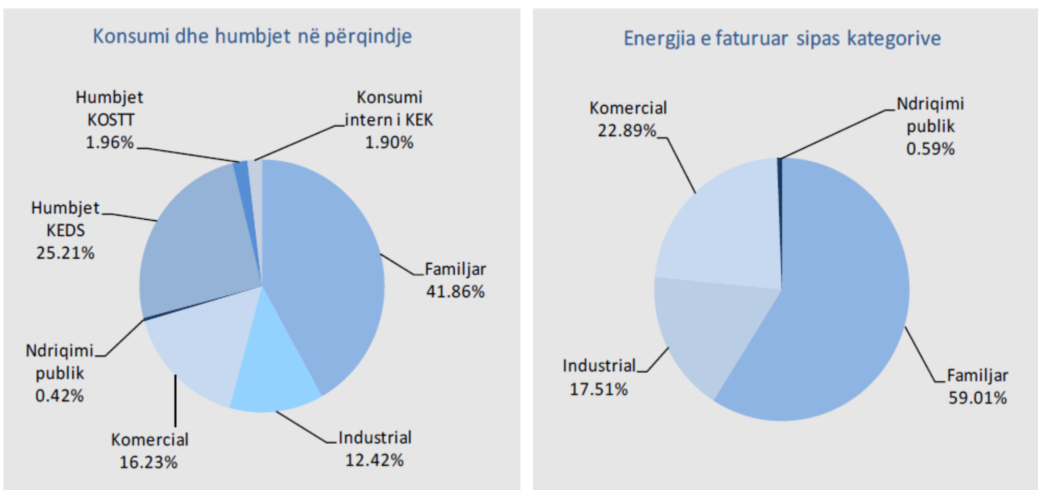

Figure 7. Participation of consumption categories with loss and no loss 2011

Electricity generation capacities in Kosova are mainly from thermal power plants which make up 91.41% of the installed capacities, or 89.29% of the net capacities, and the rest are hydropower plants and renewable energy sources (RES), wind farms and solar panels. The capacity of generating units by type of primary source, installed and operating capacity, minimum and maximum generation limits, and year of commissioning, is presented in Table 2.

Table 2. Generation capacities in Kosova's Electric Energy System

Generation unit	Unit capacity MW		Commissioning
	Installed	Net	
Kosova A1 TPP	65	Non operational	1962
Kosova A2 TPP	125	Non operational	1964
Kosova A3 TPP	200	144	1970
Kosova A4 TPP	200	144	1974
Kosova A5 TPP	210	144	1975
Kosova A TPP	610	432	
Kosova B1 TPP	339	264	1983
Kosova B2 TPP	339	264	1984
Kosova B TPP	678	528	
Ujmani HPP	35	32	1983
Lumbardhi Deçan HPP	8.08	8	(1956) 2006
Dikanci HPP	4.02		(1957) 2013
Radavci HPP	1	0.9	(1934) 2010
Burimi HPP	0.95	0.85	(1948) 2011
Total HPPs (out of support scheme)	49.05	45.09	
EGU Belaja	8.06	7.5	2016
EGU Deçani	9.81	9.5	2016
Hydroline-Albaniku III HPP	4.27	4.27	2016
Brod II HPP	4.8	4.8	2015
Restelica 1&2 HPP	2.28	2.28	2016
Brezovica HPP	2.1	2.1	2017
Wind Power	1.35	1.35	2010
Air Energy-Kitka	32.4	32.4	2018
PV LedLight Technology	0.1	0.1	
PV Onix-Spa	0.5	0.5	2016
PV Birra Peja	3	3	2018
PV Frigo Food Kosova	3	3	2018
Total RES (in support scheme)	71.67	70.08	
Total	1.409	1.075	

As seen from Table 3, total electricity generation in 2018 was 5,311 GWh, while in 2017 it was 5,300 GWh, which means that there is an increase of 0.2%. Generation, including own costs, by units and months during 2018, is presented in Table 3.

It should be noted that 11.84% of the energy from the gross generation of thermal power plants is consumed by the power plants themselves as their own expense. A part of these own costs (for both generators, Kosova A TPP and Kosova B TPP) is realized directly from the internal plants, while the rest is introduced in the transmission system and then consumed by the thermal power plants.

Table 3. 2018 Electricity Generation

Generator MWh	Total	January	February	March	April	May	June	July	August	September	October	November	December
A3 TPP gross	824,177	15,163	95,952	29,400	35,432	108,569	103,412	87,140	106,785	83,587	18,985	98,276	50,476
A4 TPP gross	712,747	97,395	42,058	110,758	91,247	0	0	0	33,334	70,422	115,457	63,254	88,823
A5 TPP gross	703, 724	0	24,749	78,474	1	32,201	82,729	110,009	77,684	107,511	105,129	28,362	56,873
A TPP Own Cost	273,457	13,205	19,854	26,045	15,285	17,039	22,655	24,571	27,024	31,150	28,613	22,781	25,035
TC A prag	1,967,192	99,352	142,905	192,588	111,395	123,731	163,487	172,578	190,778	230,170	210,958	158,111	171,137
B1 TPP gross	1,074,986	208,587	176,334	191,948	168,195	201,112	31	0	0	0	0	0	128,780
B2 TPP gross	2,284,913	206,019	184,132	196,485	185,932	206,033	187,608	206,724	189,474	105,780	209,005	200,005	207,718
B TPP Own Cost	319,371	38,586	34,229	37,315	33,719	37,174	18,345	19,831	18,061	10,894	19,459	19,588	32,169
TC B prag	3,040,529	376,019	326,237	351,117	320,408	369,971	169,293	186,893	171,413	94,886	189,545	180,417	304,329
HPP+RES Dist.	245,095	7,330	11,395	33,132	37,869	32,125	22,977	23,208	15,831	12,542	14,635	16,774	17,276
RES Dist.	58,155	3,631	4,743	8,893	9,924	9,196	5,545	5,168	3,579	2,092	1,639	1,769	1,976
Total	5,310,970	436,333	485,280	585,730	479,597	535,023	361,303	387,847	381,602	339,689	416,778	357,071	494,718

In recent years there has been an increase in installed RES generation capacities, which continue to be put into use. RES generation connected to the transmission network in 2018 was 245.1 GWh, and is higher by 79.81% compared to 2017, influenced by the generation of the Kitka wind farm with a capacity of 32.4 MW. Also, the 58.2 GWh RES generation connected to the distribution network in 2018 increased by 35.40% compared to 2017 due to the connection of two photovoltaic generators with solar panels with a capacity of 3 MW each. The following tables 4 and 5 present the generation of electricity from RES connected to the transmission network, respectively to the distribution network.

Table 4. RES generation connected to the transmission network in 2018

RES in transmission	Installed Capacity/MW	Generation/MW h	Generation share*/%
Ujmani HPP	35	98,199	40.07
Kaskada Lumbardh HPP	25.95	117,16	47.8
Air Energy/Kitka	32.4	29,736	12.13
Total RES	93.35	245,095	100

*Share of generating units in RES generation in transmission

Table 5. RES generation connected to the distribution network in the year

RES in distribution (distribution)	Installed Capacity/MW	Generation/MWh	Generation share*/%
Hydroline	4.27	11,697	20.11
Dikanci	4.02	10,453	17.97
Radavci	1	4,182	7.19
Burimi	0.95	1,790	3.08
Eurokos-JH	4.8	22,817	39.23
Brezovica HPP	2.1	5,168	8.89
Wind Power	1.35	17	0.03
Solar-LLT	0.1	123	0.21

Solar-Feti	0.1	93	0.16
Solar Onix	0.5	661	1.14
Solar Birra Peja	3	578	0.99
Solar Frigo Food	3	576	0.99
Total RES	25.19	58.155	100

*Share of generating units in RES generation in distribution

With careful analysis of data on the generation, demand, export and import of electricity in Kosova for a period of ten years (Figure 6), it can be concluded that the existing electricity generation capacities in Kosova, of which thermal power plants constitute 91.41% of the installed capacities, or 94.3% of the operating capacities, and the rest coming from hydropower plants and renewable energy sources (RES) (hydropower plants, wind farms and solar panels), meet the energy demand for the most part. The largest share is supplied by the energy generated in the two TPPs (TPP A and TPP B) and a modest amount from HPP and RES sources. Furthermore, after 2010, although we have an increase in demand, domestic generation for most of the year has met this demand, and in certain periods of time Kosova has exported electricity.

When it comes to building new generation capacities, the presented data strongly argue that the best strategy for the stability of the energy system of Kosova is the construction of a new thermal power plant which would replace TPP A after its decommissioning. This means that the construction of generating units with a capacity of about 600 MW is needed.

On the other hand, HPPs and other RES with small and unstable generation capacities do not have much impact on meeting the demand for electricity. The suggestions of part of the public opinion that oppose the construction of new capacities based on lignite, for orientation in clean energy based on renewable energy sources, are not a feasible option that offers the possibility of meeting the needs for electricity and independence of Kosova's energy system, because Kosova with its geography and climate (few rivers with short discharge, no locations with strong winds) does not have very favorable preconditions for the development of new capacities. The RES capacities installed in recent years prove this.

5. NEW GENERATION RESOURCES IN KOSOVA'S EES

As can be seen from the above analysis, in 2018 consumers were supplied with electricity mainly from fossil energy sources with 5,008 GWh (94.3%), while the share of electricity generation from renewable sources was 303 GWh (5.7%). The total output from all sources was 5311 GWh. This low share of RES contribution to the supply of electricity to consumers should be accompanied by an increase in electricity generation capacities from these resources although, as noted above, these resources are quite limited for commercial operation. Ideally (see Figure 4), even if all the theoretically predicted capacities of renewable energy sources are used, the share of these sources in the total electricity generation would barely reach 33% of the total generation. It should be noted that even this projection presents an ideal forecast, which in practical circumstances is unachievable precisely due to limited potentials and high costs. Thus, this option turns out to be unfeasible and economically unreasonable.

Thus, in 2018 TPP A generated 1,967 GWh, while TPP B (3,041 GWh), and together generated 5,008 GWh. In the same year, the generation of RES in the system was 245 GWh, while the generation of RES in distribution was only 58 GWh (see Tables 4 and 5). Therefore, the joint generation of connected capacities in the system and those in distribution was only 303 GWh, respectively only 5.7% of the total energy generated.

It is worth mentioning that the electricity supply in Kosova is based on old thermal power plants which do not provide security of regular energy supply, while unreliable electricity is the main obstacle to sustainable economic development of the country, and thus energy stability still remains the main challenge of the state of Kosova.

As a solution for sustainable supply of the Republic of Kosova with electricity, the working group thinks that there are two real options:

1. Construction of new capacities based on fossil fuels accompanied by the increase of new capacities of renewable energy, but it should be noted that so far very limited sources have been identified, and
2. Import of electricity

The working group, critically analyzing all the possibilities and energy potentials of the country, estimates that the first option, i.e. sustainable electricity supply should be achieved from local energy sources based on lignite reserves. To achieve this goal, in addition to the decommissioning of the Kosova A thermal power plant and the rehabilitation of Kosova B, the country needs new generation capacities based on fossil fuels and a number of new renewable energy capacities. In this regard, we support the construction of new energy capacities based on lignite, namely two thermal power plants of 300 to 350 MW each.

5.1. "Kosova e Re" Thermal Power Plant

The Government of Kosova, for the implementation of the strategic plan for the energy sector, had foreseen the construction of a new thermal power plant in public-private partnership. The “Kosova e Re” Thermal Power Plant (KRTPP), according to the Contract of the Government of Kosova with an international partner, as a public-private investment, was foreseen to be built with the following parameters:

Installed Capacity: 500 MW (gross) or 450 MW (net electric power),
Net power plant efficiency: > 40%,
Availability factor: ≥ 90%,
Cogeneration readiness: 10% of the electric capacity, > 200 MWth,
Designed life of the facility: 40 years,
Environmental protection: according to IED/BAT,
Carbon capture: dedicated space at location near KRTPP,
Location: near the Kosova B power plant,
Network connection: KOSTT (Kosova B),
Main fuel: Lignite from the Sibovc-south mine.

A contract was signed for the construction of the “Kosova e Re” Thermal Power Plant between the Government of Kosova and the private company “Contour Global”, which provided for the design, construction, financing, ownership, maintenance and operation in accordance with IED/BAT (Industrial Emissions Directive/Best Available Techniques).

In March 2020, the “Contour Global” company stated that it withdrew from this contract without giving detailed public reasons. On the other hand, the Government of Kosova has not proceeded with the Assembly of Kosova with the steps provided by the contract. Most likely, the requests for realization of compensations according to the obligatory contract from both parties will come to the fore.

5.2. PROPOSAL OF THE WORKING GROUP FOR NEW GENERATION CAPACITIES

Given the real objective limitations in building RES capacities in Kosova, despite the goals for building these capacities, meeting the basic needs for electricity in our country still has to rely on local energy potentials and is conditioned by the construction of thermal power plants, taking into account the highest European standards for environmental issues.

Instead of building the KRTPP with a capacity of 500 MW (gross), respectively 450 MW (net) electricity (according to the now defaulted contract), we suggest building two units, each of 300 to 350 MW, in five-year stages of construction. The first stage (Block I) to be completed and put into operation by 2025, while the second stage (Block II) to be completed by 2030. Both blocks must have subcritical parameters (SC) with pressure and temperature 170 bar/5,400 C that achieve efficiency of about 40%. Each of these units must have the possibility of cogeneration (joint generation of electricity and thermal energy) with at least (6-10)% of the nominal capacity of electricity generation (300 to 350 MW).

The proposed variant with installed power of 300 to 350 MW will be compatible with one block of the Kosova B TPP, so in case of fall from the system of the respective block, the EES of the country would not suffer imbalance and major disruption, compared to the previously proposed single unit of 500 MW if eventually this unit for various technical reasons would fall out of operation.

The use of coal as a fuel for electricity generation, despite the global trend to reduce the use of this resource due to environmental and climatic consequences, continues to dominate. According to the report of the World Energy Resources Institute, Europe alone by 2030 foresees the construction of over 70 fossil fuel power plants with a total capacity of over 65,421 MW [14].

The construction of new capacities would enable the replacement of the old generating units of Kosova A TPP and would ensure the increase of security in the energy supply, and at the same time would provide the necessary reserve capacity for uninterrupted supply of electricity. On the other hand, reliance on domestic resources, mainly lignite, and partially on renewable energy sources, would significantly reduce the country's dependence on electricity imports and the unpredictability of prices in the regional market.

The commissioning of new units and the rehabilitation of Kosova B TPP will replace the generation of electricity generated by the three units of Kosova A TPP, as well as reduce the need to import energy for average market demands. The new thermal power plant should also reduce the emission of gases into the atmosphere compared to those of the existing power plants, Kosova B and especially Kosova A, as advanced technologies will be applied, which are available today and which meet the requirements according to IED/BAT and in accordance with EU's IED.

Commercial operation of new generation capacities will ensure a stable supply of electricity and thermal energy as a precondition for future investments that will contribute to Kosova's economic development.

The working group also suggests that the Government consider the option of building new capacities with self-financing accompanied by soft loans for a period of ten years.

6. ENVIRONMENT AND IMPACT ON PUBLIC HEALTH

The operation of thermal power plants, in most parts of the world, is based on the use of coal as a raw material for heating and boiling water at high pressures and temperatures. According to data available at Kosova A and B power plants, about 8 million tons of lignite/year are consumed during a year. In 2019, TPP A spent 3,616,773 t of coal, while TPP B 4,763,859 t of coal/year. Such mass of lignite was calculated by the photogrammetric method. The main product during the combustion of lignite in TPP A and TPP B is CO_2. As a result of this process, for the calculated mass of lignite it turns out that the mass of CO_2 released is around 7 million t/year. Also, based on the values of electricity generated for 2019, the ratio is 1.53 t of lignite, 1.304 t CO_2 for 1 MWh generated in TPP A, while for TPP B this ratio is 1.298 t of lignite, 1.107 t CO_2 for 1 MWh generated. So, for 1 MWh of energy generated, in TPP A 1.118 times more coal is consumed than in TPP B. On average, 206.8 g of CO_2 were emitted from the Kosova B smokestacks in 2019 per m^3N of gases, i.e. the volumetric share of CO2 in the released gases was $\varphi(CO_2)$ = 0.1053 = 10.53%, while the partial pressure of this gas was 10.5 kPa. Based on the calculated CO_2 emission values, it turns out that the average annual volume of gases emitted within 1 s is 391 m^3N for TPP B1 and 323m^3N for TPP B2. Therefore, within 1 s during 2019 both smokestacks of TPP B have emitted an average of 131.1 kg/s CO2, while all three smokestacks of TPP A have emitted 95.3 kg/s. In addition to CO_2, during the combustion of coal, depending on its quality and the conditions in which it burns in the presence of oxygen, carbon monoxide CO is also formed to a certain extent, which is a harmful substance for the environment. During the year, in the Kosova B power plant are released over 1000 t of CO, respectively about 51 mg CO/m^3N, or based on the flow of gases 42.6 g/s are released.

These two coal combustion products, CO and CO_2, have harmful effects on the environment. The high concentration of CO_2 in the environment is considered to be the main cause of global warming or the greenhouse effect, accounting for about 55% of the impact [15]. CO is a harmful substance because it directly affects human health. In small concentrations it causes headaches, lethargy and vision problems, while in large concentrations, depending on the time of exposure, it can also cause death [16].

In modern thermal power plants, the efficiency of electricity generation has increased due to the use of advanced technologies, reducing by 25 - 30% the ratio of coal consumed for the amount of electricity generated. This releases less CO_2 for the same amount of electricity generated and at the same time reduces the cost of energy generation due to the reduction of coal costs. Simultaneously, in such installations the so-called system of carbon separation, transport and storage is used (Carbon Capture and Storage). In such facilities, CO_2 is first separated from the mixture of other gases by adsorption filters or specific membranes or absorption with aqueous solutions of amines, then depending on the distance to the landfill where it is deposited deep into the ground, CO_2 is transferred in gaseous state at high pressure through pipelines or is converted to liquid state [17].

Since the lignite used in TPP A and TPP B contains sulfur at > 1%, based on KEK data for 2019 in the ratio of Inorganic S to Organic S is 1.89. The combustion of coal in the presence of oxygen leads to the oxidation of sulfur up to SO_2. This substance in the presence of water is converted to sulfuric acid, while when SO_2 is further oxidized it is converted to SO_3, which then when reacts with water is converted to sulfuric acid. Therefore, SO_2 is the cause of acid rain that is a source of damage to plants, but also to various facilities. SO_2 is also known as a substance that is aggressive to human health. This substance attacks the lungs and can cause pulmonary and laryngotracheal edema.

In TPP B, the analyzers for measuring the emissions of gases and dust are not operational, therefore the calculated stoichiometric values of SO_2, based on the share of this element in the used lignite, are employed. The values obtained during the 2016 - 2019 period are presented in Table 6. Such results are higher than they are in reality, due to the desulfurization process. According to these calculations, it turns out that TPP B has dumped about 634.5 mg SO_2 / m^3N during 2019.

Table 6. Average values of SO2 concentration released by TPP B during 2016-2019.

Year	Average concentration of SO_2 / mg/m^3_N / B TPP	Allowed norm / mg/m^3N
2016	495.5	400
2017	603.2	400
2018	618.8	400
2019	634.5	400

Figure 8 below shows the monthly values of SO_2 emissions for 2019 based on the report of the Kosova Environmental Protection Agency [18].

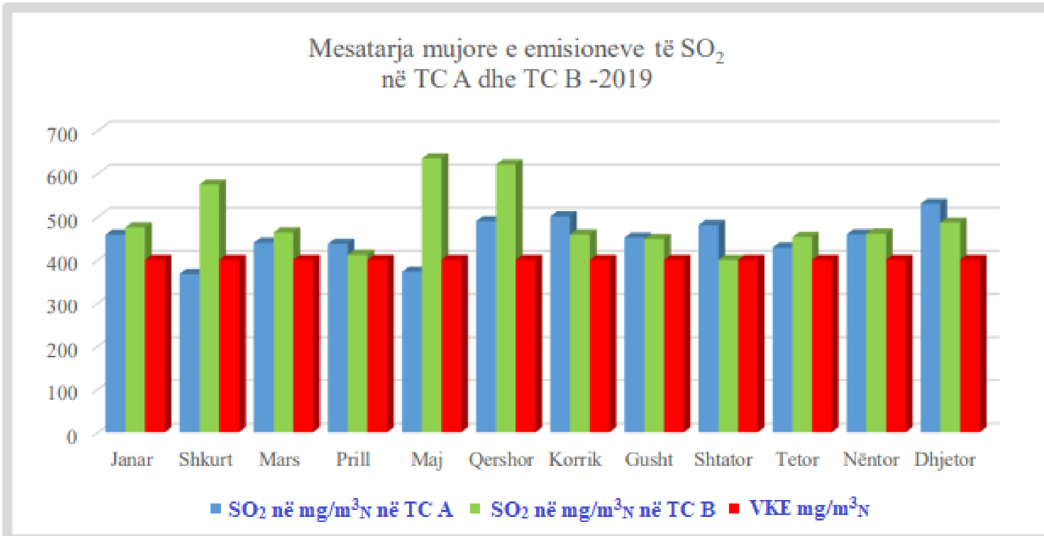

Figure 8. Average monthly emission values of SO_2 in mg/m^3N for 2019

Based on the emission measurements in the industrial zone of the Generation Division, it was found that the release of SO_2 based on the emissions made in Obiliq is within the allowed norms according to the standard.

According to the EU directives, TPP A and TPP B are required to control the amount of SO_2 released, and from 2023 it should be 200 mg/m^3N. In order to significantly reduce the emission of this gas, additional measures should be used that reduce the percentage of SO_2, e.g. using $CaCO_3$ limestone which dissolves at high temperatures (800 to 900 ^0C) and then CaO reacts with SO_2 in the presence of oxygen to form $CaSO_4$. In this way a high percentage of desulfurization is accomplished. The reaction which takes place is given below:

$$CaCO_3(s) \; --> CaO(s) + CO_2(g),$$

where (s) represents the solid aggregate state and (g) the gaseous one.

This process can take place in a furnace in a clean environment away from the power plant, as CO2 is released. Subsequently, when calcium oxide in powder form is poured into the steam generator furnace at the same time as the introduction of powdered coal, in the furnace, in addition to the combustion of the fuel, the desulfurization reaction also takes place according to the reaction:

$$CaO(s) + SO_2(g) + \frac{1}{2} O2(g) \; --> CaSO_4(s)$$

Calcium sulphate together with a quantity of ash from the fuel is separated from the gases and together with the slag and a quantity of ash falls down into the water tank of the steam generator.

Within the operation of the TPP are released quite a lot of nitrogen oxide gases, among which are NO and NO_2 which are written with the general formula NOx. These gases are a source of acid rain and in large concentrations are very harmful to health. During the winter season, these gases are a source of smog, a mixture of smoke and fog, when there are no air currents. The estimated values of NOx for TPP A and TPP B for 2019 are: 639 mg NOx/m^3N and 650 mg NOx/m^3N, while the allowed rate is 500 mg NOx/m^3N. While for the years 2015-18, for TPP B these values have been: 821, 680, 669; 746 mg NOx/m^3N.

Figure 9 shows the monthly values of NOx emissions for 2019 based on the report of the Kosova Environmental Protection Agency [17].

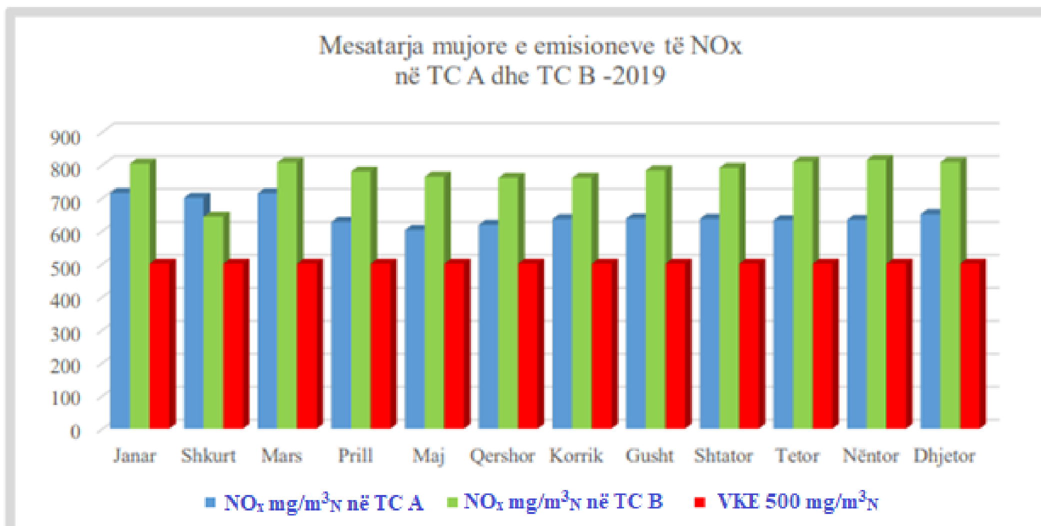

Figure 9. Average monthly NOx emission values in mg/m^3N for 2019

NOx gases are also responsible for increasing the concentration of ozone near the earth's surface, because they, under the influence of UV rays, react with oxygen and after a series of intermediate reactions ozone is released as a product of this reaction.

Measures to reduce NOx emissions are:

- Recirculation of gases from the steam generator outlet and their introduction into the steam generator furnace. This step reduces their temperature and the concentration of oxygen in the combustion zone.

- Reducing the coefficient of excess air.

This measure reduces the emission of nitrogen oxides. This is an effective measure that achieves a significant reduction in nitrogen oxide emissions, while its implementation does not require additional investment and does not increase operating costs. The use of this method is limited to the occurrence of incomplete combustion of the fuel. Under these conditions other pollutants would be generated such as carbon monoxide CO.

NO_2 is an irritating gas that is absorbed through the mucosa of the respiratory tract and causes undesirable effects on the lungs depending on the duration of exposure. Small concentrations of this gas cause an inflammation of the bronchial trachea, while higher concentrations can cause bronchitis, bronchopneumonia and acute pulmonary edema. This substance is also toxic to other biological systems and can affect the cellular immune system [19]. Large concentrations of NO_2 in the air can affect the spread of fires [20].

According to EU directives, TPP A and TPP B are required to control the amount of NOx released, and by 2026 it should be 200 mg/m^{3}N. [21] The European Commission has invested € 76.4 M in 2020 in the installation of filters in the smokestacks of TPP B, [22] in order to reduce by 4 times the amount of NOx gases and to keep it within the prescribed norms of the rules of EU [20].

In modern TPPs, the amount of NOx released into the environment is reduced by the denitrification process, in which case the reduction of these substances into elemental nitrogen is done during their treatment with ammonia (selective non-catalytic reduction) and with catalyst of vanadium or titanium dioxide (selective catalytic reduction).

Lignite used for combustion in TPPs releases many dust particles, which have different composition and dimensions. The emission value for dust particles in TPP A is around 45 mg/m^{3}N, while in TPP B this value is 5-14 times higher as shown in Figure 10 [17].

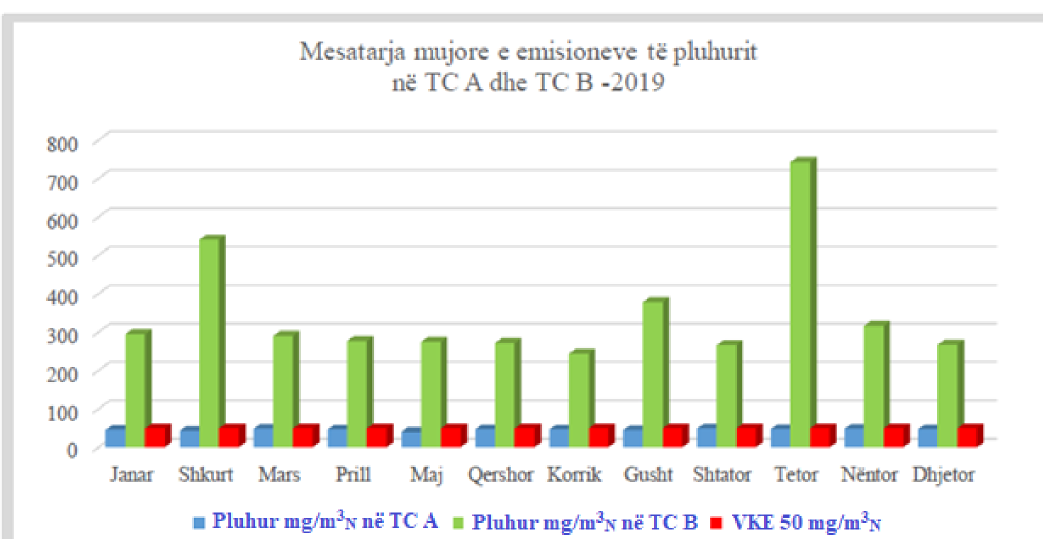

Figure 10. Average monthly dust emission values in mg/m^{3}N for 2019

The TPP B is currently installing new electrostatic precipitators to reduce dust and NOx emissions in accordance with the European Commission Directive on Large Coal-Fired Plants, which enters into force in 2023. This European Commission Directive or Regulation requires that large coal-fired power plants be able to reach dust emission values of less than 20 mg/m^{3}N. Therefore, the EU investment for the installation of filters in the smokestacks of TPP B will also affect the reduction by 35 times of the amount of dust they emit, and it will be within the norms provided by the EU Regulation [20 21].

Within the dust particles, particles with dimensions 2.5 - 10µm are distinguished, marked PM10, and those with dimensions less than 2.5µm, PM 2.5, which by means of winds can be carried over long distances up to 100 km.

PM2.5 particles, due to their very small dimensions, pass unhindered through the human body through respiration and are the cause of many problems in human health, including chronic lung diseases and malign diseases.

Measurements of PM10 and PM2.5 parameters made at air quality monitoring stations in Obiliq and Dardhishte for 2018 show high values during the autumn-winter period. These data are presented in Figure 11 [22].

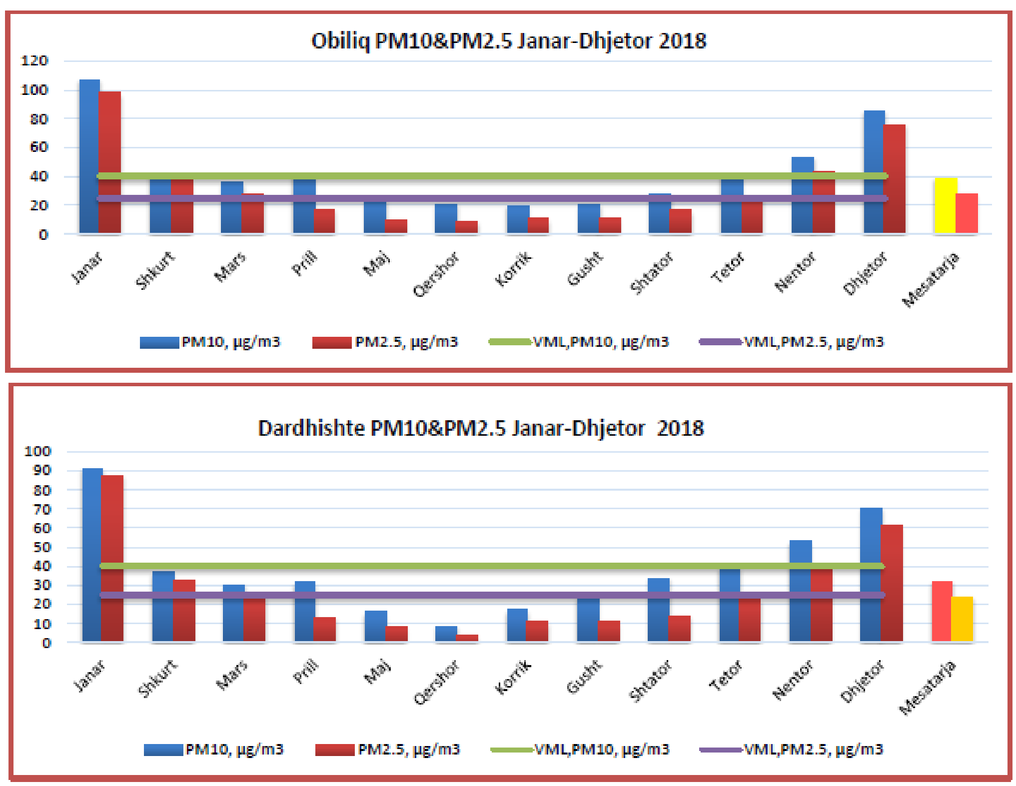

Figure 11. Measurements of PM10 and PM2.5 values in µg/m^{3}N in air quality monitoring stations in Obiliq and Dardhishte for 2018

According to a report presenting the detrimental effect of coal utilization for electricity generation, TPP B was the largest polluter in the Balkans and in Europe with PM10 dust particles emitted in 2016 [23].

The biggest causes of solid matter particles are the flying particles of burnt coal as well as to a lesser extent nitrates and sulfates. Such coal particles contain easily volatile organic substances and also contain quite a lot of SiO_2 (in amorphous and crystalline form), Al_2O_3 and CaO. Depending on the ratio of calcium and sulfur, they can be acidic, neutral or basic [24]. Such particles also contain trace metals, such as mercury, lead, cadmium and arsenic. These metals cause very harmful effects on the body [25]. Easily volatile organic substances are harmful to the body and cause the formation of ozone in the atmosphere and near the earth's surface, which is also harmful to the body.

Lignite usually contains less SiO_2 and more Al_2O_3 and CaO. During the burning of 4 tons of coal, about 1 ton of ash is generated. Most of the ash is deposited through the hydraulic transport system in the emptied spaces after the extraction of coal. Due to the high content of metal oxides, the ash raises the pH value of the water too much, above the normal value of 7, therefore such landfills must be constantly monitored so that the pollution of river water does not occur, because it causes large damages in the environment.

High values of these air pollution parameters: SO_2, NOx and PM10 and PM2.5 solids, separately and especially when present together, have a detrimental effect on the health of citizens. According to information published by the European Environment Agency for 2018, air pollution is the leading cause of premature death and disease, and therefore poses the greatest health risk in Europe [26]. Exposure of children and adults for short or long periods of time to polluted air can cause decreased respiratory function, respiratory infections and even asthma. In the family medicine centers of Prishtina and Obiliq during the autumn and winter months an increase of > 50% has been observed in the number of patients suffering from respiratory problems [17].

Although there is a lack of more data on the direct effect of pollution from TPP A and TPP B on the health of patients, based on the scientific studies highlighted above, we can emphasize that these factors can cause serious problems especially in children and adults who suffer from respiratory and cardiovascular diseases.

At the same time, the treatment of these patients and medical leaves from work increase the cost of economic damages as a result of the use of coal as an energy source.

Air pollution from the above substances also causes damage to vegetation and the ecosystem in general. NOx, ozone and SO_2 are particularly impactful in this aspect.

7. CONCLUSIONS AND RECOMMENDATIONS

Kosova's Electric Energy System has total installed capacities for energy generation of about 1,409 MW and net operating capacities of about 1,075 MW. Most of the generation comes from the two thermal power plants, Kosova A TPP and Kosova B TPP, with a net operating capacity between 900 and 960 MW.

Kosova A TPP, as the largest and oldest thermal power plant, is unsafe for generation and inefficient. Two of its five blocks, A1 and A2, are out of line, while blocks A3, A4 and A5, although partially repaired, remain unsafe for generation and operate significantly below their installed capacity. Today, the full operating capacity of Kosova A TPP is about 400 MW. Due to its age, Kosova A TPP should be decommissioned as soon as possible and replaced with new generating capacities.

Kosova B TPP, although younger than Kosova A TPP, continues to operate under installed generation capacities and also needs general rehabilitation. Kosova B net capacity is about 540 MW.

Electricity imports through regional interconnections still remain an important part of energy supply, and the value of the imported quantity is around 5-7% of the total annual consumption. The volume of imports is limited by energy surplus in exporting countries, interconnection capacity, and energy cost. The interconnection with Serbia is not secure, while the availability of electricity from Albania for sale or exchange depends on hydrological conditions. Kosova's Electric Energy System (based on lignite generation) and Albania's Electric Energy System (based on hydropower) are systems that can complement each other in periods of power shortages and should consider a complementary development to meet the requirements in their markets.

Electricity consumption has increased at an average rate of 4.6% per year, while maximum demand levels on an annual basis have increased by around 4%. Most of the demand for electricity in Kosova comes from households (about 60%), followed by the commercial sector and the industrial sector. Technical and non-technical network losses remain high and together account for about 35% of gross energy consumption.

According to the analyzes made, it is necessary to further reduce technical and non-technical losses. Technical losses are projected to decrease from 16.6% of gross supplied energy in 2010 to 8.0% in 2025. It is also assumed that reducing non-technical losses will reduce demand, as consumers will reduce energy consumption in kWh which must be paid [27].

As numerous studies have shown, Kosova has significant potential for improving energy economy and increasing energy efficiency. Progress has been made in this regard through projects to increase energy efficiency in public buildings financed mainly by foreign donors. Therefore, measures to increase energy efficiency are part of the following recommendations.

Since significant amounts of electricity can be saved by increasing efficiency, it is recommended to:

- Expand the heat supply network from the cogeneration system for the city of Prishtina, and increase the supply range and capacities of the cogeneration system for the inclusion of Obiliq and Fushë Kosovë.
- Design and introduce the central thermal energy supply system for hot water for sanitary needs for the cities of Prishtina, Mitrovica and Gjakova.
- Design and introduce the central thermal energy supply system for heating and hot water for sanitary needs for the cities of Gjilan, Ferizaj, Prizren and Peja.
- Apply thermal insulation of buildings and constructions according to norms and standards for efficient use of energy.

These measures reduce emissions of harmful substances into the environment and improve air quality for residents, reducing CO_2 and other harmful gases, and also reduce the demand for electricity for heating, thus visibly reducing electricity consumption expenses.

With careful analysis of data on the generation, demand, export and import of electricity in Kosova for a period of ten years (Figure 6), it can be concluded that the existing electricity generation capacities in Kosova, of which thermal power plants constitute 91.41% of the installed capacities, or 94.3% of the generation capacities, and the rest coming from and renewable energy sources (RES, hydropower plants, wind farms and solar panels), meet the energy demand for most of the year. The largest share is supplied by the energy generated in the two TPPs (Kosova A TPP and Kosova B TPP) and a modest amount from HPP and RES sources. Furthermore, after 2010, although we have an increase in demand, domestic generation for most of the year has met this demand, and in certain periods of time Kosova has exported electricity.

When it comes to building new generation capacities, the presented data strongly argue that the best strategy for the stability of the energy system of Kosova is the construction of a new generation capacities based on lignite, which would replace TPP A after its decommissioning. This means that the construction of generation units of about 600 -700 MW is needed.

On the other hand, HPPs and other RES with small and unstable generation capacities do not have much impact on meeting the demand for electricity. The suggestions of part of the public opinion that oppose the construction of new capacities based on lignite, for orientation in clean energy based on renewable energy sources, are not an option for Kosova's energy system, because Kosova with its geography and climate (few rivers with short discharge, no locations with strong winds, etc.) does not have very favorable preconditions for the development of new capacities. This finding is confirmed by the RES capacities installed in recent years. However, the working group thinks that the development of generating capacities from renewable energy should be continued, respecting the legal regulations and measures for environmental protection.

If the latest technologies of carbon dioxide storage and emission reduction of dust and dust particles are used, the option of building new lignite-based generation capacities, according to all analyzes, is the option that best fits to Kosova's conditions.

Finally, for the sustainable supply of Kosova with electricity, in addition to the above measures, the Working Group recommends:

I) ***Construction of new generation capacities based on fossil fuels (lignite), and in addition the construction of new RES generation capacities, or***

II) ***Import of electricity.***

The working group, after the critical analysis of all options, given the country's energy potentials and the unpredictability of energy prices and security of supply, supports the sustainable supply of electricity from local energy sources based on lignite reserves.

Supporting the first option of sustainable electricity supply, we propose:

Instead of building the KRTPP with a capacity of 500 MW (gross), respectively 450 MW (net), we suggest building two units, each of 300 to 350 MW, in five-year construction stages. The first stage (Block I) to be completed and put into operation by 2025, while the second stage (Block II) to be completed by 2030. Both blocks must have subcritical parameters (SC) with an efficiency of about 40%. Each of these units must have the possibility of cogeneration (joint generation of electricity and thermal energy) with at least (6-10)% of the nominal capacity of electricity generation (300 to 350 MW).

The proposed variant with installed power of 300 to 350 MW will be compatible with one block of the Kosova B TPP, so in case of fall from the system of the respective block, the EES of the country would not suffer imbalance and major disruption, compared to the previously proposed single unit of 500 MW, if eventually this unit for various technical reasons would fall out of operation.

Expand the heat supply network from the cogeneration system for the city of Prishtina, and increase the supply range and capacities of the cogeneration system for the inclusion of Obiliq and Fushë Kosovë in the supply system.

The construction of new capacities would enable the replacement of the old generating units of Kosova A TPP and would ensure the increase of security in the energy supply, and at the same time would provide the necessary reserve for stable supply of electricity. On the other hand, reliance on domestic resources, mainly lignite, and partially on renewable energy sources, would significantly reduce the country's dependence on electricity imports and the unpredictability of prices in the regional market.

The commissioning of new units and in addition the rehabilitation of two units of TPP Kosova B will replace the generation of electricity generated by the three units of TPP Kosova A, and will reduce the need for electricity imports.

The new generation capacities will ensure a stable supply of electricity and thermal energy, which are a precondition for new investments, and which will contribute to the economic development of Kosova.

The working group also suggests that the Government, when considering the increase of generation capacities, should consider the option of building new capacities with self-financing with soft loans for a period of ten years.

Conclusions on environmental impact:

- Reduce the amount of SO2 emissions and NOx gases emitted by smokestacks to the value of up to 200 mg/m3N by 2026, so that they are within the values allowed under EU norms to enter into force in 2023. Efforts should be made to reduce SO2 levels through the CaO desulfurization process as proposed in this report;

- Repair the electrostatic precipitators of Kosova B TPP in the gas tract in order to reduce the amount of dust emitted, which must be below 50 mg/m3N under current conditions and up to 20 mg/m3N by 2026;

- Functionalization of the pollutant gas analyzers in all blocks and make continuous and accurate monitoring of the emission of air pollutants;

- Reduce the amount of CO2 emitted by smokestacks, which in 2019 was 95.3 kg CO2/s for the three units of Kosova A TPP and 131.1 kg CO2/s for the two units of Kosova B TPP, due to its effect on global warming, while the ecological tax should be imposed in the future for every ton of CO2 generated. Currently this tax is applied in EU countries;

- Carry out continuous monitoring of water and soil pollution in the area of the Municipality of Obiliq and the surrounding area due to the impact of various ash components;

- Continue to follow the data and number of patients coming from the Obiliq and Prishtina region, who suffer from respiratory and cardiovascular diseases, in order to immediately notice the negative impact of the effect of air pollution on quality of life, and mitigate it.

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