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Modelling Kosovo's Power System and Scenarios for Sustainable Development

Sadik BEKTESHI [1)]
Skender KABASHI [2)]
Ivo ŠLAUS [3)]
Aleksander ZIDANSEK [4)]
Kushtrim PODRIMQAKU [5)] *
[1),2),5)] Faculty of Natural Sciences, University of Prishtina, **Kosovo**
[4)] R. Bošković Institute, Zagreb, **Croatia**
[5)] J. Stefan Institut, Ljubljana, **Slovenija**

1) sadbek@yahoo.com
2) skenderkabashi@yahoo.com
3) slaus@irb.hr
4) aleksander.zidansek@ijs.si
5) kushtrim.podrimqaku@uni-pr.edu

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Original scientific paper
Abstract: We present a brief study of possible baseline energy development and available options to mitigate carbon emissions. We also discuss problems associated with them. For this purpose we developed an integrated electricity supply-demand model for the period 2010-2025 and analyzed a set of energy scenarios for Kosovo considering also "The energy strategy of the Republic of Kosovo 2009-2018". In various scenarios the potential for growth of the renewable energy sector and its integration into the energy system of Kosovo is investigated. The analysis of various scenarios show that medium growth scenarios are the most favourable scenarios for achieving a stable and quality supply of consumers with electricity for the period 2010-2025 and for a sustainable development of the electricity sector. According to these scenarios, the portion of electricity generation from renewable sources would be 10% of the total electricity generation.

Modeliranje elektroenergetskog sustava Kosova i scenariji za održivi razvoj

Izvornoznanstveni članak
Sažetak: U ovom radu predstavljamo kratku studiju mogućih scenarija energetskog razvoja i opcije dostupne za smanjenje emisija. Također raspravljamo o problemima povezanim s njim. U tu svrhu smo razvijali integrirani model ponude-potražnje električne energije za vremensko razdoblje 2010-2025 i analizirali skup energetskih scenarija za Kosovo uzimajući u obzir "Strategiju energetskog razvoja Republike Kosova 2009-2018." U različitim scenarijima istražili smo potencijale i mogućnosti rasta sektora energije iz obnovljivih izvora (energije iz vjetra, biomase, solarne energije, itd.) i njegovu integraciju u energetski sustav na Kosovu. Analiza različitih scenarija pokazuje da scenariji umjerenog rasta su najpovoljniji scenariji za postizanje stabilne i kvalitetne opskrbe potrošača električnom energijom za razdoblje 2010-2025 i za održiv razvoj elektroenergetskog sektora. Prema tim scenarijima, udio električne energije iz obnovljivih izvora će biti 10% od ukupne proizvodnje električne energije.

1. Introduction

It is evident that sustainable development in Kosovo depends considerably on the rational exploration of natural resources and on the development of the energy sector. Kosovo is rich with lignite found in two larger basins called "Kosova" and "Dukagjini". Geological reserves of lignite are evaluated to be about 12.5 billion tons [1].

Kosovo's electric energy sector is mainly supplied by two lignite-fired thermal power plants (Kosova A and Kosova B) with an effective capacity of 870 MW. Hydroelectric power production is provided mainly by HPP Ujman with a capacity of 2 x 17.5 MW = 35 MW, and HPP of Lumbardhi with a capacity of 8.3 MW. Thus, available production capacity is about 900 MW [2], from which only about 3% comes from renewable energy resources. The actual annual electricity generation in Kosovo is about 4,300-4,600 GWh. During the entire period from 1999-2010, annual domestic

* Corresponding author

production of electric energy was below the level of demand.

In order to ensure a sustainable energy system, the challenge of future perspectives will be the evaluation of the hydro-potential, as well as the potential of solar, wind, biomass and geo-thermal energies, or in other words, the development of the renewable energy sector and its integration into the energy system of Kosovo.

Therefore, the two primary issues of this study are:

1. Under which conditions are Kosovo's electric power system self-sufficient; meaning, does electricity generation by this system satisfy consumer demand, while not depending on import?
2. What are the options for transition to environmentally friendly energies and for achieving a sustainable energy development?

For this purpose, in the present study, we discuss the current situation of electricity generation and consumption and the recent trends with regard to relevant demographic and economic changes, and with an exploration of various scenarios we give a set of options of the possible energy development of Kosovo.

2. Modelling the electric power sector

Electricity demand and production form a complex dynamic system that depends on many interrelated components. A well-accepted technique in scientific analysis for estimating the dynamics of the system, its components and their interactions is computer modeling. During the last few decades a lot of system dynamics models have been built in which energy resources and environmental issues are investigated. Thus, such models (among others) have been applied to: national energy policy evaluation [3,4]; inter-fuel substitution in OECD-European electricity production [5]; energy efficiency and electricity substitution by gas in the residential and industrial sectors [6]; modeling ecological and economic systems with STELLA [7], etc.

We have developed an integrated electricity supply-demand model (ESDE model) for the time period 2010-2025 to estimate the present energy demand and predict the future energy development of Kosovo (Fig. 1). This model was constructed in the STELLA program [8], which makes use of Systems Dynamics Modelling as a methodology developed by Jay Forrester [9]. Systems Thinking has been defined as "the ability to see things as a whole" [10]. System Dynamics attempts to model the basic structure of a system so as to be able to capture the behavior that the system produces [11]. Interactions between objects are accomplished by feedback loops that exist between objects within the system. In feedback loops, a change in one variable affects other variables in the system over time (often including delays), which in turn affects the original variable.

This model includes the following main features:

- Electric demand is modelled as a function of changes in population, industrial activity and development of the service sector.
- The electric power generation sector simulates investments in electric power generation in thermal power plants and in alternative sources of renewable energy (mainly wind and solar) in response to electricity demand.

The electricity supply-demand model (ESDE model) consists of four sectors: residential sector, industrial sector, service sector and electric power generation sector. These sectors are interrelated with a number of equations and assumptions.

The electricity generation sector consists of three subsectors: the nonrenewable energy subsector (that includes three thermo power plants for the production of electric energy from lignite), the renewable energy subsector (that includes four sources of electricity generation from renewable energy sources) and the primary energy subsector (that includes the production and consumption of coal, petroleum and biomass).

2.1 Analysis of the electricity consumption

Since the energy sector of Kosovo depends mainly on the electricity generation sector, we will carry out a more detailed analysis for this sector. For the purpose of the analysis and forecast of electricity consumption, electricity customers were divided into three categories and analyzed for each:

- Residential sector: space heating, cooking, hot water, other uses;
- Industrial sector: including low and high voltage industrial customers;
- Service sector: including all low voltage non residential customers such as: commercial services, public services, agriculture etc.

Total electricity consumption for 2009 was 4926 GWh, out of which 53.5% was used for residential (2301.4 GWh), 27.3% for industry (1174.3 GWh) and 19.2% for services (826 GWh). We emphasize that in this study, we refer to the effective electricity consumption by users in the different categories, irrespective of whether this energy is measured or invoiced.

2.2 The residential sector demands analysis

The residential sector is the most important sector from the electricity consumption point of view due to its high contribution to total energy consumption. Energy consumption and the foreseen demand in the residential sector under way will provide the energy forecast for space heating, cooking, hot water and other electrical uses. Population – The demographic situation and growth in Kosovo are being discussed. One of the main drivers in the energy demand projections is the increase in the size of the population.

According to the registration of the population in 1981 and other sources [12], we assumed for Kosovo an annual growth rate of 1.1 % over the entire period from 2000-2015 and 1.0 % over the period from 2015-2025. With this increase in population, Kosovo is set to reach around 2.35 million in 2025 (Fig. 3a).

When modeling energy use for this sector, the key term is the number of households (H), meaning the number of potential electric customers in dwellings. In this model, this is expressed as the ratio of the population (P) and the mean number of inhabitants per household (I) by the equation:

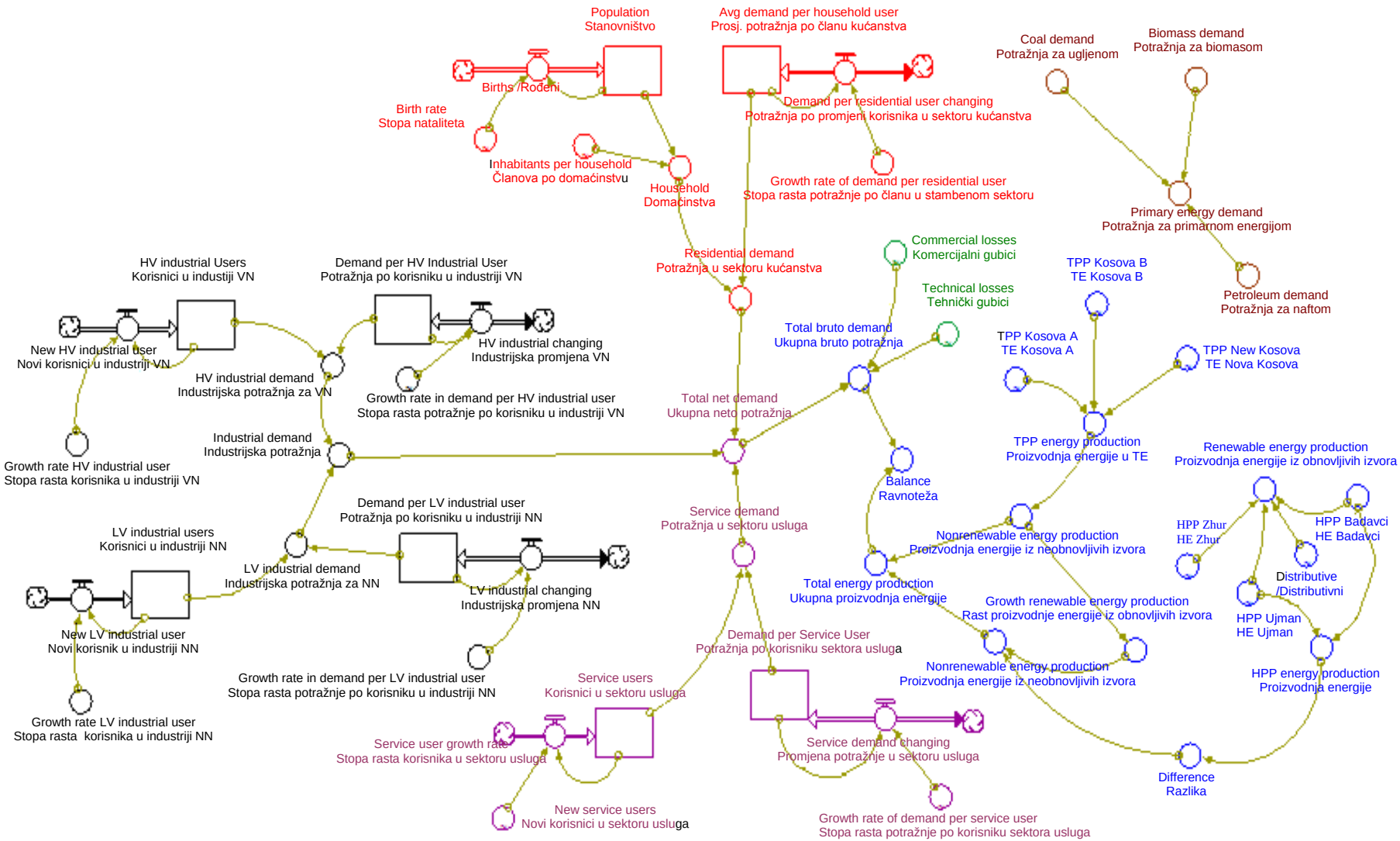

Figure 1. Electricity supply-demand model[(1)]
Slika 1. Model ponude-potražnje električne energije[(1)]
[(1)]For the details of this model contact the corresponding author.

$$H = \frac{P}{I} \quad (1)$$

Referring to previous studies and the results [12, 13], the mean number of inhabitants per household is assumed to be 5.35 and it is assumed that in 2025 the number of persons per household will drop to 3.45.

According to the population figure (about 2 million) and this value of persons per household, therefore, from equation 1 it follows that the residential electric customers were estimated to be 538,507 in 2010, i.e. there will be a total of 681,114 households in Kosovo (Fig. 2a), see Table 1. The total electricity consumption by residential sector was obtained by multiplying the total number of households with the average energy demand per household. Since according to the average energy demand per household of 4500 kWh/year has been estimated [14], a total consumption of 2,907 GWh for the residential sector in the year 2025 (Fig. 2b) has been established.

Table 1. Population growth, total number of households and inhabitants per household in Kosovo. Adapted from [12, 13].
Tablica 1. Rast stanovništva, ukupan broj kućanstava i stanovnika po kućanstvu na Kosovu. Prilagođeno prema [12, 13].

Year / Godina	Population / Broj stanovnika	Household / Broj kućanstava	Inhabitants / household / Broj stanovnika po kućanstvu
2005	2,001,133	374,043	5.35
2010	2,113,643	538,507	3.92
2015	2,232,479	611,638	3.65
2020	2,349,844	681,114	3.45
2025	2,349,844	681,114	3.45

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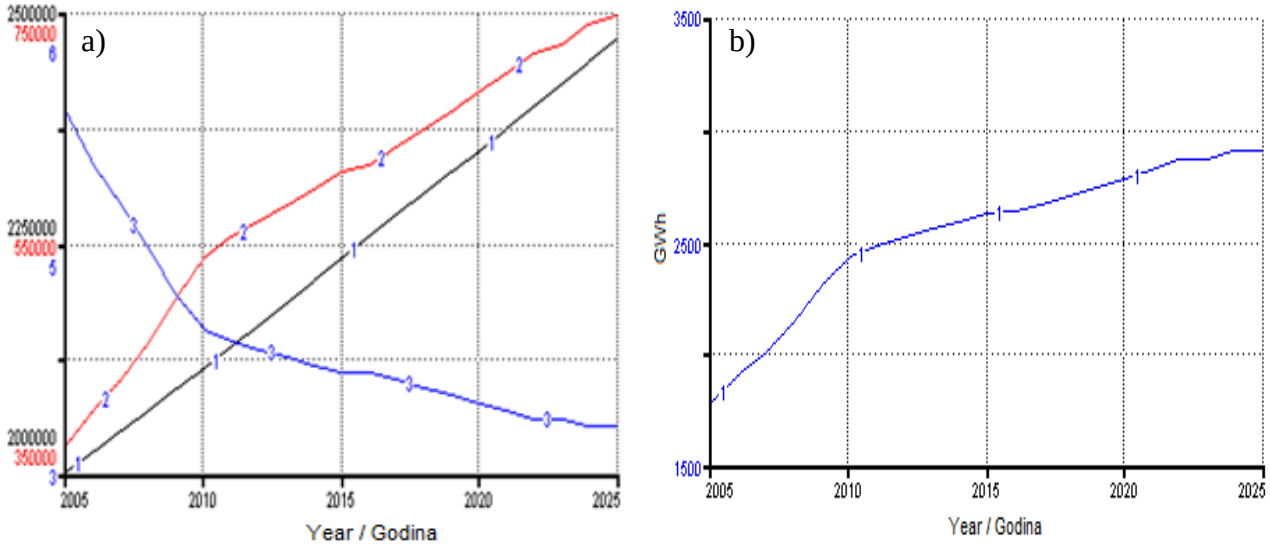

Figure 2. a) Population growth (black line - 1), total number of households (red line - 2) and inhabitants per household in Kosovo (blue line - 2) b) Electricity demand for residential sector. Adapted from [12, 13].
Slika 2. a) Rast stanovništva (crna linija - 1), ukupan broj kućanstava (crvena linija - 2) i stanovnika po kućanstvu na Kosovu (plava linija - 2) b) potrošnja električne energije za stambeni sektor. Prilagođeno prema [12, 13].

2.3 The industrial sector demand analysis

During last few years, a tendency is observed for an increase in the industrial sector. As for the energy consumption, the major contribution comes from the building materials and food production sub-sectors. In our model, industrial electricity consumption is divided into two groups: distribution customer, supplied at low and medium voltage (LV), and direct customers, supplied at high voltage (HV).

At present, the total electricity consumption of the industrial sector equals 1311 GWh, corresponding to about 28.3% of total electricity consumption. The trend of the electricity consumption in the industry has been done analyzing macro-economic indicators and the GDP trends of the industrial sector [14] as well as the invoiced energy. The forecasted electricity demand for the industrial sector in 2025 is 3,087 GWh, comprising 40.3% of overall electricity consumption (Fig. 3).

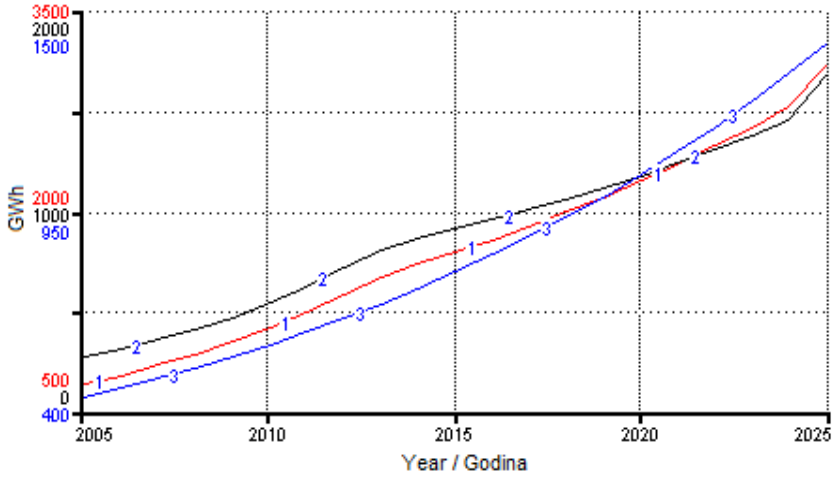

Figure 3. Forecast of electricity demand in the industrial sector. Total industrial demand (red line - 1), HV industrial demand (black line - 2) and LV industrial demand (blue line - 3) Adapted from [14].

Slika 3. Prognoza potražnje za električnom energijom u industrijskom sektoru. Ukupna industrijska potražnja (crvena linija - 1), VN industrijska potražnja (crna linija - 2) i NN industrijske potražnje (plava linija - 3). Prilagođeno prema [14].

2.4 The service sector demand analysis

In the services category, we find several groups of customers supplied as low voltage artisans, commercial services, public services, public lighting and agriculture. Energy consumption in the services sector during the period 1999-2009 increased rapidly, which was followed by a significant increase of the economic activity in this sector.

The analysis of the macro-economic indicators has shown that the service sector contributes to around 10.9% of the GDP, and will continue to grow at the same rate [14]. Therefore, by accounting for the commercial losses, it is possible to estimate the actual consumption of 889.6 GWh, whereas the predicted total electricity consumption in the service sector will reach about 1,535 GWh in 2025 (Fig. 4).

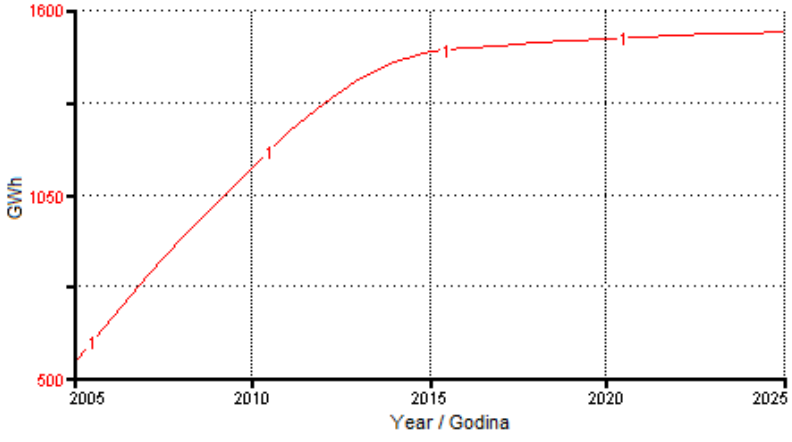

Figure 4. Forecast of electricity demand in the service sector. Adapted from [10].

Slika 4. Prognoza potražnje za električnom energijom u sektoru usluga. Prilagođeno prema [10].

2.5 Technical losses

Kosovo's electric power system faces high losses in distribution as well as in transmission networks. The estimated technical losses of the entire distribution, i.e. the MV and LV networks, were in 2006 17.93 %, in 2007 17.19%, and in 2008 about 17.1% of the electricity delivered to the network. It was established that the share of the MV network losses in the overall distribution of the technical losses was 770 GWh, while the technical losses of the transmission network in 2009 were 174 GWh.

Considering the experience of other countries and under the assumption that the modernization measures and rehabilitation of the network will be carried out appropriately and in a timely fashion, it is expected that the total losses are forecasted to decrease from 34% in 2011 to 15% in 2020 [15] and will gradually drop to 13% in 2025 (Fig. 5).

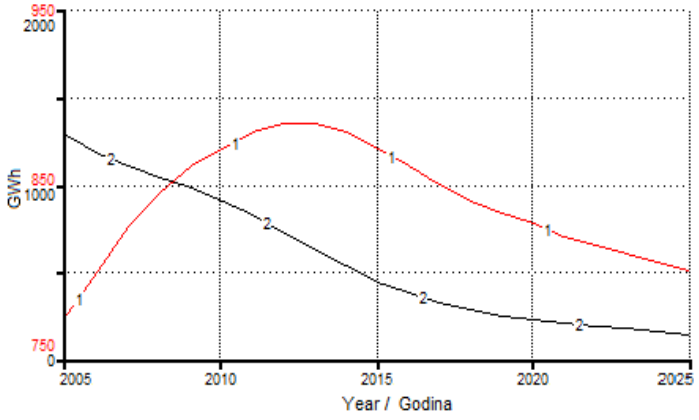

Figure 5. The forecast of technical losses (red line - 1), and commercial losses (black line - 2). Adapted from [15].
Slika 5. Prognoza tehničkih gubitaka (crvena linija - 1), i komercijalnih gubitaka (crna linija - 2). Prilagođeno prema [15].

2.6 Electricity demand forecast for all sectors

The total net demand forecasts for users are calculated by summing the electricity demands for all three sectors, for each year. It should be stressed that these values include non-technical losses. Adding this value to the technical losses estimate, we obtained the forecast of total gross electricity that must be supplied to the electrical system by the generation plants and by importing from neighboring countries.

To have a detailed view of electricity demand forecast by sector, total net demand, total gross demand and technical losses for the time period 2005-2025, refer to the Table 2. According to above data, Figure 6 shows a continuing increase in electricity demand for the period 2005-2025. It must be considered that such a growth of electricity consumption and generation might produce a wide range of environmental impacts at the local, regional, and global levels [16, 17, 18]

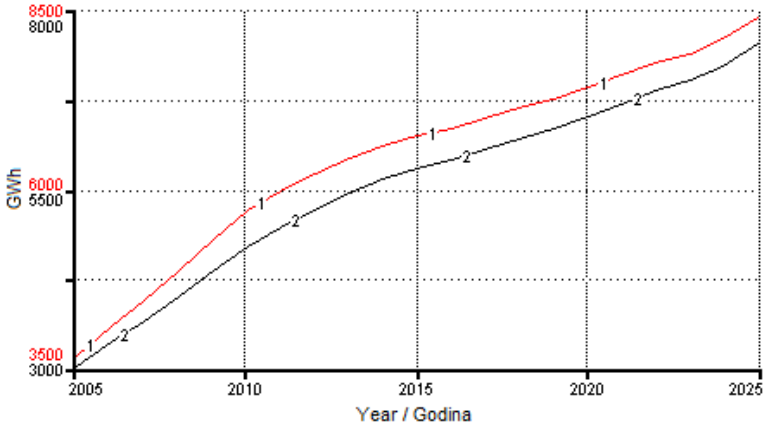

Figure 6. Total gross electricity demand forecast (red line - 1), and total net electricity demand forecast (black line - 2). Adapted from [14, 15]
Slika 7. Prognoza potražnje za ukupnom bruto električnom energijom (crvena linija - 1), i prognoza potražnje za ukupnom neto električnom energijom (crna linija - 2). Prilagođeno prema [14, 15].

2.7 Kosovo primary energy consumption and production forecast

In this chapter we present a brief overview of the estimates and insights about the current energy resources in Kosovo and the trends in the consumption and production of energy. The present energy sector of Kosovo is characterized by insufficient supplies of non-diversified fuel sources. The primary energy consumption and production structure in Kosovo is dominated by coal, which is expected to remain the dominant fuel in electricity generation on the basis of its very low costs and large domestic resources.

Coal consumption - The total estimated resources in the Kosovo lignite mines of approx. 12.5 billion tons represent one of the richest lignite sources in Europe. The production of coal has increased from 1450 ktoe in 2005 to 2784 ktoe in 2010, which shows an average annual increase of 18%. [1,2]. Shown in Fig.7 are the demands for lignite in order to supply the existing thermo plants and a thermo plant which is planned to be built, i.e. TPP "Kosova e Re" with a capacity of 1,000 MW.

Large reserves of lignite would allow the development of Kosovo's electric power system in perspective to be analyzed according to various expansion schemes, implying that also that the forecast for coal demand would depend on scenarios for electricity generation, which will be discussed later.

Petroleum consumption - Kosovo does not possess reserves of petroleum and natural gas. The demand forecast of petroleum products, which are actually used mainly for road transportation in the future, will depend strongly on economic growth. By estimation of the existing petroleum consumption, import of oil products has increased from 619 ktoe in 2005 to 721 ktoe in 2010; future consumption in 2025 is estimated to account for 1125 ktoe, [1,2], Fig.7.

Biomass consumption - There are no reliable numbers showing the level of firewood exploitation, but according to some questionnaires and analyses [1,2], the amount of exploited firewood only by households was in average 9.7m^3 per household per year. If we consider all the economic sectors, then the consumption of firewood during 2010 was 249 ktoe, whilst it is expected to reach the value 584 in 2025, Fig.7.

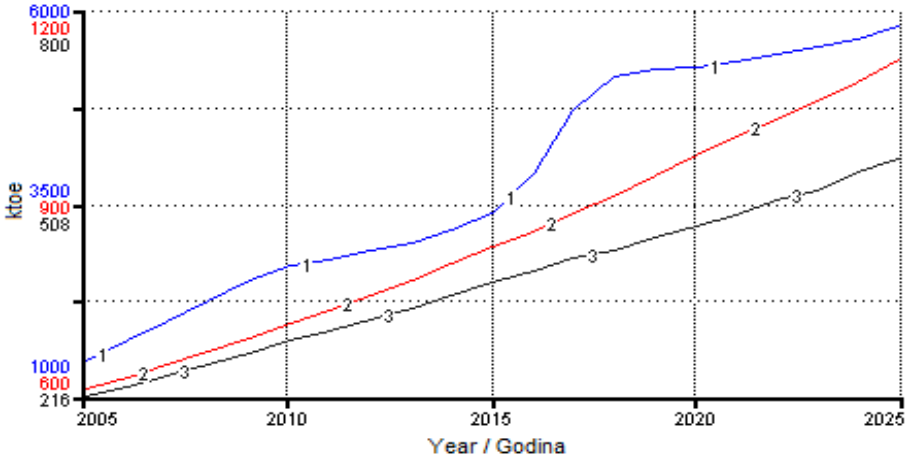

Figure 7. Forecast for coal demand (blue line - 1), petroleum demand (red line - 2) and biomass demand (black line - 3). Adapted from [1, 2].

Slika 7. Prognoza potražnje za ugljenom (plava linija - 1), potražnja za naftom (crvena linija - 2) i potražnja za biomasom (crna linija - 3). Prilagođeno prema [1, 2].

3. Analysis of electricity supply-demand forecast model simulation

Electricity in Kosovo is provided 95-97% by the lignite power plants: Kosova A and Kosova B. The construction of the TPP Kosova e Re (New Kosova) is planned for the year 2016 [2]. The rest of only 3-5% of electric power is produced from the renewable resources we will designate by RE_i. Total annual electricity generation from all of the production units is calculated by the equation:

$$E = \sum \left[KA_i + KB_i + KR_i \right] + RE_i \qquad (2)$$

where KA_i - total annual electricity generation from TPP Kosova A; KB_i - TPP Kosova B; and KR_i - TPP Kosova e Re respectively, for the year i (i=2005, 2006,…2025).

Kosovo is facing the huge task of restructuring the power sector. In the last few years, in Kosovo there has been an intensive debate about the building of a new thermo power plant, whose capacity has provoked many discussions in the scientific and public circles. The main topic of the discussion is the question of whether its capacity should be 350 MW, 600 MW, or even 1000 MW. It is forecasted that its first generating block will commence with commercial operation in 2016 [2]. This is the reason that the forecasting of electricity generation growth is based on three baseline scenarios.

On the other hand, lignite use in electricity generation in Kosovo releases an average of 2.5 million tons of CO_2, which with planned construction of a new power plant will release as much as 5 million tons into the atmosphere annually [19] and also other greenhouse gases like nitrogen oxide and methane, as well as toxic chemicals like mercury and arsenic. The entire process from mining through combustion to waste disposal releases tons of particulate matter and chemicals on an annual basis and has a direct impact on the community public health and ecological systems. [19]

Environmental problems such as air pollution and heavy metal pollution could be reduced by the development of the renewable energy sector and by increasing the efficiency of the energy explored.

Kosovo has a range of renewable energy resources including hydropower, and biomass, as well as geothermal, wind, and solar energy. The actual installed capacities of the existing HPP are: HPP Ujmani with a capacity of 35 MW, HPP Lumbardhi with 9 MW and Badavci with 1 MW. The total production from the existing HPP is estimated at 156 GWh/yr in 2010 [4]. According to [15], renewable energy resources to be developed by 2020 are: HPP "Zhur", (which is planned to be built no later than in the year 2016) with an installed capacity of 305 MW and with additional 20 'small' HPP with a capacity of 140.3 MW and construction of wind farm power stations and solar energy in various modes (solar, biomass and photovoltaic) with an overall capacity of 160 MW, so that the total power generated from renewable sources in the year 2025 will be 780 GWh/yr. Data on the installed capacities of the existing HPP within Kosovo was obtained from [15]. These data are reproduced in Table 3.

Such a development of power generation from the renewable sector could be possible and sustainable, but in this case we could obtain only 10% of the total electricity generation.

In this case, it is of interest to investigate the options for transition to environmentally friendly energies. Therefore, projected electricity generation from renewable resources is discussed for each baseline scenario, with an average growth of approximately 5%, 10% and 20% of the total electricity generation.

Thus, from this model three scenarios are generated as a basis for electricity generation growth forecasting:

High Growth Scenarios (HGS) - In these scenarios, it was assumed that the capacities of the power plants would be raised by 1000 MW by 2016, with participation of nonrenewable energy at 5%, 10% or 20% of the total electricity generation.

Medium Growth Scenarios (HGS) - In these scenarios, it was assumed that the capacities of the power plants would be raised by 600 MW by 2016, with the participation of nonrenewable energy at 5%, 10% or 20% of the total electricity generation.

Low Medium Growth Scenarios (HGS) - In these scenarios, it was assumed that the capacities of the power plants would be raised by 350 MW by 2016, with the participation of nonrenewable energy with 5%, 10% or 20% of the total electricity generation.

Thus, with this model we will explore a variety of possible scenarios, investigating the potentials and possibilities of the growth of the renewable energy sector and its integration into the energy system of Kosovo as a whole.

3.1 Simulation Results

Since it is not expected that new energy capacities will be built any sooner than in 2016, three scenarios for new generation capacity and renewable energy resources to be developed by (2016-2025) are summarized in Table 3, which we will discuss below in more detail.

High Growth Scenarios (HGS) – The basic considerations of these scenarios are that the Kosovo's electric power system will advance mainly due to the high increase of electricity production from lignite. Apart from the electric power produced from the lignite power plants Kosova A (TPP Kosovo A will remain in service throughout 2016) and Kosova B, in this scenario the growth of electricity generation from the TPP Kosova e Re with a capacity 1000 MW and planned to start operating at 2016, is also discussed, as well as the participation of nonrenewable energy comprising 5%, 10% and 20% of the total electricity generation (Fig 9a, 9b, 9c).

Realization of each of these scenarios could be favorable since electricity generation (black line) will be greater than the electricity demand (red line) for the entire analyzed period from 2016-2025 (Fig 9a, 9b, 9c). During this period the electricity generation within Kosovo will become high enough so that it would become a net exporter of electricity to neighboring countries. It would seem that these scenarios are not realizable since accordingly a TPP with a capacity of 1000 MW should be built, and furthermore taking into consideration the high costs of building such capacities as well as the likelihood of considerable impact upon the

environment due to a sharp increase in greenhouse gas emissions.

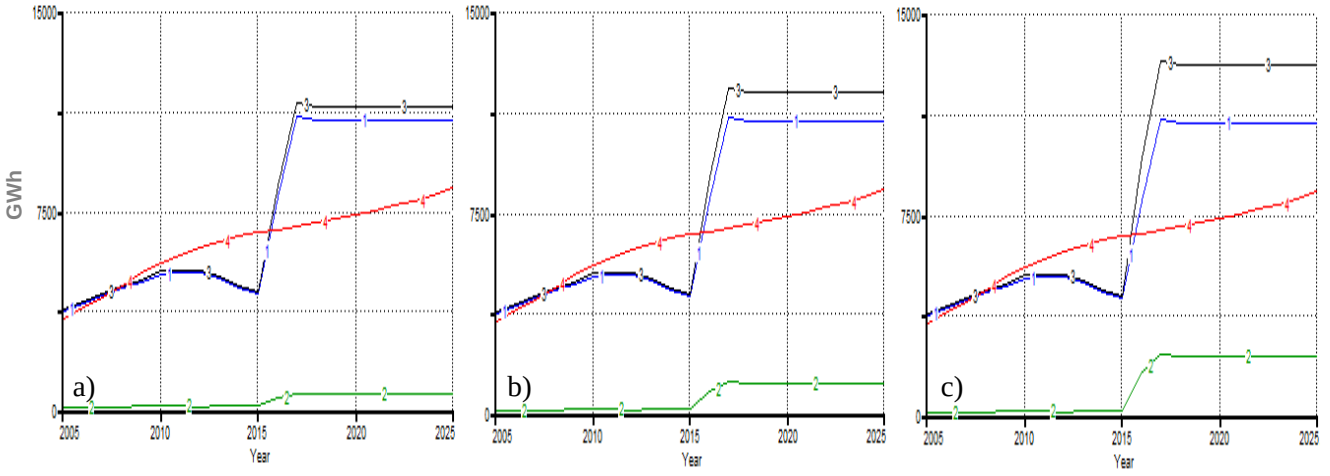

Figure 8. Values obtained from the model for HGS. Electricity from nonrenewable energy sources (blue line -1), electricity from renewable energy sources (green line - 2), total electricity production (black line - 3), total gross demand (red line - 4) with a participation of the renewable energy at a) 5% b) 10% and c) 20% of the total electricity generation.

Slika 8. Vrijednosti dobivene iz modela za HGS. Električna energija iz neobnovljivih izvora energije (plava linija - 1), električna energija iz obnovljivih izvora energije (zelena crta - 2), ukupna proizvodnja električne energije (crna linija - 3), ukupna bruto potražnja (crvena linija - 4) sa sudjelovanjem obnovljivih izvora energije a) 5% b) 10% c) 20% od ukupne proizvodnje električne energije.

Medium Growth Scenarios (MGS) - According to these scenarios, apart from electric power produced from the existing lignite power plants, construction of a TPP Kosova e re with 600 MW is taken into account, while the renewable energy from the year 2016 to the year 2025 will consist of 5%, 10% and 20% of the total electricity generation in Kosovo (Fig. 9a, 9b, 9c). In comparison with HGS, we assumed that the electric sector of Kosovo will be developed mainly due to a smaller increase of electricity production from lignite and an increase in renewable energy use by about 790 GWh.

From comparison of the MGS scenarios (Fig. 9a, 9b, 9c), it follows that in order to have a sustainable supply for the population for the period 2016-2025, a participation of the renewable energy with 10% (Fig 9b) of the total electricity generation, would be sufficient. Therefore, according to this scenario, the total electricity generation (black line) is always greater than the total gross demand (red line). Considering the resources of the renewable energy of Kosovo discussed above, such a scenario could be realized.

The main advantages of the realization of such a scenario could be:

- The increase of the renewable energy would be associated with an increase of investments in this sector. The clean energy industry can act as a driver for significant, positive economic growth through the creation of domestic jobs that are often dispersed throughout the country. This scenario, whilst delivering 10% of the electricity demand through renewable resources, according to a recent study [20, 21] can also provide more jobs than the usual business case. The business as usual case, dominated by an expanded use of low-quality coal, is not the least-cost energy option for Kosovo.
- Kosovo faces a lack of electricity, especially during the winter. Building up a domestically produced clean energy supply can address peak energy demands, potentially utilizing wind and hydropower, so that the development of the renewable energy sector can provide greater energy independence and security.
- Renewable energy and energy efficiency taken together have notable environmental benefits due to reduced CO_2 and other emissions [21].

Finally, considering investments in the non-renewable energy sector (building of a TPP with a capacity of 600 MW), in the renewable energy sector (for the generation of 800 GWh), and the influence on the diversification of the energy resources and the impacts in the environment, it seems that this scenario is the most optimal option for the sustainable energy development of Kosovo.

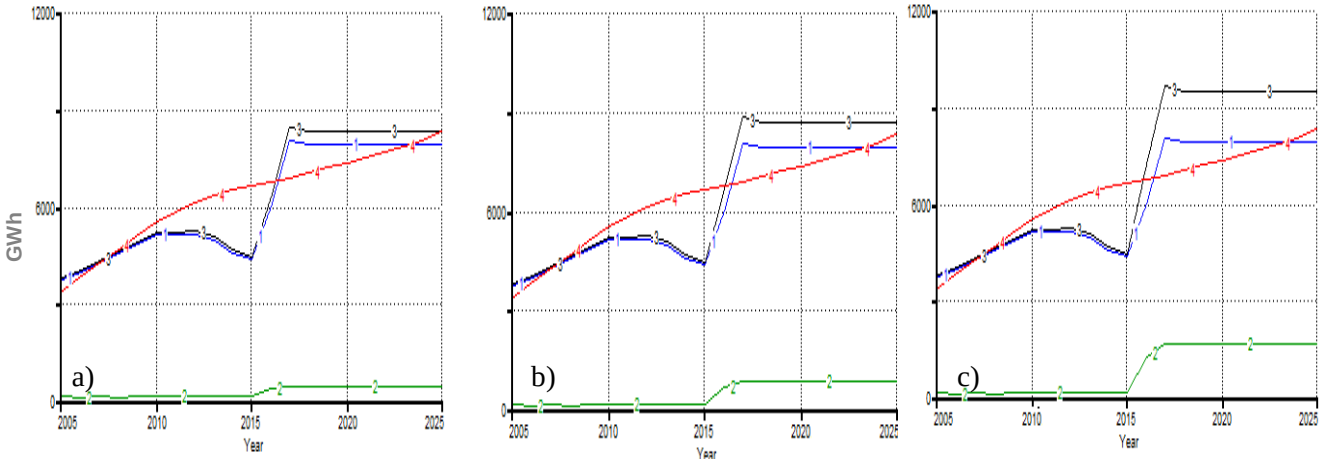

Figure 9. Values obtained from the model for MGS (Curves labeled as above).
Slika 9. Vrijednosti dobivene iz modela za MGS (krivulja označena gore).

Low Growth Scenarios (LGS) - At the moment, electricity generation is dominated by coal-fired power plants. In this scenario, the situation changes only slowly due to the low assumed investments in this sector.

According to these scenarios (Fig. 10a, 10b, 10c), construction of a TPP Kosova e re with 350 MW is taken into account, while the percentage of the participation of the renewable energy in the total electricity generation remains at the same level. In this case, according to all LGS scenarios, the total electricity generation (black line) is always lesser than the total gross demand (red line), Fig. 11a, 11b, 11c. This means that consumers' demands for electricy would not be fulfilled, so that Kosovo's electric power system would not be a self-sufficient system, therefore we will not proceed with a disussion of these scenarios.

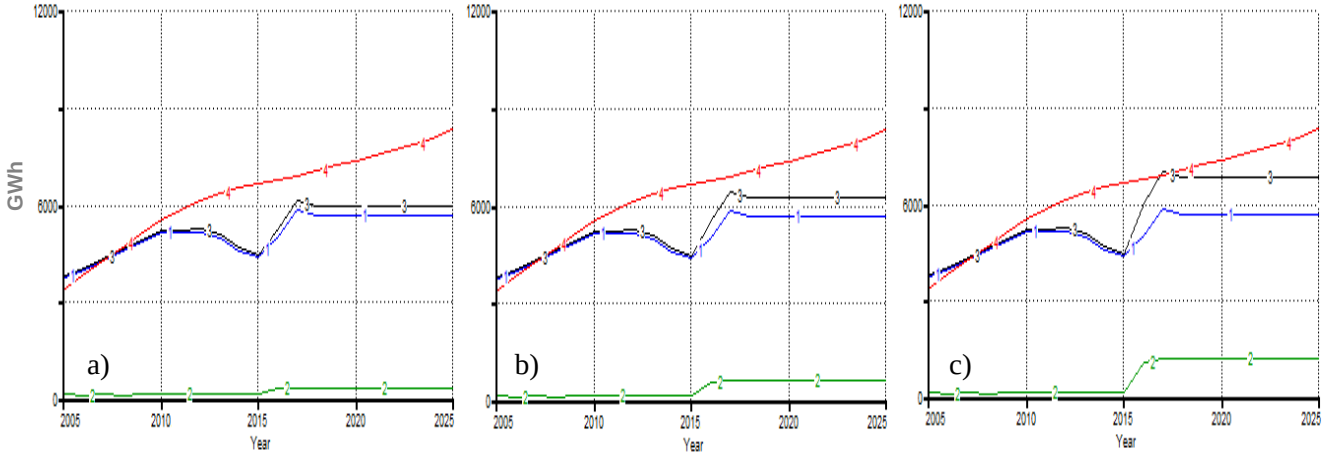

Figure 10. Values obtained from the model for LGS (Curves labeled as above)
Slika 10. Vrijednosti dobivene iz modela za LGS (krivulja označena gore)

Table 3. Values obtained from the model for electricity from non-renewable energy sources, electricity from renewable energy sources, total electricity production, total gross demand and balance by HGS, MGS and LGS scenarios for the period 2006-2025 in Kosovo

Tablica 3. Vrijednosti dobivene iz modela za električnu energiju iz neobnovljivih izvora energije, električnu energiju iz obnovljivih izvora energije, ukupnu proizvodnju električne energije, ukupnu bruto potražnju i ravnotežu po HGS, MGS i LGS scenarija za razdoblje 2006-2025 na Kosovu

		Electricity from non-renewable energy sources (GWh) / Električna energija iz neobnovljivih izvora energije (GWh)			Electricity from renewable energy sources (GWh) / Električna energija iz obnovljivih izvora energije (GWh)			Total electricity production (GWh) / Ukupna proizvodnja električne energije (GWh)			Total gross demand (GWh) / Ukupna bruto potražnja (GWh)			Balance (GWh) / Ravnoteža (GWh)		
	Year	2016	2020	2025	2016	2020	2025	2016	2020	2025	2016	2020	2025	2016	2020	2025
LGS	5%	5,000	5,900	5,900	250	295	295	5,250	6,195	6,195	6,749	7,350	8,330	-1,499	-1,155	-2,135
	10%	5,000	5,900	5,900	500	590	590	5,500	6,490	6,490	6,749	7,350	8,330	-1,249	-860	-1,840
	20%	5,000	5,900	5,900	1,000	1,180	1,180	6,000	7,080	7,080	6,749	7,350	8,330	-749	-270	-1,250
MGS	5%	6,000	7,900	7,900	300	395	395	6,300	8,295	8,295	6,749	7,350	8,330	-449	944	-35
	10%	6,000	7,900	7,900	600	790	790	6,600	8,690	8,690	6,749	7,350	8,330	-149	1,339	359
	20%	6,000	7,900	7,900	1,200	1,580	1,580	7,200	9,480	9,480	6,749	7,350	8,330	450.55	2,129	1,149
HGS	5%	8,000	10,900	10,900	400	545	545	8,400	11,445	11,445	6,749	7,350	8,330	1,650	4,094	3,114
	10%	8,000	10,900	10,900	800	1,090	1,090	8,800	11,990	11,990	6,749	7,350	8,330	2,050	4,639	3,659
	20%	8,000	10,900	10,900	1,600	2,180	2,180	9,600	13,080	13,080	6,749	7,350	8,330	2,850	5,729	4,749

4. Conclusion

Several baseline scenarios have been developed from the ESDE model to explore the possible development of Kosovo's electric power system, as well as the conditions that this system must fulfill to become self-sufficient (electricity generation by this system satisfies the consumers' demands, and does not depend on import). From the analysis of the obtained results, we can conclude that:

Our scenarios indicate a strong increase in electricity use in Kosovo during the time period 2010- 2025.

Kosovo's electric power system will be self-sufficient for:

- HGS (building of a TPP with a capacity of 1000 MW) and
- MGS scenarios (building of a TPP with a capacity of 600 MW and with electricity generation from renewable energy resources of 800 GWh).

The analysis of various scenarios show that medium growth scenarios are the most favorable scenarios for achieving a stable and qualitative supply of electricity to consumers for the period 2010-2025 and for a sustainable development of the energy sector, in compliance with European standards and approaches. According to the MGS, participation of the electricity generation from renewable sources would be 10% of the total electricity generation, that is, about 800 GWh. In this case a rational and effective exploration of the country's natural energy sources could be achieved and could have an influence on the aspects of diversification of the energy resources. Implementation of this scenario could be far easier by reducing the technical and non-technical losses [21] and by increasing the efficiency in all energy sectors [14].

For a detailed investigation of potential GHG emissions and the options for reductions, the incorporation of the GHG emission sector in this model is planned in the future.

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NOMENCLATURE

HPP	Hydro power plant
TPP	Thermo power plant
HGS	High Growth Scenarios
MGS	Medium Growth Scenarios
ktoe	kilotons equivalent
GWh	Giga watt hour
KWh	Kilowatt hour
GDP	Gross Domestic Production
MWh	Mega Watt hour
LGS	Low Growth Scenarios

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