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Hydropower Energy Source Combining with Other Renewables in the Teritory of Kosova

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Abstract: With the continuous growing of population and the economical needs in the Balkan region, as in the whole world, the need for new energy resources is getting more reasonable than ever. Considering the nowadays exponential growth in development of the renewable energy sources, in this paper, a comparison of the hydropower energy capacities with the wind and solar energy sources, in the territory of Kosova is generally presented. Today, the territory of Kosova, has 1,513 MW installed capacity of electricity, which is generated from two thermo-power plants KOSOVA A and KOSOVA B. This energy generation capacity is proved to be insufficient for meeting the entire electricity needs of the 2 million population and the overall economical development. In this paper, a specific attention is given to the electricity generation by the renewable energy sources as the wind and hydropower. A specific emphasis is given to the combination of hydropower with wind power, in Kosova, as a optimal solution for the generation of the renewable energy sources. In this paper, a concrete idea for combining the ZHUR hydro-powerplant system with the numerous wind turbines is given, which could be placed in the near zone of this hydropower-plant. In combination, these electricity regenerators would promise a more reliable energy source, and contribute to the fulfilment of the overall electricity requirements of Kosova.

Key words: Hydropower, wind turbines, renewable energy, Zhur Hydropower plant.

1. Energetic System of Kosova, Past, Present and Future

In the period between 1962 and 2002, some 115 TWh of electrical energy was produced by Kosova Energy Corporation, of which 45% was exported. The electrical energy balance is shown in Fig. 1.

During the past two decades, the Kosova energetic system has pased along three main periods, which together have made significant contribution for its difficult present situation (Fig. 1):

• The first period (during 1980-1991) is characterized with a considerable increase of the energetic consumption (energetic needs) and with the instalment of two units of TPPs (thermal-power plants), namely Kosova B1 and Kosova B2, which together had 678 MW instaled capacity;

• The second period (during 1991-1999) was known as a balanced mark and with increases in the energetic needs. Nevertheless, during this period, there were no additional investments in the aspect of new TPPs instalations. Simultaneously, the degradation of the extisting TPPs was becoming evident, as a result of lack of maintainance. From Fig. 1, it can be clearly seen that along its functioning period until the year of 1999, Kosova was a net electricity exporter;

• The third period began after the war of 1999, with considerable support in the aspect of energetic sector stabilisation, by the financing of the international community and the energetic indysty of Kosova. The problems of stabilisation of the energetic sector are still evident. Due to continuous increase of energy consumption needs and degradation of the existing TPPs, the electricity consumption reductions are applied, espetialy in the periods when the consumption needs are considerably high.

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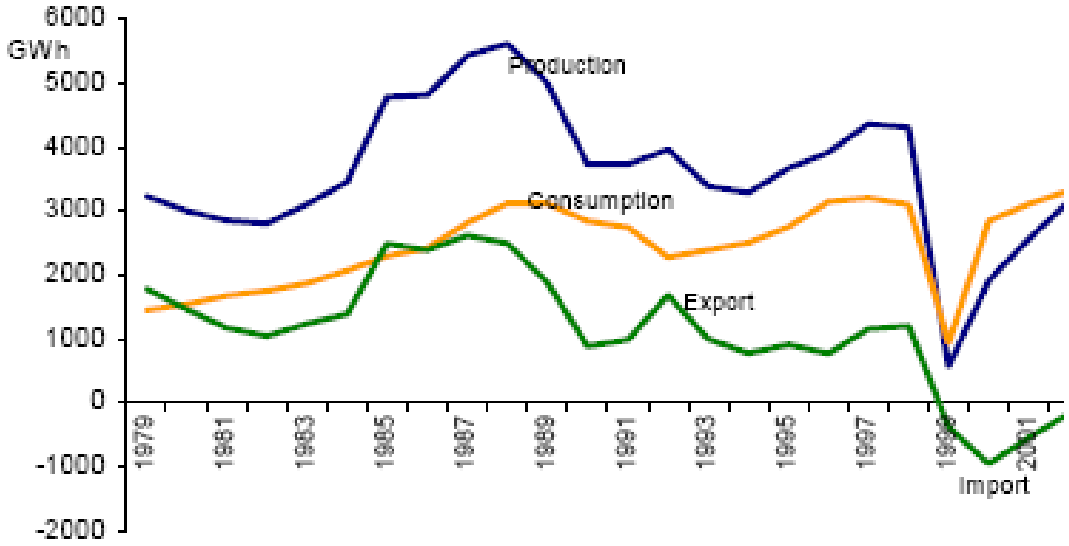


Fig. 1 Development of production, consumption and exchange.

Table 1 Existing power generation facilities in Kosova.

Power plant	Unit	Gross installed power (MW)	Net power (MW)	Start of operation
Kosova A	A1	65	58	1962
	A2	125	113	1964
	A3	200	182	1970
	A4	200	182	1971
	A5	210	187	1975
Kosova B	B1	339	309	1983
	B2	339	309	1984
HPP Gazivodë/Ujman	G1	17.5	17.5	1983
	G2	17.5	17.5	1983

Considering the retrospective, the "Master Plan" of Kosova was planned that during the year 1980-2000, the energy generation, because of the high resources of coal in the territory of Kosova, has been evaluated that till the year of 2000, thermo-power plants with a capacity of 8,000 MW will be installed. By the same "Master plan", it has been calculated that in Kosova by the end of the year 2000, hydropower plants with over 550MW electricity generation capacity was to be designed. However, this plan, considering the political factor, was not even been initiated.

Today, energetic system of Kosova generates energy by two TPPs, namely "Kosova A" and "Kosova B", and by also including the HPP (hydropower plant) in Gazivodë (Ujman), the total installed energy capacity is about 1,513 MW. For the moment, its effective production capacity is 834 MW (Table 1).

Most of the power generation units of the two thermal plants are in poor operating conditions. Overhauling and rehabilitation works in the power plants have been carried out or are still underway.

In July 2002, there was a fire in Kosova B, which contributed to the reduction of the available capacity of the system to only 640 MW. By winter 2004, the installed energy capacity was anticipated to increase to approximately 900 MW after the repairing of two units of Kosova B. Unfortunately, the production will still remain limited to approximately 650 MW due to continued constraints in coal supply, as a consequence of a major landslide in one of the two mines in November 2002. This will have severe negative

impacts on production in the short-term period, and in order to maintain the full-time power supply, the lacking power to the anticipated peak of approximately 800 MW should be imported. The total production in 2000 was 1,914 GWh; this rose to 2,568 GWh in 2001, and again to 3,153 GWh in 2002 despite the above-mentioned incidents.

Considering the continuous growth of electricity demand in Kosova, there are formulated different strategies for solving this problem. By the year of 2002, a development of 2 TPP-s was proposed, which would bring a lasting improvement and stabilisation in the power supply system of Kosova.

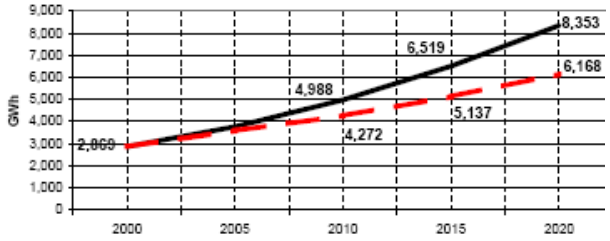
With the support from the World Bank, the ESTAP project developed a forecast of the total electricity consumption by 2020 (Fig. 2). In the absence of an official economic development strategy for Kosovo, two scenarios were analyzed: medium and high-Growth, and they provide a range of future energy demands (Fig. 2).

2. Different Types of Energy Sources and Their Potential in Kosova Region

Today, there are different types of classification of energy resources that are used for energy production. In the following, in a graph format we will name the most common types by classifying them in two major groups, namely, non-renewable and renewable energy resources, *Fig. 3*.

2.1 Coal

In Kosova region, the predominant energy resource applied is coal. The coal resources in Kosova region are evaluated to be in very large amounts, therefore, it is believed to be the main energy resource for electricity production in this region even for the coming several decades. Coal is considered to be used



	2000	2005	2010	2015	2020
HG – annual growth rate 7%					
GWh	2,869	3,769	4,988	6,519	8,353
MW	653	798	1,061	1,424	1,960
MG – annual growth rate 5%					
GWh	2,869	3,586	4,272	5,137	6,168
MW	653	749	890	1,081	1,296

Fig. 2 Energetic consumption forecast, i.e. scenarios of electricity demand growth

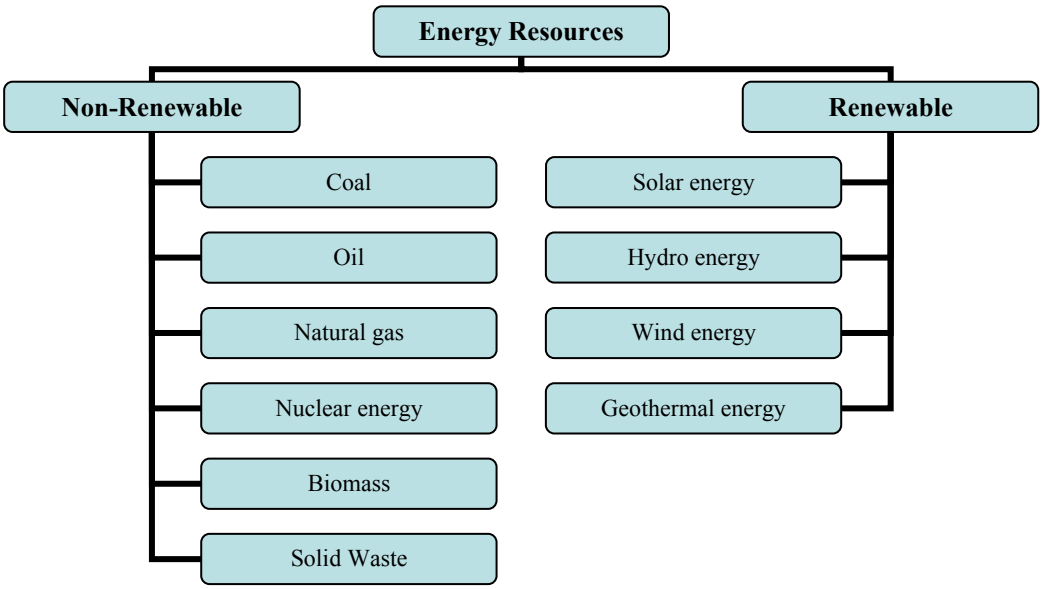


Fig. 3 Energy resources classification.

from the existing TPPs and the new TPPs (planned for construction in the near future) as well. Coal resource quantities in Kosova region are showin in Table 2.

In Fig. 4, the coal basins within the Kosova region, the existing ones, as well as the future potential places where the coal can be exploited for energy production purposes, are shown.

2.2 Oil and Natural Gas

In Kosova region, untill now, no oil and natural gas resources have been detected. Therefore, for their application, Kosova must import it from other countries.

2.3 Biomass

This type of energy is generated from different processess (mainly from burning process) of organic materials. In Kosova, this type of energy generation has not been studied yet ;

2.4 Renewable Energy Resources

Although the interest for application of renewable

Table 2 Coal resources in Kosova.

Basin	Area (km^2)	Resources in exploitation		Potential resources	
		Milion tons of mass	Milion tons of oil equivalent	Milion tons of mass	Milion tons of oil equivalent
Prishtinë	264	11,500	2,957	9,804	2,521
Dukagjin	95	2,737	782	1,625	464
Others	14	87	22	74	19
Total	373	14,324	3,761	11,503	3,004

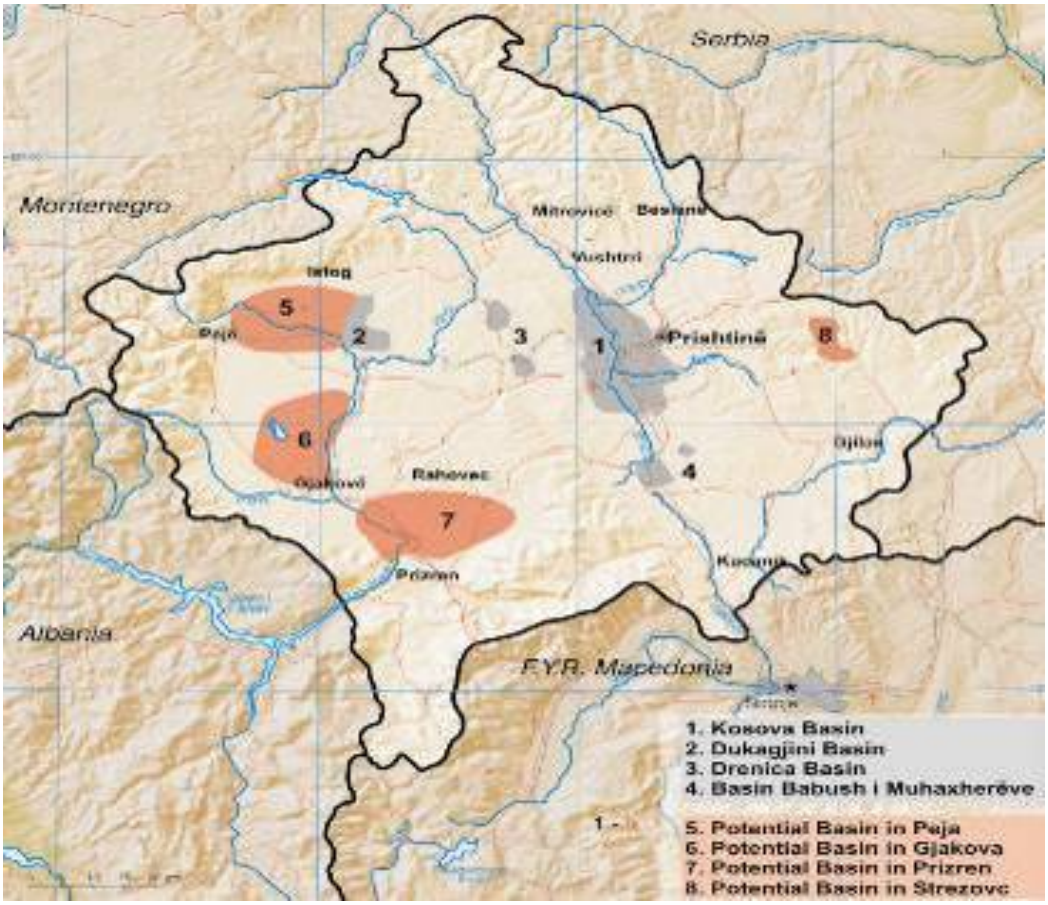


Fig. 4 Map of coal basins in Kosova.

energy resouces varies for different coutries, there are significat facts that prove, inthe recent decades, all over the world in general, there is an exponential increase for renewable energy application for energy generation. Their wide application for the future looks very optimistic and it is all on account of the recent technology advancements and the mere fact that renewable energy sources are inexhaustible (in contrast to oil, coal, and natural gas).

2.5 Solar Energy

In the latest decade, this type of renewable energy is exponentially advanced, and most of the developed countries have evidently found its application. Nevertheless, that this technology is relatively new and continuouslly advancing, the results obtained from it in practice are quite remarkable, and its perspective for future wider application is quite promissing.

For the present time, its application in Kosova region is not evaluated as a strategic investment which would significantly facilitate to surpass the present difficulties in the energy sector of Kosova. Its been evaluated that for the future 15 years, solar energy can not be expected to be applied in Kosova region.

2.6 Geothermal Energy

In Kosova region, the application of geothermal energy, as well as in other countries, is considered to be applied in residential buildings. However, its application in Kosova has not started yet..

Apart from the above mentioned energy resouces, for the Kosova region, considering the existing energy production facilities and the recent studies on renewable energy generation in Kosova, it has been concluded that the hydropower and wind energy generation, excluding the thermal energy generation, are very reasonable and strategic options for application in Kosova region.

The application of hydro and wind energy in Kosova, could significantly improve and stabilise the energy sector, positively affect the ecology, reduction of pollutant emissions from TPPs, economical rehabilitation, reduction of unemployment, and provide environmental protection.

In the following, the possible utilisation of these two renewable energy resources for energy production in Kosova, will be elaborated in more detail, and ther influence in the overall energy sector will be determined.

3. Hydro-Energy Resources in Kosova

Apart from the idea of developing new TPPs, after the year 2000, it has been greatly revitalized the idea of regenerating electricity by hydropower plants, especially ZHUR hydropower plant with an installed electricity capacity of 293 MW. This idea has been provoked considering many factors, as the economic aspect, ecologic and political aspect as well. This project is considered that in a very effective way would contribute in the future stabilization of energetic production.

Kosova territory is characterised with a hydrographical network of rivers and streams that posses insufficient hydro-energy potential for satisfying the overall energy need of Kosova. Nevertheless, hydro-energy potential in Kosova can play a significant role for the energy sector, and ought to be considered for generation of energy from it. Observing the hydrography of Kosova, it can be concluded that the west side of the territory consists the bigger part of the total hydro energy potential. In Table 3, the hydro-power potential of the 5 main watersheds of Kosova can be seen.

The overall applicable hydro-energy potential in Kosova is considered to be 700 GWh/year. About half of this hydro-energy potental can be generated in the “Drini i bardhë” watershed, respectively, by utilization of a new HPP near the ZHUR district. This hydropower plant is evaluated to annually generate 377 GWh/year of electricity, or 53% of the overall hydro-energy potential of Kosova. Merely due to this fact, it is noteworthy to briefly elaborate the main characteristics of the ZHUR HPP, that would

eventually be realised, and also to determine the economical benefits from its utilisation in practice.

The idea for realisation of ZHUR hydropower plant exists since the beginning of the 50-ies of the 20th century, when it was assumed the realisation of a hydropower plant with installation discharge and with an installation power. In the year of 1969, the Serbian electro-economy, considering the fact that in those years existed a united electro-energetic system in a ex-Yugoslav level, decided the expansion of the hydropower plant capacity in 293 MW. All of this was made as a function of reduction of hydropower plant working time from 4,000 h to 2,000 h.

The ZHUR hydropower plant represents accumulative hydropower plant with derivation, located in the south-west part of the Kosova, between the municipality of Prizren and Dragash. The existing slope of the terrain is used by two hydropower plants: ZHUR 1 situated in the ZHUR country and ZHUR 2 in the close area of the "Drini i bardhë" river.

ZHUR hydro-energetic system is planed to use the waters flowing from the SHAR mountain streams, starting from the accumulation of the Çajle river and its branches, the waters of the Plava river and its branches (as Brod and Rastelica branches, and other branches). All these waters accumulate in the accumulative Plava lake, from which, with the aid of a tunnel, are conducted in to the accumulative lake of Llapusha.

The location of the ZHUR hydropower plant can be visually conceived in Fig. 5.

The annual production of the ZHUR hydropower plant with a production capacity of 398 GWh is a very considerable value, and as it is, affects in the improvement of the annual energetic balance.

The exclusive positive attribute of the ZHUR hydropower plant in the overall energetic system of Kosova, will undoubtedly be the phenomenon that the variable portion of the daily consumption diagram

Table 3 Possible economical and technical hydro-power potential in Kosova.

Watershed	Technical electricity potential (GWh)	Economical electricity potential (GWh)
Drini i Bardhë	554	554
Ibri and Sitnica	103.27	102.17
Morava e Binçës	8.57	8.57
Lepenci	23.8	16.53
Total	689.64	681.27

Fig. 5 ZHUR HPP position in Kosova region, and the accumulative lakes.

which unable to be covered by the Kosova A and Kosova B thermo power plants, will be covered by the hydropower plant.

If this hydropower plant would be realised in the present period, it would also prolong the need for developing of a thermo power plant with a capacity of 300 MW, considering the aspect of electrical power deficiency (not energy deficiency).

ZHUR HPP, in addition to its peak hydropower character, will also have an intervening character for insuring the continuous energy supply in the case of TPPs malfunctioning. It also would serve as an insurance for energy selling to other consumers outside Kosova, but this case, however, would be in question only when the Kosova energy production would be extremely improved.

ZHUR HPP represents around 53% of the overall hydropower capacity in the Kosova region, and considering the present thermo power installed capacity of 1,513 MW (arond 600 MW of present generation capacity) in comparison with the 293 MW capacity of ZHUR HPP, we could simply conclude that the influence of ZHUR hydropower plant in the development of energetic system of Kosova is considerably important. Its eventual realisation would considerably improve the energetic system of Kosova, and exceed the present energetic production insufficiency.

4. Wind-Energy Resources in Kosova

In the last decades, due to the new technology acheivements in the area of wind energy generation by wind turbines, the development of the wind industry worldwide began. Due to the latest technology acheivements, this type of renewable energy source is very much promissing. The attractive positive features that possess wind energy generation, such as: pure environmental energy, high installed capacity, application for industry energy, low electricity prices, no fuel requirement, non-exhautible energy resource, and many other features, make this industry competitive even to the thermal energy generator industry.

In Kosova region, the application of wind turbines has not yet stareted. However, the last two years, there have been considerable analyses of wind energy potential for the Kosova region, in order to detect potential regions where the installation of wind turbines for energy generation would be economicaly feasible [2-4].

In Fig. 6, it is shown the Kosova region wih several cities where meteorologic measurements were taken for a considerable time period. Also in Fig. 6, it is shown the topography of the region, i.e., the most influencing spatial factors that dictate the main current flows of the wind in a local point of view.

Fig. 6 Kosova cities where wind meassurements are taken and terrain topography.

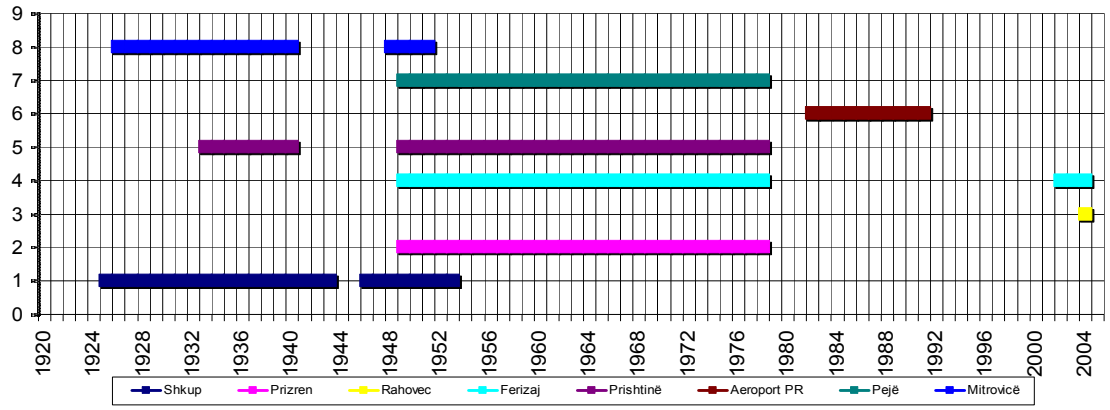


Fig. 7 Years with available database of meteorological measurements for different cities.

In Fig. 7, the years of available data of daily wind speed and wind direction meassurements for different cities can be seen. However, it has to be pointed out that these meaurements are taken to a height of 10 m, therefore the precise evaluation of wind speed at wind turbine hub height is not possible presently. According to these meassurements, it has been determined the main wind currents within the entire region of Kosova, i.e., wind roses.

Considering these measurements, the mean wind speed at 10 m height for different cities was in the range of 2-3 m.

Experimentally, it is shown that the wind speed is continuously increasing with the increasing of height and dependantly of the terrain orography. Also the terrain effects (natural tunnel, hills, mountains) have a considerable role in wind speed increasing (in th range of +2.5~+3 m/ms).

Eventually, taking in to consideration all of these factors, it has been concluded that there are several regions in Kosova territory where strong winds for wind energy industry development are considerably good (mean annual wind speeds higher than 6 m/s). In the previous analysis taken by Idrizi, I., and Idrizi, Z. the detection of these places with high wind energy potential has been done (Fig. 8).

5. Combination of Hydropower with Wind Power in Kosova Region

The main concept of this paper consists of the idea of rationally combining the hydro and wind energy in order to obtain the maximal benefit by minimal financial investments (Fig. 10). This kind of approach is more than necessary, especially for a poorly economic developed country as Kosova.

The benefits obtained by incorporation of ZHUR HPP and wind turbines in the existing energy sector of Kosova, can be clearly conceived by Fig. 9. In Fig. 9, it can be seen that the present energy consumption needs of Kosova can be fulfilled by installation of ZHUR HPP with installed energy capacity of 270 MW, and wind turbines with installed energy capacity of 150 MW.

The competitive cost of HPP and wind turbines installation in comparison to TPP costs, as well as the short time of their installation and incorporation in the existing energetic system of Kosova, puts these alternative energy generation equipments in serious consideration for their future realisation.

The philosophy of rational combination of HPP and wind turbines consists of the idea of preserving the hydro-energetic potential in times of high wind speed, i.e., high wind energy generation by wind turbines.

A very important phenomenon worth mentioning is the wind and hydro energy generation potentials change in accordance with the energy consumption needs. In other words, when energy consumption needs are high, as in the winter period, the wind and hydro energy generation potentials are higher due to strong winds and high water levels.

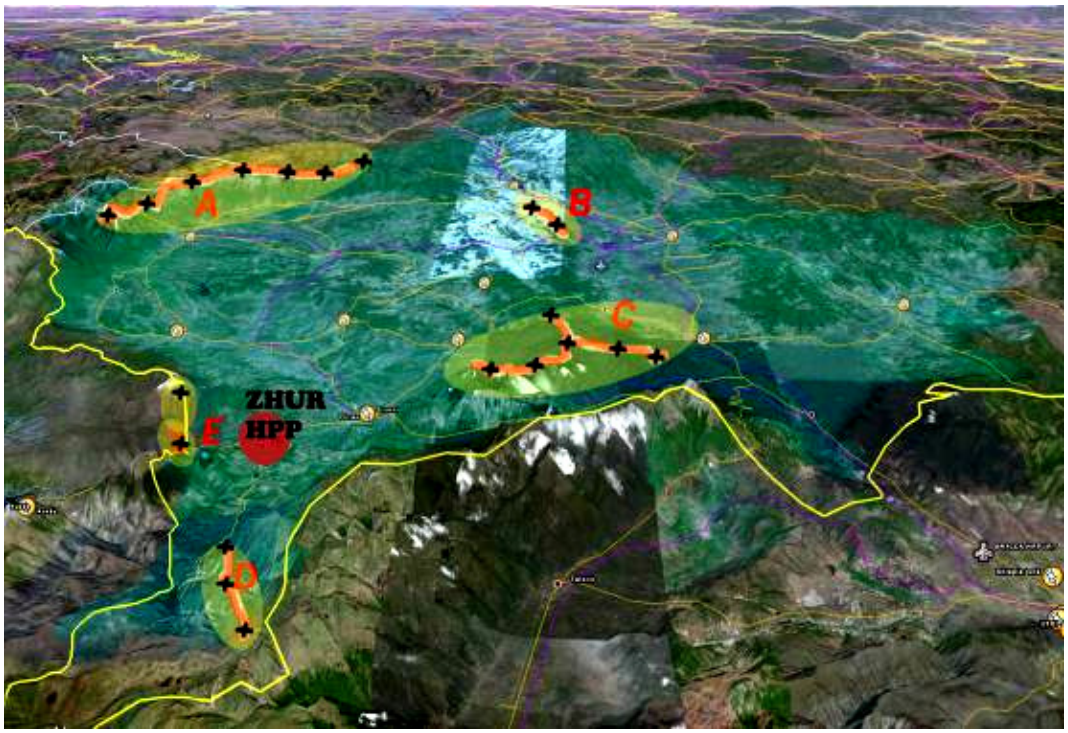


Fig. 8 Detected places with average wind speed of greater than 6.0 m/s.

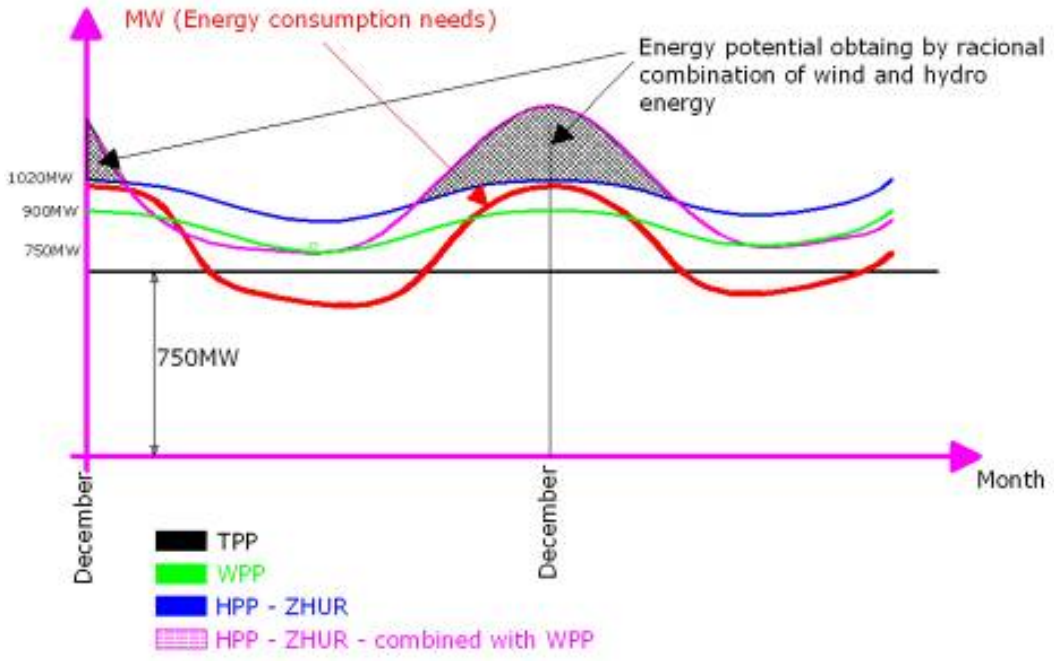


Fig. 9 Advantage of combination of wind and hydro energy.

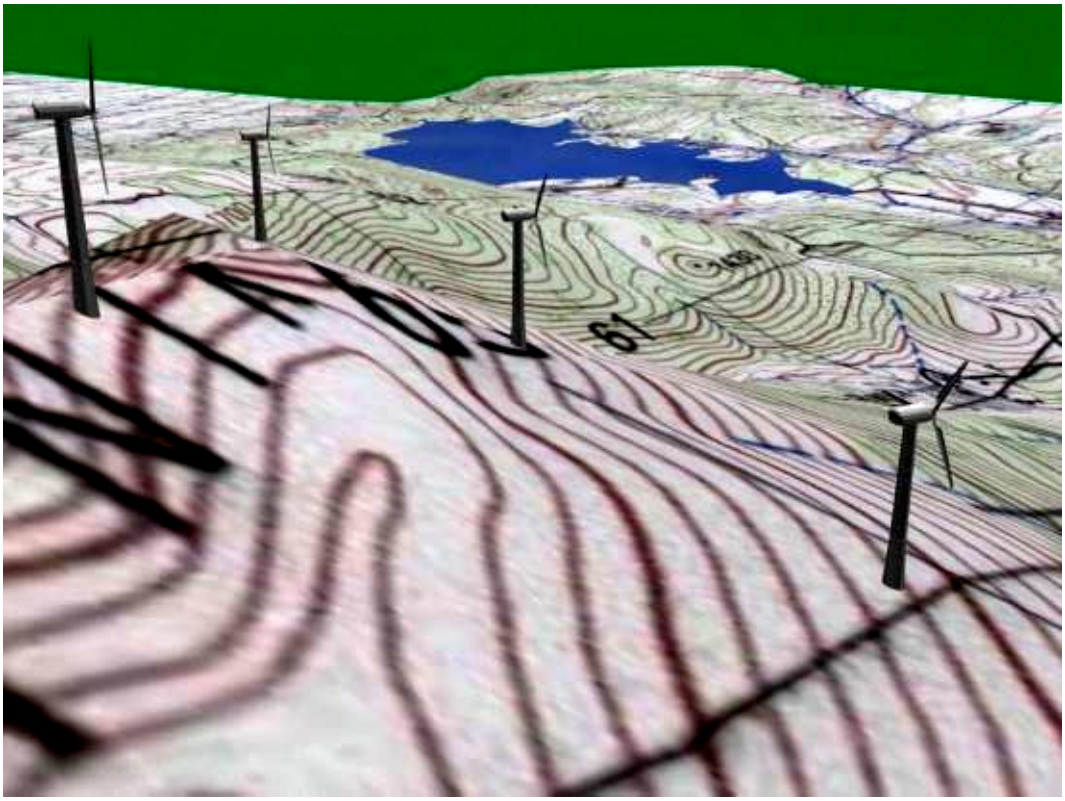


Fig. 10 Situation scheme of ZHUR TPP and wind turbines.

Considering that the future development and maintainance strategy for the energy sector of Kosova, where the "Kosova A" TPP is highly damaged (need considerable maintainance works, or total reconstruction), it is very clear that the deficitary energy needs must be replenished by alternative resources as well as new TPPs.

While the installation of new TPPs is planed to be completed by the year of 2020, and on the other hand, the installment of alternative energy generation equipments can be made within a short period of time (wind and hydro), it is more than necessary to be considered the application of alternative energy resources as well as their incorporation within the existing energetic system of Kosova.

From the above presented results, it is evident that, Zhur HPP, wind turbines instalation in Kosova and several micro-hydro-power plants, could considerably improve the present state of overall energetic system. It could also stabilise the electricity consumption, increase the variability of energy resources, decrease the unemployment, reduce oil dependence economy, and it would definately place Kosova in the group of electricity exporter countries in the wider region, as it was 2 decades before.

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