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Analysis of the Potential for Renewable Utilization in Kosovo Power Sector

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Abstract: The reduction in greenhouse gas emissions and the decarbonization of the power sector through the utilization of available renewable technologies are challenging issues that Kosovo has to tackle right now, in order to fight the high pollution caused by a coal-based power system. Around 91.43% of installed capacities for electricity generation in Kosovo are based on coal-fired power plants. The aim of this paper is to show the potential for renewable utilization, using data measurements of wind, solar irradiation, biomass, and average water flows at different area locations to identify their utilization potential. Furthermore, a review on the currently available and future renewable energy projects integrated into the electricity sector is presented. A 54% carbon dioxide emission reduction potential was estimated in the power sector when considering maximum utilization potential of biomass, wind, solar renewable energies compared to a referent scenario. The results obtained from this review have shown the pathways for identifying the potential utilization of renewable as well as the actual and planned use of renewable implemented projects into the Kosovo Power Sector.

Keywords: renewable energy; coal; power; Kosovo; climate change

1. Introduction

Kosovo is a member of the Energy Community Treaty. Due to this, Kosovo is obliged to meet the energy targets for renewable energy sources, based on the Decision of the Council of Ministers of the Energy Community D/2012/04/MC-EnC for the implementation of Directive 2009/28/EC [1]. A target accounting (29.47%) was set by the National Action Plan for the implementation of Renewable Energy Sources (RES) in the Kosovo Energy System 01/2013. Kosovo is located in the central Balkan Peninsula with an estimated population of 1.836 million [2]. Kosovo is among one of the poorest countries in Europe according to World Bank data. GDP per capita in Kosovo as an average value is estimated to be 3060.36 USD from 2000 until 2016, reaching over this time, a highest value of 3890.07 USD in 2016 and a record low value of 1919.84 USD in 2000 [3]. Consumption of electricity per capita in Kosovo is estimated to be 3.0 MWh/capita. Kosovo has natural energy resources, which mostly consist of coal, limited hydro, solar, biomass, and wind. These energy potentials mostly are used as primary energy resources for power generation and utilization in different industrial processes.

More than 91.43% of electrical energy produced in Kosovo comes from burning of fossil fuels, i.e., respectively coal, with a low caloric value of 7200 kJ/kg in existing power plants Kosovo A and Kosovo B [4]. Thermal power plant Kosovo A consists of five units with installed power capacities as follows: A1 = 65, A2 = 125, A3 = 200, A4 = 200, and A5 = 210 MW, while Kosovo B consists of two units with an overall production capacity 2 × 339 MW [5].

Kosovo has an estimated reserve of coal equaling 12.5 billion t, which ranks Kosovo as the country with the second largest lignite reserves in Europe and fifth largest reserves in the world [1].

These reserves are located in three main locations: Kosova Basin, Dukagjini Basin and Drenica Basin. This quantity of coal entirely is predominated by lignite with 99.5%.

In addition to that, the extensive use of coal for electricity generation in coal-fired power plants Kosovo A and Kosovo B has harmed the environment, as well as causing respiratory diseases for inhabitants.

Currently, the main contributors to greenhouse gas (GHG) emissions in Kosovo are coming from two old thermal power plants (Kosovo A and Kosovo B). The Government of the Republic of Kosovo has made efforts for several years to build new power generation capacities from coal-fired power plants by the implementation of new technologies.

The construction of a new power plant called TPP "Kosova e Re" with a capacity of 500 MW, where the source of energy is coal, is still unfeasible because the Republic of Kosovo does not have sufficient funds to implement this project and for several years, has been seeking to find potential investors through international procurement. On the other hand, the technology for the construction of the mentioned power plant has a high cost in order to meet the environmental requirements.

To cover current and future energy demand, in addition to the implementation of renewable energy projects, it is seen that the construction of TPP "Kosova e Re" is necessary, which will have an impact on emissions and the increasing price of electricity.

From analysis of several scenarios done in the literature [6], from 2015 to 2025, emissions of carbon dioxide are projected to increase from 7.5 to 10 Mt/year, whereas sulfur dioxide and dust emissions are to decrease from 22.5 to 16 kt/year and 11.7 to about 6 kt/year, respectively. Nitrogen oxide emissions are expected to decrease slightly compared to 21.5 kt/year in 2015. Their analysis shows that a low-carbon path exists for Kosovo that ensures sustainable energy development through integrating the use of both renewable and nonrenewable energy sources while reducing the emissions of GHG gases and air pollutants.

Identification, utilization and exploration of the potential for using RES in Kosovo could provide sustainable pathways for energy production with unharmful effects on the environment.

The objective of this paper is the identification of current renewable potential and their utilization in the Kosovo energy system, by analysis of their potential, current and future projects licensed by Kosovo institutions, respectively, the Energy Regulatory Office (ERO). In addition, further analysis can be developed for addressing the integration of renewable energy sources into the Kosovo energy system based on economic, sociological, and environmental points of view through the use of different simulation tools, but this is not the scope of this paper.

2. Literature Review

Within analysis of the existing literature, internet resources and technical reports, it has been shown that existing power generation in Kosovo is fraught with uncertainties. Generation is entirely dependent on coal-fired power plants and technologies that are not stable enough to meet the present and future electricity demands because all units have exceeded their operational lifetime. A unidirectional strategy for power generation from a new coal power plant is currently in discussion to be built in Kosovo. The government of Kosovo has proposed the installing of the coal-fired power plant, the so called TPP "Kosova e Re". A detailed analysis of the implementation effects of TPP "Kosova e Re" was done by the Institute for Energy Economics and Financial analysis [7]. Since Kosovo has planned to start building a new coal-fired power plant called "Kosova e Re", some of the existing studies have also criticized this project based on its impacts on water usage and water cuts, including related statements [8].

Over the past several years, the Thermal Power Plant "Kosova e Re" (TPP "Kosova e Re") project has gone through a series of design changes driven by political and technical considerations. Original plans to build a 2000 MW plant were scaled back to 600 MW due to a lack of demand [9]. Then, plans for a one unit 600 MW base-load plant were changed due to a lack of electricity demand and

because of the concerns that the size presented potential reliability problems in the event of outages [7]. Two 300 MW units, rather than one larger 600 MW unit, were proposed for a plant that would generate 560 MW net capacity (because 40 MW would be required to run the plant), but would use outdated and inefficient subcritical coal plant technology.

A platform for analyzing the electricity options, costs, and impacts for Kosovo as a nation, which is a critical part of the debate over centralized versus distributed electricity generation, was analyzed in reference [7]. The results have revealed the role of fossil fuels versus cleaner electricity options to meet growing demands. Researchers discovered that a range of alternatives exists to meet present supply constraints, all at a lower cost when comparing with scenarios that took into account constructing a proposed 600 MW TPP "Kosova e Re" coal-fired power plant.

At the end of 2017, the Government of the Republic of Kosovo signed a contract with the American company "Contour Global" for the construction of a new power plant with a gross capacity of 500 MW for the amount of 1.3 billion euros, which has not yet begun to be implemented.

The construction of TPP "Kosova e Re" has a comprehensive impact on the economy, the state budget, health, environment, population displacement, public debt and other impacts. To reflect the impact of this project on the price of electricity, the GAP Institute [10], in its analysis, has built two scenarios. The first scenario estimates that the operation of TPP "Kosova e Re" in 2023 will increase electricity tariffs by 44%. According to the second scenario, which includes the construction of a new power plant and other planned investments in the energy sector, electricity tariffs will increase cumulatively by 60.4%.

The installation of generating capacities set by the European Commission which should fulfill the Republic of Kosovo for RES by 2020 is far from achievable. Until now, the target of 30% has been reached. Failure to do so is due to difficulties of various nature, as written in the following.

The rivers of the Republic of Kosovo are not rich in water flow. The size of these rivers does not create large hydropower potential due to the small difference between water intake and discharge and as a result, the generating capacity of new hydropower plants is not high. New and under construction hydropower plants are a type of derivation that causes the degradation of the river bed. The degradation of the river bed and the significant damage to the flora and fauna has caused the community in the areas where these hydropower plants are located to continue to resist the development of such projects. As a result, the difficult configuration for buildings has made their construction costly. On the other hand, the annual production of energy from hydropower plants in Kosovo is higher compared to other RES, i.e., solar and wind. Therefore, despite the high cost of their construction and the barriers that arise in their construction compared to other RES, the production of water energy to meet the demand arising from Directive 2009/28/EC on renewable energy still remains a high priority.

Therefore, the cost of installing solar modules for electricity generation in recent years has dropped significantly, making the use of this technology quite attractive around the world. Due to its geographical position, the Republic of Kosovo has good potential for the production of electricity from the sun (the number of sunny days and solar radiation in Kosovo is high), which represents a high potential for meeting the indicative targets required by Directive 2009/28/EC. On the other side, the cost of installing solar photovoltaic modules (PV) in recent years has dropped significantly, but unfortunately, the Ministry of Economic Development and the ERO have imposed restrictions on the installation capacity of electricity generation from the Sun, where until 2020, in the territory of the Republic of Kosovo, installation of only 10 MW was allowed, although the requirements from investors are significantly higher. Currently, 10 MW are installed, and another 100 MW are in process of pending [4]. The feeding tariff approved by the ERO for PV for these 10 MW has remained the same price as it was eight years ago (136.4 EUR/MWh), although the cost of their installation has decreased two to three times. The installation of another 20 MW is in the discussion phase, where the feeding tariff will be lower.

Studies show that the Republic of Kosovo has relatively good potential for electricity productions from wind, where generating capacity is several times higher than allowed. The feeding tariff approved by the ERO has remained the same as eight years ago (85 EUR/MWh) [11]. Currently, the quotas approved by the ERO of 150 MW have been given final authorization and are in the waiting phase for another 235 MW. Therefore, as you can see, the generation of electricity from wind for investors is being seen as a good opportunity to do business.

The generation of electricity by biomass from investors is not being seen with interest, even though the installation of 14 MW is allowed. So far, only the thermal heating plant of the city of Gjakova has applied for the final authorization for 1.2 MW [4]. The great lack of interest of investors to invest in this sector is due to the difficult procedures for obtaining licenses and the high cost of installing appropriate technology.

There are many of the existing studies in the field based on journal publications and proceedings directly into the case studies based and focusing specifically on Kosovo [8,12–14]. In the literature [15], low, medium and high growth scenarios between 2010 and 2025 for Kosovo were taken into account with renewable energy shares, which were considered to be at least 10% of the total electricity generation.

3. Potential of Using Renewable Energy Sources in Kosovo

To encourage the use of RES, Kosovo has set up a legal framework as well as a support scheme through feed-in tariffs for hydropower, wind, photovoltaics, and biomass. According to the Kosovo ERO, the electricity produced from renewable resources has the following prices: water 67.3 EUR/MWh, wind 85.0 EUR/MWh, biomass 71.3 EUR/MWh, and from solar panels/photovoltaic 136.4 EUR/MWh [11]. RES will play an important role for energy production when stating long term country objectives and policies. Since the aim of this paper is based on reviewing renewable projects and their utilization potential, it is of great importance to address the implementation of RES to the actual and foreseen electricity generation capacities, in 2020, according to the promoted target. For filling the target 20/20/20, Kosovo institutions have planned to install RES capacities in the Kosovo power system as follows: 150 MW wind, 10 MW photovoltaic, 240 MW hydro and 14 MW biomass.

3.1. Wind Potential

3.1.1. Wind Energy Potential in Kosovo

Kosovo did not possess a wind atlas as of last year, which might have helped in the implementation and installation of wind generators, but for 2018, the World Bank has provided wind atlases for every country globally and Kosovo [16], as given in Figure 1.

For identifying the plant area locations that may have higher potential for power generation by wind, an atlas was extracted by [16], using a GIS tool in a format of raster images. When comparing the municipality potential, it revealed that Peja, Dragash, Prizren, Gjakova, Istog, Podujeva, Shterpca and Kaçaniku have higher potential for utilization of wind power plants compared with other municipalities.

Some other studies have investigated the wind potential in several municipalities. According to a study done by Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) and Hydro Meteorological Institute of Kosovo (HMIK), the measurements of wind speeds were done in ten different locations and different altitudes, which are presented in Table 1, in order to identify the potential locations for installation of new wind generators [17–19].

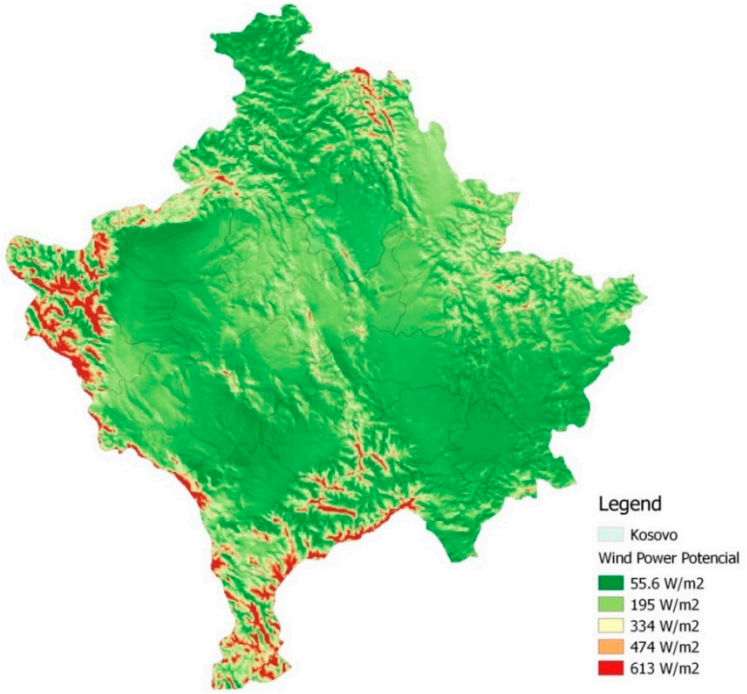

Figure 1. Wind power potential for 1 m^2 of surface rotor turbine installed at 100 altitudes above the ground level in different Kosovo area locations [16].

Table 1. Measuring location of wind speed at different zones in Kosovo [17–19].

Measuring Place	Altitude [m]	Average Speed [m/s]	Height [m]	Years of Measurements
Prishina	573	2.9	-	2004–2013
Ferizaj	578	3.0	-	2004–2013
Peja	498	1.4	-	2004–2013
Lipjan ETEX	733	3.6	33	2009–2010
Gjilan Ebud	592	3.3	33	2009–2010
Theranda BBUD	1667	7.0	38	2009–2010
Theranda SDUL	858	4.4	34	2009–2010
Klina WGJU	578	3.8	44	2009–2010
Abri e Eperme EABR	763	4.6	45	2009–2010
Prizren BBZYM	658	3.4	37	2009–2010
Kaçanik SSTA	578	4.1	37	2009–2010
Rahovec BBZAT	1016	7.1	35	2011–2012

The objective of the data provided by such measurements was to create a regional wind map for Kosovo, which might help potential investors to invest in building new wind farm generators. All presented wind data measurements were done for a one-year horizon, from 2009 to 2010. Measurements of wind speeds for locations Prishtina, Ferizaj and Peja are taken from the HMIK [17] and their results are presented in Figure 2.

Since the measurements of wind speeds are not done at the same height levels, it is not possible to compare such data for visualizing the potential of different locations for power generation, as the wind speeds differ with height above the site measured levels. A better map that can be used for comparing the area locations when considering wind power potential is shown in Figure 1. The power density of wind generators using online-provided datasets is shown in Figure 1. As can be noted, the Sharri Mountains have greater wind speed compared with areas with lower altitudes.

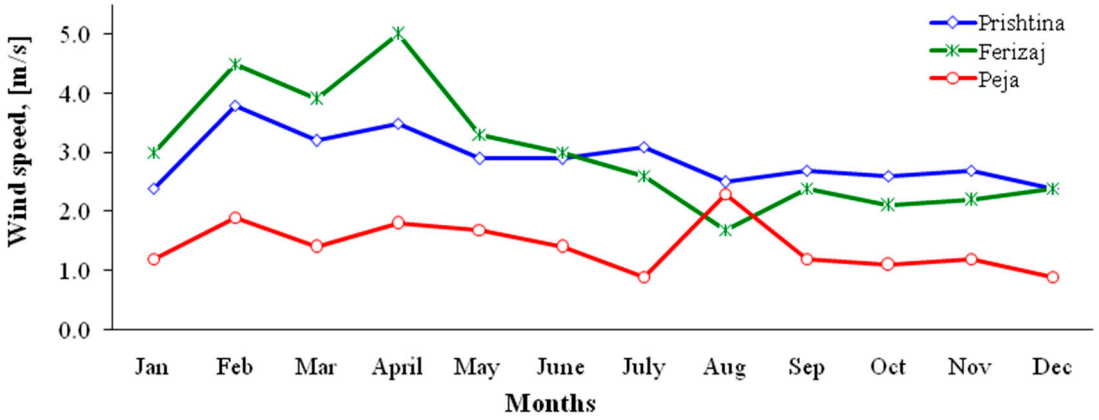

Figure 2. Monthly wind speeds at three different zones in Kosovo [17].

Figure 3 shows the average monthly measured wind speeds at different area locations in Kosovo [18,19].

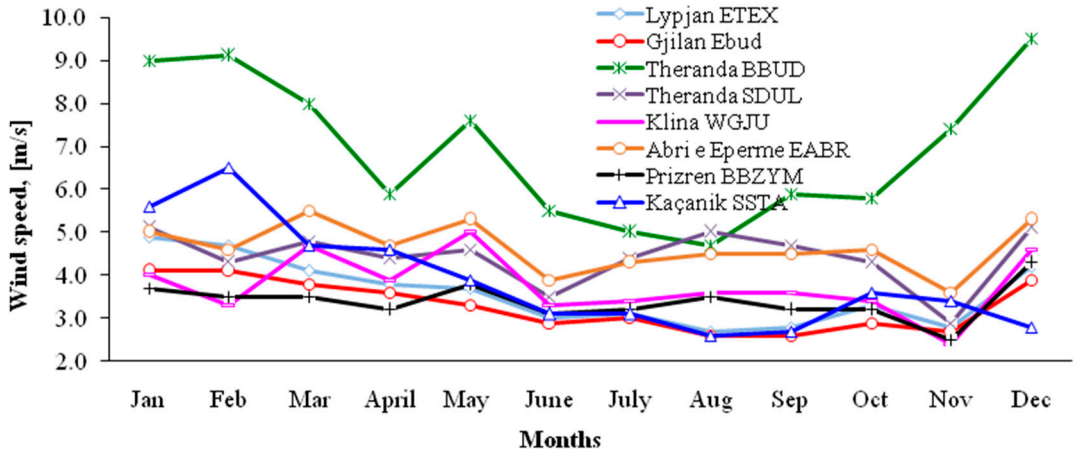

Figure 3. Average monthly measured wind speeds at different area locations in Kosovo [18,19].

3.1.2. Current and Planned Projects for Wind Energy

In the year 2010, the first wind generators were put into operation in the location of Golesh with power production of 1.36 MW, which is shown in Figure 4.

This location is well known for excellent distribution of wind speeds, but no measurements or research have been provided so far. In 2018, the second wind farm, called Kitka, has started the operation. Its installed electric capacity is 32.42 MW and it is located in the Kamenica Region (Figure 4).

A planned wind park with a total production of 30 MW, in the location Zatriç (Rahovec), is selected, since this location for one-year data observations has shown excellent potential of average wind speed at 7.14 m/s (Table 2). This project is in the final authorization stage by ERO. Another wind park is planned to be installed in Budakov near Prizren. The overall capacity of power produced from this park is estimated to be 30–40 MW. This park will be built between altitudes of 1200 and 1300 m above the sea level. Moreover, projects Shtime 1 and Shtime 2 have delivered applications for connection to an electrical transmission network called KOST in 2010. Generation capacity for this park is planned to be 127 MW. Furthermore, under a cooperation between Kosovo and Italy, in Bajgore and Skenderaj, wind parks are planned to be installed with capacities of 50 MW for each. Measurements of wind speeds carried out in those locations have shown extremely promising potential for wind utilization. In addition, in Bajgore, seven wind generators are estimated to be installed, in which, the wind speed reaches the values 9–12 m/s. According to the above elaborated projects, the overall capacity of power

generation from the wind parks which are planned to be built is 288.36 MW. From these planned projects, only the Kitka project is integrated into the electricity transmission network. As presented above, the target for production of electricity from wind generators was set to be 150 MW. With projects presented in Table 2, this target will be exceeded for 95%.

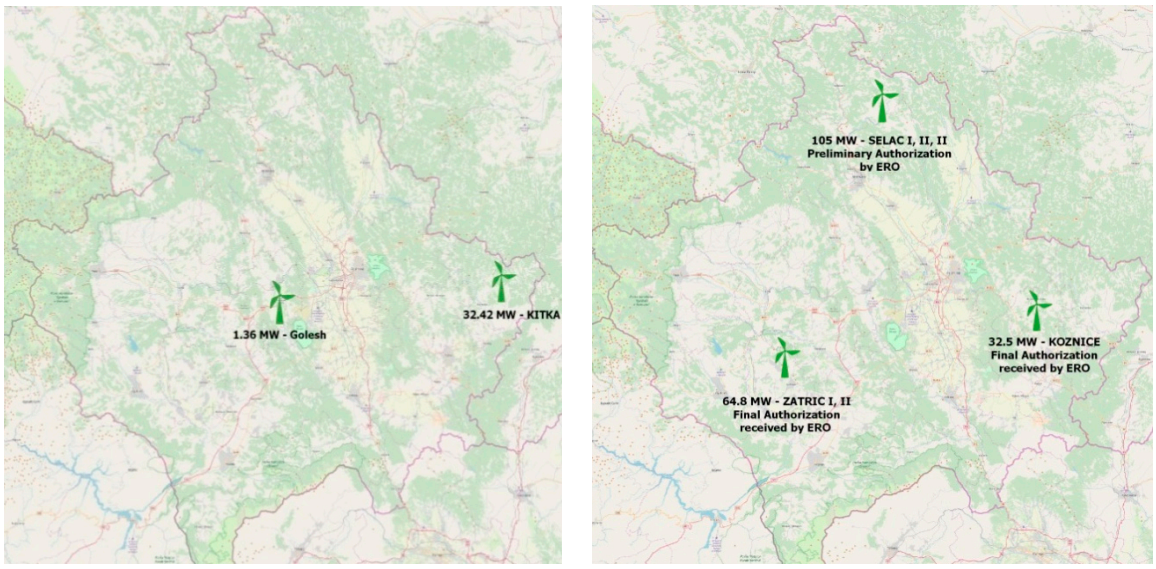

Figure 4. Installed (**left**) and planned (**right**) wind farm plant projects in Kosovo [4].

Table 2. Presentation of projects for wind power generation in Kosovo [19].

Nr.	Projects	Generation Capacity in [MW]
1.	Shtime 1	100
2.	Shtime 2	27
3.	Kitka	30
4.	Golesh (Windpower)	1.36
5.	Nek Zatriq	30
6.	Bajgore	50
7.	Skenderaj	50
	Total	288.36

3.2. *Photovoltaic Potential*

It is estimated that the global radiation (given by NASA) that reaches the Earth's surface in Kosovo is nearly similar with the measured data, which are given in Figure 5. Moreover, by interviews with some local investors who have installed PV, the overall power generation is a little bit higher than the prediction of power generated by using the data provided by reference [20]. Through this conclusion, potential investors in Kosovo can use online-provided data regarding solar radiation, which are given in the source [20].

A comparison of global horizontal radiation data taken from the literature [17,20] are analyzed and presented in Figure 6.

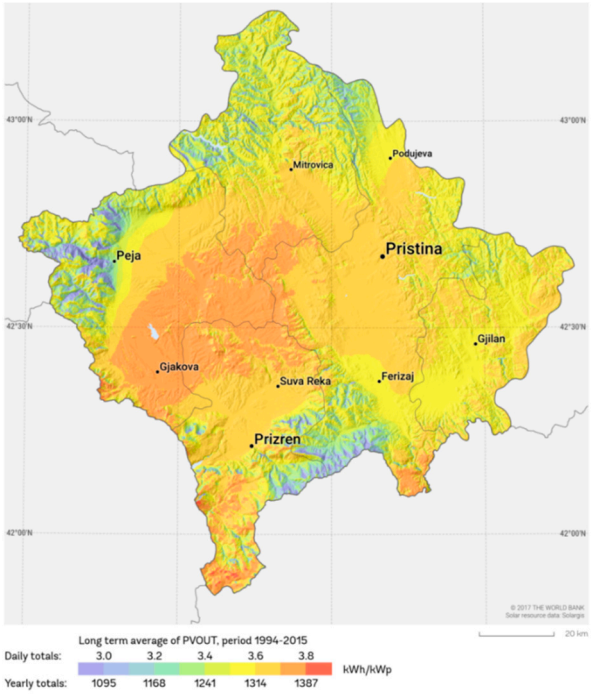

Figure 5. Global horizontal radiation in [kWh/m^2] [20].

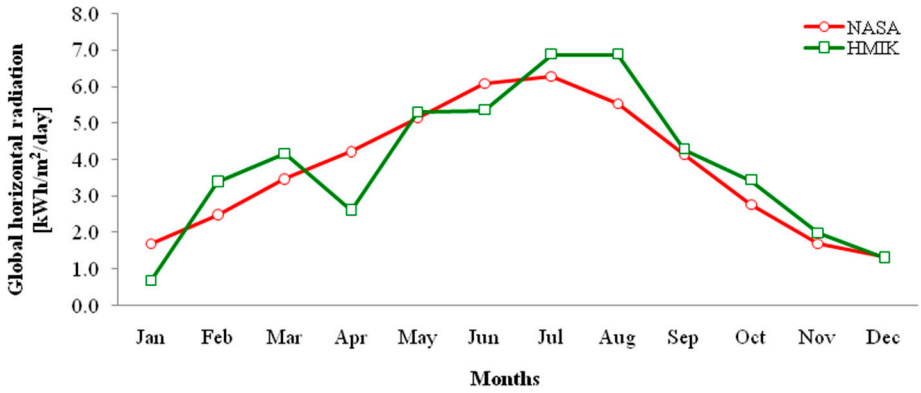

Figure 6. Comparison of global horizontal radiation data collected from a satellite (NASA) and measured by HMIK for the time period 2003–2013.

3.3. Hydro Potential

The hydropower potential of Kosovo is very limited. Kosovo is poorer in water resources compared with countries of the region. There is a hydropower plant installed named Ujmani, with a rated power output 35 MW, and some small hydropower plants, such as Lumëbardhi, Dikanci, Radavci and Burimi, which contribute to electricity generation with 8.08, 4.02, 1.0 and 0.95 MW respectively. Other small hydropower plants, such as "Belleja", "Deçani", "Brodi II", "Restelica I and II", "Albaniku II", and "Brezovica", which were recently put into operation, have installed capacities: 8.06, 9.80, 4.8, 2.28, 4.267, and 2.1 MW, respectively [4]. There are some other mini hydropower plants, which are not connected to the electrical grid, but they are used for standalone (off-grid) applications. Except water energy resources, other RES which are connected to the power grid are wind and photovoltaics, with installed capacities 33.75 and 6.602 MW, respectively [4]. The main rivers within the border of Kosovo together with their characteristics are presented in Figure 7, respectively, in Tables 3 and 4. As can be seen, the hydrology of water sources consist of four rivers: Drini i Bardhë, Ibri, Morava e Binçës and Lepenci.

Table 3. Distance in km and the surface of main River Basins of Kosovo [21].

Name	River Basin in [km] Inside the Country of Kosovo	Surface in [km^2]
Drini i Bardhë	122	4.622
Sitnica	90	2.873
Lumbardhi i Pejës	62	424.9
Morava e Binçës	60	1.552
Lepenci	53	479
Ereniku	51	510.3
Ibri	42	1.155
Lumbardhi i Prizrenit	31	262.6

Table 4. Maximum, minimum and average values of flow rate in m^3/s measured in hydro meteorological stations in the Republic of Kosovo.

Nr.	River	Station	River	Q_{min}	Q_{max}	Q_{ave}
1.	Drini i Bardhë	Berkovë	Istogut	0.48	186	3.75
2.		Drelaj	Bistrica Pejës	0.32	83.5	4.2
3.		Grykë	Bistrica Pejës	0.46	194	5.95
4.		Klinë	Klina	0	49.2	1.49
5.		Mirushë	Mirusha	0.02	23.3	1.21
6.		Deçan	Bistrica e Deçanit	0.6	58	4.28
7.		Rakovinë	Drini i Bardhë	0.8	358	24.64
8.		Gjakovë	Ereniku	0.06	542	12.33
9.		Piranë	Toplluha	0.04	55.4	3.47
10.		Gjonaj	DriniiBardhë	0.1	1118	48.8
11.		Prizren	Bistrica e Prizrenit	0.03	424	4.47
12.	Ibri	Drenas	Drenica	0.02	32.8	1.52
13.		Lluzhan	Llapi	0.9	63.8	5.01
14.		Nedakovc	Sitnica	0.5	328	13.2
15.		Milloshevë	Llapi	0	82.7	4.48
16.		Prelez	Ibri	0.8	452.8	13.39
17.		Leposaviq	Ibri	0.5	667	30.85
18.	Morava e Binqës	Konçul	Morava Binçës	0.03	1012	9.21
19.		Domarovc	KrivaReka	0.2	30.8	2.6
20.		Viti	Morava Binçës	0.05	18.7	1.06
21.	Lepenci	Kaqanik	Nerodime	0.15	17.5	4.17
22.		Hani i Elezit	Lepenci	0.1	184	10.49

Kosovo is characterized by rivers and streams with a hydropower potential that can be considered for the production of electricity. In the western part of Kosovo, the river "Drini i Bardhë" is located, which accounts for more than half of Kosovo's hydropower potential (Table 5). Utilization potential of electricity generated from hydro energy in Kosovo is estimated to be about 0.7 TWh/year. The main hydropower plant that might be built in Kosovo is the hydropower plant of Zhurit, in the stream of Drini i Bardhë, with an estimated electric capacity generation potential 0.377 TWh/year. The streams of Drini i Bardhë, Ibri, Morava, Lepenci, and Llapi are characterized by considerable potential for electricity production. Table 5 presents their potential for production of electricity.

Table 6 shows data about new planned small hydropower plants, which have proceeded to license documentation for integration into the Kosovo power sector, where the planning period for building is from 2013 till 2020. As can be seen from Table 6, the overall installed generation of electricity from these small hydro power plants will be 63.7 MW.

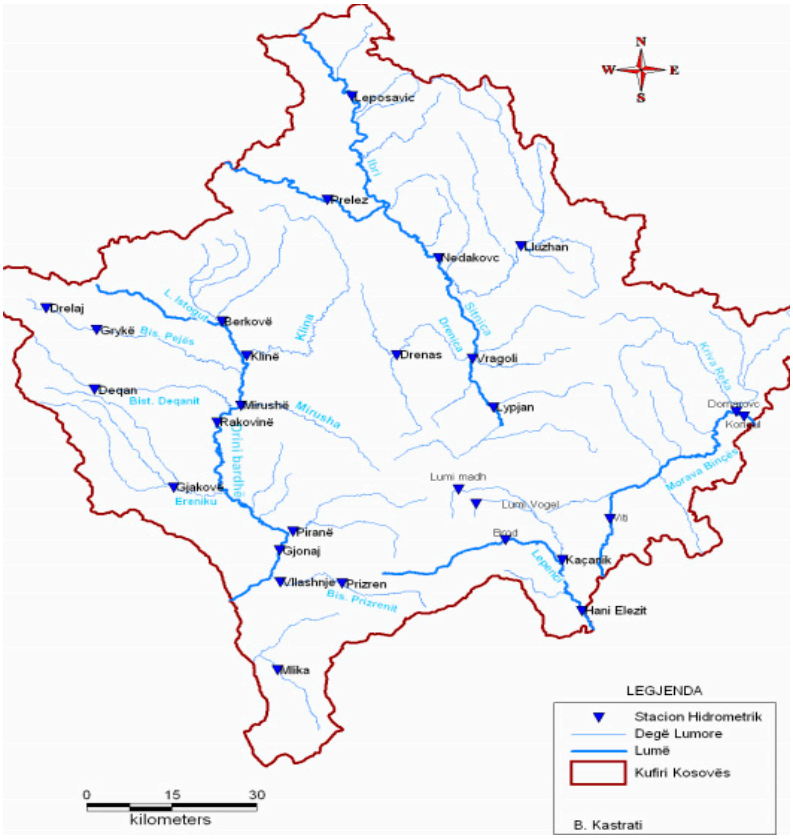

Figure 7. River basins and hydro meteorological stations in the Republic of Kosovo [21].

Table 5. Hydro energetic potential of Kosovo Rivers [21].

Nr.	River	Technical Utilization Hydro Energetic Potential [GWh/year]	Economical Utilization Hydro Technical Potential [GWh/year]
1.	Drini i Bardhë	554	554
2.	Ibri	103.27	102.17
3.	Morava e Binçës	8.75	8.75
4.	Lepenci	23.8	16.53
	Total	689.82	681.45

Table 6. Hydro energetic potential of rivers in Kosovo [22].

Nr.	Name	Power [MW]	Energy [GWh]	Flow [m^3/s]	Head [m]	River
1.	SHPP "Kuqishta"	3.90	17.00	6.00	80	
2.	SHPP "Drelaj"	6.20	27.00	6.50	120	Lumbardhi i Pejës
3.	SHPP "Shtupeq"	7.60	35.00	8.00	120	
4.	SHPP "Bellajë"	5.20	25.00	5.00	130	Lumbardhi i Deçanit
5.	SHPP "Deçan"	8.30	39.00	6.50	160	
6.	SHPP "Lloçan"	3.10	14.00	1.50	250	Lumbardhi i Lloçanit
7.	SHPP "Mal"	4.00	18.00	2.40	200	
8.	SHPP "Erenik"	2.00	9.00	2.40	100	Erenik
9.	SHPP "Jasiq"	1.90	9.70	2.60	90	
10.	SHPP "Dragash"	2.20	10.00	5.00	55	Plavë
11.	SHPP "Orçush"	5.60	25.60	7.00	100	
12.	SHPP "Reçan"	1.50	6.70	2.60	70	Lumbardhi i Prizrenit
13.	SHPP "Brezovicë"	2.10	10.00	4.50	60	Lepenc
14.	SHPP "Lepenci"	3.50	16.00	7.60	60	
15.	SHPP "Bajska"	0.30	1.40	0.50	85	Basnjke
16.	SHPP "Batare"	1.10	5.80	2.30	60	Bistrica (Batare)
17.	SHPP "Majanc"	0.60	2.90	1.50	50	Kaçandoll
18.	SHPP "Mirusha"	4.60	22.00	45.00	15	D. i Bardhë & L. i Deçanit

Table 6. *Cont.*

Nr.	Name	Power [MW]	Energy [GWh]	Flow [m^3/s]	Head [m]	River
19.	SHPP "Radesha 1"	0.75	3.66	0.40	186	Radesha
20.	SHPP "Radesha 2"	1.49	7.37	0.53	200	
21.	SHPP "Restelica 1"	0.53	2.51	0.31	169	
22.	SHPP "Restelica 2"	1.40	6.74	0.42	231	
23.	SHPP "Restelica 3"	1.09	5.35	0.84	130	Restelica
24.	SHPP "Restelica 4"	0.32	1.56	0.98	40	
25.	SHPP "Restelica 5"	1.50	7.37	1.31	110	
26.	SHPP "Brodi 1"	0.81	3.90	0.36	219	
27.	SHPP "Brodi 2"	1.11	5.37	0.52	140	Brod
28.	SHPP "Brodi 3"	1.06	5.13	1.25	85	
29.	SHPP "Brodi 4"	1.44	6.97	1.44	100	
30.	SHPP "Lepenci 1"	0.37	1.79	0.23	80	
31.	SHPP "Lepenci 2"	0.55	2.61	0.49	110	
32.	SHPP "Lepenci 3"	0.80	3.96	0.83	100	
33.	SHPP "Lepenci 4"	1.72	8.40	3.76	45	
34.	SHPP "Lepenci 5"	2.80	13.64	4.14	69	Lepencë
35.	SHPP "Lepenci 6"	2.77	13.34	4.66	60	
36.	SHPP "Lepenci 7"	0.44	2.14	0.29	150	
37.	SHPP "Lepenci 8"	0.53	2.45	0.26	200	
38.	SHPP "Lepenci 9"	1.19	5.73	0.28	420	
39.	SHPP "Ibr 1"	0.24	1.22	0.18	140	
40.	SHPP "Ibr 2"	0.56	2.84	0.35	157	Iber
41.	SHPP "Ibr 3"	0.63	3.25	0.59	86	
42.	SHPP "Ibr 4"	0.39	1.96	0.29	131	
43.	SHPP "Llapi 1"	0.53	2.93	1.28	45	
44.	SHPP "Klina 1"	0.47	2.20	0.75	65	Klina
45.	SHPP "Klina 2"	0.47	2.44	1.10	50	
46.	SHPP "M. e Binçës 1"	0.11	0.49	0.20	43	Morava e Binçës
47.	SHPP "M. e Binçës 2"	0.17	0.80	0.34	50	
48.	SHPP " Istogu 1"	0.45	2.23	1.50	30	Istog
49.	SHPP "Nerodime 1"	0.17	0.84	0.20	85	
50.	SHPP "Nerodime 2"	0.13	0.62	0.09	140	Nerodime
51.	SHPP "Nerodime 3"	0.120	0.60	0.45	30	
52.	SHPP "Çajlana 1"	0.38	2.00	0.50	78	Çajlana
53.	SHPP "Sitnica 1'	0.11	0.55	0.12	87	Sitnicë
54.	SHPP "R. e Aliagës 1"	1.20	6.22	0.35	330	Reka e Aliagës
55.	SHPP "R. e Aliagës 2"	0.76	3.98	0.76	100	
56.	SHPP "D. I Bardhë 1"	2.03	11.88	5.30	35	Drini i Bardhë
57.	SHPP "Jabllanica"	1.01	5.16	0.69	137	
58.	SHPP "Lepenci II-1"	3.59	17.54	5.71	60	
59.	SHPP "Lepenci II-2"	2.81	15.05	6.08	45	Lepenci
60.	SHPP "Lepenci II-3"	6.07	30.36	8.15	75	
61.	SHPP "Prizreni 1"	1.15	5.79	0.70	170	
62.	SHPP "Prizreni 2"	2.99	15.17	1.34	220	
63.	SHPP "Prizreni 4"	2.53	13.04	4.35	58	
64.	SHPP "Prizreni 5"	2.84	14.72	5.21	60	Lumëbardhi i Prizrenit
65.	SHPP "Prizreni 6"	1.19	5.99	0.91	131	
66.	SHPP "Prizreni 7"	1.66	8.09	1.07	119	
67.	SHPP "Prizreni 8"	1.78	8.86	0.78	225	
68.	SHPP "Prizreni 9"	1.68	8.41	1.01	165	
69.	SHPP "Peja 4"	0.77	3.90	0.95	80	
70.	SHPP "Peja 5"	1.33	6.64	1.18	114	
71.	SHPP "Peja 6"	1.20	6.00	0.79	150	
72.	SHPP "Peja 7"	1.05	5.14	0.88	119	Lumëbardhi i Pejës
73.	SHPP "Peja 8"	0.93	4.52	0.44	209	
74.	SHPP "Peja 9"	0.36	1.84	0.24	149	
75.	SHPP "Peja 10"	1.72	8.54	0.41	406	
76.	SHPP "Peja 11"	0.85	4.30	0.44	186	
77.	SHPP "Lloçani 1"	0.67	3.61	0.50	130	
78.	SHPP "Lloçani 2"	1.50	7.92	0.57	250	Lumëbardhi i Lloçanit
79.	SHPP "Lloçani 4"	1.06	5.66	1.47	95	
	New SHPP Totals	128.2	621.82			

3.4. Biomass Energy

Biomass is an organic material made from plants, including animals and microorganisms. Plants absorb the sun's energy in photosynthesis and store the energy as biomass. An estimated total of 1.84×10^{12} t of dry mass exists on the continent. In order to evaluate the energy stored in plants, a parameter named calorific value, or low heating values, is used. When the burning process happens, the chemical energy stored in biomass is released as heat or thermal energy. Biomass can be converted

for electricity generation with appropriate technology, including direct combustion and gasification. Biomass has some advantages over other renewable sources that can essentially contribute to power generation. Furthermore, biomass finds application in many sectors, but for this paper, the actual focus will be for the production of thermal and electrical energy and co-generation.

In Table 7, the production potential from biomass in Kosovo is presented. As can be seen from this table, the quantity of biomass produced from farming has the highest value. A detailed analysis of biomass can be found in the literature [23].

Table 7. Total production potential of biomass in Kosovo [23].

Type of Biomass	Total Quantity Produced (t/year)	Quantity That Actually Can Be Utilized from Energy Needs (t/year)	Exploitable Potential Energy Needs (t/year)
Biomass from forests	1,247,434.00	346,418.00	1,247,434.00
Biomass from agriculture	696,541.00	209,962.00	208,962.00
Biomass from orchards and vineyards	17,356.00	17,356.00	17,356.00
Biomass from farming	4,383,170.00	3,813,358.00	3,813,358.00
Biomass from industrial timber waste	15,138.00	15,138.00	15,138.00
Biomass from urban waste	606,000.00	264,309.00	606,000.00
Total	6,965,639.00	4,665,541.00	5,908,248.00

Table 8 shows the annual amount of electricity, thermal energy and cogeneration, which can be produced by all types of biomass.

Table 8. Annual amount of electricity, thermal energy, and co-generation from biomass [23].

Type of Biomass	Electricity		Thermal Energy		Co-Generated Energy			
					Electricity		Thermal	
	(GWh/year)	(ktoe/year)	(GWh/year)	(ktoe/year)	(GWh/year)	(ktoe/year)	(GWh/year)	(ktoe/year)
Forestry Biomass	423	36.38	1027	88.35	242	20.79	725	62.36
	1523	131	3699	318.13	870	74.85	2611	224.56
Biomass from cereal	179	15.43	436	37.46	103	8.815	308	26.445
Biomass from fodder	-	-	-	-	28	2.39	21	1.83
Biomass from orchard and vineyards	24	2.05	56	4.97	14	1.17	41	3.51
Biomass from livestock farming	-	-	-	-	430	36.99	330	28.36
Biomass from timber industry and sawmills	22	1.85	52	4.49	12	1.06	37	3.17
Biomass from urban waste	165	14.22	468	40.28	110	9.48	331	28.44
	379	32.6	1074	92.36	239	21.73	758	65.2
Total	813.02	62.92	2041	175.56	938	80.68	1792	154.11
	2126.65	182.92	5318.89	457.42	1709.37	147.01	4105.54	353.08

In Kosovo, biomass has a great potential for fulfilling the targets for production of electricity. These targets are defined by the National Plan of Action for Renewable Energy Sources [24]. According to the abovementioned target, it is estimated that Kosovo in 2020 can produce 105 GWh of electricity from biomass [23]. With the biomass potential presented in Tables 3 and 4, predicted targets will be fulfilled.

4. Environmental Power Sector Analysis

According to the International Energy Agency IEA [25] and Kosovo Agency of Statistics [26], the annual carbon dioxide emission released by the energy sector in 2016 was 9 Mt. In total, 7 Mt CO_2 are released into the atmosphere because of coal utilization in coal-fired thermal power plants for power generation with 94.4% and in other forms, 5.59%. This reveals the fact that renewable utilization potential in the power sector can significantly reduce CO_2 emissions. Apart from power sector emissions, the remaining 2 Mt is discharged from the oil burning process, particularly from the transport sector. Actual annual electricity generation by source for a referent year (2016) and potential electricity generation by RES are presented in Table 9. If we consider a scenario which takes into account maximal utilization of renewable reviewed potential, hence, CO_2 can be significantly decreased. Biomass, hydro and other variable renewable energy are considered as free carbon energy sources, even those that are some emissions from burning processes of biomass utilization sources. A rough estimation shows that CO_2 emissions in the power sector can be reduced significantly accounting for a 54.8% decrease compared to emissions in reference scenario 2016. In this context, the Kosovo power sector is the first step to initiate the transition of the Kosovo energy system towards environmentally friendly electricity production sources.

Table 9. Actual annual electricity generation by source for a referent year (2016) and potential electricity generation by RES in Kosovo.

Generation of Electricity by Source	Electricity Production in 2016 [GWh/year]	Actual CO_2 Emission [Mt/year]	Electricity Production Scenario with RES Potential [GWh/year]	CO_2 Emission with RES Potential Utilization [Mt/year]	ΔCO_2 Emission Reduction Potential [Mt/year]
Coal	5736	7	2588.1	3.158	3.842
Hydro	245	-	621.8	-	-
Wind	-	-	631.5	-	-
Photovoltaic	-	-	13	-	-
Biomass	-	-	2126.6	-	-
Total	5981	7	5981	3.158	3.842

5. Discussion

Through the information provided in this paper, the actual total installed electric capacities in the Republic of Kosovo is 1408.75 MW and are presented in Table 10.

Table 10. Actual power generation capacity in Kosovo.

Generation of Electricity by	Power [MW]	%
Coal	1288.00	91.43
Hydro	80.40	5.71
Wind	33.75	2.40
Photovoltaic	6.60	0.47
Biomass	0.00	0.00
Total	1408.75	100.00

As can be seen, thermo power plants dominate in front of RES, whose representation is not that significant. If there all the identified projects were to be installed, related to the utilization of RES, the foreseen scheme of installed electric generation capacities will be as follows in Table 11.

The share of RES in the foreseen scenario that considers renewable utilization potential of installed capacities in the electricity sector through identified projects is higher at 31.72%, compared with the actual scenario, 8.58%.

Table 11. Electric installed and planned capacity potential in Kosovo.

Generation of the Energy by	Power [MW]	%
Thermo	1288.00	68.27
Hydro	286.21	15.17
Wind	288.36	15.28
Photovoltaic	10.00	0.53
Biomass	14.00	0.74
Total	1886.57	100.00

6. Conclusions

Regarding the electricity generation capacities and their utilization in the Kosovo power system, fossil fuels still have advantages compared to RES. Currently, the main contributors of RES are small and mini hydropower plants, while wind, solar and biomass are still quite far from reaching the renewable energy targets for electricity generation. In order to meet the targets set by the European Commission regarding the share of RES, the Government of the Republic of Kosovo should develop several strategic plans that incorporate integration of renewables into all sectors (electricity, heating, cooling, transport, water) and not just the electricity sector. This is because the reviewed studies have shown that decarbonization of future energy systems powered by renewables cannot be done without strong interconnections between sectors.

The integration of new and appropriate renewable energy generation technologies into different sectors can be a significant contribution to the future energy decarbonization of the Kosovo energy system and the development of its economy. This study has revealed a way to help evaluate the choices and possible pathways for developing the power system of Kosovo.

In conclusion, the use of the RES, currently small and mini hydropower plants, and in the future, wind and PV will help towards CO_2 emission reduction, and decarbonization of the Kosovo Energy system. In contrast, the integration of wind and PV will destabilize the power grid flexibility, so new technologies integrated into the sectors will be needed for allowing the smooth transition of Kosovo Energy system from coal to renewable energy. Despite new technologies and available funding sources, the biggest threats are policy and legislation. The presented analysis indicates the big potential of the renewable energy sources in Kosovo. Therefore, the only reasons of the miscarriage of the goals outlined in energy strategies in Kosovo are political decisions and fossil fuels lobbies.

Future work would be the comparative analysis of supply electricity scenarios, needed for decarbonization of the power sector. In this context, proper technical, economic and environmental analysis of the entire energy system by 2030 and 2050 are needed for the transition of the coal energy system towards renewable electricity production. All sectors in the energy system should be analyzed, including future CO_2 taxes in order to produce electricity with lower costs.

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