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Effects of Kosovo's energy use scenarios and associated gas emissions on its climate change and sustainable development

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ABSTRACT

Climate change will be the first truly global challenge for sustainability. Energy production and consumption from fossil fuels has central role in respect to climate change, but also to sustainability in general. Because climate change is regionally driven with global consequences and is a result of economic imperatives and social values, it requires a redefinition as to the balance of these outcomes globally and regionally in Kosovo. Kosovo as one of the richest countries with lignite in Europe, with 95–97% of the electric power production from lignite and with 90% of vehicles over 10 years old, represents one of the regions with the greatest ratio of CO_2 emissions per unit of GDP, as well as one of the countries with the most polluted atmosphere in Europe. The modelling is carried out regionally for Kosovo for two dynamical systems which are the main emitters of greenhouse gases (CO_2, CH_4, NO_x, etc.) and air pollutants (CO, SO_2, dust CH_x, etc.): electricity generation and transportation emissions systems, for the time period 2000–2025. Various energy scenarios of the future are shown. We demonstrate that a transition to environmentally compatible sustainable energy use in Kosovo is possible. Implementing the emission reduction policies and introducing new technologies in electrical power production and transportation in Kosovo ensure a sustainable future development in Kosovo, electric power production and transport that become increasingly environmentally compatible.

1. Introduction

Because emission of GHG is regionally driven with global consequences, the harnessing of renewable energy sources regionally in each country and improvement of the new technology on burning the fossil fuels is vital to constraining the extent of climate change [1,2]. In the following we present a case study about possibilities for transformation of energy production and use in Kosovo towards cleaner energy technologies, which would also reduce the greenhouse gas emissions and air pollution that represents significant challenges, because Kosovo as one of the richest countries with lignite in Europe with 95–97% of the electric power production from lignite and with 90% of vehicles over 10 years old, represents one of the regions with the greatest CO_2 output per GDP per unit of economic activity, as well as one of the countries with the most polluted atmosphere in Europe. In this relation we must consider the fact that Kosovo is a developing country [3,4]. The modelling is carried out regionally for Kosovo for two dynamical systems which are the main emitters of GHG (CO_2, CH_4, NO_x, etc.) and air pollutants (CO, SO_2, dust, etc.) i.e., for electricity generation and transportation emission systems. Models presented here for the electricity generation and transportation sectors, incorporate environmental policies and new clean technologies which will reduce the GHG and air pollution in both sectors and increase the coefficient of the exploitation of lignite in electricity generation sector, ensuring a sustainable energy demand–supply for Kosovo, that becomes increasingly environmentally compatible. For electricity emission system we develop two scenarios. According to scenario

Abbreviations: GHG, greenhouse gases; ESTAP, Energy Sector Technical Assistance Project; KOST, Kosovo transmission system; MEM, Ministry of Energy and Mining; MESP, Ministry of Environment and Spatial Planning; TPP, thermo power plant; HPP, hydro power plant; IEA, international energy agency; MVRAK, motor vehicle registration authority of Kosovo; EPCT, energy power community treaty; VKMT, vehicle kilometres travelled; EIA, energy information agency; GDP, Gross Domestic Product; HDI, Human Development Index; UNDP, united nations development program; CDIAC, carbon dioxide information analyses centre.

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1, electric power is produced 95–97% from the lignite and only 3–5% from renewable resources for the time period 2000–2025. As a result of the energy production from lignite we have an increase in emission of CO_2 other GHGs and air pollution. According to scenario 2, the renewable energy will increase from the year 2015 to the year 2025 from 8% to 15% of total energy production in Kosovo whereas the reduction of CO_2 emission up to 20.7% in comparison with the year 2006. Also we will have significant reduction for other GHGs (CH_4 and NO_x) and air pollutants (SO_2, dust and CO). In Modelling the Dynamic mobile source emission systems in Kosovo, at first emissions of GHGs (CO_2, CH_4 and NO_x) and air pollutants (SO_2, dust, CH_x and CO) from two types of vehicles: light and heavy vehicles (cars, buses, tractors, vans, trailers, etc.), is calculated. Total emission from transport is calculated for the year interval t = 2000–2025. A study undertaken by Pasternak in year 2000, demonstrated a close correlation between per capita electricity consumption and overall HDI score. Data for countries in South-East Europe and for Kosovo in 2004 show similar findings to Pasternak's study.

2. Kosovo energy scenarios

We developed integrated energy demand–supply and emission model for Kosovo, a model that integrates the electricity generation and mobile sources emission systems in Kosovo.

2.1. Electricity generation, greenhouse gases and air pollution emitting

2.1.1. Scenario 1

In Kosovo the electric power is produced 95–97% from the lignite power plants: Units $A_j = \{A_1, A_2, A_3, A_4, A_5\}$ and $B_j = \{B_1, B_2\}$ [4,5]. The beginning of construction of the unit $C_j = \{C_1, C_2, C_3\}$ is planned for the year 2012. The rest of only 3–5% of electric power is produced from the renewable resources we will designate by R_j. Total annual energy production from the all production units U_j is calculated by the following equation

$$EP = \sum_j (A_j + B_j + C_j + R_j) \cdot EP_j \quad (1)$$

According to this scenario, the electric power production is predominates with 95–97% of the energy produced from lignite. From Fig. 1 we see that until the year 2017 (when the A unit is expected to terminate the production) the energy demand–supply are balanced, whereas from the year 2017 we will witness a great increase in production which will continue until the year 2025, when the C_1, C_2 and C_3 units are expected to start production, and a further increase in production as well. According to this scenario, the renewable energy participates with 2.6–3% of the total energy production for the time period 2000–2017, with an increase of 3–5% for the time period 2017–2025. As a result of the energy production from lignite we have the emission of gases that cause the greenhouse effect, such as CO_2, CH_4, and NO_x and air pollutants such as SO_2, dust, and CO. Emission is calculated by the formula

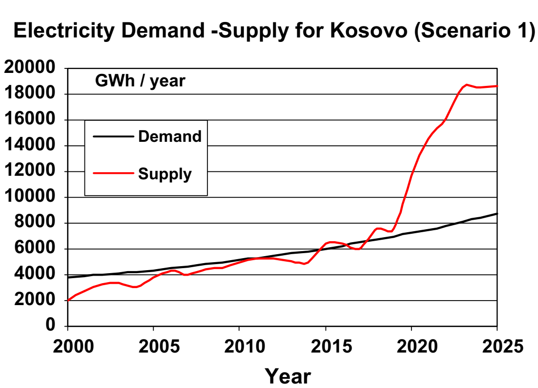
$$E_i^{TPP} = \sum_j (A_j + B_j + C_j + R_j) \cdot EP_j \cdot EF_{ij}^{TPP} \quad (2)$$

where E_i^{TPP} is the total annual emission of GHG and air pollutants from TPP, EF_{ij}^{TPP} is the emission factor for GHG and air pollutants indicated by the subscript i, from production unit j (t/MW h) and EP_j is the energy production from unit j. For the initial values of the emission factors we have taken the values presented in Table 1.

These values will change to imposed standards of emissions as well as with the advance in new clean coal technologies which will reduce the GHG and air pollution and increase the coefficient of the exploitation of lignite. Using these initial values for emission and the values that are expected in the future, from the Eq. (2) for the emission of GHG per year and air pollution per year we obtain the results shown in Fig. 2. From Fig. 2 we see that according to the scenario 1, we will have an increase in emission of GHG and air pollutants (except dust) until the year 2010, and thereafter a decrease in emission until the year 2017. In course of this period the units A as the greatest pollutants and emitters of GHG will fall out of use. In the year 2017 the TPP C_1, C_2 and C_3 will start with production, with a power capacity of 2100 MW and as a result we have an increase of the CO_2 and other GHG, and air pollutants (except dust) outputs.

2.1.2. Scenario 2

According to this scenario, the renewable energy from the year 2012 to the year 2025 will consist in 12–5% of the total energy production in Kosovo. The renewable energy potentials (middle and small hydro power stations, solar, wind, etc.) are: existing: 2 × HPP = 35 MW; 5 × HPP = 11.82 MW. 18 other small HPPs could



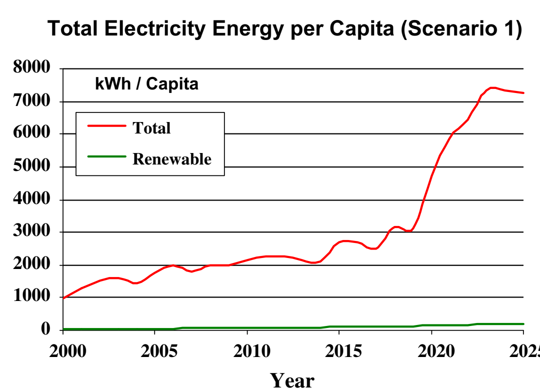


Fig. 1. Total electricity energy demand–production (GW h/year) with dominant 95–97% fossil fuels (lignite) and 3–5% renewable (solar, wind biomass and HPP) and total electricity production per capita (scenario 1).

Table 1
Emission factors for TPP.

CO_2 (t/MW h)			NO_x (kg/MW h)			SO_2 (kg/MW h)			Dust (kg/MW h)			CH_4 (kg/MW h)			CO (kg/MW h)		
EF_A	EF_B	EF_C	EF_A	EF_B	EF_C	EF_A	EF_B	EF_C	EF_A	EF_B	EF_C	EF_A	EF_B	EF_C	EF_A	EF_B	EF_C
1.5	1.4	0.8	4	3.8	1.55	3.2	3.1	0.5	3.4	1.4	0.05	0.33	0.3	0.07	0.065	0.06	0.027