

Sustainable Energy Production with Closed-Loop Methods: Evaluating the Influence of Power Plant Age on Production Efficiency and Environmental Impact

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Abstract—In Kosovo, the problem with the electricity supply is huge and it does not meet the demands of consumers. Older thermal power plants, which are regarded as big environmental polluters, produce most of the energy. Our experiment is based on the production of electricity using the closed method that does not affect environmental pollution by using waste as fuel that is considered to pollute the environment. The experiment was carried out in the village of Godanc, municipality of Shtime, Kosovo. In the experiment, a production line based on the production of electricity and central heating was designed at the same time. The results are the benefits of electricity as well as the release of temperature for heating with minimal expenses and with the release of 0% gases into the atmosphere. During this experiment, coal, plastic, waste from wood processing, and agricultural wastes were used as raw materials. The method utilized in the experiment allows for the release of gas through pipes and filters during the top-to-bottom combustion of the raw material in the boiler, followed by the method of gas filtration from waste wood processing (sawdust). During this process, the final product, gas, is obtained. This gas passes through the carburetor, enabling the combustion process to put the internal combustion machine and the generator into operation and produce electricity that does not release gases into the atmosphere. The results show that the system provides energy stability without environmental pollution from toxic substances and waste, as well as with low production costs. From the final results, it follows that, in the case of using coal fuel, we have benefited from more electricity and higher temperature release, followed by plastic waste, which also gave good results. The results obtained during these experiments prove that the current problems of lack of electricity and heating can be met at a lower cost and have a clean environment and waste management.

Keywords—Energy, heating, atmosphere, waste management, gasification.

I. INTRODUCTION

BASED on the age of the power plants and the production capacity that Kosovo has, the needs of consumers are still not met, knowing the rate of economic development of the country and the ever-increasing demands. In total, the production of electricity in Kosovo is about 800 MWh, including a small percentage produced by hydroelectric power plants and solar and wind energy [1].

In Kosovo, about 90% of the electricity supply comes from fossil coal reserves, which are considered major environmental pollutants. The rest of the supply is made by two hydropower

plants.

The impact of air pollution on health substantial scientific research requires the impacts on public health of air pollution and particularly particulate matter (PM). The main effects of PM on public health are respiratory diseases and cardiovascular effects. WHO reports that in 2005, the following were linked to transient exposure to contaminated air: hospitalizations for respiratory and cardiovascular diseases, emergency visits, primary health care visits, use of respiratory and cardiovascular drugs, limited activities, absenteeism from work and school, acute symptoms (sneezing, coughing, phlegm, respiratory tract infections), physiological changes (such as lung function), and even death [1]. Attributable effects of long-term exposure include mortality due to cardiovascular and respiratory diseases, chronic respiratory diseases (asthma, chronic obstructive pulmonary disease, and chronic pathological changes), lung cancer, chronic cardiovascular diseases, and intrauterine growth retardation (for example low birth weight at normal birth [[1]]).

Findings above highlight the urgent need to transition towards cleaner and more sustainable energy sources, emphasizing the importance of decarbonization efforts, particularly in the context of electricity production. This transition represents a new dimension in the global pursuit of reducing environmental and health risks associated with energy production and consumption. From a climate perspective, renewable energy encourages innovation in new energy sources, a better use at a lower cost. In addition to the problems of energy production, there is also the problem of heating. Mainly as a raw material for heating in Kosovo, wood and coal are used, which still aggravates the pollution of the environment and an unaffordable cost for consumers, considering that the periods with low temperatures during the winter are prolonged.

The project in question aims to produce electricity and heat at the same time at a low cost without affecting the environment.

Kosovo lacks proper waste management for almost all types of solid waste (from homes, manufacturing, healthcare, and dangerous substances). There is a lack of collection, classification, recycling and treatment system, as well as infrastructure for municipal waste. Data and information systems for waste collection are scarce. Cost recovery for

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services is low. Illegal landfills and improperly constructed and managed landfills are numerous. There is a lack of capacity built and in operation for hazardous waste - for example, Kosovo does not have any licensed capacity for the incineration of hazardous waste. These shortages cause serious health and environmental impacts arising from unregulated or inadequately regulated landfills, particularly in rural regions, result from substantial quantities of uncollected waste being disposed of in illicit landfills (frequently located near rivers, thereby giving rise to additional environmental risks), or incinerating them. Large amounts of coal ash (from lignite power plants) and mining waste are also dumped each year without any degree of recycling [[1]].

Waste is a by-product of our daily personal and professional lives, generated by our homes, businesses, industry, construction sites, hospitals and government offices. The things we throw away must be stored, collected, transported, processed, recycled, handled and disposed of safely.

The Law on Waste transposes the European rules for waste management and provides a comprehensive framework for the development of the waste management sector. It provides definitions, principles, scope, strategic planning framework, responsibilities of different actors, and requirements for each stage in the waste management chain for different types of waste. The law guides the preparation of this Waste Management Strategy. The existing strategy was approved in 2013, while it is a legal requirement that it be updated every 5 years. Through the implementation of the measures foreseen in this strategy, Kosovo's obligations arising from the Stabilization and Association Agreement (SAA) and sectoral policies in the field of waste management similar to those of the EU will be addressed, thus accelerating the European integration process. In addition, the European Reform Agenda (ERA) has been designed to maximize the economic and political benefits of the SAA. Pillar II - Competitiveness and investments - emphasizes the further improvement of policies and their implementation in the field of the environment, focusing especially on waste management, the "polluter pays" principle, and environmental responsibility. This strategy presents the government's approach to integrated solid waste management (IMS) in Kosovo. It represents the next step toward the realization of these national strategic priorities. The strategy defines strategic objectives, specific objectives, goals, and indicators for the waste management and recycling sector. The strategy covers a 10-year period from 2021 to 2030 and includes a three-year Action Plan from 2020 to 2023 [[2]].

One of the main challenges in improving the state of the environment in Kosovo remains sustainable waste management. Despite the achievements and progress in strengthening the legal and programmatic basis for the waste sector, despite the improvement of the infrastructure for their management, there is still commitment and work needed to improve the situation in the waste sector. We are aware that for the improvement of waste management, more efficient and sustainable cooperation of institutions and responsible organizations at all levels is needed. In addition to the commitment of legislative and executive institutions, waste

collection management companies, companies that manage sanitary landfills, civil society organizations, donors and other actors also have an important role in the waste sector. Therefore, in order to better coordinate all actors and donors, we have also established the Steering Committee for the Waste Management Sector, which aims to coordinate activities, projects, and donations for this sector. Currently, difficulties and problems in the municipal waste sector are evident in all processes of their management, from collection, separation, recycling, treatment, and disposal. However, we strongly believe that with better commitment and coordination, Kosovo can build a modern and functional system for municipal waste management. Above all, we need to change the perception and approach we have as a society to waste. Good waste management practices treat waste as a resource, and in addition to management, it is used as an important resource for development. Therefore, even in Kosovo, the time has come to think beyond the concepts of collection, treatment, and disposal of waste. The time has come for waste and the waste sector to be an important part of the national sustainable development strategy, waste to be an important part of the green and circular economy, waste to be a source of energy or even a raw material in many processes manufacturing. Above all, improving waste management will help to achieve the primary goal of the Ministry of Environment and Spatial Planning, the improvement and preservation of our environment and natural resources for us and for the generations that will come after us [[3]].

II. MATERIAL AND METHODS

A. Materials

Boiler: The boiler, measuring 600 mm x 120 cm x 2.5 mm, serves as the combustion chamber for the raw material. Also, in this tank are placed the pipes with dimensions of 26.9 mm x 2.50 mm in a circular shape that crosses the tank, with which it is possible to heat the water for heating.

Tank: The tank, measuring 800 mm x 120 cm x 2.50 mm, is interconnected with cobbles and functions as a component for gas recycling; during this process, a liquid byproduct known as diesel is released.

Cooling devices: These consist of pipes measuring 48 mm x 2.50 mm, and their role is to cool the gas.

Filter: Measuring 400 mm x 600 mm x 2.50 mm, filled with waste from wood processing, its role is to filter the gases released during the ignition process. Valves are installed in this filter to control the entry and exit of gases during the closing and opening process.

Aspirator: It is located at the junction of the valves where it enables the absorption of gas from the boiler.

Generator: It is an internal combustion engine that produces electricity.

Raw material: The raw materials encompass a variety of waste types, including plastic, paper, medical waste, agricultural waste, wood, coal, tires, and other materials. During the burning of this substance, a temperature of up to 850 °C is released, which enables the heating of the water, which

passes through the boiler and is used for heating houses and greenhouses.

The entire system is equipped with pressure relief valves.

B. Method

The experiment is based on the use of the method which enables the release of gas through pipes and filters during the combustion process of raw material from top to bottom in the

boiler. On this journey, a liquid called crude oil is released. The process involves gas filtration through waste from wood processing, specifically utilizing bark for this filtration method. During this process, the final product is obtained - gas, which passes through the carburetor, which enables the process of gas combustion and puts into operation the internal combustion machine, the generator, and produces electricity.

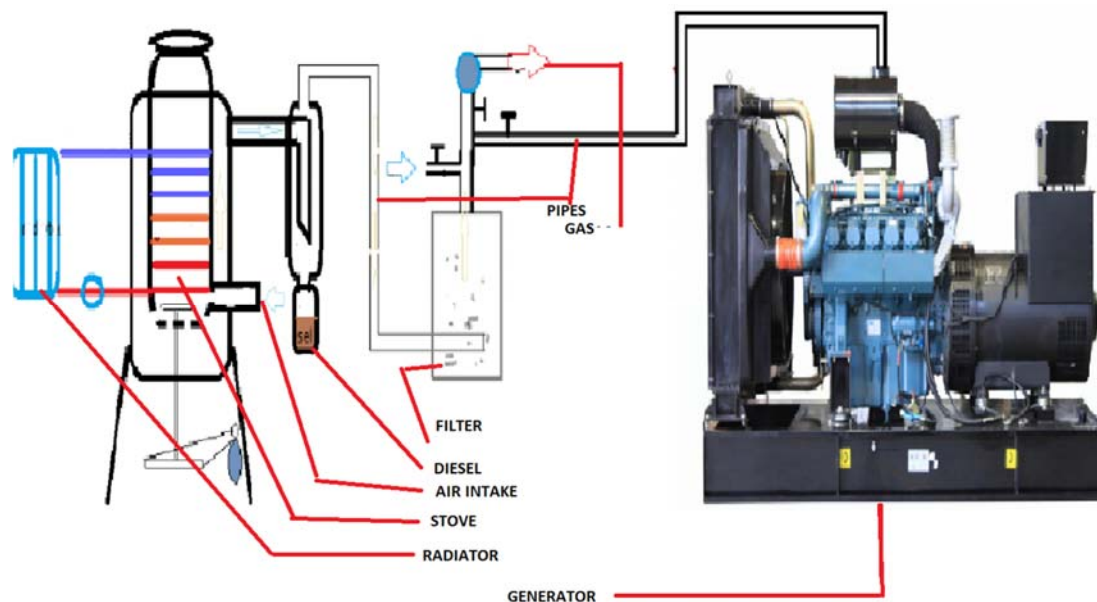


Fig.1 Electricity production and heating system according to the closed method

C. Research Objective

Kosovo's energy system is designed mainly for the production of basic electricity, which is based on lignite as a raw material, but not for covering maximum loads and balancing the system, which remains a big challenge for all participants in the sector. Kosovo has an installed production capacity of 1,431 MW, including the generating capacity from Energy Regulatory Office (ERO); [4] however, the operational capacity is considered to be around 1,099 MW, of which, lignite thermal power plants (TC) account for about 87.36%, while the rest consists of HC Ujmani with 2.91%, wind generator "Kitka" (Air Energy) with 2.95% and other RES (hydropower plants, solar panels, and wind power plants) with 6.78%. In the longest period, these capacities would be sufficient to cover the demand. However, the age of the power plants and their limited flexibility to adapt to varying demand, especially during peak times, result in a need for imports and sometimes exports to balance the system. The introduction of generators by ERO increases the operational generating capacity, but in most cases, they are unpredictable and are in the priority dispatching regime, therefore they do not have an impact on improving the balancing of the energy system, and sometimes even increase the imbalances [[4]].

Recently, we have witnessed climate changes caused by the human factor as a result of environmental pollution from various industrial gases. In the family economy as well as in

businesses, the use of wood for heating has caused disturbance to the ecosystem by destroying the entire surface of the forests. Then, the burning of forests has further aggravated this problem. A very small percentage of these areas have been reforested. The use of carbonized coal also results in the release of carbon monoxide (CO) into the atmosphere.

There is still much work to be done, and we cannot afford to become complacent, despite the great progress made in recent years in the fields of energy efficiency and reductions in greenhouse gas emissions. Moreover, the growth of various RE outputs will be affected by their environmental impacts - including any inputs of scarce minerals - as they are ramped up to replace fossil fuels and any resulting citizen opposition [[5]].

This experiment has a direct positive impact on preserving the ecosystem and protecting the environment from gas pollution. Families, businesses and industries that deal with the production of electricity from coal will also benefit from this experiment.

The experiment is located in the village of Godanc, municipality of Shtime, region of Ferizaj, Republic of Kosovo. The main purpose of this experiment is the use of non-composite waste of vegetable origin and medical waste that consists of the production of electricity and the release of a liquid called diesel.

III. RESEARCH RESULTS AND DISCUSSION

The main objective of our research is the production of electricity and heat through a closed system using different materials from different waste for combustion such as plastic waste, wood, paper, coal, agricultural waste, etc., with a focus on minimizing material costs. Through this system, it is also possible to heat the greenhouses to produce vegetables and flowers, which enables the extension of production, the supply of the market with fresh vegetables out of season, the reduction of the number of imports, and their more competitive price for the consumer.

During the winter season in regions with heavy snowfall, not only production in greenhouses but also the construction of greenhouses is at risk. By heating them through our system, this risk is eliminated.

The air quality data provided by the Hydrometeorological Institute of Kosovo (HMIK) indicate the monitoring of air pollutants, showing that PM concentrations in Pristina exceed the limit values from the EC, even the values from the WHO guidelines: urban PM10 = 78 $\mu\text{g}/\text{m}^3$ and urban PM2.5 = 40 $\mu\text{g}/\text{m}^3$ (Renaissance Building); suburb PM10 = 48 $\mu\text{g}/\text{m}^3$ (IHMK station). This shows that the concentration of PM2.5 in the outskirts of Pristina is 24 $\mu\text{g}/\text{m}^3$ (0.5*48, respecting the proportion of PM2.5/PM10 of 0.5). During winter, ambient levels of PM10 and PM2.5 are much higher than at other times of the year. This is likely due to the lignite used by the power plants in Obiliq and by homes that burn wood and coal for heating [[5]].

This experiment is based on environmental protection, where during the burning of the mentioned material the release of gases into the atmosphere is zero. In this combustion process, a liquid gas called diesel is released.

Lignite is of extraordinary importance for Kosovo. It contributes 97% of total electricity generation, while the rest of production is about 3%, based on hydropower plants. With 12.44 Mt, Kosovo possesses the world's fifth-largest proven reserves of lignite [6]. In the territory of Kosovo, lignite deposits are in the basins of Kosovo, Dukagjini, and Drenica, while the exploitation has been limited to the basin of Kosovo. According to the Independent Commission for Mines and Minerals, the first systematic records of lignite exploitation date from 1922, when small-scale, shallow underground room and pillar mining commenced in the Kosovo Basin. Large-scale mining of lignite began with the first production from the Mirash (1958) and Bardh (1969) open-pit mines, using bucket wheel excavators [[6]].

Kosovo produces the largest amount of electricity from burning coal in power plants. Data from the Energy Regulatory Office (ero-ks.org) show that Kosovo's whole capacity for producing energy in 2020 was 1,110 megawatts [[7]]. Some 86.5% of this quantity comes from thermal power plants, with the power coming from hydroelectric facilities and alternative energy sources (hydropower plants, wind power plants, and photovoltaic panels) [[7]].

In recent years, Kosovo has had continuous problems in terms of environmental pollution, from thermal power plants, as well as from the burning of coal by businesses and private

homes. This pollution is aggravated even more due to the age of the power plants and the inability to filter the gases that are emitted into the atmosphere. This has aggravated people's health by causing chronic cardiovascular and pulmonary diseases.

Our system for the production of energy and heat consumes a very small amount of fuel and all types of waste, preventing environmental pollution from waste, but also the emission of gases into the atmosphere from the combustion of these materials is zero.

TABLE I
 PRODUCTION OF ELECTRICITY, HEAT AND DIESEL THROUGH CLOSED SYSTEM

No.	Fuel (kg)	Quantity (kg)	Kwh	Diesel/ l	Temperature/C
1	Coal	30	42	1.50	850
2	Plant waste	30	22	0.75	800
3	Plastic waste	30	35	1.00	800
4	Waste from wood processing	30	32	1.20	780

The data obtained can be seen in Table I and show that, in the case of using coal as a fuel, we obtained 42 kWh from the 30 kg mass, while the plastic waste produced 35 kWh. We obtained 22 kWh from 30 kg of vegetable waste, and 32 kWh from wood waste. Regarding oil discharge, the highest value was recorded by coal fuel 1.5 l/h, followed by wood waste 1.20 l/h, and plastic waste 1.0 l/h. In vegetable waste, the value is lower at 0.70 l/h. During this process, heat is released where the highest value was the use of coal 850 °C as well as vegetable and plastic waste 800 °C. The lowest value was for wood waste 780 °C.

IV. CONCLUSIONS

Throughout the course of the experiment, we have reached the determination that the utilization of the aforementioned fuels can yield both electricity and heat through the process of production:

1. Low manufacturing cost,
2. Environmental protection from solid waste pollution,
3. Protection of the environment from pollution with toxic gases in the atmosphere,
4. Waste management, and
5. Preservation of human health.

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