THESIS OF THE DOCTORAL (PhD) DISSERTATION

BIOMASS POTENTIAL AND ITS PERSPECTIVES FOR HEAT USE IN KOSOVO

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1. INTRODUCTION OF THE TOPIC AND THE OBJECTIVES

The world is becoming overpopulated, the size of agricultural land is decreasing, and non-renewable sources are on the way to running out, meaning that the world will have the most difficult challenge in the near future. Furthermore, the effects of global warming have started to affect agriculture in general. From other perspectives, water and energy seem to be two main issues, starting from agriculture and involving all other sectors. These are the concerns from where the idea of the research originated. The research is planned to give a view of combining biomass, agriculture, and renewable energy sources, which is a great possible solution for these challenges. So renewable energy can manage global warming, reduce pollution that comes especially from central heating power plants, and mitigate dependence on different fossil fuels as is the case in Kosovo.

As a new and developing country, Kosovo needs to have a stable energy supply to provide adequate infrastructure and a safe environment for the development of all sectors. Nonetheless, Kosovo is requesting to join the European family in this order it must meet all the criteria, in terms of the environment as well. According to the Ministry of Economic Development (Ministry of Economic Development of Kosovo, 2017), Kosovo has a wealth of natural resources, including geological coal reserves such as lignite, making it the second-largest lignite reserve in Europe and the fifth in the world. Right now the bulk of the energy supply is coming from Kosovo's two major coal-fired power facilities, unfortunately, they are obsolete, resulting in substantial air pollution and environmental issues. Due to its enormous lignite reserves, Kosovo has been mostly dependent on homegrown lignite, or low-grade coal, to supply its energy needs. For the past ten years, Kosovo's yearly lignite production has ranged between 7 to 9 million tons, roughly matching the country's yearly lignite demand. Due to their age, rigidity, and inefficiency, Kosovo's two lignite power plants contribute to severe load shedding and inadequate supply security (IEEFA, 2020).

Agriculture and energy are critical components of the country's GDP and employment (Ministry of Environment and Spatial Planning of Kosovo, 2015). Furthermore, 129220 agricultural households (*ASK DATA - Select Table*, n.d.) take up 419 thousand hectares (ha) of agricultural land. In general, the sector is defined by small farms, and challenges such as fragmented agricultural lands, low efficiency, and insufficient infrastructure. Farms in Kosovo are characterized by an unfavorable structure that is fragmented into an average of seven plots, which poses a challenge to the productivity and agricultural efficiency of the farm, which makes it even more difficult to implement agricultural practices, affecting the sustainability of the farm (Miftari et al., 2015) Although Kosovo is not yet a member of the European Union, it is recognized by more than half of the world's countries. Kosovo is working toward the EU's clean energy production and supply targets. Renewable energy is not a new concept in Kosovo; it has been around for a long time, although production is still insignificant.

Based on current conditions and forecasting potentials in terms of biomass, its energy utilization may significantly improve farmers' incomes and decrease the unemployment rate in rural areas. In this regard,

the final output would be what is the importance of biomass energy sources in Kosovo, what is the theoretical biomass potential, and which are the types of biomass available to be used for heating in practice. Biomass energy can be produced in any agricultural plant, in addition, Kosovo has adequate resources, all it needs is just the organizing of the efforts and long-term plans and projects to have a stable energy supply from renewable sources too.

Global energy consumption has increased continuously in recent decades, owing largely to economic development and the growing demands of a fast-expanding global population. As countries industrialize and urbanize, the demand for energy to power businesses, transportation, and homes grows (Shao, 2017). To address this increasing need, a variety of energy sources are being used, including fossil fuels, nuclear energy, and renewable resources. Fossil fuels, including coal, oil, and natural gas, currently account for the vast bulk of global energy use. Despite the environmental impacts such as greenhouse gas emissions and the effect of climate change, this source of energy is used widely and globally due to its low cost and availability. In contrast, their huge usage has created worse environmental issues and has encouraged the use of renewable energy sources.

Renewable energy sources (solar, wind, hydro and geothermal) are considered to be an alternative method to fossil fuels. Their positive environmental effects have created an opportunity to minimize the consequences of energy generation from traditional sources. However, some obstacles impact the acceptance and usage of these sources such as the storage of energy, integration in the grid system, and different expenses that are related to them (Alshahrani et al., 2019; Fernandez et al., 2024). Like nuclear energy offers low-carbon emissions, its implementation is limited by waste management, safety, and high prices. In this regard, many countries are doing research and development strategies to boost the efficiency and the costs related to them.

The shift towards a more sustainable energy structure is projected to be gradual but progressively, with technological innovation, different incentives, and cooperation between countries. Even though renewable energy sources are a transition to a greener landscape, fossil fuels continue to be an important component in the future of the energy mix.

Biomass encompasses organic matter derived directly or indirectly from photosynthesis in plants, as well as animal-derived organic material, excluding fossilized substances. Given this broad definition, biomass materials are widely utilized in practice (Peng et al., 2012). The recent prioritization of lignocellulose materials from forests and agriculture underscores biomass's growing importance in energy production (Arteaga-Pérez et al., 2015). Common types of biomass include wood, sawdust, straw, seed residues, organic manure, paper waste, household waste, and sewage (Soltero et al., 2018). While some materials can be used directly as fuels, others require pre-treatment through advanced technologies.

Biomass offers several advantages, depending on the factors assessed. Biomass serves as an energy source for natural biomass, contributes to a low-carbon economy, can be used for non-food purposes, and offers

benefits such as CO_2-neutral conversion and climate change mitigation (Vassilev et al., 2015). However, the environmental assessment of firewood (which is critical in heat generation) was considered a highly polluting fuel, in fact, a non-renewable energy source, especially by the least informed (older, poorer, and less educated) in the United States (Plate et al., 2010) and Hungary (Szakály et. al., 2021). According to a survey conducted using a choice experiment methodology, GHG emissions rank lower in terms of sustainability features than land demand and local income (Dombi et al., 2012). Furthermore, biomass benefits rural development by revitalizing and generating income, creating new jobs, and restoring contaminated and degraded lands (Vassilev et al., 2013). Furthermore, it has technological advantages, such as large and economical sources of biofuels, fertilizers, building materials, material synthesis, and recovery of specific elements and compounds. The extraction of raw materials from the countryside (Perea-Moreno et al., 2017) is one of the job development opportunities offered by biomass.

Another important component of biomass output is the storage of solar energy; in recent years, significant emphasis has been placed on the gasification process, which is used to generate bioenergy (Fang et al., 2021). Furthermore, focused solar thermochemical gasification of biomass is expected to increase the utilization of biomass feedstock and energy efficiency by up to 30% and 40%, respectively, thus effectively saving solar energy in the producer gas. Another publication evaluates the thermodynamic and economic performance of a solar biomass gasification polygene ration system, which is also positive (Bai et al., 2018). This technology reduces CO_2 emissions and offers alternatives to renewable energy sources such as solar and biomass.

Scientific experts are currently interested in biomass as a biofuel. In recent years, the number of scientific articles in various fields has expanded enormously, significantly influencing the changing behavior of scientific research (Popp et al., 2018). Furthermore, the increase in documents may reflect a change in scientific knowledge in a particular sector. Furthermore, an increasing number of publications indicates that a particular field is becoming more important.

Annual primary biomass output on Earth's surface is estimated to be around 1260 EJ (Exajoules) (Popp et al., 2013), moreover the same author years later mentioned the overall world biomass supply from agriculture and forestry is estimated to be approximately 11.9 billion tons of dry matter per year, with agriculture producing 61% and forestry producing 39% (Popp et al., 2021). Biomass generation is an important part of the Earth's natural carbon cycle because it collects sunlight and carbon dioxide and converts them into organic matter that supports ecosystems and life on Earth. Agricultural biomass is defined as any organic material obtained from agricultural activities that can be used to generate energy, raw materials, or other useful goods. It refers to a wide range of plant-based materials produced as byproducts or residues of agriculture, such as crop leftovers, leaves, stems, roots, and husks (Akhayere & Kavaz, 2021). Agricultural biomass also includes energy crops grown expressly for bioenergy generation, such as corn, sugarcane, switch grass, and hemp. Crop residues, which are plant components left over after the primary food crops have been harvested, are one of the most common types of agricultural biomass.

Wheat straw, rice husks, corn stalks, and sugarcane bagasse are also excellent biomass sources. These materials can be used in a variety of applications, including bioenergy generation, bioplastics, and other byproducts.

In its "A New Circular Economy Action Plan for a Cleaner and More Competitive Europe," the European Commission highlights that the current global consumption trajectory is unsustainable. The Commission draws attention to a critical problem: although there is only one planet, Earth, worldwide consumption is expected to reach levels comparable to three planets' worth of resources by 2050 (European Union EUR-lex, 2020). This concerning prediction emphasizes how vital it is to move toward more sustainable production and consumption practices. Numerous causes, including population growth, growing earnings, and fast urbanization, are contributing to the anticipated increase in consumption. An important and concerning trend was brought to light in the 2018 OECD communication: the world's use of metals, minerals, biomass, and fossil fuels is predicted to quadruple by 2060 (OECD, 2018). The quantity of garbage produced will rise by 70% concurrently. These forecasts highlight the mounting strain on the environment and natural resources as the demand for raw materials keeps rising on a worldwide scale. Such patterns have significant ramifications for future generations' well-being, the viability of economic systems, and the health of ecosystems.

Located in Southeast Europe, with an area of 10,908 km^2, Kosovo is the youngest country in Europe, in terms of history and population. Moreover, the average age was 26 years old in year 2018, which could be more likely to adopt new rules and technologies for faster development (Ministry of Agriculture of Kosovo, 2018). However, Kosovo continues to be considered one of the countries with the youngest population in Europe (MAFRD, 2023). Kosovo is a rural country, approximately half of the population is living in rural areas (*ASK DATA - Select Table*, n.d.). Furthermore, the majority of the population in rural areas is dealing with agriculture. Agriculture’s contribution to the total GDP is estimated at 7.4% (658 million euros) (MAFRD, 2023). This share of agriculture in the entire GDP of the country in the last and 15-year period decreased from 14.8 to 7.2%. However, the contribution of agriculture is comparatively high, still, agriculture is dealing with some challenges such as high production costs, low labor efficiency, and fragmentation of the land. Nevertheless, as a result of good geographical position and quality of land, agriculture remains the most promising sector for future development.

The leading agricultural sectors include fruits, vegetables, and livestock. In the year 2017, there were approximately 259,729 heads of bovines, 210,688 heads of sheep and goats, and 41,086 heads of pigs (Ministry of Agriculture of Kosovo, 2018). In addition, there were a total of 120,746 hectares of cereal with a production of 477,880 tons. In the case of any biogas plants in a country such as Kosovo will therefore evidently have adequate raw materials, as a result of developed agriculture.

Kosovo is a country located on the European continent, of course, the global economic crisis and the electricity markets have also affected the energy system of Kosovo. This result of the impact of this crisis

showed once again that the energy system of Kosovo must be improved to a very high degree in order to become more self-sufficient and as little as possible dependent on price fluctuations in the international market (Ministry of Economy of Kosovo, 2021). From the total final consumption of electricity, the largest part, or 61.2% was consumed by families or households expressed in the amount of 3131 GWh. While non-resident customers or companies consumed the remaining percentage or in the amount of 1986 GWh.

Kosovo faces its biggest energy challenges during the cold winter months, as some residents use electricity for heating, which increases demand to a maximum and simultaneously strains the grid, resulting in outages in some rural areas. However, these challenges have been managed better and better over the years. In recent years, there has been much talk about the possibility of building a network to bring gas from other Southeast Europe countries, especially from North Macedonia (ERO, 2021). Many studies in different parts of the world show that when agricultural biomass is used for energy production, it has also a significant impact on the development of new jobs, especially in developing countries (Alatzas et al., 2019; Ang et al., 2022; Bilandzija et al., 2018; Okafor et al., 2022; Popp et al., 2021; Toklu, 2017; Tun et al., 2019). This has a positive domino effect on the overall social and economic development of both rural areas and the entire country.

Some people have inefficient wood or coal-burning appliances, which then cause greenhouse gas emissions and air pollution. While the rest of the citizens use heating appliances powered by electricity, these cause an increase in the demand for energy, energy that often has to be imported (*Lignite Mining Development Strategy*, n.d.). Based on these two challenges, Kosovo aims to produce up to 35% of its electricity from renewable sources, this priority remains as a target for 2031. At the same time, it is planned to set a price for carbon pollution for those polluters (Ministry of Economy of Kosovo, 2021). So through such policies, the goal remains to gradually move away from the use of coal, if not soon, then the target remains 2050.

The transmission network is also considered a very important challenge by many stakeholders, as mentioned above, there is progress, however, it remains a phase that needs more work to do in the future, to increase the quality of distribution and to have as few losses as possible regarding the distribution system (Ministry of Economy of Kosovo, 2024). The Kosovo country has also made investments regarding more efficient energy in public buildings, from these investments based on measurements it has resulted that annual energy savings were 1.67 ktoe in 2023, while in 2022 they were only 0.78 ktoe.

A study (Alicia et. al., 2015) examines three major biomass sources - wood, livestock leftovers, and agricultural straw - that have a high potential for power production in Kosovo. It is expected that accessible biomass sources can produce around 6600 GWh of electricity each year. According to the 2014 agricultural census, the total amount of used agricultural land was 413,635 hectares, divided into 129,884 farms with an average size of 3.2 hectares (Agriculture, 2018). According to an agriculture report (Ministry of Agriculture of Kosovo, 2020), agriculture accounts for approximately 11% of GDP. In Kosovo, agriculture employs 362,700 people, with 130,775 registered farmers (Muriqi et al., 2019). This sector is characterized

mostly by tiny farms, fragmented land, low efficiency, and inadequate infrastructure. As a result, energy self-sufficiency can be very beneficial in terms of increasing farm efficiency.

The purpose of this study is to present the theoretical and practical potential of biomass use for energy purposes in Kosovo. In this regard, first of all, let's get deeper into the Kosovo case scenario. As for the year 2020, in Kosovo, 98% of electricity was produced from two out-of-date thermal power plants, which use lignite with poor quality parameters (caloric value of lignite is 7200 kJ/kg, (Lajqi et al., 2020). In addition, the energy system in Kosovo becomes more aggravated during the winter period due to the reliance on electricity for residential heating (Ministry of Economic Development of Kosovo, 2017). There is a lot of room for carbon dioxide reduction, its extent was estimated at 54%, by considering the maximum utilization of all types of renewables, starting with biomass, solar, and wind energies, comparing with the referent current scenario (Lajqi et al., 2020).

The government of Kosovo by the support scheme, through feed-in tariff for renewable energy sources was supporting the electricity produced from biomass as a renewable resource with a price of 71.3 Eur/MWh. In Kosovo was suggested an installation to generate electricity by biomass in the amount of 14 MW (Lajqi et al., 2020). However, this sector was not being seen with high interest from investors' point of view due to the high cost of installation technology and difficulties of the procedures that are needed for obtaining licenses. Regarding the biomass potential in Kosovo, forests have a sharing of 44.7% of the total land area, wherein 62% is classified as public forest and the rest part goes to private ownership (FAO, 2015). There are two main groups that are very suitable for the production of biomass in Kosovo, the first group includes cereals such as wheat, maize, oats, barley, and rye. While in the second group are plants that are harvested in green conditions such as hay, grass, green wheat, and green rye (Sahiti *et al.*, 2015), whereas the waste with origin from cereal that can be used for further processes for energy production ranges from 10-40%. It important to highlight what theoretical and technical biomass potential means, in this regard, theoretical biomass potential refers to the total quantity of biomass that can be produced (or formed) given physical and biological limits, whereas technical biomass potential refers to the fraction of the theoretical capacity that is attainable under certain technical parameters associated with the existing technology (Gonzalez-Salazar et al., 2014; Silván-Hernández et al., 2017). A report from the World Bank (World Bank, 2017) identifies theoretical and technical biomass potential of 844 ktoe, and 665 ktoe respectively, more importantly, the unconsumed biomass potential is estimated to have a negative value of -157 ktoe as a result of unsustainable practices of using biomass. These unsustainable practices are coming from inadequate forest management techniques and logistical infrastructure. The annual increment of wood per hectare of forest area is a measure of forest management practices. In Kosovo, it is measured as (3-4 m^3/ha). Furthermore, there appears to be a lack of regional market structure. According to the same reference (World Bank, 2017), the use of biomass for heating might be enhanced sustainably by roughly 20% not just in Kosovo, but also in other regional nations.

According to another report by the World Bank (World Bank, 2017) on using biomass as the primary heating resource in Western Balkan countries, it shows that biomass is used inefficiently because of two factors, the lack of drying biomass before use and outdated equipment. More importantly, according to one article (Ymeri *et al.*, 2020) in Kosovo, it shows that 90.7% of farmers were willing to sell their wheat straw to a bioenergy plant and only 9.3% did not want to sell it. As per corn straw 51.5% of the farmers were willing to sell more than 50% of their yield is available. Lastly, the same article (Ymeri *et al.*, 2020) indicates that contractual relationships and specific market prices are two main components that determine the willingness of farmers to sell their straw for energy purposes.

The research has some major questions that correspond with some major goals and objectives:

The research has some major questions that correspond with some major goals and objectives which are elaborated with research questions in the following subchapter.

1.1. The objectives and research questions

Objective 1

The assessment of the theoretical importance of biomass energy source in Kosovo.

R.Q.1.

a) What are the types of biomass energy sources available in Kosovo?
b) What is their theoretical, technical, and practical potential for energy production?
c) How do Kosovo's natural and agricultural resources contribute to the development of biomass energy sources?

To address this research gap, the dissertation proposes the following hypotheses:

H1: Biomass has the potential to contribute significantly to Kosovo's total energy consumption.

Biomass is undoubtedly one of the important forms of the renewable energy mix. Another important reason for using biomass for energy needs is the use of agricultural, forestry or solid waste, which have not been used for any other purpose. Such use of biomass for energy needs would also have positive domino effects on the development of jobs or the improvement of the well-being of rural areas.

Hypotheses 1 will be answerd on section 3.2.

The following hypothesis is as follow:

H2: A significant proportion of the total biomass in Kosovo is suitable for energy production.

A significant portion of all biomass resources in Kosovo can be utilized for energy needs, especially for heating. By taking this resource into account, Kosovo can then improve its energy supply mix and become more independent and sustainable.

Hypotheses 2 will be answerd on section 3.2.

Objective 2

To assess the level of environmental consciousness among students and evaluate how their awareness translates into sustainable practices and lifestyle choices as some future policymakers.

R.Q.2.

a) What is the level of environmental consciousness among students in Kosovo?
b) What are the main clusters among the students for their perceptions regarding types of energy use?
c) What role does government policy and legislation play in the development and promotion of bioenergy in Kosovo?
d) What is the level of public awareness and acceptance of bio-energy sources in Kosovo?

To address this research gap, the dissertation proposes the following hypotheses:

H3: The 15% increase in the price of heating significantly increases students' concerns.

This hypothesis proposes to explore the level of student reaction to the sensitivity of the increase in the price of heating, with the goal of explaining that the level of student concern about the increase in the price is a deciding factor of environmental and economic awarness.

Hypotheses 3 will be answerd on section 3.3.

The following hypothesis is as follow:

H4: Students' preferences are increasingly influenced by environmental concerns in Kosovo.

Based on the environmental challenges that are present in Kosovo, an awareness of students in this regard has been observed. This change in awareness is also very clearly seen in their preferences towards the actions they take in relation to the environment. Over time, it is likely that students will show rationality towards more sustainable practices. This hypothesis positioning it as a key factor in the country's sustainability and the well-being of its population.

Hypotheses 4 will be answerd on section 3.3.

To assess the level of environmental consciousness among students and evaluate how their awareness translates into sustainable practices and lifestyle choices as some future policymakers.

2. MATERIAL AND METHODS

This methodological chapter contains important information on the organization's approach to collecting data, for the main purpose of identifying the potential of biomass for energy needs in Kosovo and the approach of individuals in this regard. This study incorporates a mixture of qualitative and quantitative methods, with the combination of data from different sources, whether from academic literature, various reports from public institutions, and statistics extracted from state databases. This chosen methodology allows us to have a high level of reliability in achieving the assessment of the potential of biomass and its incorporation into energy generation. In this context, the involvement of questionnaires as a primary research method and the use of reports and comparative studies as secondary data allows the author to rely on data that are credible and reliable. The latter paves the way to find coherent results and actual assessment of potential. This technique not only examines the current biomass energy production potential but also proposes practical measures for Kosovo's sustainable energy development. This methodology offers the groundwork for a thorough examination of the viability of biomass-based energy sources, ultimately benefiting rural development, environmental protection, and energy sustainability.

2.1. Primary and secondary sources

The data-collection methodology employed requires the usage of secondary and primary sources. This research would be based on a review of existing data (such as statistics, some reports, journal articles, books, and other literature) regarding the potential production of biomass in Kosovo. In addition, this research will include other relevant survey data, combining both quantitative and qualitative methods. Worthy to mention is that in the context of secondary data, this remains a significant challenge in the context of researching the biomass potential in Kosovo as a result of the lack of official and comprehensive statistics. These shortcomings relate to the lack of information on the current quantity that Kosovo possesses in terms of types of biomass potentially usable for energy needs, the location and availability of agricultural and forestry biomass. Therefore, this complicates research and creates inefficiencies in the research process. On the other hand, data on biomass energy consumption also presents a challenge itself, with a lack of information regarding the fulfillment of the country’s energy mix needs. Based on the above-mentioned data, the researcher will make a calculation on final energy production from biomass sources in Kosovo and its utilization by taking into consideration other aspects of use.

2.2. Estimation of potential

To use biomass, first of all, is necessary to evaluate theoretically the availability of biomass for energy production. The evaluation of potential was carried out based on national government reports and then by the help of scientific studies the author was able to make the estimation of biomass potential in Kosovo level.

2.3. Analyses and interpretations

Different analyses from descriptive (distribution, averages, clusters analysis, correlation between different variables, a one-way ANOVA and Pearson's Chi2 508 test) were performed by using different statistical

software such as the SPSS (Statistical Program for Social Sciences), VOSviewer, R package ‘’support BWS’’. It will be presented by different means such as narratives of case studies, organograms, tables, classifications in categories of fields of works, pictures as illustrations and charts.

2.4. Applied methodology for VOSviewer

To get more information and to know the trend, challenges and future directions of the biomass topic and its utilization, the author has decided to apply first of all a bibliometric analysis of this topic. Bibliometric studies provide an interesting perspective on a country's scientific production and its international status, assisting policymakers in making well-informed decisions about scientific programs. In this study, an exhaustive search was undertaken using Elsevier's Scopus database, focusing on the subfields (TITLE-ABS-KEY (biomass AND potential) AND TITLE-ABS-KEY (biomass AND utilization)) to uncover relevant papers from 1974 to 2021. The year 1974 was chosen as the starting point since it coincided with the publishing of the first foundational text addressing these two topics. The keywords "biomass potential" and "biomass utilization" were chosen for further analysis, and the search fields included titles, abstracts, and keywords. After accessing the Scopus database, the author were able to review and take into account a large number of publications that were used as a basis for their detailed analysis, extraction of results and interpretation. The main reason for selecting the Scopus database was the reliability of the data contained in the database and its consideration as one of the most important databases of scientific articles. According to the study by (Niñerola et al., 2019), this database had about 80 million records in 2019, suggesting that it has a high appreciation by scientists. It is also known as an important archive of literature that contains rigorous reviews of various research literature (Salmerón-Manzano & Manzano-Agugliaro, 2018). Other studies highlight the reliability of Clarivate Analytics Web of Science (WoS) and Elsevier Scopus in the context of providing a wide range of bibliographic data that can be used for various analyses as a result of their high quality (Heradio et al., 2016), (Duque-Acevedo et al., 2020). Given this, both databases were used to conduct examinations of the extent of the data that would be used in our methodology. From this, the author concluded that Scopus, in addition to containing the data included in WoS, also contains additional bibliographic data from various research conference proceedings. It is important to keep in mind that the number of citations can vary between different databases and this can create a kind of uncertainty and inconsistency in this regard (Heradio et al., 2016). Above all, by analyzing all the factors, Scopus was chosen as the sole source of data used in this study. Continuing on, Scopus allows its users to visualize the data they need through an application called VOSviewer (Duque-Acevedo et al., 2020), suggesting that it is a very user-friendly database. This tool (VOSviewer) is free software that enables the analysis of bibliometric networks when using data from databases such as Scopus Scopus (de la Cruz-Lovera et al., 2017). For more information about how the author acted within the framework of our research analysis, it is presented it in the Figure 1.

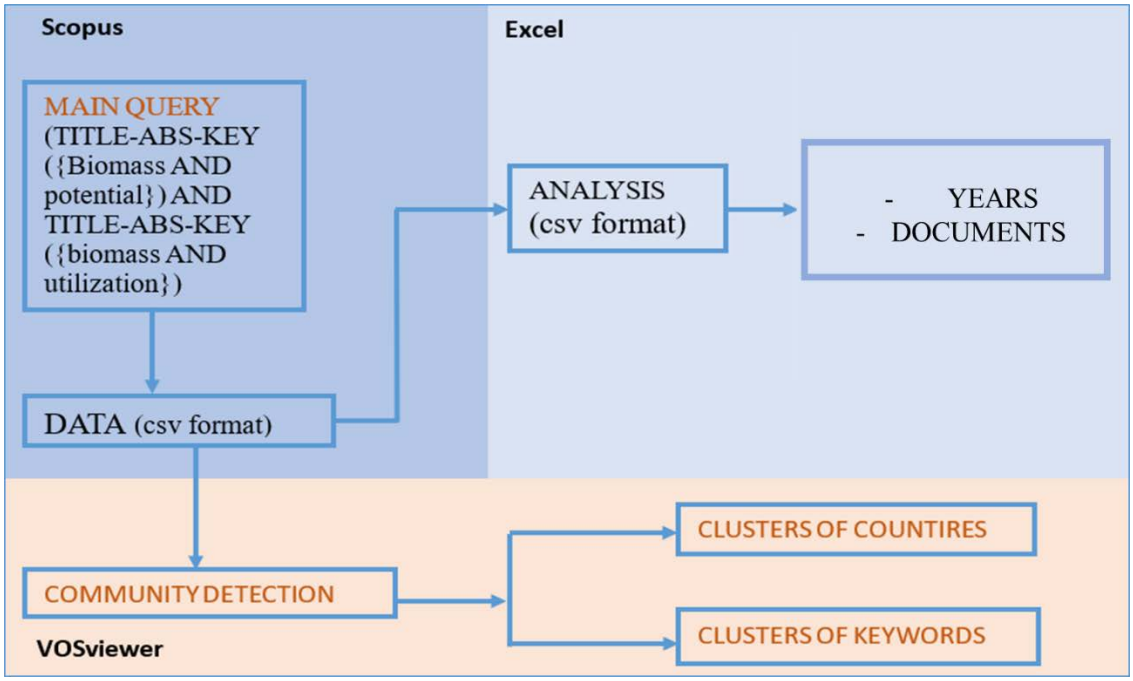

Figure 1. Methodology scheme for bibliometric analyses

Source: Author own figure based on (Sertolli et al., 2022).

2.5. BWS method

Best-Worst Scaling (BWS) is a discrete choice model that not only explains but also quantifies respondents' preferences (Jordan J. Louviere, n.d.). It is a reliable method for determining the relative importance of various traits that asks participants to select the "best" and "worst" features from a list of possibilities. This approach aids in determining a preference score for each quality based on the choices made. This chosen method helps in achieving the result of respondents' preferences based on the choices that the latter have made. The BWS method is of particular importance since it provides details and clear knowledge about how individuals prioritize the choices that suit them. The advantage of BWS is that this type of analysis includes respondents of different profiles, with unique characteristics and special qualities. Then respondents are asked to select the "best" (most preferred) and "worst" (least preferred) attribute, based on their perspective.

The authors used the object case BWS with the following introduction (as seen in the Table 4): "*In the following section, the author would like to understand what is important to you when using renewable energy sources. You will be asked to indicate, in three different scenarios, the most and least important attributes that affect your purchasing decisions for a specific renewable energy source."*

Table 1. Example of the BWS decision format.

What factors do you consider most important and least important regarding the use of renewable resources?		
Feature	The most important	The least important
Price		

Availability		
Knowledge		

Source: Created by the author.

The selected characteristics were established after research conducted in the literature related to our topic and are attributes that find application in everyday circumstances regarding preferences, having the certainty that these are attributes that have an extremely significant impact when considering decisions about renewable energy. The students were subjected to the questionnaire and tried to be as realistic as possible so that the data collected would be reliable and unbiased.

Table 2. Attributes used in the object-case BWS questions.

No.	Attributes
1	Eco-friendliness
2	Price
3	Investment cost
4	Convenience
5	Multifunction
6	Knowledge
7	Availability

Source: Created by the author.

3. MAIN FINDINGS OF THE DISSERTATION

3.1. Biomass potential and utilization on world scale

Initially, it was deemed necessary to research the issue of biomass potential and its utilization on a global scale. Therefore, in this regard, the author has also published results that demonstrate important indicators and factors towards important trends in terms of countries and keywords in this field. The volume of publications originating from a country or region serves as a valuable measure of their scientific activity. Analyzing the various trends and efforts of countries or regions in a specific subject of study is especially important. This method enables researchers to uncover and highlight the most recent patterns in the evolution of the topic while contextualizing their results.

The immense potential of biomass highlights the need for extensive research to identify the most viable and effective combinations or portfolios of biomass-use strategies adapted to the specific characteristics of a given region or area. With the fast-expanding need for energy and the emerging value of specialized energy crops and plantations, the energy-related usage of biomass is receiving more attention in scientific literature. However, the use of bioenergy technology is limited by competing biomass usage methods and the growing importance of alternative renewable energy sources. This emphasizes the importance of including bioeconomic considerations to enable the efficient and sustainable use of biomass. Algae-focused studies have grown at the fastest rate and sparked the most interest in biomass use research, with the most referenced publication also falling into this area. This rise in attention can be linked to algae's extraordinary theoretical potential as a raw material for next-generation fuel production and anaerobic digestion processes.

3.2. Theoretical energy biomass potential in Kosovo and its utilization

Kosovo has access to the raw resources required for the shift from lignite to biomass energy production. However, issues such as energy price ratios, infrastructure, and farm size in the agricultural sector provide substantial barriers to future utilization. As a result, the goal is to estimate the potential of these resources in Kosovo, compare them to national energy consumption, and rank them against other countries. Kosovo has natural resources that can be used to generate energy through renewable technologies, such as biomass from cereal straw, livestock wastes, forests, and solid waste. While some of these resources can be used to generate energy, the majority is used for organic fertilizers, the timber industry, feedstock, and bedding. However, solid waste stands out because it may be completely utilized 100% for energy production, as seen in the Figure 2.

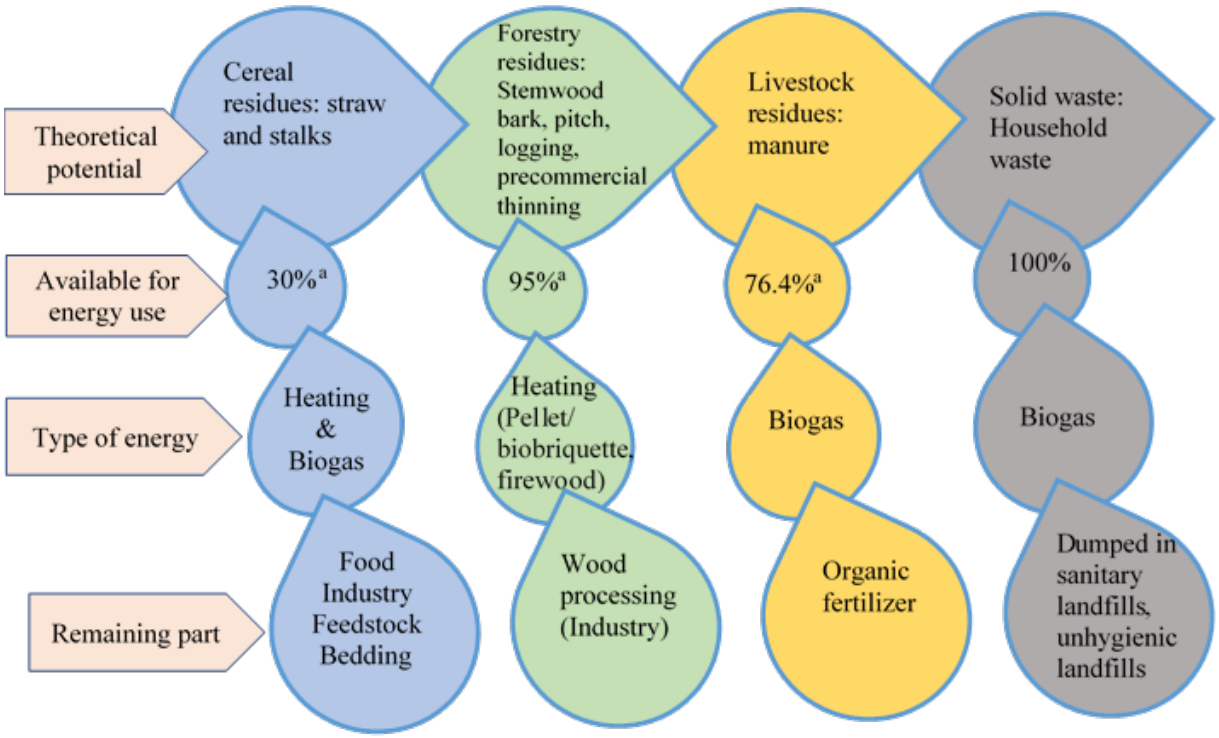

Figure 2. Main contributors to biomass potential in Kosovo. Legend: a—estimation of the Ministry of Economy (Ministry of Economy of Kosovo, 2015).

Source: Author own figure (Sertolli et al., 2022).

Overall biomass production capacity in Kosovo

The theoretical potential of different biomass kinds is shown in the Table 3, and it totals 6,131,719 tons annually. It is predicted that 4,578,652 tons of this total are available annually for energy use. This suggests that, on average, 74.6% of the biomass's entire potential may be used to supply energy. This high proportion demonstrates how important biomass may be to Kosovo's renewable energy industry. The significance of biomass as a sustainable energy source is highlighted by its capacity to transform such a significant amount of it into energy. Kosovo may lessen its dependency on fossil fuels and promote energy security and environmental preservation by making the best use of the biomass that is now available.

Table 3. Theoretical and energy potential of biomass production in Kosovo and its heating value.

Type of Biomass	Total Biomass Produced (t/Year)	The total amount that can be used for energy purposes (t/Year)	Heating Value (PJ)
Forest Biomass	957,600	909,720	17
Cereals Biomass	827,281	248,184	3 *
Livestock Biomass	3,842,602	2,935,748	3 *
Municipal waste biomass	506,630	485,000	3.6 *

Total	6,134,113	4,578,652	26.6

* Note: the values are calculated based on the calorific value for each of the categories of biomass (biogas 20 MJ/m3; wood 19 GJ/ton; solid waste 20.03 MJ/kg) (Barnett et al., 1978; Deng et al., 2020; Petrov et al., 2023), (Eaktasang et al., 2019; Forest Research, 2023).

Source: Author own calculation (Sertolli et al., 2023).

Based on the calculations made and the research literature, the author conclude that the total potential of biomass that can be used for energy has a heating value of 26.6 PJ. Among other things, according to data from the Kosovo Agency of Statistics (KAS, 2023), the total primary energy consumption of Kosovo in 2022 was 116 PJ. This implies that biomass can cover 23% of the total energy consumption in Kosovo, which is a promising and encouraging value. Based on data from the Kosovo Agency of Statistics (KAS, 2023), the total energy produced from biomass in 2022 was 15 PJ. To further support our findings, it is worth highlighting the findings of a study by the Institute for Energy Economics and Financial Analysis (IEEFA, 2020) that estimates that biomass in Kosovo has a total technical potential of 28 PJ. In this regard, the results of the IEEFA study are in good agreement with the research calculations, which show a heating potential of 26.6 PJ from the biomass types reviewed above. These findings highlight the potential participation of biomass to be a suitable component of energy production in Kosovo and emphasize its great importance as an energy source. Promoting sustainable energy development in the country requires recognizing and prioritizing biomass as an energy source.

3.3. Biomass heat energy in Kosovo: prospects and environmental limits

Students' perspectives of renewable energy at Prishtina's Faculty of Agriculture and Veterinary show a rising knowledge of the importance of sustainable practices to meet environmental concerns. This awareness reflects a better understanding of the essential role renewable energy plays in addressing climate change and reducing environmental damage. Students at this faculty increasingly realize the importance of shifting to sustainable energy sources, not only for environmental protection but also for future generations' economic and social well-being. The following sections will explore the greater detail how renewable energy is perceived, understood, and integrated into both academic learning and practical applications at the Faculty of Agriculture and Veterinary.

When students were asked about their environmental consciousness, 96% said they were aware (Figure 3). This demonstrates a strong dedication to sustainability among the younger generation. Of this group, 24% identified as very conscientious, while the remaining 72% defined themselves as mostly environmentally conscious. These findings show the student community's strong environmental awareness, indicating a shared knowledge of the need to safeguard the world and adopt sustainable habits. Almost similar levels of awareness were found in Almulhim's survey (Almulhim, 2022), confirming the growing environmental awareness among young people, a trend that is important for the future. Improved environmental attitudes and heightened levels of awareness have the potential to significantly influence lifestyle behaviors and

perspectives. Students who are environmentally concerned are more inclined to reduce trash, save energy, and promote eco-friendly products. Furthermore, their collective commitment may result in increased advocacy for greener policies and projects, building a culture of sustainability that goes beyond the academic context. This increased awareness places the younger generation as crucial stakeholders in supporting and implementing significant environmental change.

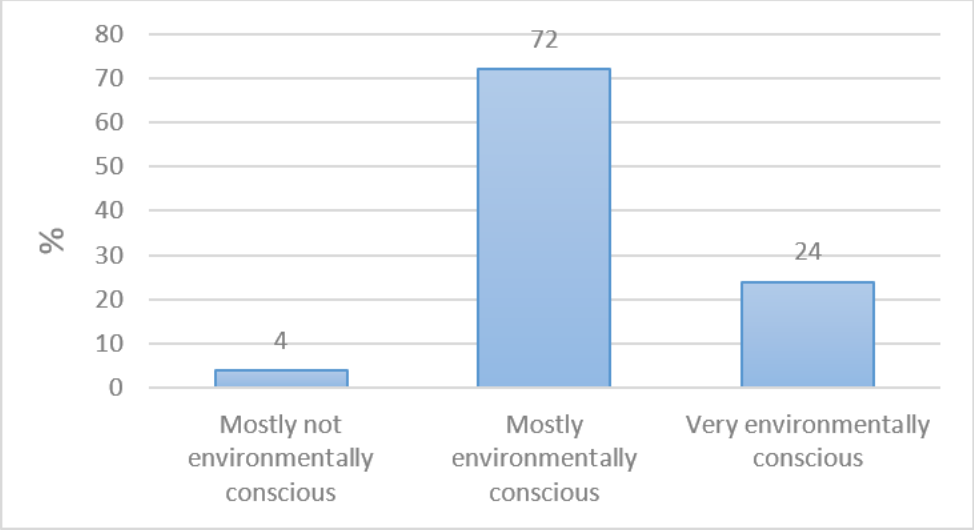

Figure 31. Student's opinion regarding the question: How environmentally conscious do you do you consider yourself?

Source: Created by author.

The research wanted to explore how households might react to a hypothetical 15% increase in energy prices, especially for that part of consumers who rely on electricity for heating. The data, presented in the Figure 4, provide information on the extent of concern and the potential impact of a price increase on household budgets.

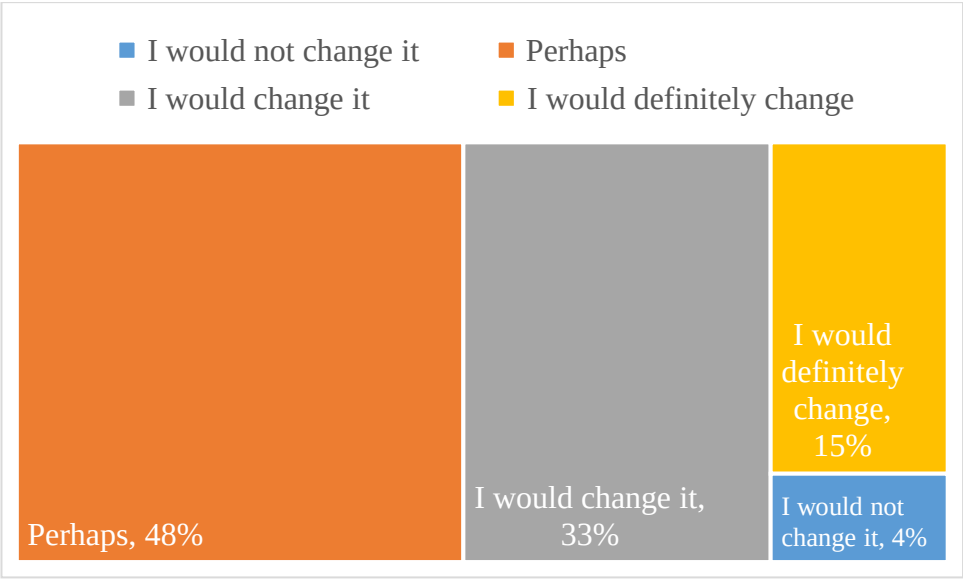

Figure 4. Students' responses to the question: "If you rely on electric heating and electricity prices were to increase by 15%, would you consider switching to alternative heating sources?

Source: Created by author.

The shift in perceptions towards environmental sustainability represents a high achievement and realization across countries, which are working towards a state where the environment is a very important point. Based on the results of the survey, the fact that almost all students (94%) expressed concern about a 15% increase in heating energy bills indicates a clear level of awareness and good management of their energy bills.

Assessment of cluster analysis outcomes

To investigate preference heterogeneity, the author ran further statistical analyses with individual-level Best-Worst values (Table 17). This approach allowed us to examine differences in preferences throughout the sample. Non-hierarchical clustering was done using the Best-Worst values for the seven parameters under consideration. After testing many clustering algorithms, the author determined that the four-cluster strategy was most suited to capturing the data's underlying patterns. The four-cluster method was chosen because it is consistent and easy to comprehend, and it provides a clear separation of preferences. It identified diverse groups of people with different priorities and attitudes toward the factors investigated. These clusters not only highlighted the diversity of tastes but also identified possible prospects for focused interventions or individualized approaches within the study's framework.

1. Table 1. Description of clusters according to different factors

Denomination*	Cluster 1 ’Greenies’	Cluster 2 ‘Passive Environmentalist’	Cluster 3 ‘Eco-Skeptics’	Cluster 4 ’Moderate Adopters’	Test-value	Significance value
Respondent number (100)	30	22	23	25		
BWS_Convenience**	-1.20c	1.27a	0.61ab	0.04b	F= 29.32	p<0.001
BWS_Availability	-1.73b	-1.23ab	-0.48a	-0.96ab	F= 6.49	p<0.001
BWS_Price**	1.90a	-0.18b	1.96a	0.80b	F= 12.59	p<0.001
BWS_Knowledge	-1.3	-0.36	-1.13	-0.64	F= 2.58	p=0.058
BWS_Investment_cost	1.20a	0.09b	0.78ab	-1.72c	F= 27.03	p<0.001

BWS_Eco_friendly**		1.53ab	2.23a	-0.39c	1.44b	F= 17.56	p<0.001
Age (year)	Mean: 20.63	20.97	21.09	20.52	19.92	F= 2.04	p=0.113
Gender	Male (n=16)	6	3	2	5	χ^2=1.66	p=0.646
	Female (n=84)	24	19	21	20		
Field of study	Food Technology (n=67)	20	15	16	16	χ^2=0.19	p=0.980
	Agricultural Economics (n=33)	10	7	7	9		
Knowledge fossil fuels to RE (rank means)		62.67a	46.02ab	46.22ab	43.78b	Kruskal-Wallis H value: 8.85	p=0.031
Environmentally consciousness (rank means)		54.9	43.59	51.37	50.5	Kruskal-Wallis H value: 3.19	p=0.362
Electricity price increase by 15 % (rank means)		52.98	47.82	48.43	51.78	Kruskal-Wallis H value: 0.67	p=0.879
Marketing energy transition (rank means)		54.28	49.8	45.48	51.2	Kruskal-Wallis H value: 1.51	p=0.680
RES Kosovo 2040 (rank means)		58.3	52.27	39.2	49.98	Kruskal-Wallis	p=0.076

					H value: 6.88	
RES vs coal (rank means)	59.15	54.68	45.59	40.96	Kruskal -Wallis H value: 7.78	p=0.051

*Different letters show significant differences; in ONE-WAY ANOVA the letters represent Tukey HSD post-hoc tests results

2. **Levene-test was significant ($p<0.05$) therefore F value represents the Welch-test results and the letters represent Games-Howell post-hoc test results

3. Source: Created by author.

In our final analysis, the author looked at the outcomes of the four clusters created by the K-Means clustering technique, and the results were presented in a Table 17 for clarity. The respondents were distributed rather evenly among the clusters, with 30, 22, 23, and 25 individuals in each. The first cluster, dubbed "Greenies", included those who had a thorough understanding of the shift from fossil fuels to renewable energy. This group had strong environmental awareness, highlighting the significance of sustainability in energy policies. They also acknowledged the significance of advertising and marketing in helping the energy transition, emphasizing the importance of successful public awareness campaigns and communication techniques to foster change. The participants of this group are identified with a strong reaction to price change signals, with a large proportion of them expressing the opinion that they would change their heating method if heating prices faced an increase by 15%. This fact suggests that they are sensitive to price increases and are trying to find more sustainable and cost-effective ways of heating. Furthermore, this group has been an advocacy group for the inclusion of renewable energy as the future of Kosovo's energy sector. The majority of participants stated that by 2024, renewable energy sources will become the main source of energy and they considered renewable energy as a better option compared to coal in Kosovo's energy mix. The perceptions and ideas of this group are in line with the concepts of sustainability and energy independence, reflecting a positive, proactive, and environmentally sensitive worldview. Respondents from this cluster saw renewable energy as extremely important for creating Kosovo's future energy landscape.

The second cluster, nicknamed "Passive Environmentalists" included respondents who had a very different worldview than the group from the first cluster, were more limited in the process of transitioning from fossil fuels to renewable energy, and had a lower level of environmental awareness. Members of this cluster showed a degree of reluctance to adopt new, possibly more sustainable technologies, especially when rising prices could cause financial difficulties in the future. For example, even when heating expenses increased

by 15%, they were less likely to switch to a different heating source. Although this group was not listed as being very proactive in terms of environmental sustainability and specific practices for alternative energy, they did consider marketing to be an influencer in the energy transition. Participants acknowledged that marketing is a strategy that can help raise awareness of renewable energy sources, although this position was expressed less consistently than in the previous group. It is noteworthy that despite their minimal involvement in the economic and environmental aspects of the energy transition, this group expressed a promising level of support for the future role of renewable energy in Kosovo's energy system. A large number of respondents in this category affirmed that renewable energy sources will dominate Kosovo's energy mix by 2040.

The "Eco-Skeptics," specifically the third cluster, included students who showed strong environmental concerns, but strangely, they questioned the role of marketing strategy in supporting a change in attitudes about energy. While expressing strong environmental concerns, they had limited awareness and were skeptical of the transition from fossil fuels to renewable energy. This lack of knowledge seems to have a significant impact on their overall confidence and the possibility of implementing renewable energy solutions in the future. A distinctive characteristic of this group was their skepticism about the composition of Kosovo's energy mix and the potential dominance of renewable energy in this regard. This cluster group did not fully support the idea that renewable energy would be a dominant aspect of the energy structure by 2040. This skepticism was reflected in their practical actions, as this group was reluctant to switch to alternative energy sources despite the increase in energy prices. This cluster group's hesitation also extended to their attitudes towards Kosovo's energy mix. While they recognized the importance of renewable energy, they were not convinced that it was a better option than coal. These reflections displayed by this cluster group reflect a lack of confidence in the practicality of large-scale towards renewable energy. This can be identified with a lack of reliability, infrastructure barriers, and economic consequences. In general, "Eco-Skeptics" is a cluster group that values environmental sustainability, but is skeptical and seeks more information and education on the technical, economic, and practical elements of adopting renewable energy. Their skepticism highlights the importance of information campaigns that inform individuals about the benefits and importance of renewable energy sustainability, to close the gap between their environmental concerns and personal reservations about this approach.

"Moderate Adaptors" is the title of the fourth cluster group, which consists of students who had a moderate level of environmental awareness and viewed marketing with a balanced belief in the impact of changing energy access. While this group was concerned about environmental issues, their approach to the technical and economic intricacies of switching from fossil sources of energy production to renewable energy practices was inadequate. This group was necessarily open to economic issues, and reported a strong decision to switch to alternative energy sources if energy prices for heating increased, demonstrating their sensitivity to cost-related incentives and their desire for energy efficiency. This suggests that, while their environmental knowledge may be at a lower level than in the other groups, they are willing to move forward

with sustainable solutions that align with their financial interests. Regardless of all factors, “Moderate Adopters” were less likely to agree on the importance of renewable energy versus coal in Kosovo’s energy mix. Furthermore, they seemed to be less convinced that renewable energy should dominate the country’s energy mix in the future. However, their perceptions show an interesting approach, in which economic and practical concerns can overshadow environmental goals. Furthermore, this group paid very little attention to the long-term strategy of renewable energy in Kosovo’s energy system. Their moderate approach and stances suggest that they need more detailed knowledge about the impact of renewable energy sources and their environmental, economic, and social benefits, to deepen their perceptions of the positive aspects of their use and conception. Overall, "Moderate Adopters" are a cluster group with potential for further involvement in the energy transition, even though they have a moderate dose of current knowledge. Various activities aimed at informing and informing individuals in the form of better education and communication can help this group have a better attitude and perspective on the benefits of renewable energy and its role in creating a sustainable future for the energy sector in Kosovo.

4. CONCLUSION AND NOVEL FINDING

There is a great deal of potential for theoretical and practical energy production from biomass based on the existing use of energy from biomass sources in Kosovo, as well as the data examined and computations carried out. The by-products of cereals, especially wheat, and maize, the two most significant crops in the nation, should be given priority in this process. If farmers were to use renewable sources of biomass, this would also give those farmers financial advantages, towards achieving greater efficiency. Farmers should try to diversify in terms of products, reduce energy costs, and increase farm productivity. Furthermore, if farmers promote the use and exploitation of by-products for energy needs, as is the case with cereals, this, in addition to increasing their productivity, also contributes to the elimination of environmental damage from the burning of cereal by-products, which was a phenomenon of this last decade. Furthermore, this practice also degrades the microbiological organisms that are in the soil, not forgetting the harmful effect on air quality. Therefore, the sustainable use of biomass also encourages and promotes rural development, thus having a domino effect on all important sectors and areas of rural life.

The livestock sector in Kosovo produces a considerable amount of organic manure, which has environmental effects starting from air pollution, then also the potential for groundwater pollution to the emission of some greenhouse gases, such as methane or nitrous oxide. These emissions are undoubtedly some concerns for the population of the country, in this case, the use of this manure or its further use for energy needs would have positive effects. So a negative aspect can turn into a positive output if it is used further. The location of the farms plays an important role here, that is, the location of the farms to each other or in other words the distance between them, to utilize these resources. In this context, at close distances, the collection of this manure would be much easier and would have a higher efficiency output.

According to this research findings, forest residues offer a substantial biomass potential that is mostly used for home and public institutions. However, centralized monitoring mechanisms must be put in place to guarantee the effective and long-term utilization of this resource. Establishing permissible cutting levels based on yearly forest growth is essential to preventing overexploitation because a significant amount of forests are held by the government. The country's energy supply might be stabilized if this theoretical potential is effectively realized, especially during the winter season. More significantly, it would lessen the need for power for heating, which would ease the strain on the electrical grid and help Kosovo develop a more sustainable energy system.

Even when additional applications are taken into consideration, Kosovo is predicted to have 4.57 million tons of biomass available each year that can be used to produce bioenergy. Although there is a great deal of promise for using biomass in agricultural settings, doing so is still very difficult. This is mostly because of things like low public interest, opposition to change, and a lack of funding from the local government and populace. Taking into consideration these obstacles, adopting energy-efficient habits is a particularly challenging task.

The study aimed to assess the theoretical potential of biomass in Kosovo and the perspective of its use for heating. At the same time, it measured the students' approach towards readiness and awareness of students regarding the environment and the use of renewable energy sources. The findings present different degrees of compatibility with these hypotheses, providing insights into the assessment of the theoretical potential and also the approach of students as future decision-makers. Hypothesis evaluation are as follow:

H1: Biomass has the potential to contribute significantly to Kosovo's total energy consumption.

Biomass is undoubtedly one of the important forms of the renewable energy mix. Another important reason for using biomass for energy needs is the use of agricultural, forestry or solid waste, which have not been used for any other purpose. Such use of biomass for energy needs would also have positive domino effects on the development of jobs or the improvement of the well-being of rural areas. This hypothesis is accepted, due to the finding of 74.6% of total biomass can be used for energy from all of these types of biomass.

H2: A significant proportion of the total biomass in Kosovo is suitable for energy production.

A significant portion of all biomass resources in Kosovo can be utilized for energy needs, especially for heating. By taking this resource into account, Kosovo can then improve its energy supply mix and become more independent and sustainable. Also this hypothesis is accepted by taking into consideration the potential which is calculated to be 23% of Kosovo's overall energy consumption coming from biomass, which is an promising value.

H3: The 15% increase in the price of heating significantly increases students' concerns.

This hypothesis proposes to explore the level of student reaction to the sensitivity of the increase in the price of heating, with the goal of explaining that the level of student concern about the increase in the price is a deciding factor of environmental and economic awarness. This hypothesis is accepted because majority of the students were ready to change if there was 15% increase in heating energy bills, this is a strong indicate of a clear level of awareness and good management of their energy bills.

H4: Students' preferences are at a high level in terms of awareness influenced by environmental concerns in Kosovo.

Based on the environmental challenges that are present in Kosovo, an awareness of students in this regard has been observed. This change in awareness is also very clearly seen in their preferences towards the actions they take in relation to the environment. Over time, it is likely that students will show rationality towards more sustainable practices. This hypothesis positioning it as a key factor in the country's sustainability and the well-being of its population. This hypothesis is strongly accepted by taking into consideration the fact of positive attitude of students, when they were asked about their environmental consciousness, 96% reported they were aware.

In conclusion regarding the BWS method applied to students, the survey results clearly show that students' preferences are increasingly influenced by environmental concerns, with "eco-friendliness" appearing as the most highly valued feature. The considerable emphasis on sustainability reflects an increasing awareness among individuals about the environmental consequences of their decisions. As a result, many people are willing to accept concessions in areas like availability to support ecologically friendly products and services. This shift in consumer behavior is most likely caused by increased awareness of global

environmental challenges such as pollution, resource depletion, and climate change. The comparatively low ranking of "Availability" highlights customers' changing priorities. Given the increased emphasis on environmental effects, convenience is no longer the most important factor driving purchasing decisions.

This shift in consumer behavior reflects larger cultural trends toward sustainability, which are values such as supporting environmentally responsible businesses, reducing waste, and choosing to make choices about specific items. Universities have a role to play in environmental stewardship. By including sustainability in their curricula, they empower their educators to shape students' environmental awareness. Academic offerings should include courses and programs that focus on environmental science, green corporate practices, and sustainability. In addition, colleges should position themselves as sustainability leaders by pursuing interdisciplinary research that advances global environmental stewardship. Universities can use these insights to educate a growing and articulate generation of environmentally conscious individuals who are committed to human rights and critical environmental issues. Collaborations with government organizations, nonprofits, and companies that have similar sustainability goals can bring together universities that will make their commitment to sustainability. These collaborations can include research projects, internships, and events on sustainability that give students hands-on experience in the green economy. Such alliances will not only help to address broader environmental goals, but they will also provide students with important educational opportunities that are in line with current trends. In addition, colleges can reduce their environmental footprint while also equipping students with the knowledge and skills they need to take many more into their professional lives.

Finally, instilling a positive attitude towards renewables is not reported in the Faculty of Agriculture and Veterinary Medicine is critical for driving change in both the agricultural sector and the wider society. Students who can become knowledgeable champions of their successful practices, gaining practical experience and participating in their community. These students can contribute to the transformation of the world towards a more sustainable and resilient agricultural system, which is not the way to adapt their knowledge to the growing demand for renewable energy. The profiles of the four students revealed differences in environmental awareness and involvement in sustainability. The first group, with its high level of environmental awareness, was more likely to encourage the adoption of the renewable path. In contrast, the second and third groups of skepticism, questioning the role of marketing and the real transition to renewables in the country's future. The third group, in nature, showed an unwillingness to change the sources of the fight against rising prices. While demonstrating moderate environmental awareness, the fourth group was ultimately more open to changes motivated by economic incentives and warnings of the meaning of the entire sector of operation.

Moreover, this study had some limitations:

> Inaporpiate avaiability of data: The current research on biomass potential in Kosovo is characterized by a low level of data availability and also updated data. This in a way also explains the lack of research of this

type. But also on the other hand this research is notable for having a great novelty since it is the first of its kind at the national level.

Even though the sampling with student for BWS method was limited to the largest agricultural education institution, it should be noted that Kosovo is a small country with no significant cultural differences, such as the majority of the population belonging to a single nationality. Furthermore, the average age of the population represents the younger generation, which makes the study even more reliable.

Providing financial incentives or, in the case of subsidies, for example, for solutions such as heat pumps or solar panels, could certainly help encourage the use of renewable energy technologies. Overall, many respondents expressed a willingness to switch energy sources in response to rising prices, implying that economic incentives would play a key role in encouraging more environmentally friendly energy options. The findings of this study provide a solid platform for additional comparative research on the function of education in sustainable energy management, which is crucial for the stable future of all sectors in the country. A focused investigation of the knowledge and attitudes of people with post-secondary education compared to other social groups would provide important insights into the overall impact of education on sustainability and energy transition efforts.

In terms of future prospects, studies on algae have shown the fastest development rate and attracted the most attention in the field of biomass utilization research. Interestingly, this category also includes the most cited article in this field. This increase is probably related to the fact that algae are a promising resource for sustainable energy solutions since they have the highest theoretical potential for anaerobic digestion and next-generation fuel production. Given these developing countries' tremendous biomass supplies, fast-expanding economic prospects, and considerable environmental dangers, this tendency is unsurprising. Food, direct combustion, and biogas production are the top priorities in these regions. In contrast, the US focuses on first- and next-generation transportation fuels, whereas in the European Union, other renewable energy sources, particularly wind and solar power, dominate research efforts.

A good recommendation would be to incorporate and develop renewable energy sources into the curriculum of the Faculty of Agriculture and Veterinary as an important process that would provide students with new and adequate knowledge, particularly given the close relationship between agricultural research and renewable energy. Another item to emphasize is the course content's vertical depth. The faculty can introduce additional classes, possibly even electives, for various types of RES to pique students' interest, provide opportunities for growth, and promote their internal motivation.

Policymakers should be focused on precise future steps to reach effective results for practical achievements in terms of biomass utilization.

The following are some significant novelties in this dissertation:

1. I confirm that this dissertation successfully combined the ideas of biomass potential at the country level as regards the state of Kosovo, using different research methods. Based on the data analysis and a significant model of the research results, I conclude that the findings of the theoretical potential has shown a huge importance in the country total energy supply.

2. Based on the bibliometric analysis, the network of keyword co-occurrences related to biomass potential and its utilization from 1974 to 2011, compared to the years 2012-2021, the number of keywords in clusters has changed significantly, moreover the number of keywords in green has increased. Especially the blue cluster has seen a significant increase in popularity over the past decade, resulting in an increase in searches for keywords for third and fourth generation biofuels, such as biofuels, algae, microorganisms, biodiesel, and microalgae. Furthermore, the bibliometric map of search results revealed that third and fourth generation biofuels are now in development and will soon reach the point where they can be produced on an industrial scale.

3. The theoretical potential of the various forms of biomass in Kosvo is calculated to be 6,131,719 t/year. The entire amount that can be used for energy purposes is 4,578,652 t each year. On average, 74.6% of total biomass can be used for energy from all of these types of biomass. According to the estimation, the overall biomass potential that can be used for energy can exceed 26.6 PJ heating potential. Furthermore, it has the potential to account for 23% of Kosovo's overall energy consumption, which is an promising value.

4. The study results unambiguously reveal that environmental concerns are increasingly influencing students' preferences, with "eco-friendliness" emerging as the most highly valued feature. The overwhelming emphasis on sustainability suggests that students are becoming more aware of how their actions influence the environment and are willing to operate with opportunity cost in other areas, in order to support ecologically friendly goods and services.

5. SUMMARY

This topic was carried out to achieve research on the potential of biomass and its prespective for heat use in Kosovo. The topic is important because it highlights the potential that Kosovo possesses in the framework of biomass as a form of sustainable energy, which significantly affects the reduction of dependence on energy generation from fossil sources. By analyzing energy trends in the region and the world, and considering the fact that renewable energy is a sustainable form of energy, it is essential to understand the potential that Kosovo possesses and create long-term energy security that impacts environmental sustainability.

In terms of research, the research objectives are presented as follows:

- Biomass potential and ulitization in worldwide research trends;
- To achieve an assessment of the biomass current volume that exist in Kosovo, including agricultural, forest biomass and waste materials;
- To explore the benefits that could be obtained from the use of biomass in the energy spectrum;
- To find the willingness and perceptions of students, as future decision-makers in terms of the importance of RES and its utilization.

In order to achieve these stated objectives, a combination of research methods were used, including field data collection and analysis, a review of the literature and similar studies that allowed us to make predictions about possible projections in local conditions.

As a result of this research, the author reached the following results:

- Kosovo is a country with a favorable position that positively affects the development of agriculture, as an important sector. Its favorable position also affects the rich potential of forest and agricultural biomass, which play an important role in energy generation, especially affecting the development of rural areas.
- The United States, China, South Korea, Japan, and the United Kingdom are the five largest users of biomass, as well as the top net importers. At the same time, the top countries in terms of net exports are also the largest users of biomass resources, including Brazil, India, Indonesia, Cyprus, and Latvia.
- Organic fertilizer has the capacity to produce 142.6 million m3/year of biogas. Cattle provided the most to this value, accounting for approximately 80%, followed by sheep and goats at around 12%. Biogas has a calorific value of 20-26 MJ/m3, making its total heating value 2853 TJ.
- Combining the biomass from the "cereals" and "forage and green cereals" tables and using it for energy yields a total of 827,281 tons per year. Furthermore, the overall heating value of both tables (cereals, forage, and green cereals) is 3226 TJ.

- The estimated forestry potential resulted in a heating value of 17,285 TJ from 909,720 tons of firewood, based on a calorific value of 19 GJ/tons.
- The fact that 96% of students reported being environmentally sensitive is an extremely encouraging sign of the younger generation's rising dedication to sustainability. With 24% claiming to be highly conscientious and an additional 72% identifying themselves as generally environmentally concerned, it is apparent that environmental awareness is strongly established in the student community.
- The standardized BWS values for Cohen's aspects make it easy to understand the feature order. It should be noted that eco-friendliness is quite important (0.41), but the cost of the equipment (0.39) is also an important consideration. Furthermore, investment cost (0.04) and convenience (0.02) are considered indifferent. The least popular features include multifunctionality (-0.19), knowledge (-30), and availability (-0.38).

The findings from this research lead us to propose that Kosovo should develop a national strategy in line with European Union policies regarding the most effective use of biomass. This strategy should encompass many factors, focusing on promoting investments in infrastructure, promoting local production, and increasing national and international partnerships to ensure an increase in sustainable energy generation from these valuable types of resources.

Ultimately, the research findings and recommendations are useful for policymakers, investors, students and energy sector professionals, while providing detailed and up-to-date data on the comprehensive analysis of biomass potential by type in Kosovo. This research provides data and knowledge about how important biomass is and how important its integration into the country's strategy is, serving as an aid to policymakers in shaping policies that encourage sustainable and efficient energy production, which also impacts environmental and economic sustainability.

6. LIST OF PUBLICATIONS RELATED TO THE DISSERTATION

Articles, studies, book chapters (to be considered as own publications)

1. **Sertolli, A.,** Pestisha, A., Balogh, P., Bai, A.: Prospects of Biomass Heat Energy in Kosovo, its Environmental and Usage Limits
   Biomass. *5*(1), 14, 2025.
   DOI: https://doi.org/10.3390/biomass5010014
   CiteScore: 2.9
   Citations: 0
2. **Sertolli, A.,** Bai, A., Gabnai, Z., Mizik, T., Pestisha, A.: Theoretical and energy biomass potential of heat and electricity production in Kosovo.
   Energies. 16 (20), 1-23, (article ID: 7209), 2023.
   DOI: https://doi.org/10.3390/en16207209
   IF:3
   Quartiles: Q1
   Citations: 5
3. **Sertolli, A.,** Gabnai, Z., Lengyel, P., Bai, A.: Biomass Potential and Utilization in Worldwide Research Trends - A Bibliometric Analysis.
   Sustainability. 14 (9), 1-20, 2022.
   DOI: https://doi.org/10.3390/su14095515
   IF:3.3
   Quartiles: Q1
   Citations: 52
4. Bai, A., **Sertolli, A**., Balogh, P.: Power-to-Gas technologies (PtG, P2G, PtH, PtM)
   New Economics for Sustainability_Time, ELSEVIER (Book chapter)
   DOI: https://doi.org/10.4337/9781035310371.000101
   Published: 22 May 2025
5. Bai, A., Gabnai, Z., **Sertolli, A.,** & Balogh, P.: Biogázcélú algatermesztés és -felhasználás perspektívái hazánkban és Indiában
   ENERGIAGAZDÁLKODÁS 63: Különszám pp. 27-31., 5 p. (2022)
   Publication:32856868

Conference papers

1. “SUSTAINABLE ECONOMY –SUSTAINABLE SOCIETY", International Scientific Conference 2024 – "Biomass heat energy and competitive products in Kosovo, its environmental effects and usage barriers: Applying BWS method", **Sertolli, A.,** Pestisha, A., Bytyci, N., & Bai, A.

2. Conference for PhD Students 2023 – "Research trends in biomass utilization—A Systematic Review", **Sertolli, A.**

List of other publications (not to be considered as own publications, or published in another reseach area)

Articles, studies

1. Bytyqi, N., Bai, A., Balogh, P., Mehaj, E., **Sertolli, A.**: Analysis of consumers' preferences for local cheese in Kosovo applying conjoint choice analysis.
   Journal of Hygienic Engineering and Design. 41, 203-210, 2022.
   IF: 0.158 (2021)
   Quartiles: Q4
   Citations: 6
2. Gabnai, Z., Németh, K., Péter, E., **Sertolli, A.,** Pestisha, A., Mezőfi, N., Bai, A.: Opportunities for wastewater heat recovery in Hungary and its role in the circular economy.
   Abstract. 15 (3-4), 81-90, 2021.
3. Pestisha, A., Bai, A., **Sertolli, A.,** Bytyci, N., Balogh, P.: Farmers' willingness toward energy self-sufficiency in Kosovo
   Energies. 18 (6), 1-32, (article ID: 1332), 2025.
   DOI: https://doi.org/10.3390/en18061332
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   Quartiles: Q1
   Citations: 0

Total IF of journals (all publications): 9.45

Total IF of journals (publications related to the dissertation): 6.3

Scopus/WoS ranking: 3

7. REFERENCES

1. Akhayere, E., & Kavaz, D. (2021). Synthesis of silica nanoparticles from agricultural waste. *Agri-Waste and Microbes for Production of Sustainable Nanomaterials*, 121–138. https://doi.org/10.1016/B978-0-12-823575-1.00028-7
2. Alatzas, S., Moustakas, K., Malamis, D., & Vakalis, S. (2019). Biomass potential from agricultural waste for energetic utilization in Greece. *Energies*, *12*(6). https://doi.org/10.3390/en12061095
3. Alicia English, Anila Qehaja, Flamur Breznica, Arif Hoti, M. W. & J. M. (2015). *Energy consumption and Potentials for Energy Efficiency Implementation: Analyzing Low Income Low Service Areas of Kosovo*. *August 2016*. https://doi.org/10.13140/RG.2.1.4816.1368
4. Almulhim, A. I. (2022). Understanding public awareness and attitudes toward renewable energy resources in Saudi Arabia. *Renewable Energy*, *192*, 572–582. https://doi.org/10.1016/j.renene.2022.04.122
5. Alshahrani, A., Omer, S., Su, Y., Mohamed, E., & Alotaibi, S. (2019). The technical challenges facing the integration of small-scale and large-scale PV systems into the grid: A critical review. *Electronics (Switzerland)*, *8*(12). https://doi.org/10.3390/electronics8121443
6. Ang, T.-Z., Salem, M., Kamarol, M., Das, H. S., Nazari, M. A., & Prabaharan, N. (2022). A comprehensive study of renewable energy sources: Classifications, challenges and suggestions. *Energy Strategy Reviews*, *43*, 100939.
7. Arteaga-Pérez, L. E., Segura, C., Espinoza, D., Radovic, L. R., & Jiménez, R. (2015). Torrefaction of Pinus radiata and Eucalyptus globulus: A combined experimental and modeling approach to process synthesis. *Energy for Sustainable Development*, *29*, 13–23. https://doi.org/10.1016/j.esd.2015.08.004
8. *ASK DATA - Select table*. (n.d.). Retrieved February 18, 2025, from https://askdata.rks-gov.net/pxweb/en/ASKdata/
9. Bai, Z., Liu, Q., Gong, L., & Lei, J. (2018). Thermodynamic and economic analysis of a solar-biomass gasification system with the production of methanol and electricity. *Energy Procedia*, *152*, 1045–1050. https://doi.org/10.1016/j.egypro.2018.09.118
10. Barnett, A., International Development Research Centre, Pyle, L., & Subramanian, S. K. (1978). *Biogas technology in the third world*.
11. Bilandzija, N., Voca, N., Jelcic, B., Jurisic, V., Matin, A., Grubor, M., & Kricka, T. (2018). Evaluation of Croatian agricultural solid biomass energy potential. *Renewable and Sustainable Energy Reviews*, *93*, 225–230. https://doi.org/10.1016/J.RSER.2018.05.040
12. de la Cruz-Lovera, C., Perea-Moreno, A. J., de la Cruz-Fernández, J. L., Alvarez-Bermejo, J. A., & Manzano-Agugliaro, F. (2017). Worldwide research on energy efficiency and sustainability in public buildings. *Sustainability (Switzerland)*, *9*(8). https://doi.org/10.3390/su9081294

13. Deng, L., Liu, Y., & Wang, W. (2020). Biogas technology. *Biogas Technology*, *4*(12), 1–363. https://doi.org/10.1007/978-981-15-4940-3
14. Dombi, M., Kuti, I., & Balogh, P. (2012). Aspects of the sustainable utilization of renewable energy sources. Applied Studies in Agribusiness and Commerce, 6(5), 91-94. https://doi.org/10.19041/APSTRACT/2012/5/15
15. Duque-Acevedo, M., Belmonte-Ureña, L. J., Yakovleva, N., & Camacho-Ferre, F. (2020). Analysis of the circular economic production models and their approach in agriculture and agricultural waste biomass management. *International Journal of Environmental Research and Public Health*, *17*(24), 1–34. https://doi.org/10.3390/ijerph17249549
16. Eaktasang, N., Suma, Y., & Kingkeaw, S. (2019). Feasibility study of municipal solid waste for producing refuse-derived fuel (RDF): A case study of Bangkok, Thailand. *IOP Conference Series: Earth and Environmental Science*, *291*(1). https://doi.org/10.1088/1755-1315/291/1/012010
17. ERO. (2021). Annual Report 2021. In *Government of Kosovo* (Vol. 9, Issue 1). https://www.ero-ks.org/zrre/en/publikimet/raportet-vjetore?q=sq/publikimet/raportet-vjetore
18. European Union EUR-lex. (2020, November 3). *EUR-Lex - 52020DC0098 - EN - EUR-Lex*. https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX:52020DC0098
19. Fang, Y., Paul, M. C., Varjani, S., Li, X., Park, Y., & You, S. (2021). Concentrated solar thermochemical gasification of biomass : Principles , applications , and development. *Renewable and Sustainable Energy Reviews*, *150*(July), 111484. https://doi.org/10.1016/j.rser.2021.111484
20. Fernandez, M. I., Go, Y. I., Wong, D. M. L., & Früh, W. G. (2024). Review of challenges and key enablers in energy systems towards net zero target: Renewables, storage, buildings, & grid technologies. *Heliyon*, *10*(23), e40691. https://doi.org/10.1016/J.HELIYON.2024.E40691
21. Gonzalez-Salazar, M. A., Morini, M., Pinelli, M., Spina, P. R., Venturini, M., Finkenrath, M., & Poganietz, W. R. (2014). Methodology for estimating biomass energy potential and its application to Colombia. *Applied Energy*, *136*, 781–796. https://doi.org/10.1016/J.APENERGY.2014.07.004
22. Group, W. B. (2017). *Biomass-Based Heating in the Western Balkans – A Roadmap for Sustainable Development*. *October*.
23. Heradio, R., De La Torre, L., Galan, D., Cabrerizo, F. J., Herrera-Viedma, E., & Dormido, S. (2016). Virtual and remote labs in education: A bibliometric analysis. *Computers and Education*, *98*, 14–38. https://doi.org/10.1016/j.compedu.2016.03.010
24. IEEFA. (2020). Beyond Coal : Investing in Kosovo ' s Energy Future. In *Institute for Energy Economics and Financial Analysis* (Issue September).
25. Jordan J. Louviere, T. N. F. A. A. J. M. (n.d.). *Best-Worst Scaling: Theory, Methods and Applications - Jordan J. Louviere, Terry N. Flynn, A. A. J. Marley - Google Books*. Retrieved January 29, 2025, from https://books.google.al/books?hl=en&lr=&id=W9uCCgAAQBAJ&oi=fnd&pg=PR8&ots=66x3SO7Dn7&sig=63cEQdh2YPqr3QW6NEcu2V-luOo&redir_esc=y#v=onepage&q&f=false
26. KAS. (2023). *Seria 3 : Statistikat Ekonomike Bilanci vjetor i energjisë në Republikën e Kosovës*

për vitin 2022. Kosovo Agency of Statistics. https://askapi.rks-gov.net/Custom/41b4024f-3fcb-42de-8fe4-fb08ea20c554.pdf

27. Krajnc, D. N., Rok Pisek, M. S., Michael R. Waschak, P. D., & Alicia English, P. D. (2015). *Wood biomass sector in kosovo*. http://www.fao.org/3/a-i4968e.pdf
28. Lajqi, S., Đurin, B., Berisha, X., & Plantak, L. (2020). Analysis of the Potential for Renewable Utilization in Kosovo Power Sector. *Environments*, *7*(6), 49. https://doi.org/10.3390/environments7060049
29. *Lignite mining development strategy*. (n.d.). https://www.esiweb.org/pdf/bridges/kosovo/10/11.pdf
30. MAFRD (2018). Ministry of Agriculture Forestry and rural Development. *Kosovo Green Report 2018*.
31. MAFRD (2023). Ministry of Agriculture Forestry and Rural Development. *G R E E N R E P O R T 2 0 2 2*. https://www.mbpzhr-ks.net/repository/docs/Kosovo__Green_Report_2022.pdf
32. Miftari, A. I., Hoxha, B., & Gjokaj, E. (2015). *Kosovo *: Agricultural Policy Brief (CAPB)*. https://app.seerural.org/wp-content/uploads/2016/11/2015-10_Country-policy-brief-Kosovo-Final.pdf
33. MAFRD (2020). Ministry of Agriculture Forestry and Rural Development. *Green Report 2020*. https://www.mbpzhr-ks.net/repository/docs/Green_Report_2020r.pdf
34. Ministry of Economic Development of Kosovo. (2017). *Energy Strategy of the Republic of Kosovo 2017 - 2026*. *110*(9), 1689–1699.
35. Ministry of Economy of Kosovo. (2021). Energy Strategy of the Republic of Kosovo 2022-2031. In *Ministry of economy*. https://me.rks-gov.net/wp-content/uploads/2023/04/Energy-Strategy-of-the-Republic-of-Kosovo-2022-2031-1-1.pdf
36. Ministry of Economy of Kosovo. (2024). *Ministry of Economy opens the Call for Subsidy of Efficient Heating Equipment for Households*. https://me.rks-gov.net/en/blog/ministry-of-economy-opens-the-call-for-subsidy-of-efficient-heating-equipment-for-households/
37. Ministry of Environment and Spatial Planning of Kosovo. (2015). *Environment , Climate and Water Resources Management* (Issue June).
38. Muriqi, S., Fekete-Farkas, M., & Baranyai, Z. (2019). Drivers of cooperation activity in Kosovo's agriculture. *Agriculture (Switzerland)*, *9*(5), 1–12. https://doi.org/10.3390/agriculture9050096
39. Niñerola, A., Sánchez-Rebull, M.-V., & Hernández-Lara, A.-B. (2019). Tourism research on sustainability: A bibliometric analysis. *Sustainability (Switzerland)*, *11*(5). https://doi.org/10.3390/su11051377
40. OECD. (2018). *Global Material Resources Outlook to 2060 Economic drivers and environmental consequences HIGHLIGHTS*.
41. Okafor, C. C., Nzekwe, C. A., Ajaero, C. C., Ibekwe, J. C., & Otunomo, F. A. (2022). Biomass utilization for energy production in Nigeria: A review. *Cleaner Energy Systems*, *3*(May), 100043. https://doi.org/10.1016/j.cles.2022.100043

42. Peng, F., Peng, P., Xu, F., & Sun, R. C. (2012). Fractional purification and bioconversion of hemicelluloses. *Biotechnology Advances*, *30*(4), 879–903. https://doi.org/10.1016/j.biotechadv.2012.01.018
43. Perea-Moreno, A.-J., Perea-Moreno, M.-Á., Hernandez-Escobedo, Q., & Manzano-Agugliaro, F. (2017). Towards forest sustainability in Mediterranean countries using biomass as fuel for heating. *Journal of Cleaner Production*, *156*, 624–634. https://doi.org/10.1016/j.jclepro.2017.04.091
44. Petrov, P., Zgureva-Filipova, D., Filipov, K., & Ganev, I. (2023). Analysis of the overall potential for electricity production from farm animals manure in Bulgaria. *IOP Conference Series: Earth and Environmental Science*, *1128*(1). https://doi.org/10.1088/1755-1315/1128/1/012001
45. Plate, R. R., Monroe, M. C., & Oxarart, A. (2010). *June 2010 Article Number 3FEA7 Public Perceptions of Using Woody Biomass as a Renewable Energy Source*. *48*(3).
46. Popp, J., Balogh, P., Oláh, J., Kot, S., Rákos, M. H., & Lengyel, P. (2018). Social network analysis of scientific articles published by food policy. *Sustainability (Switzerland)*, *10*(3), 1–20. https://doi.org/10.3390/su10030577
47. Popp, J., Harangi-rákos, M., Petô, K., & Nagy, A. (2013). *Bioenergy : Risks to food- , energy- and environmental Security*. https://ojs.lib.unideb.hu/apstract/article/view/6212
48. Popp, J., Kovács, S., Oláh, J., Divéki, Z., & Balázs, E. (2021). Bioeconomy: Biomass and biomass-based energy supply and demand. *New Biotechnology*, *60*, 76–84. https://doi.org/10.1016/J.NBT.2020.10.004
49. Research, F. (2023). *Typical calorific values of fuels*. Foreset Research. https://www.forestresearch.gov.uk/tools-and-resources/fthr/biomass-energy-resources/reference-biomass/facts-figures/typical-calorific-values-of-fuels/
50. Sahiti, N., Sfishta, A., & Gramatikov, P. (2015). Energy Potential of Agricultural Crops in Kosovo. *Proceedings of the Sixth International Scientific Conference – FMNS2015*, 27–32.
51. Salmerón-Manzano, E., & Manzano-Agugliaro, F. (2018). The higher education sustainability through virtual laboratories: The Spanish University as case of study. *Sustainability (Switzerland)*, *10*(11). https://doi.org/10.3390/su10114040
52. Sertolli, A., Bai, A., Gabnai, Z., Mizik, T., & Pestisha, A. (2023). Theoretical and Energy Biomass Potential of Heat and Electricity Production in Kosovo. *Energies*, *16*(20), 1–23. https://doi.org/10.3390/en16207209
53. Sertolli, A., Gabnai, Z., Lengyel, P., & Bai, A. (2022). Biomass Potential and Utilization in Worldwide Research Trends—A Bibliometric Analysis. *Sustainability (Switzerland)*, *14*(9). https://doi.org/10.3390/su14095515
54. Shao, Z. (2017). On electricity consumption and economic growth in China. *Renewable and Sustainable Energy Reviews*, *76*, 353–368. https://doi.org/10.1016/J.RSER.2017.03.071
55. Silván-Hernández, O., De la Cruz-Burelo, F., Macías-Valadez, M., & Pampillón-González, L. (2017). Theoretical and technical biomass resource assessment from swine and cattle manure in

Tabasco: A case study in southeast Mexico. *Sustainable Energy Technologies and Assessments*, *23*, 83–92. https://doi.org/10.1016/J.SETA.2017.09.005

56. Soltero, V. M., Chacartegui, R., Ortiz, C., & Velázquez, R. (2018). Potential of biomass district heating systems in rural areas. *Energy*, *156*, 132–143. https://doi.org/10.1016/j.energy.2018.05.051
57. Toklu, E. (2017). Biomass energy potential and utilization in Turkey. *Renewable Energy*, *107*, 235–244. https://doi.org/10.1016/J.RENENE.2017.02.008
58. Tun, M. M., Juchelkova, D., Win, M. M., Thu, A. M., & Puchor, T. (2019). Biomass energy: An overview of biomass sources, energy potential, and management in Southeast Asian countries. *Resources*, *8*(2). https://doi.org/10.3390/resources8020081
59. Vassilev, S. V., Baxter, D., Andersen, L. K., & Vassileva, C. G. (2013). An overview of the composition and application of biomass ash.: Part 2. Potential utilisation, technological and ecological advantages and challenges. *Fuel*, *105*, 19–39. https://doi.org/10.1016/j.fuel.2012.10.001
60. Vassilev, S. V, Vassileva, C. G., & Vassilev, V. S. (2015). Advantages and disadvantages of composition and properties of biomass in comparison with coal : An overview. *FUEL*, *158*, 330–350. https://doi.org/10.1016/j.fuel.2015.05.050
61. Ymeri, P., Gyuricza, C., & Fogarassy, C. (2020). Farmers ' Attitudes Towards the Use of Biomass as Renewable Energy — A Case Study from Southeastern Europe. *Sustainability (Switzerland)*, 1–18.
62. Zoltán Szakály, Péter Balogh, Enikő Kontor, Z. G. and A. B. (2021). *Attitude toward and Awareness of Renewable Energy Sources :* 1–25. https://www.mdpi.com/1996-1073/14/1/22

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Subject: PhD Publication List

Candidate: Ardit Sertolli
Doctoral School: Doctoral School of Management and Business
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List of publications related to the dissertation

Articles, studies (5)

1. Bai, A., **Sertolli, A.**, Balogh, P.: Power-to-gas technologies.
In: Elgar Encyclopedia of Energy Economics. Ed.: Menegaki Angeliki, Edward Elgar Publishing, Cheltenham, 377-384, 2025. ISBN: 9781035310371

2. **Sertolli, A.**, Bai, A., Pestisha, A., Balogh, P.: Prospects for Biomass Heat Energy in Kosovo: Environmental Considerations and Usage Limitations.
Biomass. 5 (1), 1-29, 2025. EISSN: 2673-8783.
DOI: http://dx.doi.org/10.3390/biomass5010014

3. **Sertolli, A.**, Bai, A., Gabnai, Z., Mizik, T., Pestisha, A.: Theoretical and energy biomass potential of heat and electricity production in Kosovo.
Energies. 16 (20), 1-23, 2023. ISSN: 1996-1073.
DOI: http://dx.doi.org/10.3390/en16207209
IF: 3

4. Bai, A., Gabnai, Z., **Sertolli, A.**, Balogh, P.: Biogázcélú algatermesztés és -felhasználás perspektívái hazánkban és Indiában.
Energiagazdálkodás. 63 (Klsz.), 27-31, 2022. ISSN: 0021-0757.

5. **Sertolli, A.**, Gabnai, Z., Lengyel, P., Bai, A.: Biomass Potential and Utilization in Worldwide Research Trends - A Bibliometric Analysis.
Sustainability. 14 (9), 1-20, 2022. ISSN: 2071-1050.
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List of other publications

Articles, studies (3)

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   Energies. 18 (6), 1-32, 2025. ISSN: 1996-1073.
   DOI: http://dx.doi.org/10.3390/en18061332
   IF: 3 (2023)

7. Bytyqi, N., Bai, A., Balogh, P., Mehaj, E., **Sertolli, A.**: Analysis of consumers` preferences for local cheese in Kosovo applying conjoint choice analysis.
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8. Gabnai, Z., Németh, K., Péter, E., **Sertolli, A.**, Pestisha, A., Mezőfi, N., Bai, A.: Opportunities for wastewater heat recovery in Hungary and its role in the circular economy.
   Apstract. 15 (3-4), 81-90, 2021. ISSN: 1789-221X.
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