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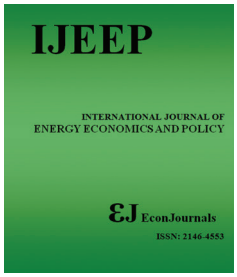
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Impact of Bioenergy on Economic Growth and Development: An European Perspective

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ABSTRACT

The development of a country's economy depends heavily on its access to energy. It is extensively used in agriculture and related industries, including the production and delivery of fertilisers, pesticides, and farm equipment. This study investigated the impact of Bioenergy on economic growth and development in Europe with major focus on Greece. The study used a questionnaire to collect data from 400 professionals in the energy sector in Greece. The study showed that increased bioenergy production positively affects economic growth and development. It was established that there is a significant relationship between dependence on renewable and low-carbon energy systems and investing in sources of bioenergy positively affect economic growth and development. Households require bioenergy for heating, lighting, and cooking. Electricity, coal, petroleum, natural gas, uranium, and other fuels can all be used to produce energy. Bioenergy influences a state's economic performance and a good correlation with the level of innovation in the industry or with energy derived from natural gas. The article discusses the disparity in bioenergy use across nations as well as how they have changed during the investigated time. All of these factors lend credence to the advantages that bioenergy will bring about for the long-term growth of the bioeconomy. Production of bioenergy has the potential to significantly reduce climate change while long-term energy resource diversification is guaranteed.

Keywords: Bioenergy, Bioeconomy, Economic Growth, GDP, Economic Development
JEL Classifications: O44, O10, A10

1. BACKGROUND TO THE STUDY

The world's population has grown exponentially and meeting the demand for clean energy is becoming more and more difficult. The supply of fossil fuels such as coal, oil and natural gas, is dwindling and getting stronger each year - to the point that supplies may well be depleted in the not-too-distant future. As a consequence of this crisis in conventional energy sources, there is an increasing need to strengthen our knowledge on bioenergy use instead of using fossil fuels as much as possible – which will be a major factor in determining economic growth and development around the world (Cui et al., 2022). Bioenergy is a term used to describe the use of biomass and biofuels, as well as other renewable energy sources (Fotourehchi, 2017). It is important in the context of climate change mitigation and sustainable development because it helps reduce the need for fossil fuels such as coal, oil and gas. Bioenergy can play an important role in European policy to decarbonise the energy system. However, the scope for a significant contribution from bioenergy will depend on how successful European countries are at addressing some key challenges such as biomass availability and cost competitiveness with fossil fuels (Philippidis et al., 2016; Stamopoulos et al., 2021).

Since the Paris Agreement was adopted, there has been an increase in interest in reducing climate change on a global scale (Bhuiyan et al., 2022). Achieving the suggested objective will require increasing

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the percentage of energy derived from renewable sources in the energy mix. For a growing quantity of renewable energy, many customers are prepared to pay more, but renewable energy should come from a range of renewable sources (Ntanos et al., 2018). Bioenergy has several benefits over other methods. The cost of generating bioenergy is still less expensive when compared to other renewable technologies, like solar or wind technology (Cîrstea et al., 2019; Žarković et al., 2022). Additionally, bioenergy is a transportable and storable energy source that, when combined with wind or solar energy sources, may provide a workable remedy for intermittent and storage issues (Cîrstea et al., 2019; Kuchler, 2010). The consequences of renewable energy over Europe's energy dependency are highlighted by (Golonis et al., 2022). In addition, several studies provide qualitative models that emerging economies may use to enhance their public policies and improve their energy security and independence (Isik and Radulescu, 2017). Golonis et al. (2022) emphasize that improving energy supply security may be difficult to accomplish at the European level.

The goal of the study is to examine the implications, relationships, and effects of the shift to a sustainable renewable bioenergy economy. This article's goal is to draw attention to the connections between the production of bioenergy and its innovative, technical, economic, and environmental aspects. Energy dependence, CO_2 emissions, fossil fuel production, and level of investment in bioenergy sources as well as their impact on economic growth and development, have been measured.

2. OBJECTIVES OF THE STUDY

This study sought to investigate the impact of Bioenergy on economic growth and development, an European perspective. The study also focused on different specific objectives that include the following;

1. To assess the effect of increased bioenergy production on economic growth and development
2. To explore the relationship between dependence on renewable and low-carbon energy systems on economic growth and development
3. To assess the effect of investing in sources of bioenergy and its impact on economic growth and development
4. To explore the different economic aspects of bioenergy.

2.1. Research Questions

1. What is the effect of increased bioenergy production on economic growth and development
2. What is the relationship between dependence on renewable and low-carbon energy systems on economic growth and development
3. What is the effect of investing in sources of bioenergy and its impact on economic growth and development
4. What are the different economic aspects of bioenergy.

2.2. Hypotheses

H1: Increased bioenergy production positively affect economic growth and development.

H2: There is a significant relationship between dependence on renewable and low-carbon energy systems on economic growth and development.

H3: To Investing in sources of bioenergy positively affects economic growth and development.

2.3. Significance of the Study

The study put much emphasis on Bioenergy and its impact on economic growth and development in Europe and this greatly contributes new knowledge to the area of Bioenergy research.

2.4. Conceptual Framework

Figure 1 shows an illustration of the relationship between the dependent and independent variable.

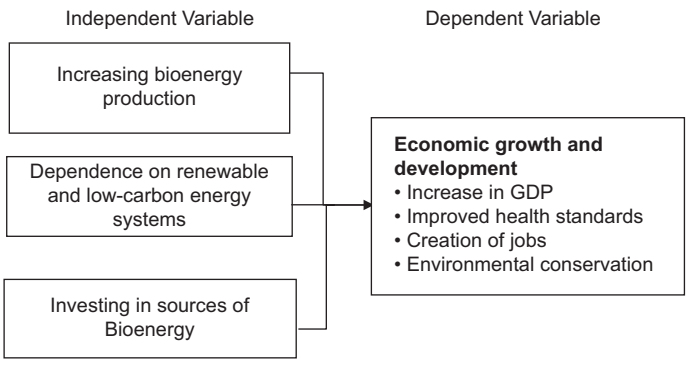
3. LITERATURE REVIEW

3.1. General Overview of Bioenergy

Bioenergy is defined as "the use of renewable energy sources including biogas, biomass (for example wood and organic waste), hydro, geothermal energy and wind (Solberg et al., 2014). Vlad and Toma (2022) revealed that in the European Union in 2013 just over 383 million tons of biofuel was used for electricity generation but by 2020 this will be increased to a massive 1.7 billion tons per year. This sharp increase is due to additional policies like prevailing feed-in tariffs which can give investors the potential for high returns. Bioenergy is the use of bioprocess technology to convert biomass into energy or fuel (Isik and Radulescu, 2017; Liu, 2022). The renewable, strain-free, clean-burning nature of bioenergy can provide a means to combat global warming while contributing to sustainable development. Biofuels are one type of bioenergy; however, so are biomass gasification and chemical processes like cellulose conversion. Biomass conversion can take place in both industrial settings and small family farms, which produces a diverse range of other products for community use that increases food security worldwide (Cui et al., 2022; Vlad and Toma, 2022).

Biomass-based energy is an important component of a sustainable European future, with potential for economic growth and development of rural areas. The EU plans to invest in research, innovation and development to promote the increased use of biomass as a renewable energy resource (Fernández-González et al., 2022). The objective is a long-term sustainable supply of bioenergy contributing to the security and competitiveness of Europe's economies, reducing greenhouse gas emissions,

Figure 1: Conceptual framework



increasing employment opportunities and fostering technological progress (Domac et al., 2005).

Bioenergy is a concentrated form of biomass that can be converted into sustainable fuels or industrial materials and can contribute about 16% of total EU final primary energies, or 8% if international transport is excluded (Wei et al., 2022). The European Union (EU) has set a target for renewable energy to reach 20% of total final energy consumption by 2020, with 10% coming from bioenergy (Stamopoulos et al., 2021). Bioenergy is a broad category that consists of any renewable fuels, primarily from living organisms, used for producing energy. Bioenergy is a new way to generate power in an environmentally sustainable manner. The production process for bioenergy usually has lower environmental and social impacts than conventional fuel sources due to the fact that biomass can take a lot more space than fossil fuels so there is less need for deforestation and land filling (European Commission, 2018).

3.2. European Perspective of Bioenergy

Recently, much attention has been given to renewable sources for power generation, such as solar and wind power. Their existence and role in solving climate change may have overshadowed the usage of bio-energy sources like biomass gasification or bio-methane production that uses agricultural waste, organic wastes from urban families, plantation forestry or even animal dung. A number of policies – such as subsidies, tax exemptions and regulations – have been put in place in Europe to support the development of new technologies, large scale projects and agricultural production.

The European Union (EU) has committed to reducing greenhouse gas emissions by 40% by 2030 compared to 1990 levels (European Commission, 2018). Bioenergy has been identified as an important tool for meeting this target due to its low carbon footprint. Bioenergy is often touted as a saviour from bad environmental consequences of fossil fuel consumption. However, the relative contribution to economic growth two forms of energy have different effects on development (Vlad and Toma, 2022). Busu (2019) revealed that fossil fuels contribute far more greatly than bioenergy does in terms of economic growth rates and poverty reduction rates in Europe. Therefore, biofuel policies should consider development (e.g., by giving support for biofuels which are good for development) as well as environment (e.g., by discouraging food crops).

Bioenergy (including agro-waste, forest resources and renewables) has the potential to contribute significantly to both economic growth and sustainable development. Bioenergy can have positive impacts on rural livelihoods, help reduce poverty by providing jobs in rural economies, provide a safe and secure supply of energy with associated lower cost of living and fewer adverse environmental impacts, while also supporting other areas like transport with biofuels substitutes for fossil fuels (Bhuiyan et al., 2022).

Bioenergy is a term used to cover fuels derived from biomass sources such as wood waste, agricultural waste and various other plant material. Marinaş et al. (2018) examined the importance of bioenergy in Europe and what types of policies are required to ensure that countries can take advantage of its use for growth. Marinaş et al. (2018) found that biofuels sector has a vital role in achieving Europe's sustainability goals and reinforcing its competitiveness on the global market. This is why it is important that policymakers make smart decisions about how to bolster their country's position within this industry through efficient policymaking.

A number of factors contribute to a country' economic growth. Economic growth is primarily influenced by automation (whether due to technological or demographic change), efficiency improvements, business investment and innovation (Stamopoulos et al., 2021). The use of bioenergy in the European Union will have a positive impact on economic growth and development, by reducing dependence on imported fossil fuels, diversifying energy sources, creating new jobs and fostering entrepreneurship (Fotourehchi, 2017; Landsberg, 1980).

3.3. Bioenergy in a Bioeconomy

Majeed et al. (2021) refealed that a "bioeconomy," sometimes known as a bio-based economy, is driving research into innovative alternatives to the fossil fuel-based economy. The sustainable development of renewable bioresources to lessen the consequences of human climate change and dependency on fossil fuels, and the increase of the general value of biomass materials with minimum resource consumption are the two core tenets of the bioeconomy (Majeed et al., 2021). Therefore, assessing the bioresources' potential, converting them into new products, recycling nutrients, or looking at the relationships between climate change adaptation strategies are important avenues for creating a sustainable bioeconomy (GEF, 2012).

Golonis et al. (2022) revealed that bioeconomy is much associated with expanding markets and competitiveness in the bioeconomy; investing in research, innovation, and skill development; and improving the interaction between regulatory policies. The bioeconomy depends heavily on biotechnology, but new technologies must be developed in order to fully use its advantages (Domac et al., 2005; Isik and Radulescu, 2017). However, bioenergy may be essential for ensuring energy security, enhancing the different energy sources, and halting climate change (Apergis and Danuletiu, 2014).

Cui et al. (2022) revealed that bioenergy is important in achieving many of the objectives of sustainable development. The majority of the energy production and consumption methods used today necessitate that a large portion of the energy come from renewable resources. The idea's technical, environmental, and legal aspects have all been thoroughly investigated in recent literature. To understand the vast majority of the processes, consequences, and impacts that bioenergy may have on society, decision-making, business, or policy, research in the economic, social, ecological, or innovative areas is necessary (Forsell et al., 2016; Golonis et al., 2022; Žarković et al., 2022).

According to EU Directive 2009/28/EC, Member States must create strategies to achieve their renewable energy goals. These National Renewable Energy Action Plans demonstrate

the substantial investment that Member States have made in biomass production (European Commission, 2018). It would be necessary to replace fossil fuels and significantly increase biomass consumption in order to transition to a biologically based economy. While bioenergy predominates as a fuel in less developed countries, particularly in remote areas without access to electricity, it is used as a sustainable alternative to hydrocarbons in applications such as transportation, combined energy and heat generation, and residential heating in developed countries (Christensen et al., 1959; Majeed et al., 2021). Calliope et al. (2020) assert that this sector may provide opportunities for both industrial and economic development.

In countries where renewable energy is heavily employed, bioenergy takes up a significant component of the energy mix. Energy independence and climate change are the main forces behind the growth of bioenergy, and they also guarantee a large socioeconomic impact by creating thousands of jobs throughout the whole value chain globally (Calliope et al., 2020). Recent studies have provided extensive analysis of the economic worries, climatic or environmental changes, as well as the feasibility and social consequences of bioenergy, using a variety of important sustainability criteria (Liu, 2022; Syamni et al., 2021). About 75 percent of all renewable energy used globally comes from bioenergy. This kind of energy contributed 1.4% to global energy production in 2015 and 10% to total final energy consumption (Liobikienė et al., 2022).

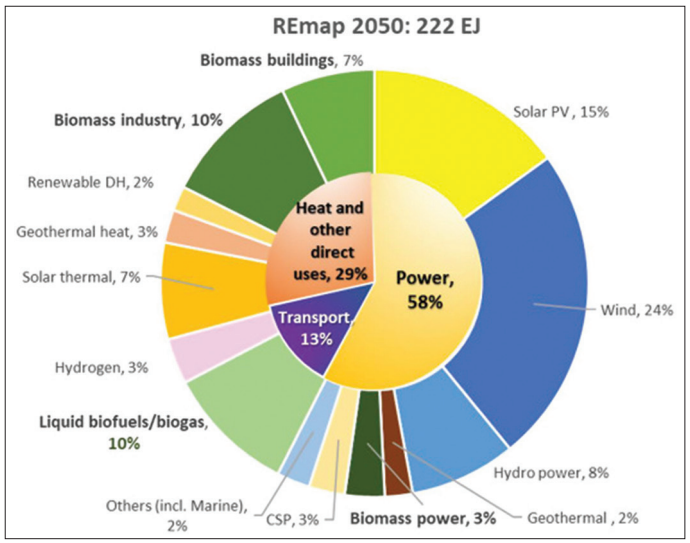
3.4. Bioenergy in Economic Growth and Development

In a world where economic development is on the rise, energy security is a very hot topic. Numerous studies have been conducted in this area, ranging from those that look at the objectives of regulatory policies in reducing energy dependence to those that use neural networks to predict a state's future energy dependence or look into the global aspect of energy security, particularly inter-state dependent relationships (Domac et al., 2005; Janssen and Rutz, 2012; Žarković et al., 2022). The bulk of research examines policy harmonisation and required standards, develops scenarios to predict future national, regional, or global effects and implications of energy dependency, or searches for strategies to lessen energy dependence (Fu et al., 2021).

Cui et al. (2022) revealed that the emergence of a low-carbon society has a higher influence on the energy security of a country with high GDP levels than certain socio-economic situations. According to Cîrstea et al. (2019), the EU has to synchronise its policies in this field, create a competitive market, and provide an appropriate certification system for the bioenergy industry to thrive. Maltsoglou et al. (2010) revealed that areas like Saharan Africa have insufficient energy security and yet disregard the benefits and potential of bioenergy. Bioenergy may aid certain nations in lowering their reliance on foreign oil while also slowing climate change.

The possibilities for renewable energy would be fairly varied on a national scale. This is a result of the abundance of energy resources that are currently available, the anticipated increase in energy demand, the current share of renewable energy sources, and other factors. For all economies, nevertheless, the share of renewable energy must dramatically rise. It is possible to flatten the primary energy supply by raising the gains in energy intensity from its current level of 1.8% to as high as 2.8% per year until 2030 which is consistent with the SDG 7's goal of energy efficiency (Cîrstea et al., 2019). Up until 2050, there is still work to be done (Gozgor et al., 2018; Lacrosse et al., 2021). Improvements in energy intensity will be brought about by energy savings from more energy-efficient renewable energy sources as well as the introduction of efficiency measures (including electrification). With a few minor exceptions, the findings of numerous recent, independent investigations are generally consistent (Devlin, 2013; Syamni et al., 2021).

Figure 2 depicts a breakdown of how renewable energy is used. 222 EJ (EJ) of renewable energy are consumed in total. The electricity sector accounts for 58% of the economy. Increased use of renewable energy in connection with electrification is one example of this (notably electric vehicles and heat pumps). The implementation of this type of renewable energy could potentially fall under the purview of the end-use industries. Particular attention must be paid to the vital roles that wind (24%) and bioenergy (32%, including district heating), play in the deployment of all renewable energy sources (Busu, 2019).



Source: (Busu, 2019).

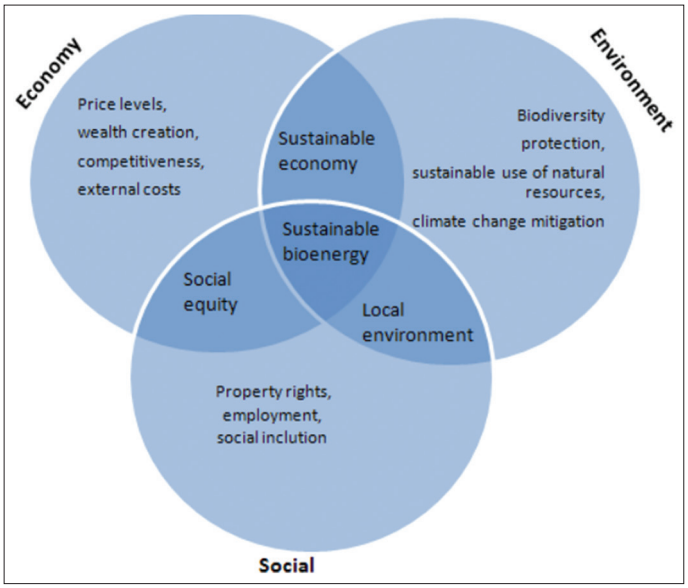
An approach to planning and decision-making that strives to achieve long-term and permanent good consequences on the environment, society, and economy is known as sustainable development (Marinaş et al., 2018). The United Nations Conference on Environment and Development in 1992 and the World Commission for Sustainable Development report from 1987 both contributed to the present concept of sustainability, which includes three dimensions: economic, environmental, and social (Figure 3). Cultural values are also crucial to take into account, particularly in areas with a high level of racial, ethnic, and cultural variety (Camacho Ballesta et al., 2022). The primary components of sustainability are characterised by a high level of interaction and often have a lot of overlap.

International and national energy policies and drivers promote the use of sustainable bioenergy and establish targets for reducing

global warming and energy usage (Figure 2). Recent global trends in woody biomass consumption and bioenergy production are influenced by factors such as energy security and supply, greenhouse gas reduction, and economic growth (FAO, 2016). Sustainable energy generation, economic efficiency, and challenges related to emission reduction must all be taken into account for biomass supply chains to be viable. The capacity of future generations to satisfy their demands must not be compromised in order for the feedstock supply chain to be sustainable advantages from forest biomass must be achieved now (Ntanos et al., 2018).

Natural and managed forests, crops specifically bred for energy, and non-forest trees may all serve as sustainable sources of woody biomass. Another sustainable source of woody biomass for electricity may be byproducts and wood waste from the forestry sector (FAO, 2016). The profitability of forestry and sustainability are influenced by the capacity to develop consecutive cycles of wood without suffering productivity losses (Maltsoglou et al., 2010). Sustainable forest management is a crucial component in producing sustainable energy, and it is crucial that any potential negative impacts, such biodiversity losses, do not exceed the advantages of producing and using bioenergy (Isik and Radulescu, 2017; Remedio and Domac, 2003). If biomass consumption rates do not eventually outpace increase, bioenergy production is regarded as sustainable (Cîrstea et al., 2019; Gaetano, 2022). This guarantees that forests serve as a carbon sink, potentially offsetting CO2 emissions from the creation of wood-based electricity (Figure 2).

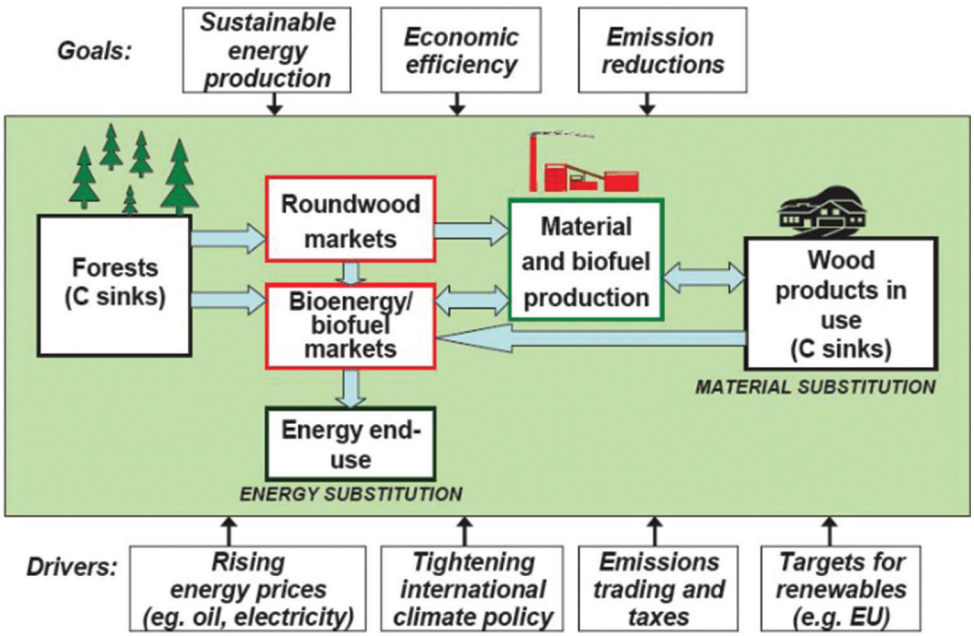
Figure 2: Sustainable bioenergy production



Sutcu and Kemal (2022) discussed how bioenergy can be used to turn around the current situation of low economic growth by providing a boost to agriculture, industry, and employment. According to Sutcu and Kemal (2022), bioenergy would have an overall positive impact on society because it has the potential to increase employment levels while at the same time decreasing costs. This is due to its ability in lowering feedstock production costs as well as a low environmental impact (Kalogiannidis et al., 2022). Additionally, they claim that there would be an increased demand for these fuels as they cut down on greenhouse gas emissions (Bhuiyan et al., 2022; Cui et al., 2022). The use of bioenergy sources (agricultural, forest and biomass) has increased in recent years due to it being a renewable and sustainable source of energy (Bhuiyan et al., 2022; Cui et al., 2022). Bioenergy sources have the potential to lower greenhouse gas emissions, replace fossil fuels and provide electric power in remote areas (Kuchler, 2010; Syamni et al., 2021).

The development of the world economy is mainly influenced by a number of factors. The main reason for the development would be food, water, and energy that are crucial for human life (Fu et al., 2021; Vlad and Toma, 2022). Impacts of these resources

Figure 3: Dimensions of bioenergy sustainability



have been analyzed on economic growth and development. Neuhaus (2016) discussed various impacts in detail with examples and causes associated with them as well as application avenues that are being explored to counter such impacts and found that bioenergy is an important source of clean energy which can lead to sustainable economic growth and long-term development success (Busu, 2019; Cui et al., 2022).

Fankhauser and Jotzo (2018) used the heterogeneous OLS and dynamic OLS techniques to examine the link between biomass energy usage and economic development in G-7 nations. Their empirical investigation found that, like other production inputs like capital and labour, biomass energy use supports economic development. Philippidis et al. (2016) used the limits testing and VECM Granger causality methodologies to evaluate the relationship between biomass energy usage and economic growth for the US economy. The findings demonstrated that using biomass energy both causes and supports economic development.

3.5. Bioenergy in the Greece Perspective

Relevant literature is evaluated with regard to Greece's evidence on use of renewable energy, CO2 emissions, and economic development. Investigating the results of a survey regarding the growth of renewable energy resources in Greece would be a great place to start. Greece's government established some challenging goals for the development of renewable energy sources in the National Renewable Energy Plan, which was enacted in 1988 (Camacho Ballesta et al., 2022; Solberg et al., 2014). The goals of the plan for the year 2000 weren't achieved, according to an analysis of how these resources are now being developed. Numerous financial, legal, structural, and attitudinal restrictions are blamed for the sluggish rate of progress. A thorough approach to overcoming them is suggested after analysing the nature and severity of these restraints (AUC-ECA, 2013; Ministry of the Environment and Energy Greece, 2019). The lack of political commitment and the opposition of certain institutions that seem to feel threatened by the advancement of renewable energy sources are the two main barriers that stand in the way of solving these issues. The remaining issue is whether public pressure will be sufficient to compel the administration to take prompt, decisive action. It is said that planned interventions should not be restricted to the electricity production sector but must also encompass all energy demand and supply sectors in a thorough analysis of the role of renewable energy sources within the scope of the Kyoto Protocol for the instance of Greece (Liobikienė et al., 2022). Greece has a very high potential for renewable energy (RE), particularly for solar and wind resources (Golonis et al., 2022; International Energy Agency, 2017). The Aegean Sea area is very rich in RES, it should be noted. Lesbos, Lemnos, Samothrace, Chios, Andros, Patmos, Kea, Kimolos, and a select few other islands have a significant potential for energy savings in the residential sector, whereas Rhodes, Naxos, Amorgos, Syros, Ios, and Kythnos have a lesser potential (Stamopoulos et al., 2021).

One of the primary sources of fuel for heating in many nations is biomass, particularly fuelwood. According to a poll on public opinion on fuel wood, most people are in favour of the environment. Concerns about environmental preservation and the significance of sustainable development seem to be on their minds (Cîrstea et al., 2019; International Energy Agency, 2017; Ntanos et al., 2018). The demand for fuelwood has increased over time since its price is relatively cheap when compared to that of oil or gas. The average amount of fuelwood used by households was estimated to be 11.5 tonnes during questionnaire surveys on residential fuelwood consumption that were undertaken in Northern Greece (Grevena and Kozani prefectures), with heating being the primary fuelwood usage. The respondents said that because fuel wood is less costly than oil, they prefer it. Reforestation and the construction of forest plantings on agricultural land might be used to provide homes with enough fuel-wood amounts at affordable rates (Kalogiannidis et al., 2022).

Stamopoulos et al. (2021) highlights how the Greek consumer choice has changed as a result of the economic crisis, favouring fuelwood. Examining scenarios involving fuelwood demand and cost is a step towards that preference flip. The study comes to the conclusion that an excessive fuelwood demand might result in a greater rise in anticipated cost than a moderate increase in demand (Liobikienė et al., 2022). In a recent paper, the issue of optimising higher fuel wood transportation costs is discussed. A supply chain network that is optimally designed aims to lower overall costs can benefit both businesses and customers in a variety of ways. When comparing reports on the use of wood fuels in green energy supply schemes in northern Greece and the case of Thrace, it becomes clear that Greece's use of wood fuels improves energy and financial independence, enhances the sustainable management of forestry species, and fosters the production and delivery of indigenous, high-quality energy for heating and cooking while minimising operational, maintenance, and transportation costs (Ministry of the Environment and Energy Greece, 2019).

Regarding photovoltaic systems, Greece's climate makes it a good place for solar technologies. Up to June 2012, more than 820 MWp had been deployed, accounting for 55% of the 2014 national PV goal capacity of 1500 MWp. The first PV systems were linked to the mainland electricity grid in May 2007. The faster construction rate—26 MWp/month in 2011 and 49 MWp/month in 2012—and the fact that 33% of the contractual PV capacity has already been installed make it clear that, despite the nation's current economic crisis, the 2014 PV goal capacity is quite doable (International Energy Agency, 2017; Stamopoulos et al., 2021). Technical issues like the delay in transmission grid expansion may be the sole significant danger to the increase of PV penetration. In a research on photovoltaic innovations and public investment intentions, it was discovered using cluster analysis that there are two clusters, with the second cluster (61% of instances) being more receptive to solar investment, mostly for residential.

Applications (Golonis et al., 2022).

4. METHODOLOGY

4.1. Research Design

The researcher utilized a cross-sectional survey design to understand the relationship between Bioenergy and economic growth and development in Europe. A survey will be developed

and administered through emailing to collect data. The survey contained different questions that were multiple choice, and also based on a Likert scale. The researchers utilized this approach and effectively synthesized the different trends revealed by the collected data. The survey was sent to selected professionals in the energy sector of Greece and these were a representation of the entire Europe.

4.2. Sample

A sample size of 400 professionals in the energy sector of Greece was selected for the study based on a study population of 200,000 professionals across Europe. This was determined using the formula developed by Yamane (1973) as below.

$$n = \frac{N}{1 + N(e)^2}$$

Where

n = sample size sought

N = population

e = level of significance

1 = constant

Using a 5% (0.05) level of significance

Sample size

$$n = \frac{200,00}{1 + 200,00(0.0025)}$$

$$n = 399.57 \cong 400$$

4.3. Data Collection

The study used a questionnaire as a tool for data collection, structured with closed ended questions. The questions were developed in line with the four objectives of the study and using the five point Likert scale. The survey questionnaire was handed to professionals in the energy sector in Greece on prior arrangement. The researchers were in charge of dissemination. The survey questionnaires were given to the respondents via email at the same time. Participants got 1 week (email) to complete the survey questionnaire once it was sent out. The researcher pooled a raw data file from professionals in the energy sector in Greece for data analysis after the participation deadline passed.

4.4. Data Analysis

The quantitative data analysis process involved editing and coding the data. After this, the data will be entered into the computer with the facilitation of Statistical Package for Social Sciences (SPSS) version 20.0 for analysis. Descriptive statistics that provide frequencies and percentages were used to examine the data. Regression analysis and significance levels were performed using the ANOVA statistics of adjusted R2 and beta values. In order to determine the general predictive potency of the various independent factors on the study's dependent variable, regression analysis was carried out. A multiple regression model was crucial in this situation for calculating various predictive values.

$$Y = \beta_0 + \beta_1 X_1 + \beta_2 X_2 + \beta_3 X_3 + \varepsilon \quad (2)$$

Where;

Y = Economic growth and development

β_0 = constant (coefficient of intercept);

X_1 = Increasing bioenergy production

X_2 = Dependence on renewable and low-carbon energy systems

X_3 = Investing in sources of bioenergy

ε = Represents the error term in the multiple regression model

$\beta_1 \ldots \beta_3$ = Represents the three independent variables' regression coefficients.

The study's hypotheses were tested at the 5% level of significance (0.05), and the null hypotheses were accepted or rejected according to the decision rule that states that if $P < 0.05$, the null hypothesis should be accepted and if $P > 0.05$, the null hypothesis should be rejected.

5. RESULTS

The results on characteristics of the study participants are presented in Table 1.

5.1. Demographic Characteristics

Results of the study in Table 1 revealed that slightly more than half of the participants were males 297 (74.3%) and only 103 (25.7%) were females. Concerning the age of respondents. Majority (42.5%) were in the bracket of 36-46 years followed by 31% in the bracket of 25-35 years and only 1.8% were below 25 years. Concerning the years spent in the energy sector, most respondents (46.5%) had spent 5-10 years in in the energy sector followed by 33.5% that had spent 1-4 years in the energy sector and 17.7% had spent above 10 years in the energy sector.

5.2. Descriptive Statistics

The study assessed the effect of increased bioenergy production on economic growth and development, and the results are presented in Table 2.

The results in Table 2 show that majority of the study participants (60.9%) agreed that Manufacturers and producers may make

Table 1: Background characteristics of the study participants

Item	Categories	Frequency	Percent
Gender	Male	297	74.3
Female	103	25.7	
Age of respondent	Below 25 years	7	1.8
25-35 years	124	31.0	
36-46 years	170	42.5	
Above 46 years	99	24.8	
Years spent in Energy sector	Below 1 year	9	2.3
1-4 years	134	33.5	
5-10 years	186	46.5	
Above 10 years	71	17.7	
Total	400	100.0	

Source: Primary data (2023)

Table 2: Bioenergy production positively affect economic growth and development

Statement %	SD	D	NS	A	SA
	%	%	%	%	
Manufacturers and producers may make more money from a smaller output because biomass technology is far more affordable	2.6	11.7	13.1	60.9	11.9
The manufacturing of biodiesel helps a nation's economy by enhancing tax income, and an increase in GDP.	9.8	5.7	20.5	52.4	11.6
Decarbonization in bioenergy production may promote environmental conservation.	10.1	19.9	22.1	37.3	10.7
Bioenergy production creates millions of jobs across Europe	9.2	14.2	14.6	45.2	16.9
Biomass can be produced sustainably and used more widely in many socioeconomic sectors, reducing its impact on the climate and its dependency on fossil fuels.	3.9	6.6	8.2	69.9	11.5

Source: Primary data (2023)

Table 3: Results on relationship between dependence on renewable and low-carbon energy systems on economic growth and development

Statement	SD	D	NS	A	SA
	%	%	%	%	%
Consumption and dependence on biomass energy greatly to reduce the level of CO_2 emissions	6.5	10.3	23.4	48.2	11.7
Modern biomass energy is a substitute to lessen reliance on foreign oil because it is plentiful, renewable, and generated everywhere.	2.1	6.5	14.7	76.7	0.0
Many developed countries' policy makers promote the use of biomass energy as an alternative energy source	2.6	8.5	10.4	64.6	13.9
Most households in Greece depend on conventional energy sources to meet their daily cooking and heating needs.	10.0	50.4	5.2	18.6	45.8
Living a low-carbon lifestyle lowers greenhouse gas emissions and conserves resources which then boosts the economy	11.3	2.6	13.7	70.7	1.7

more money from a smaller output because biomass technology is far more affordable. Concerning whether the manufacturing of biodiesel helps a nation's economy by enhancing tax income, and an increase in GDP, majority of the participants (52.4%) agreed and only 5.7% disagreed. Relatedly, most respondents (37.2%) agreed with the notion that decarbonization in bioenergy production may promote environmental conservation. Regarding whether Bioenergy production creates millions of jobs across Europe, majority (45.2%) agreed and only 9.2% strongly disagreed. Majority of respondents (69.9%) agreed with the biomass can be produced sustainably and used more widely in many socioeconomic sectors, reducing its impact on the climate and its dependency on fossil fuels.

The study also explored the effect of investing in sources of bioenergy and its impact on economic growth and development and the results are presented in Table 3.

From Table 3, most participants (48.2%) agreed with the notion that Consumption and dependence on biomass energy greatly to reduce the level of CO_2 emissions. The results show that 76.7% of the study participants agreed that Modern biomass energy is a substitute to lessen reliance on foreign oil because it is plentiful, renewable, and generated everywhere. Majority of the participants (64.6%) agreed that many developed countries' policy makers promote the use of biomass energy as an alternative energy source. Majority of the participants (50.4%) disagreed with the notion that most households in Greece depend on conventional energy sources to meet their daily cooking and heating needs. It was agreed by most respondents (70.7%) that living a low-carbon lifestyle lowers greenhouse gas emissions and conserves resources which then boosts the economy.

The established the effect of investing in sources of bioenergy and its impact on economic growth and development and the results are presented in Table 4.

The results in Table 4 regarding whether investing in modern bioenergy may serve as a foundation for rural income and employment creation, majority of the participants (48.3%) agreed. Majority of the study participants (47.2%) agreed that as the cost of solar panels, wind turbines, and energy storage batteries decline, renewable energy becomes more affordable, improving the sector's investment appeal. Concerning whether energy crops, algae, and agricultural and forestry waste are all included in biomass, an organic renewable energy source (65.8%) agreed. The results show that 66.2% of participants agreed that producing electricity from fossil fuels with no greenhouse gas emissions while lowering some forms of air pollution. Finally, most participants (61.9%) noted that by generating energy on-site, buying green electricity, or purchasing renewable energy, local governments may set an example for others to follow.

The study also established the different economic and development aspects of bioenergy and the results are presented in Table 5.

The results in Table 5 show that majority of respondents (47.2%) agreed that modern bioenergy can provide a basis for employment

Table 4: The effect of investing in sources of bioenergy and its impact on economic growth and development

Statement %	SD	D	NS	A	SA
	%	%	%	%	
Investing in modern bioenergy may serve as a foundation for rural income and employment creation.	0.0	17.8	22.1	48.3	11.8
As the cost of solar panels, wind turbines, and energy storage batteries decline, renewable energy becomes more affordable, improving the sector's investment appeal.	2.6	15.6	10.3	47.4	24.4
Energy crops, algae, and agricultural and forestry waste are all included in biomass, an organic renewable energy source.	2.6	5.2	15.7	65.8	10.7
Producing electricity from fossil fuels with no greenhouse gas emissions while lowering some forms of air pollution.	3.4	5.7	13.0	66.2	11.7
By generating buying green electricity, or purchasing renewable energy, local governments sets an example for others to follow.	1.3	11.4	3.9	61.9	21.5

Table 5: Economics aspects of bioenergy

Statement %	SD	D	NS	A	SA
	%	%	%	%	
Modern bioenergy can provide a basis for employment and income generation.	1.2	7.8	22.1	47.2	21.7
Bioenergy is important in eradicating environmental pollution in Europe	2.6	15.3	13.4	45.4	23.4
Bio-energy is economically less expensive as compared to fossil fuels.	2.6	5.2	14.7	65.8	11.7
By supplying domestic clean energy sources, bioenergy may help create a more secure, sustainable, and prosperous future.	3.4	5.7	13.0	66.2	11.7
Leveraging the interconnections between bioenergy, environment, and economic policies may increase GDP.	11.9	10.3	4.9	51.3	21.6

and income generation. Majority of the study participants (45.4%) agreed that Bioenergy is important in eradicating environmental pollution in Europe. Concerning whether Bio-energy is economically less expensive as compared to fossil fuels (65.8%) agreed and only 5.2% disagreed. The results show that 66.2% of participants agreed that by supplying domestic clean energy sources, bioenergy may help create a more secure, sustainable, and prosperous future. Finally, most participants (51.9%) noted that leveraging the interconnections between bioenergy, environment, and other economic policies may increase GDP.

5.3. Multivariate Analysis

The results of the analyses were presented in tables as shown below. The hypotheses were to test the relationship between bioenergy and Economic growth and development in Europe. Table 6 below presents results on correlation analysis and coefficient of determination.

The R-value of 0.754 indicates a very significant positive association between bioenergy and Economic growth and development in Europe, which is consistent with the findings in Table 6 above. The three primary characteristics of bioenergy account for 73.1% of the variability in economic growth and development in Europe, according to the coefficient of determination (R-square) of 0.731. Table 7 below presents results on the goodness of fit with respect to the model overall.

The findings in Table 7 above show that the model was statistically significant overall, with an F-statistic of 36.295 and a P = 0.000 (less than the significance threshold of 0.05). So, Economic growth and development in Europe is significantly impacted by the many aspects of bioenergy.

The model also showed that a positive performance of 0.249 would still exist even if all the predictors were kept constant. If all other factors remained unchanged, a one unit change in bioenergy production would result in a 0.003 unit change in economic growth and development. If all other factors remained unchanged, a change in the level of dependence on renewable and low-carbon energy systems would result in a shift of 0.549 in Economic growth and development. If all other factors remained equal, a one unit change in Investing in sources of bioenergy would result in a 0.376 unit change in Economic growth and development.

The statistical significance of each aspect of bioenergy on economic growth and development was equally tested. In view of the results in Table 8 are presented as follows.

Increased bioenergy production was found to be statistically significant in explaining economic growth and development in Europe since the p-value was 0.003 (which is lower than the significance level of 0.05). Therefore, hypothesis One (H1) was accepted meaning that increased bioenergy production positively affect economic growth and development.

Dependence on renewable and low-carbon energy systems was found to positively related to economic growth and development (P = 0.000). This led to acceptance of hypothesis Two (H2) that there is a significant relationship between dependence on renewable and low-carbon energy systems on economic growth and development.

Also investing in sources of bioenergy was found to have a significant effect on economic growth and development since the P-value is (0.013). This led to acceptance of hypothesis Three (H3) that investing in sources of bioenergy positively affects economic growth and development

6. DISCUSSION

The study focused on establishing the impact of bioenergy on economic growth and development, a European perspective. The study showed that increased bioenergy production positively affects economic growth and development. It was established that there is a significant relationship between dependence on renewable and low-carbon energy systems and Iinvesting in sources of bioenergy positively affect economic growth and development. Burning organic material, such as agricultural byproducts and other biomass waste, produces bioenergy, an alternative energy source. Since the 1970s, there has been a steady rise in the usage of bioenergy worldwide. Global bioenergy output increased from 6% in 2000 to 12.3% of the world's net electricity generation in 2011. In order to meet international commitments and reduce greenhouse gas emissions, many countries have set ambitious goals for incorporating high levels of renewable energy into their domestic electricity mix. However, these goals are not being met because of insufficient funding for large-scale projects and incentives that favour conventional fuels like natural gas and coal (Camacho Ballesta et al., 2022; Fankhauser and Jotzo, 2018; Ntanos et al., 2018).

This finding suggests that rising biomass energy consumption has a direct impact on economic development, which in turn encourages rising biomass energy consumption in the nation. For these nations, where biomass energy consumption raises income levels, economic strategies aiming at enhancing the biomass energy infrastructure and expanding the biomass energy supply are the best possibilities. To attain greater economic development, policymakers in the examined nations should take into account enhancing the biomass energy infrastructure and growing the biomass energy. According to empirical findings, these nations must boost their use of biomass energy. In the nations analysed, biomass energy is crucial for economic development. In this situation, biomass energy might be acknowledged as a crucial component of these nations' sustainable growth.

The study showed that bioenergy is renewable energy and normally comes from living or recently living organisms. Bioenergy can be generated from heat, electricity, light and motion that are created by plants and some form of life. The power of bioenergy is unlimited as it relies on the natural process of growth which no external source is needed to keep the cycle going. The use of bioenergy sources (agricultural, forest and biomass) has increased in recent years due to it being a renewable and sustainable source of energy (Cui et al., 2022; Golonis et al., 2022). Bioenergy sources have the potential to lower greenhouse gas emissions, replace fossil fuels and provide electric power in remote areas. It is an important part of the action needed to combat climate change (Calliope et al., 2020; Forsell et al., 2016). It is important to take into account the necessity for the development of the necessary high-tech bioenergy infrastructure when considering how to convert advanced biofuels and biogas into bioenergy with low greenhouse gas emissions. The creation of thresholds to maintain a balance between the need to create clean energy and biodiversity needs was considered by European lawmakers as a way to expedite the process (Landsberg, 1980; Stern, 2004; Wei et al., 2022). Maintaining the proper balance with the help of unambiguous laws is the approach used by the European Union to combat any excessive unsustainable consumption of bioenergy, to combat the growth of the ecological footprint, and to protect the natural biocapacity (Apergis and Danuletiu, 2014; Gozgor et al., 2018). Regarding its expanded ecological agricultural lands, Greece achieved success in this area. In light of this, the present research assesses the European bioenergy elements that may have an effect on the country's sustainable economic growth (Bhuiyan et al., 2022; Janssen and Rutz, 2012). The study also showed that bioenergy can relate to the production and consumption of biological materials, including bioethanol, biogas, and other feedstock materials. The European Union supports a wide range of policies designed to stimulate a sustainable use of bioenergy in Europe (Devlin, 2013; Fankhauser and Jotzo, 2018; Rumpold et al., 2001). Bioenergy continues to be a good source of heat for industrial processes as well as electricity generation which contributes to sustainable economic development. It is also clean if it's sourced from managed forests or other land that has been used for agricultural production or

Table 6: Model summary

Model	R	R square	Adjusted R square	Std. error of the estimate
	0.754[a]	0.731	0.615	0.83402

[a]Predictors: (Constant), Increasing bioenergy production, Dependence on renewable and low-carbon energy systems, Investing in sources of bioenergy

Table 7: ANOVA table

ANOVA[a]					
Model	Sum of squares	Df	Mean square	F	Sig.
Regression	31.489	3	7.196	36.295	.000[b]
Residual	11.287	397	0.330		
Total	43.414	400			

[a]Dependent variable: Economic growth and development. [b]Predictors: (Constant), Increasing bioenergy production, Dependence on renewable and low-carbon energy systems, Investing in sources of bioenergy

Table 8: Regression coefficients

Model	Unstandardized coefficients		Standardized coefficients	t	Sig.	95% confidence interval for B	
	B	Std. Error	Beta			Lower bound	Upper bound
(Constant)	0.249	0.607		0.410	0.684	0.982	1.479
Bioenergy production	0.003	0.213	−0.001	0.013	0.003	0.434	0.428
Dependence on renewable and low-carbon energy systems	0.549	0.092	0.669	5.934	0.000	0.361	0.736
Investing in sources of bioenergy	0.376	0.167	0.246	2.247	0.013	0.037	0.715

[a]Dependent variable: Economic growth and development. [b]Predictors: (Constant), Increasing bioenergy production, Dependence on renewable and low-carbon energy systems, Investing in sources of bioenergy

forestry (Bhuiyan et al., 2022; Fotourehchi, 2017; Fu et al., 2021). Bioenergy therefore has the potential to contribute significantly to increasing energy efficiency in transport and buildings whilst reducing greenhouse gas emissions from combustion processes (Cui et al., 2022; Marinaş et al., 2018; Ntanos et al., 2018).

7. CONCLUSION

The study focused on establishing the impact of bioenergy on economic growth and development in Europe. The research identifies a number of connections between the most significant bioenergy indicators in order to provide a benchmark for the transition to the bioeconomy, taking into account both the literature and its own practical data. The links between bioenergy output and the indices indicating the nation's economic efficiency, degree of innovation, or energy sector capabilities are emphasised based on the created model. Biomass resources may also provide significant advantages for soil, habitat, and land. For instance, certain bioenergy plants (such as native prairie grasses) may flourish on infertile soils that cannot be exploited for farming. Additionally, they may enhance soil health, provide habitat for animals, and aid in preventing pollutants from contaminating surrounding rivers. By using biofuels instead of nonrenewable fuels, the emission of hazardous air pollutants from car tailpipes may be decreased. By generating energy from waste materials found in landfills, mills, and woods, methane that would otherwise be released into the environment owing to the decay of discarded wood and agricultural waste is prevented. Identifying the connections between the production of bioenergy and energy reliance on the one hand, and the production of renewable energy on the other, is one of the primary contributions of the study conducted to the development of the specialist literature, according to the findings obtained. This research offers a unique analytical methodology and demonstrates how changing certain economic, environmental, or innovation parameters affects the output of bioenergy. It is difficult to ignore the importance of energy in the global economy. A major issue, moreover, is that fossil fuel resources are finite and will eventually run out. To mitigate this issue, increasing attention within the scientific community has been drawn towards the use of bioenergy derived from renewable sources such as agricultural waste, crop residues and animal dung as a possible alternative to fossil fuels. Bioenergy can offer countries with a supply of agricultural resources (such as Norway) an opportunity for economic growth and development from any new bioenergy industry which may arise in their country over the next decade.

7.1. Implications of the Study

A few managerial, regulatory, or strategic implications of the research are also included. The first one talks about how bioenergy, which is less expensive than fossil fuels or other renewable energy sources, may boost a state's energy security. The data made available indicate a number of adjustments that may be made to regulatory procedures as well as the way renewable energy sources are subsidised. The study suggests a methodology of quantification of the changes produced by the evolution of certain national indicators for the development of national policies.

The study focuses on determining the bioenergy gap across EU member states as well as the link between bioenergy and a variety of major socioeconomic variables. While the theoretical implications of our results are discussed above, they are merely a starting step in understanding the relationships between bioenergy and other socio-economic variables that it impacts or is impacted by both during and after the current economic crisis. We may predict responses to upcoming economic crises by understanding how these relationships evolve, which will assist to lessen their impact on bioenergy.

7.2. Limitations of the Study

The study's primary weakness is that it only analyses at the level of EU Member States. Therefore, it is impossible to extend the findings to the level of other continents or to the global level. Another drawback was the absence of data for certain nations over a longer time period that would have allowed the detection of various relationships. To comprehend the economic, social, environmental, legal, and commercial dimensions of occurrences, new research, concepts, ideas, and models are always needed due to the complexity, timeliness, and relevance of this subject. Applying global or continental analysis to this present study as a starting point will be a further step to see if there are variations across continents.

7.3. Areas for Future Research

In order to better understand and assess the consequences of the European Commission's decisions and initiatives planned in this respect in the EU nations, this research may be enhanced by adding other variables to quantify the characteristics of sustainable economic development.

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