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Determination of suitable strategies for the development of biomass energy investments in Turkey by AHP method

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Abstract

Biomass energy investments are very important for Turkey. Biomass energy can be an important resource for Turkey's energy security. Considering that Turkey is a foreign-dependent country for energy, these investments will contribute to the country's energy independence. In this context, it would be appropriate for Turkey to take action to increase biomass energy investments. The purpose of this study is to identify appropriate strategies to increase biomass energy investments in Turkey. Within this framework, four different criteria are selected by focusing on literature review. In the following stage, the weights of these items are calculated by AHP methodology. The findings indicate that technological plays an essential role to improve the biomass energy investments in Turkey. Additionally, legal efficiency should also be taken into consideration in this context. However, financial evaluation and customer satisfaction are on the last ranks. It is understood that technological development is of great importance to increase biomass energy investments. Technological developments can contribute to increase efficiency in biomass energy production. Thus, both efficiency of the project will be increased, and the operating costs will be reduced. This situation provides the opportunity to increase the competitiveness of biomass energy projects. Technological developments can also increase the environmental sensitivity of these projects. Owing to advancing technologies, biomass energy projects that do not cause any carbon emissions will be able to be created.

Keywords: Sustainability, Biomass Energy Projects, Energy Investments, AHP
JEL Classification: Q56; O13; Q42

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Türkiye'deki Biyokütle Enerji Yatırımlarının Geliştirilmesine Yönelik Uygun Stratejilerin AHP Yöntemi ile Belirlenmesi

Öz

Biyokütle enerji yatırımları Türkiye için çok önemlidir. Biyokütle enerjisi, Türkiye'nin enerji güvenliği için önemli bir kaynak olabilir. Türkiye'nin enerjide dışa bağımlı bir ülke olduğu düşünüldüğünde, bu yatırımlar ülkenin enerji bağımsızlığına katkı sağlayacaktır. Bu bağlamda Türkiye'nin biyokütle enerji yatırımlarını artırmak için harekete geçmesi uygun olacaktır. Bu çalışmanın amacı, Türkiye'de biyokütle enerji yatırımlarını artırmak için uygun stratejileri belirlemektir. Bu çerçevede literatür taramasına odaklanılarak dört farklı kriter seçilmiştir. Sonraki aşamada, bu faktörlerin ağırlıkları AHP metodolojisi ile hesaplanmıştır. Bulgular, teknolojinin Türkiye'deki biyokütle enerji yatırımlarını iyileştirmede önemli bir rol oynadığını göstermektedir. Ayrıca, bu amaca ulaşabilmek için hukuki alt yapının geliştirilmesi de dikkate alınmalıdır. Ancak mali değerlendirme ve müşteri memnuniyeti son sıralarda yer almaktadır. Biyokütle enerji yatırımlarının artması için teknolojik gelişmenin büyük önem taşıdığı anlaşılmaktadır. Teknolojik gelişmeler, biyokütle enerji üretiminde verimliliğin artırılmasına katkı sağlayabilir. Böylece hem projenin verimliliği artırılacak hem de işletme maliyetleri azaltılacaktır. Bu durum, biyokütle enerjisi projelerinin rekabet edebilirliğini artırma fırsatı sunmaktadır. Ayrıca, teknolojik gelişmeler bu projelerin çevresel duyarlılığını artırabilmektedir. Gelişen teknolojiler sayesinde karbon salımına neden olmayan biyokütle enerji projeleri oluşturulabilecektir.

Anahtar Kelimeler: : Sürdürülebilirlik, Biyokütle Enerjisi Projeleri, Enerji Yatırımları, AHP
JEL Sınıflandırması: Q56; O13; Q42

1. Introduction

Bioenergy is the utilization of energy derived from biological sources. However, there are certain drawbacks to investing in bioenergy (Levenda et al., 2021). Bioenergy facilities may be expensive to build and maintain. Furthermore, the storage and transportation of biomass and biogas might be difficult. As a result, technical advancements and legislative changes are critical to the success of the bioenergy sector (Shahbaz et al., 2020). Therefore, investments in bioenergy may improve environmental sustainability, provide energy security, drive economic growth, and minimize reliance on renewable energy sources (Vakulchuk et al., 2020). However, it is critical to promote technological advancements and regulatory changes in this field. Bioenergy offers significant potential for ecologically friendly energy generation and can be an essential component of the energy sector's future (Olabi & Abdelkareem, 2022). Given the considerations, biomass energy investments have both advantages and disadvantages. As a result, developing the correct methods to boost these investments is critical. According to the literature analysis, one of the most serious problems in this sector is the lack of technical infrastructure (Thellufsen et al., 2020). Since they are projects with a complex structure, a technological and systematic infrastructure is needed to a large extent. Energy policies and incentives are another technique that can be applied to encourage biomass energy investments. For these investments to be effective, government policies must be supportive (Dinçer, et al., 2023). In conclusion, there are several ways to achieve success in biomass energy investments. The important thing here is to choose the best plan among these options. Accordingly, the purpose of this study is to identify appropriate strategies to increase biomass energy investments in Turkey. Within this framework, four different criteria are selected by focusing on literature review. In the following stage, the weights of these items are calculated by AHP methodology.

2. Conceptual Framework

Energy is classified into two types: material energy and light energy. Material energy, on the other hand, is classified into two types: potential energy and kinetic energy. Kinetic energy is the energy that anything that moves possesses. Potential energy, on the other hand, is the quantity of energy that a substance accepts as a result of its physical condition. Energy is fundamental to all economic operations and international politics. Energy is limited, and its sustainability is a worry since it is frequently exogenous. Because energy is such an essential aspect in all economies, it is critical to assess energy sustainability. However, energy production puts significant strain on the environment and frequently relies on limited resources. Energy sustainability entails delivering enough, safe, and economical energy to fulfill social and environmental needs (Paramati et al., 2022). Energy is a critical component utilized in numerous processes, from manufacturing to energy generation. The fast growth of the world's population, industrialization activities, technical breakthroughs, living standards, and consumer expenditures all contribute to a high need for energy. Many different types of energy are employed in various areas (Jiang, 2021).

Energy is a critical aspect in the long-term and economic growth of many countries throughout the world. Nations' industrial and agricultural expansion, as well as their long-term economic and social development, are all dependent on availability to stable energy sources. Governments are developing responsible energy policies in response to rising global energy demand and growing knowledge of the environmental consequences of old energy sources. In this regard, protecting nonrenewable energy

resources in accordance with sustainable development goals is crucial. When the energy policies of governments are evaluated, it is possible to discern aims that alter depending on their access to energy resources, and from this perspective, the countries of the globe may be divided into three major groups (Kober, 2019). Because their own resources are limited, foreign-dependent countries prioritize energy supply security and diversification. Energy-rich countries prioritize the development of their existing energy resources and capacity. In terms of source type, energy may be classified as renewable or non-renewable. The importance of energy in achieving sustainable development cannot be overstated. Renewable and nonrenewable energies have diametrically opposed consequences on policy concerns. However, because changes in business cycle phases impact economic development and energy consumption, choosing between renewable and non-renewable fuels at different times of the business cycle becomes critical (Su et al., 2021).

Non-renewable energy is a source of energy that will ultimately deplete. Many nonrenewable energy sources are fossil fuels including coal, gas, and oil. They are natural resources that are depleted considerably quicker than they are created, even though they take several years to develop and shape. These resources, which cannot be created on a large enough scale to keep up with the pace of use, are frequently in constant supply and are devoured far quicker than nature can restore them. Many companies rely on these natural resources for electricity. Traditional fossil fuels are favored in energy production to fulfill rising demand since they are less expensive. Nonrenewable energy, on the other hand, has significant drawbacks, including severe environmental repercussions and limited supply. Nonrenewable energy sources can be utilized for a variety of purposes. While nonrenewable energy sources account for more than 70% of energy utilized in industrial operations, fossil fuels are also employed for a variety of home functions (Dong et al., 2021). Nonrenewable energy is utilized for things like power, heating, manufacturing, and transportation. Non-renewable energy sources include advantages such as being easy to discover, producing a lot of energy from a small quantity of fuel, and being easy to transport. Nonrenewable energy has the drawbacks of being finite, causing harm to the environment and public health, and increasing expenses (Lund et al., 2021).

Surface mining, also known as open pit mining and mountain top extraction mining, is a broad type of mining in which soils and rocks above a deposit are removed. The dirt and rock that conceals the coal are removed in this procedure, and special equipment is utilized to reveal the coal seam (Wang, 2023). After the cover has been removed, it is replaced, coated with dirt and manure, and the seeds are sown. This aids in the restoration of ecological equilibrium and the prevention of erosion (Dai, 2020). Surface mining has the advantage of being less expensive than underground mining. Surface mining has the problem of leaving lasting markings on the landscape (Onifade et al.,2020). When coal is buried hundreds of kilometers below the surface, it is mined underground.

A continuous miner cuts and loads a rectangular column of coal from the short end, and hydraulically operated self-propelled ceiling supports offer a protective cover. In the underground mining process known as chamber and column mining, retreat mining is the removal of columns. Coal has the greatest average share of nonrenewable energy sources, followed by gas and petroleum oil. In the literature, the high value of coal in the category of non-renewable energy indicators has been related with three key factors: ease of availability, affordability in terms of cheap price, and diversity of applications compared to natural gas and fuel oil. Coal is also a key component in many goods. The coking technique produces coke, city gas, tar, benzene, and ammonia, which are utilized in the iron and steel industry,

heating industry, and chemical industry (Kong et al., 2021)

The combustion technique produces electricity and heat, which are utilized in thermal power plants and heating. The gasification technique is used to produce synthesis gas. This gas is employed in the iron and steel industries, as well as in heating, chemical, and thermal power plants. Finally, the liquefaction technique is used to generate solid oils and synthetic gasoline (Cheng & Pan, 2020). Thermal power plants, transportation, and chemistry all employ these products (Li & Wang, 2019). Coal is a nonrenewable energy source and a fossil fuel that is used to create power. A coal-fired power station is a major source of pollution, emitting significant amounts of particles into the atmosphere as aerosols. Coal has the most carbon of any fossil fuel. This implies that it emits a lot of greenhouse gases, which is detrimental for the environment (Liu & Liu, 2020).

Once recovered from the soil, natural gas is transported to a processing facility where it is purified and divided into its many components (Hu & Gholizadeh, 2020). Natural gas can be difficult to locate since it is sometimes trapped in deep subterranean rocks. Natural gas may also be found in coal seams as coalbed methane, as well as landfill methane (Ruan et al., 2021). While natural gas is a nonrenewable energy source, landfill gas, which originates from decomposing waste, is a renewable supply of methane. Propane, on the other hand, is a natural gas derived from oil and natural gas (Liang et al., 2020). Neutrons, protons, and electrons make up an atom (Wenzhi et al., 2020). They have a core that generates nuclear energy. Nuclear energy in an atom can be obtained in two ways. The sun's operating principle is nuclear fusion, which involves the merging or fusing of atomic nuclei (Pickl, 2019). The alternative approach is nuclear fission, which involves the separation of atomic nuclei. This is the process through which nuclear power reactors create energy. Because its nucleus easily divides when attacked by a neutron, uranium-235 is the most extensively employed type of uranium for energy generation. A neutron bombards the nucleus of a uranium atom during a nuclear fusion process. Uranium is a radioactive element that formed when the universe first started. It is found naturally in certain types of rocks (Dinçer et al., 2022). Because uranium is one of the few easily degradable elements, it is utilized as a fuel in nuclear power plants. Even though uranium may be found all over the world, it is a non-renewable energy source. Environmental concerns and concerns about safe energy use have encouraged governments to explore alternate and cleaner energy sources rather than fossil fuels (Dinçer et al., 2023). Nuclear energy is widely employed in many developed and developing nations as part of the recent shift to clean energy. The role of nuclear energy in the perspective of sustainable development is still debatable. There are concerns about the safety, public health, and societal acceptance of nuclear power plants. Nuclear energy, on the other hand, is recognized as a sophisticated energy technology that provides an alternate energy solution for countries with rising energy demands and decreasing fossil fuel sources. It is also employed as a clean energy source, providing a safe and ecologically beneficial source of energy. In most sustainable energy initiatives, nuclear energy has been employed as an alternate power generating source that improves human capital by supporting creative and ecologically beneficial technology (Yüksel et al., 2023).

3. Renewable Energies

Renewable energy is energy that can be easily replenished. Renewable energy sources are plentiful, long-lasting, and ecologically beneficial. Renewable energy sources, unlike fossil fuels, will never deplete since they are continually regenerated, regardless of how much is utilized. Although fossil fuel resources such as coal and oil may ultimately be depleted, renewable energy supplies will not be depleted if the earth continues to spin (Dinçer, et al., 2023). Wind is just the movement of air (Güney, 2019). Wind turbines are used to generate power. The sun's energy is absorbed at varying rates on the Earth's surface depending on the kind of surface. Land regions, for example, absorb the Sun's radiation at a different pace than bodies of water (Rahman & Velayutham, 2020). Because of the uneven heating of the earth's surface, the air we call wind moves. Wind may be viewed as a basic airflow composed of numerous gases in our environment. It gets its kinetic energy from relatively large-scale phenomena like the rotation of the globe and temperature differences caused by unevenly distributed warming in the atmosphere. Many other factors, such as undulating topography, might influence density dispersion (Mujtaba, 2022). Wind is thus seen as a sustainable energy source since it is renewable, widely spread, and abundant in nature. Increased usage of wind energy can lead to less reliance on fossil fuels and a steady reduction in global greenhouse gas emissions (Dong, et al., 2020). Wind turbines, which are man-made structures, may be used to transform it into power. This power is suitable for both household and business use. Wind turbines transform wind kinetic energy into motion energy, which creates electricity. Wind turbine operation principles may be summarized as follows (Qiu et al., 2020).

Solar energy is energy derived from the sun's beams' heat and light. This is known as radiant energy because the sun emits a lot of it every day. It is a renewable energy source, which means it will never run out. Solar energy may be utilized to generate electricity or to heat air, water, or other liquids. Solar energy is utilized to generate heat in the form of air, water, or other liquids. Solar energy electricity is used to power people's homes, schools, and infrastructure like telecoms and water pumps. Solar technology is classified into two categories. The first is solar thermal technology, in which sunshine is turned into thermal energy or heat (Xiong et al., 2021). Solar energy is often used to heat space or water in most solar energy systems. Day heat systems that use solar energy to create hot water are one example of this form of energy. The other is solar photovoltaic (PV) technology, in which sunlight is directly turned into energy using photovoltaic cells. Annual growth in worldwide energy consumption, as well as environmental challenges and concerns, play major roles in the vast transmission of sustainable and renewable energy. Solar energy systems have received the greatest attention in the previous decade, out of all renewable energy systems. The most essential advantages of solar energy are that it is renewable, which means that it will never run out, that it is simple to create, that it is quiet, and that it is clean (Gao et al., 2021).

The amount of energy that can be generated by a hydroelectric power plant is affected by two elements. Pressure and flow are examples of this (Gyamfi et al., 2020). The pressure determines how far the water falls. Flow is the amount of water that passes through the system. A high head hydroelectric power plant, in general, requires less water flow to produce the same amount of electricity as a low head power station. Hydroelectric power plants, which are considered renewable and clean, are a combined technique for generating energy from water sources. Hydroelectric project investments are essential in developing ecologically friendly energy sources (Fan et al., 2020). Although the adoption of HEPPs remains a contentious subject in the worldwide power market. The energy shift has driven the globe to pursue clean and renewable energy sources in recent years (Stocks et al., 2021).

The heat within the Earth generates geothermal energy. It can generate power, heat houses and buildings, and supply hot water. The Earth's core is made up of incredibly hot molten iron that surrounds a solid iron core (Dalla Longa et al., 2020). When the plates that make up the Earth's crust are pushed and forced apart, the crust can fracture or thin, allowing hot magma plumes to rise into the crust. Drilling exploration wells to locate geothermal reserves near the earth's surface. After locating a resource, production wells are dug to deliver hot water and steam to the surface. In power plants near producing wells, hot water and steam are utilized to generate energy. Injection wells recycle used geothermal fluids back into the reservoir. Geothermal energy has several applications, including heating, manufacturing, spas, agriculture, and aquaculture. Geothermal energy is a carbon-free renewable energy source with unrealized potential to mitigate the threat of climate change (Soltani et al., 2021). To establish a sustainable growth path, the evaluation of technical and economic limits, as well as social and legal difficulties that occur during the execution of geothermal projects, must be addressed. High capital costs, the location and quality of the resource at varied depths, and hostility from local communities are major challenges to large-scale deployment of geothermal resources (Lebbihiat et al., 2021).

Biomass is defined as any live or recently existing organic matter that may be utilized as a source of energy. Simply speaking, biomass is any once-living entity (Popp et al., 2021). As a result, biomass is derived from trees, crops, and seaweed. It can be wood derived from plants or animal waste, for example. All biological stuff includes sun-stored energy. The energy that plants get from the sun is stored in their leaves, stems, fruits, and roots. When we eat plant-based foods, we use the energy they contain to move and grow (Antar et al., 2021). The combustion of biomass, such as wood and waste, produces heat that may be utilized in homes, cooking, and industry. The combustion of biomass can also create power. Organic waste is burnt to generate power in 'energy-from-waste' facilities. Biomass may be utilized to generate methane, a gas that is used in stoves and furnaces. Biogas is a gas that is created by the combustion of waste items and may be used to illuminate homes and prepare food. Biomass may also be processed into ethanol and biodiesel fuels, which can be utilized in a variety of vehicles. One of the finest aspects of biomass is that it is a renewable energy source. This means that through increasing, we can always generate more (Lepage et al., 2021).

The capacity of biomass and biofuels to reduce carbon dioxide emissions is quite limited. Because both biomass and biofuels emit significant amounts of CO2 into the atmosphere when burned. Furthermore, enormous volumes of water are consumed in the process of producing electricity from biomass and biofuels. Wind power, solar electricity, and hydropower are more successful in conserving water, reducing pollution, and lowering carbon dioxide emissions. Solar energy forecasting is a critical component in boosting the competitiveness of solar power plants in the energy market and reducing economic and societal dependency on fossil fuels. It is critical to be able to integrate a larger amount of renewable electricity in the energy mix to create an environmentally friendly and robust electrical grid. Many benefits of renewable energy over fossil fuels include dependability, continuity, cheap operating costs, and reduced global warming emissions. Renewable energy has the disadvantages of being vulnerable to weather conditions and other climatic phenomena, having limited energy supplies, having high development costs, requiring huge installation sites, and not being ubiquitous. Alternative clean energy sources not only address rising energy demand but also improve worldwide environmental quality. Increased usage of renewable energy aids countries in meeting their long-term sustainable development objectives by offering access to inexpensive and clean energy sources.

4. An Evaluation for Biomass Energy Investment for Turkey with AHP Methodology

Biomass energy investments are very important for Turkey. Biomass energy can be an important resource for Turkey's energy security. Considering that Turkey is a foreign-dependent country for energy, these investments will contribute to the country's energy independence. On the other hand, biomass energy is considered a sustainable energy source. This situation contributes to the country not harming the environment while producing energy. Biomass energy provides lower carbon emissions compared to fossil fuels. This can contribute to reducing environmental impacts and combating climate change. In this context, it would be appropriate for Turkey to take action to increase biomass energy investments. In this study, it is aimed to find appropriate strategies to improve biomass energy investments in Turkey. For this purpose, four different criteria are defined as a result of literature review. Table 1 gives information about the details of these criteria.

Table 1: Criteria List

Criteria	References
Financial Evaluation	Carayannis et al. (2023); Wan et al. (2023)
Legal Efficiency	Yüksel and Dinçer (2023); Moiseev et al. (2023)
Customer Satisfaction	Mikhaylov et al. (2023); Ai et al. (2023)
Technological Improvement	Niu et al. (2023); Kou et al. (2023)

These determinants are evaluated with AHP methodology. This technique is considered to find the weights of the factors (Silahtaroğlu et al., 2021; Yüksel et al., 2021; Eti et al., 2023; Dinçer and Yüksel, 2018, 2019). Additionally, hierarchical directions can also be computed by using this approach (Wang et al., 2019; Kou et al., 2021; Dinçer et al., 2023; Li et al., 2021). The details of the weights are given in Table 2.

Table 1: Weights

Criteria	Weights
Financial Evaluation	0,2303
Legal Efficiency	0,2401
Customer Satisfaction	0,2354
Technological Improvement	0,2942

It is determined that technological plays an essential role to improve the biomass energy investments in Turkey. Additionally, legal efficiency should also be taken into consideration in this context. On the other hand, financial evaluation and customer satisfaction are on the last ranks.

5. Conclusions

This study tries to find appropriate strategies to improve biomass energy investments in Turkey. In this scope, four different criteria are defined by focusing on literature review. In the following stage, these items are weighted by AHP methodology. It is concluded that technological plays an essential role to improve the biomass energy investments in Turkey. Additionally, legal efficiency should also be taken into consideration in this context. On the other hand, financial evaluation and customer satisfaction are on the last ranks. It is understood that technological development is of great importance to increase biomass energy investments. Technological developments can contribute to increase efficiency in biomass energy production. Thus, both efficiency of the project will be increased, and the operating costs will be reduced. This situation provides the opportunity to increase the competitiveness of biomass energy projects. Technological developments can also increase the environmental sensitivity of these projects. Thanks to advancing technologies, biomass energy projects that do not cause any carbon emissions will be able to be created.

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