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Article

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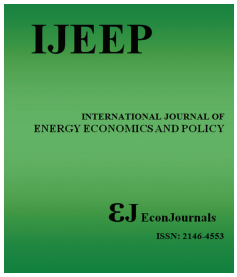

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Features of the Use of Renewable Energy Sources in Agriculture

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ABSTRACT

The article considers the prospects of using renewable energy sources in agriculture. The authors focused on the following types of renewable energy sources: Solar, biomass, wind, and hydro generated power. Based on the analysis of Renewables Global Status Report data, the authors identified a decrease in the amount of investment in renewable energy and fuel by developed countries in developing countries. This work highlights the main reasons for the development of renewable energy (environmental safety, energy independence), as well as positive and negative aspects of the transition to renewable energy. The authors of the article reveal the features of job creation in the renewable energy industries, which will compensate for the loss of jobs in the field of fossil energy. Much attention is paid to the economy of renewable energy sources, revealing the relationship between energy use and economic growth. According to the authors, the use of RES not only increase the level of energy supply to remote rural settlements, but also can have a significant positive impact on the economy of agriculture.

Keywords: Agriculture, Renewable Energy Sources, Energy Economy
JEL Classifications: Q10, Q29

1. INTRODUCTION

Undeniably, agricultural production is the sole provider of human food. With the growing global population, which is projected to rise by 25% in the next 20 years, the demand for food and energy is also expected to increase significantly (Korovin et al., 2018. p. 114). Most of the farming machines and agricultural industries are driven by non-renewable energy sources like fossil fuels that are known to emit greenhouse gases and leads to climate change as well as global warming. In this regard, more sustainable resources tend to reduce growing concerns about the environmental impact of these non-renewable fuels.

One of the main outcomes of the United Nations Conference on sustainable development (2015) was the adoption of 17 sustainable development goals for the period up to 2030 by member States. In relation to this, a separate objective in the field of energy was adopted, in order to confirm the importance of energy as one of the key factors of sustainable development. To achieve this goal by 2030, it is proposed to significantly increase the share of renewable energy in the global energy balance, as well as to intensify international cooperation to facilitate access to research and technology in the field of renewable energy.

In the agricultural sector, the idea of sustainable energy is based on the creation of balance between maximizing agricultural production and promoting economic growth, while also reducing harmful environmental effects. As well, it entails replenishing the agricultural land through the use of renewable inputs such as natural fertilizers.

Thus, the purpose of this study is to identify the possibility of using renewable energy sources in agriculture. To achieve the goal, the following tasks should be performed:

- Review of the literature on the use of renewable energy in agriculture;
- Analysis of the level of development of renewable energy sources in the world;
- Consideration of the economics of renewable sources.

2. LITERATURE REVIEW

Understanding the attributes of the renewable energy in agriculture requires exploring the four main forms of renewable energy sources mainly solar, biomass, wind, and hydro generated power.

Solar energy is the primary source of natural energy. Naturally, agricultural production relies on solar energy in the process of photosynthesis. Lukutin (2008) notes that the sun is the most affordable and environmentally friendly as the use of solar energy on a large scale does not violate the existing energy balance of rural areas.

At the same time, industrial solar energy technologies have been integrated into agricultural activities where it is used as a direct energy source or in supplementing other energy requirements in farms (Chel and Kaushik, 2011. p. 93). For instance, solar energy dryers are used in crop and grain drying and produce a more uniform and quality drying technique than the other energy sources. This is discussed in detail by John and William (2013), they reveal the possibility of using solar energy for various technologies, including for drying crops. A basic solar energy source comprises of a solar collector, solar energy converter and turbines that are fitted to various energy consuming systems like farms and agricultural processing firms.

Biomass is a source of fuel that is generated from dead and decaying plant materials. It is comprised of wood, crop residues, and animal wastes. Given type of energy sources is considered in many different literatures. Batidzirai et al. (2012) detailed the different types of bioenergy potentials such as theoretical, technical, market, environmentally sustainable and implementation potentials. In the works of Daioglou et al. (2016) the main parameters of biomass potential development are related to total land-use change, impact of carbon stocks, net availability of residual biomass, etc. Which are considered and analysed for different future scenarios in terms of land-use change and agricultural management.

Agricultural-industrial economies and farms use biomass energy in various different forms. Mainly, the biomass utilization technologies use biomass raw inputs, which are applied to produce electrical energy in power plants. Chemical process can also be used to convert biomass into fuels such as methane, which is a potential source of fuel in the form of natural gas. Cordell (2010) also notes that biomass, in addition to energy production, can be used to process plant nutrients, especially phosphorus.

The economics of biomass use is based on the fact that the overall quantity of biomass energy available is finite since it depends on the available forested land. Also, biomass energy is minimal in relation to the energy consumption requirements in most developed nations. Thus, it must be supplemented with other energy sources to sustain the agricultural energy requirements.

Hydroelectric power is the current largest source of renewable energy in the world, where it generates 16% of global electricity (Timmons et al., 2014). Since most of the developed nations have a reliable source of water, hydropower has been regarded as a reliable renewable energy source in stimulating agricultural production in farms and industries.

With the introduction of renewable hydropower sources, the smart power grid is being updated to incorporate solar photovoltaic power and wind turbines (Vandaele and Porter, 2015. p. 3). This has promoted efficient transmission of energy into agricultural production activities, thereby increasing agricultural production. In most developed nations, the need to boost agricultural production through the mechanization process, as well as food processing and value addition has been fueled by significant additional hydropower developments such as dam construction. Notably, dam construction and water source availability are the primary external costs used in hydropower generation. This, in turn, influences the potential hydropower generation and reliance among different nations.

By 2010, the United States had developed about 16% of its hydropower technical potential while China is said to have developed only 24% of its technical potential (Timmons et al., 2014. p. 8). However, Lehner et al. (2005) analysed the possible impacts of climate change on Europe's hydropower potential at the country level. The results clearly showed that the hydropower potential in Europe depends on climate change, with a possible reduction of 25% or more for the countries of southern and South-Eastern Europe.

Like hydropower, solar and biomass, the wind power has been used to produce energy since the ancient times. Wind power is produced by the moving air energy which is tapped using modern windmills and wind turbines and then transformed into electrical energy (Bezrukikh, 2010).

Increase in wind velocity means more potential energy and better yield. Also, this translates into lower cost of energy generation for a particular energy quantity. According to Sundararagavan and Baker (2012) for the integration of wind turbines and power systems need three key factors: The displacement of the load frequency support at the levels of transmission and distribution and the quality of power to smooth out power fluctuations.

Ngô and Natowitz (2009) highlight that problems associated with the use of wind energy sources include wind power outages and additional costs of energy transfer to residential areas. Because wind turbines are installed in windy areas where population densities tend to be lower, offshore wind turbines are considered a viable alternative for land-based turbines, especially in areas with limited land resources.

The economic and environmental benefits relating to renewable resources aided by favorable economic and legislative climate are projected to increase the integration of renewable resources in the developed economies. For instance, in the United States, the government and policy makers remain committed to increasing renewable energy which stands at 13% based on annual energy outlook from Energy Information Administration (Vandaele and

Porter, 2015. p. 3). This emphasis on the use of renewable capacity has been increasing significantly since 2005. This linear trend implies that by 2040, the overall energy generation from renewable resources is expected to increase to 67%. Also, this linear increment of renewable capacity will result in 20.5% in market share by 2040, which will be higher than the Energy Information Administration outlook projection of 16% (Vandaele and Porter, 2015. p. 3). Notably, exponential economic growth and government support will be the propelling factors in increasing this projection going forward.

A literary review of the introduction and use of renewable energy sources in agriculture revealed the main driving forces that have allowed to effectively develop this direction:

- Balance of the cost of energy produced from traditional sources and from RES, including in connection with the tightening of environmental requirements for the energy of traditional power plants;
- Continuous reduction of the cost of renewable energy equipment by improving the technological base;
- A systematic approach to the use of renewable energy sources;
- Energy saving, continuous energy loss reduction;
- Availability of a clear, reasoned and full-fledged regulatory framework in the field of renewable energy and energy saving.

3. THE LEVEL OF RENEWABLE ENERGY DEVELOPMENT IN THE WORLD

Inexhaustibility and ecological purity of renewable energy sources are the main reasons for the rapid development of renewable energy in the world and optimistic forecasts of their development in the coming years.

According to the Renewables Global Status Report (2018), new investments in renewable energy and fuel amounted to 280 billion USD in 2017. That is 46 billion USD more than in 2013 (Table 1).

In recent years, the amount of investments made by developed countries has decreased from 133 billion US dollars in 2013 to 103 billion us dollars in 2017. Observed over the last 5 years the increase of the amount of investment developing countries is 76 billion US dollars.

According to the Renewables Global Status Report (2018) in 2017, China, the US, Japan, India and Germany were the leaders of global investments in renewable electricity and fuels. However, when measured per unit of gross domestic product, the Marshall Islands, Rwanda, Solomon Islands, Guinea-Bissau and many other developing countries invest as much or more in renewable energy as developed and developing economies (Table 2).

According to Renewable Energy Statistics (2018), the production of renewable energy sources is increasing annually. Solar energy is developing faster than anyone else. In 2017, compared to 2013, the growth rate of solar power was 275.98%. In second place in terms of growth is wind energy. In this industry, the average annual rate of power growth in the considered period of time was 171.3% (Table 3).

Considering which countries are leaders in the types of renewable energy production (Table 4).

According to the Renewables Global Status Report (2018), China and the US are clear leaders in the production of renewable energy sources.

Table 1: Global new investment in renewable power and fuels in developed, emerging and developing countries, 2013-2017
Billion USD

Indicators	2013	2014	2015	2016	2017	Difference of changes: 2017 in comparison to 2013
Overall investment	234	284	323	274	280	+46
Developed countries	133	151	146	126	103	−30
Developing and emerging countries	101	133	177	148	177	+76

Compiled by the authors using Renewables 2018: Global Status Report, REN21

Table 2: Top 5 countries on investments in renewable energy in 2017

Indicators	Place				
	1	2	3	4	5
Investment in renewable power and fuels (not including hydro over 50 MW)	China	United States	Japan	India	Germany
Investment in renewable power and fuels per unit GDP	Marshall Islands	Rwanda	Solomon Islands	Guinea-Bissau	Serbia

Compiled by the authors using Renewables 2018: Global Status Report, REN21. GDP: Gross domestic product

Table 3: Production of renewable energy sources for 2013-2017 in the world Megawatts (MW)

Types of renewable energy sources	2013 (MW)	2014 (MW)	2015 (MW)	2016 (MW)	2017 (MW)	Growth rate: 2017 in comparison to 2013 (%)
Solar	137899	174139	225033	297019	380572	275.98
Bioenergy	84297	89631	95644	103681	108958	129.25
Hydropower	1032807	1069118	1101616	1130474	1153911	111.73
Wind	299801	349103	416737	467488	513547	171.30
Overall	1554804	1681991	1839030	1998662	2156988	138.73

Compiled by the authors using Renewable Energy Statistics (2018)

There are at least two reasons to develop renewable energy: Environmental safety and energy independence. The obvious advantage of RES is that when the payback period is reached, the generated electricity becomes almost free. The downside is in unstable production, which still has to be reserved by traditional generation. Governments (and more often consumers) have to pay for gas and coal plants to be able to load power units quickly on cloudy or windless days. Humanity is on the way to developing energy storage devices that can solve this problem, but on an industrial scale, these solutions are not yet used.

Other benefits of the transition to renewable energy include the supply of energy-deficient and remote rural areas, as well as the creation of new jobs.

According to the international renewable energy Agency (IRENA), in 2017, the renewable energy industry provided 10.34 million jobs in the world. Among the renewable energy industries, solar energy (3.57 million people) and bioenergy (3.06 million people) were the leaders in the number of jobs. In recent years, there has been a decrease in the number of jobs in hydropower, which are associated with the use of new technologies in production (Table 5).

New jobs that appear with the further development of RES, compensate and block the loss of jobs in the field of fossil energy. However, the macroeconomic benefits of green jobs depend on short-and long-term goals. Developing renewable energy and energy efficiency are typically more labour intensive and more manual labour (in component production, installation and facility maintenance) than is required for the extraction and transport of fuels in more automated and capital-intensive fossil fuels.

4. RENEWABLE ENERGY ECONOMICS

Modern agriculture is the main source of greenhouse gas emissions on the Planet, as well as one of the main consumers of fossil fuels. Therefore, it is advisable to use alternative energy sources for the agricultural economy. After all, some agricultural activities, such as irrigation, can be fed from renewable sources.

The idea of renewable economics is based on the integration of energy saving technologies and promoting energy efficiency during the energy consumption cycle (Kvon et al., 2018). Given the current rate of economic development and socioeconomic modernization of the global economies, the need to promote a high level of secure energy in the production process has increased considerably. The idea is that secure energy has been recognized as the primary pre-determiner of a state development strategy that aims to reduce the ever-increasing threats of non-renewable energy in the long term (Yessengeldin et al., 2018. p. 116). To achieve a secure energy level, global energy security management should be committed to promoting an economically sustainable development of renewable resources.

Fundamentally, sustainable renewable energy entails that there should be an association between energy use and economic growth. The study by Al-Mulali et al., (2014) examines the impact of renewable and non-renewable energy consumption on economic growth in 18 Latin American countries. Based on the results of this study, it is recommended that the countries under study increase their investments in renewable energy projects to increase the role of electricity consumption from renewable sources.

At the same time, the major concept of replacing non-renewable energy with renewable relies on the extensive development of energy production infrastructure (Owusu and Asumadu, 2016). Notably, even when the required technology for higher energy production efficiency is available, renewable energy investments tend to incur high costs of infrastructural development per unit of energy coupled with uncertainties and risks (Er et al., 2018. p. 181). Thus, despite the significant potential of renewable energy, their integration to the total power production remains low in most developed and emerging nations. This is the case in countries such as U.S, China, Kazakhstan, Saudi Arabia, and South Africa.

In Kazakhstan, for instance, some regions experience electricity supply shortage despite having vast renewable resources due to factors such as high energy intensity of the economy, as well as irrational utilization of fuel resources (Abayev, 2018. p. 90). Similarly, countries such as South Africa are experiencing rising pressure of demand over supply due to the unsustainability caused by over-reliance on non–renewable resources like coal technology (Ateba and Prinsloo, 2018). Such problems can be addressed through the integration of infinite renewable energy such as advancement towards hydropower.

Table 4: Top 5 countries by types of renewable energy production in 2017

Indicators	Place				
	1	2	3	4	5
Solar	China	USA	Japan	Germany	Italy
Bioenergy	USA	Brazil	China	India	Germany
Hydropower	China	Canada	Brazil	USA	Russia
Wind	China	USA	Germany	India	Spain

Compiled by the authors using Renewables 2018: Global Status Report, REN21

Table 5: Number of jobs in the renewable energy sector Million people

Types of renewable energy sources	2013	2014	2015	2016	2017	Changes: 2017 in comparison to 2013
Solar	2.27	2.50	2.77	3.09	3.57	+1.3
Bioenergy	2.50	2.99	2.88	2.74	3.06	+0.56
Hydropower	1.74	1.66	1.63	1.52	1.51	−0.23
Wind	0.83	1.03	1.08	1.16	1.15	+0.32
Others	0.89	1.15	1.35	1.28	1.05	+0.16
Overall	8.23	9.33	9.71	9.79	10.34	+2.11

Compiled by the authors using Renewable Energy and Jobs: Annual Review (2018)

The realization of sufficient renewable energy resources to sustain agricultural and economic development globally is a practicable endeavor. In fact, a study by (Chel and Kaushik, 2011) indicated that renewable resources like wind, water, and solar could sustain the global society energy requirements by 2030. Also, it could replace all existing non-renewable energy resources by the year 2050. Given that the approximated demand in energy by 2030 is 17 trillion watts, the provision of wind, solar, and water energy surpasses both agricultural and other sectored energy needs worldwide.

Hence, the use of RES in agricultural energy systems is a promising and feasible task. Agriculture has the greatest potential to unlock the benefits of renewable energy, at the same time addressing the most pressing problems of rural energy supply.

The introduction of integrated energy-efficient systems of autonomous and mixed energy supply of rural buildings using renewable and local energy resources will allow:

- To improve the level and quality of electricity, heat and water supply to rural settlements and buildings;
- To reduce loss of resources, to ensure energy saving;
- To increase energy efficiency; to increase the level of energy supply of remote, dispersed rural facilities of small and medium capacity.

5. CONCLUSION

The concepts of renewable energy sources in agriculture among developed countries are predicated on the balance between maximizing agricultural production while minimizing the use of finite energy resources as well as their environmental effects. Current agricultural production and economic activity rely heavily on fossil fuels such as oil and coal. These energy sources are purely non-renewable can cause detrimental environmental effects. Ideally, the use of renewable resources like hydroelectric, solar power, wind, and biomass in agricultural production has been integrated as a more sustainable and environmentally friendly energy source.

Despite their numerous benefits, however, the adoption of these renewable energy sources depends on the availability of natural resources like wind and water. Also, efficient technologies are needed to establish the necessary infrastructure to integrate these energy sources. The speed of the integration into renewable energy sources will also be highly influenced by policy formulation and support from national governments. Given the fact that the renewable energy is cost-effective, environmentally friendly and can stimulate immense agricultural as well as economic production, all necessary procedures, policy and infrastructural development should be enacted to ensure ultimate reliance on these renewable energy resources in the future.

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