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Review Article

OPPORTUNITIES FOR ALTERNATIVE ENERGY IN UZBEKISTAN: ANALYSIS AND RESULTS

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Abstract
The article explores the widespread use of alternative energy sources in the regions of Uzbekistan, the development of the electricity sector by meeting the population's demand for electricity, and by investing in renewable energy resources. Currently, the population of Uzbekistan is over than 33 million and it is the most densely populated country in Central Asia.
Uzbekistan's demand for electricity in 2019 was 69 billion kWh, while 64 billion kWh of electricity was produced in the country. By 2030, the country's electricity demand will reach 117 billion kilowatt-hours. Unfortunately, electricity generation in the country is highly dependent on fossil fuels and the country's electricity generation infrastructure is relatively outdated. Therefore, it is important to develop alternative sources of energy using the experience of developed countries. Diversification of the fuel balance through the use of renewable energy resources, ie reduction of their share in generating electricity and heat by replacing traditional types of fuels with renewable energy, implementing a long-term program to reduce energy consumption in the economic sectors, and improving the environmental performance of industrial zones.

Keywords alternative energy, capacity expansion, electricity investment, energy efficiency, energy sustainability, renewable energy, Uzbekistan

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INTRODUCTION

The concept of alternative energy began to enter Uzbekistan in the early part of the last century. One of the main reasons for this is that people have come to realize that oil and gas, coal and natural resources will be depleted after a certain period and that they will not be restored. In addition, millions of tons of CO2 emissions from various fuels are causing the ozone layer to decompose.

In ancient times, when oil and gas were not discovered, people used sunlight to heat and dry water.
Hydrocarbon fuels for thermal power plants are increasing year by year and its environmental impact is enormous. Therefore, there is a growing demand for alternative types of energy in the world and research is underway.

The first alternative power plant was launched on September 30, 1882, on Vulcan Street, Wisconsin, USA. Author of the project G.D. Rogers is the CEO of Appleton Paper and Pulp. A generator of about 12.5 kW was installed at the station. The electricity produced at the station was enough for Rogers' home and two paper fabrics.

Until now, only hydroelectric power stations (HPPs) from renewable sources have been developing at the expense of rivers with high flow capacity. Hydroelectric power plants account for about 15-20% of the world's electricity. However, the construction of such hydroelectric power stations will require significant investment and natural conditions. Funds may be available, but natural conditions are not always available. Therefore, hydropower stations are not available everywhere.

Currently, alternative energy sources are becoming more popular around the world, and the results of the surveys show that the largest global energy consumers are China, USA, India, Russia, Japan, South Korea, Germany, Canada, Brazil, Iran, Indonesia, and France.

When analyzing wind energy, windmills have become one of the most important sources of energy production worldwide.

China is the leader among the countries with the best development of wind energy and the best energy generation. It is followed by the USA, Germany, India, Spain, France, Brazil, Canada and Italy. However, we can see that Uzbekistan still does not use wind energy.

While much work can be done to utilize renewable energy, a number of countries have made use of solar radiation as a source of electricity. Germany, China, Japan, Italy, and the United States are the leaders in the use of solar energy**.**

Currently, Uzbekistan pays great attention to the development, search, creation, and improvement of alternative energy sources, and there is a lot of research to improve the efficiency of use.

The strategy of action on the priority directions of development of the Republic of Uzbekistan for 2017-2021 approved by the Decree of the President of the Republic of Uzbekistan Shavkat Mirziyoev "On the strategy of further development of the Republic of Uzbekistan" and modernization of existing and improved fuel and energy resources, as well as renewable energy the implementation of measures to expand the use of resources.

LITERATURE REVIEW

Although investment in renewable energy has been discussed in many studies, practical solutions from developing countries appear to be lacking. According to the International Renewable Energy Agency [IRENA], in 2017 Africa and the Middle East provided just 3% of total renewable energy. Such a small part indicates the need to realize the significant social and economic potential in these areas.

Since most developing countries have problems financing renewable energy projects, the Kyoto Protocol and the Paris Agreement require the help of countries that have more financial resources than poorer countries. This goal can be achieved through FDI, but the political situation in developing countries and the changing economic policies make foreign

investors vulnerable [Ali Shimbar, Seyed Babak Ebrahimi. 2020].

An empirical study of international investment arbitration with five Central Asian states shows that corruption is very large and the energy sector is the most corrupt. Nevertheless, the dilemma caused by corruption does not exceed the level of energy attraction, so many foreign companies, despite the corruption situation, constantly challenge and compete for the energy sector in Central Asia. After all, corruption, although impressive, is one of the factors influencing investor decisions. For countries with energy deficits, meeting energy demand is more important than the risk of corruption [Liu Junxia. 2019].

As one of the main problems in our research on hydropower, which is a form of alternative energy, there are several approaches for the effective use of water in Tajikistan. Responsibility of interested countries, support of international intermediaries and investments is required to prevent and understand water conflicts. The water problem in Central Asia is one of the major problems of today.

We can see that Tajikistan and Kyrgyzstan are located in the water intake area of the Amudarya and Syrdarya rivers flowing from the upstream countries as Uzbekistan, Turkmenistan, and Kazakhstan, as the downstream countries [Karimov et al., 1995]. At the same time, water is required mainly for summer irrigation, and in winter for electricity generation.

Also, another study [Kasra Mohammadi et al., 2014] shows the potential and properties of solar energy monthly and annual global solar radiation and accuracy, as well as monthly average daily light (direct) and dispersed radiation. The optimum angle of the solar surfaces facing south. Similarly, the opportunities and features of wind energy were studied based on hourly, monthly, and annual wind energy analysis. After evaluating the potential for wind energy, appropriate wind turbines were introduced and evaluated for urban installation. These three free economic and industrial zones are important because most traders are doing their business there. Clearly, imported goods such as solar equipment and wind turbines are not subject to customs duties.

The vision of introducing renewable energy sources in Uzbekistan's housing sector has been explored [Eshchanov Bakhtiyor, 2013]. The findings show that the availability of centralized natural gas and electricity and the availability of state-funded funds are the three main factors for renewable energy inflows, a major factor in the reduction of renewable energy prices. It was also found that residents of urban-type apartment buildings have little access to renewable energy because of their small roofs and insufficient space in the neighborhood.

The Weibull statistical distribution function was used to calculate the feasibility study for capacity and annual energy intensity for all regions [Arian Bahrami, etc.]. The results of all the sites considered show that the best places for wind energy development in Uzbekistan are Nukus, Kungrad, White Baytal and Bukhara regions. Also Besides, the performance characteristics of several commercial wind turbines in the range of 1.53.0 MW were studied.

A preliminary assessment of the technical potential of solar energy in the Republic of Uzbekistan was carried out [E. Yu. Rakhimov et al. 2017]. We can see the detailed modeling of the Uzbek energy system and the analysis of the differential effects of the identified policies [Antonio Gomez et al.].

RESEARCH METHODOLOGY

Panel data were collected on 14 subjects of the Republic of Uzbekistan. In processing this data, it is necessary to build econometric models based on the analysis of panel data.

Panel data analysis - there are several objects $(i = 1,\ldots,n),$ short-term follow-up $(t = 1,\ldots,T).$

Each object under consideration is represented by parameters:

$$X_{it} = (X_{it}^{1},\ldots, X_{it}^{k}) \in R^{k}$$

For most panel databases, it is typical for them to track a large number of objects in a relatively short time.
Check it out:

Y_{it} - t in time i a dependent variable for an economic unit:

ε_{it} - compatible error;

We also include "joint" observations and errors.

$$Y = \begin{bmatrix} Y_1 \\ \text{K} \\ Y_n \end{bmatrix}, X = \begin{bmatrix} X_1 \\ \Lambda \\ X_n \end{bmatrix}, \varepsilon = \begin{bmatrix} \varepsilon_1 \\ \Lambda \\ \varepsilon_n \end{bmatrix}.$$

The model relies on the structure of panel data, which allows for the calculation of measurable individual differences of objects [Gardiner and others. 2009]. These differences are called effects (Fixed – effects).

Fixed effect panel data model. In this model, effects are interpreted as a barrier parameter, and the evaluation focuses on their elimination.

The model is described by the equation below.

$$y_{it} = \alpha_i + x'_{it} \cdot \beta + \varepsilon_{it}$$

Value α_i t time-dependent i represents the individual effects of objects, while in regressions x'_{it} there is no constant.

Random effect panel data model (Random-effects model) [Peter Diggle and others. 2002].

In this model, individual differences are assumed to have random features.

The model is described by the equation below.

$$y_{it} = c + \beta_1 x_{it,1} + \Lambda + \beta_n x_{it,n} + u_{it,} i = 1,\text{K}, N;$$
$$t = 1,\text{K}, T$$

$$u_{it} = f_i + \varepsilon_{it}$$

$$\varepsilon_{it} \sim N(0, \sigma_\varepsilon^2),\ f_i \sim N(0, \sigma_f^2)$$

The Hausman test is used to identify endogenous independent variables in a regression model. Endogenous variables are such that their values are determined by other variables in the system[Jeffrey M.2002]. If the model has endogenous independent variables, the least-squares method is not applicable here, since the least-squares method is the relationship between one independent variable and the residual part. In this case, you can use the tool variable input method. First, you need to check whether the independent variables are endogenous. The Houseman test conducts such an investigation.

This article builds a model based on the analysis of panel data by region. A comparison is made between the generation and

consumption of electricity. SWOT analysis of alternative energy sources in Uzbekistan.

ANALYSIS AND RESULTS

It is worth noting that Uzbek scientists also contributed to the formation and development of alternative energy sources. In particular, the first experiences in the field of alternative energy have been studied since the 1950s by academician Ubay Aripov and Sadik Azimov. They have previously designed solar collectors to heat their homes and provide hot water, and several homes have been built and tested.

However, it is clear that at present Uzbekistan is not sufficiently developing innovative research and development activities on alternative energy, and as a result, the use of these sources of energy is slowing. The country uses traditional methods of energy production.

Here, if you look at the situation with electricity generation in Uzbekistan, you will see a 20% increase in electricity generation in 2018 compared to 2010 (Figure 1).

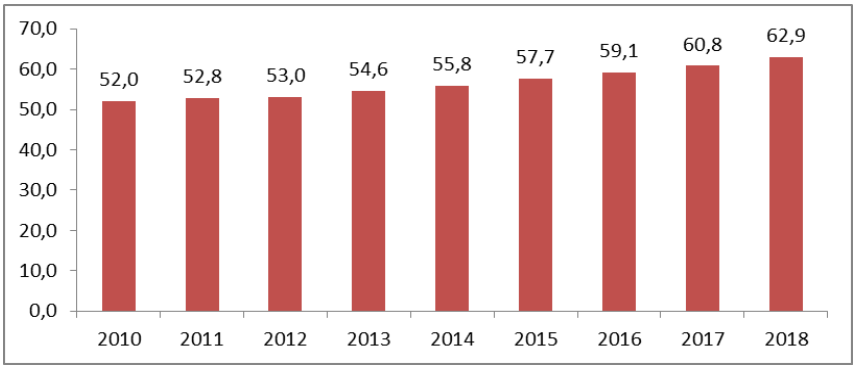

Figure 1. Dynamics of Electricity Production (billions KWh)

Looking at energy consumption in 2016-2018. We can see that electricity consumption increased by only 9% in 2018 compared to 2016 (Figure 2). This indicates that electricity production is underdeveloped.

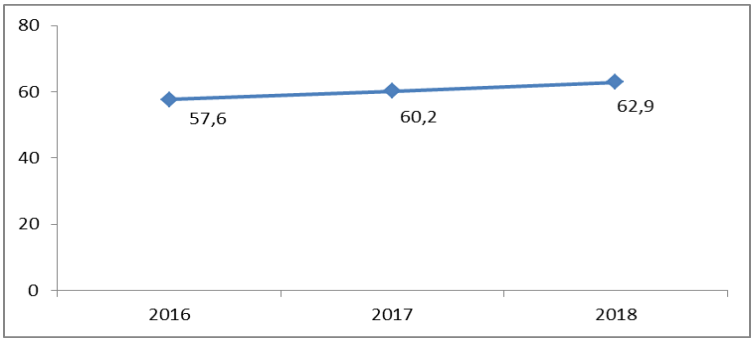

Figure 2. Electricity consumption (billions of kWh)

As the demand for electricity in Uzbekistan grows, so does the need to develop alternative energy sources using the experience of developed countries.

Conducting a SWOT analysis of electricity generation in Uzbekistan by identifying alternative sources of energy, we have identified the advantages and disadvantages of this sector, as well as potential opportunities and threats.

SWOT analysis of alternative energy use

Strengths: • environmentally friendly energy source; • have unlimited resources; • the nature of the revival; • low cost of heat and electricity; • does not produce harmful waste; • photovoltaic modules are durable (30 years or more), easy to install and use; • It provides high-quality electricity when providing local electricity.	**Opportunities:** • Efficient energy use, resource-saving, and energy-saving technologies in local energy systems; • storage of non-renewable resources; • energy independence; • profitable investments for investors; • Application of innovative technologies. • investment attractiveness; • active development of the industry.

Weaknesses:	**Threats:**
• high capital investment; • dependence on solar radiation; • the importance of the useful area for the unit of power; • low technical skills • the high cost of non-renewable energy today; • limited capacity to ensure the sustainability of production activities; • the complexity of technical regulation and licensing; • difficulties with access to networks; • nonconformity of energy production from renewable energy.	• the need to upgrade outdated energy equipment; • inadequate regulatory and legal frameworks; • reconstruction of the energy system; • Insufficient qualification of production and engineering personnel;

The following regional indicators are selected in the model:
Gdp - Gross Domestic Product;
Production - volume of industrial products;
Agriprod - volume of agricultural products;
Popul - population;
Services - volume of rendered services;
Constr - volume of construction works;
Elenprod - electricity production.

Fixed – effects (within) regression

$$\hat{y} = -10096{,}29 + 0{,}382 \cdot \text{indprod} + 0{,}5825 \cdot \text{agriprod} + 5{,}018 \cdot \text{popul} + 0{,}7686 \cdot \text{servies} - 0{,}128 \cdot \text{constr} + 0{,}258 \cdot \text{elenprod}$$

$$F(6{,}106) = 2282{,}24 \quad prob = 0$$

According to the fixed-effect analysis, the following results were obtained:
When industrial production increases by 1 billion soum, GDP will increase by 0.382 billion sums.
If the volume of agricultural products rises by 1 unit, GDP will increase by 0.5825 billion sums.
An increase in population per 1 person will cause GDP to increase by 5,018 billion sums.
If services increase by 1 unit, GDP will increase by 0.7686 billion sums.
When the volume of construction works goes up by 1 billion sums, the GDP will decrease by 0.128 billion sums.
If electricity production increases by 1 kWh, GDP could increase by 0.258 billion sums.

Random – effects GLS regression

$$\hat{y} = -695{,}5612 + 0{,}3328 \cdot \text{indprod} + 0{,}6933 \cdot \text{agriprod} + 0{,}5605 \cdot \text{popul} + 0{,}7467 \cdot \text{servies} + 0{,}2626 \cdot \text{constr} + 0{,}125 \cdot \text{elenprod}$$

$$F = (6.106) = 12180.61 \quad prob = 0$$

The result of the fixed effect panel data model is as follows:
When the rate increases by 1 som, GDP will increase by 0.3328 billion sums.
If the volume of agricultural products per unit, GDP will increase by 0.6933 billion sums.
Population growth per 1 person will increase GDP by 0.5605 billion.
If services increase by 1 unit, GDP will increase by 0.7467 billion sums.
When the volume of construction works goes up by 1 sum, GDP will increase by 0.2626 billion sums.
If electricity production increases by 1 kWh, GDP could increase by 0.125 billion sums.

Table 3. Hausman test results

	(b)	(B)	(b-B)	
	fe	re	Difference	S.E.
indprod	0,3823002	0,3328306	0,0494697	0,0118609
agriprod	0,5825168	0,6933068	-0,11079	0,0380591
popul	5,018224	0,5605975	4,457626	1,457874
services	0,7686389	0,746757	0,0218818	0,0159459
constr	-0,1280457	0,2626104	-0,3906562	
elelnerprod	0,2581068	0,1251725	0,1329343	0,0626336
	b = consistent under Ho and Ha;			
	B = inconsistent under Ha, efficient under Ho;			
	chi2(6) = 20,73			
	Prob > chi2 = 0,0020			

According to the Hausman test results, it is possible to reject the null hypothesis that the difference in coefficients of fixed effect and random effect models is not systematic. Because the p-value of the Chi-square test statistic is less than 0.05. It means that the random effect model is quite different from the fixed effect model. Therefore, the result implies that we should use the fixed-effect model to conclude about the relationship between independent variables and the dependent variable.

CONCLUSION

In conclusion, it is necessary to study the experience of alternative energy sources in the developed countries, to introduce new technologies and technologies that are appropriate to the conditions of the country, to further improve the alternative energy sources. The growing demand for electricity in Uzbekistan requires the use of alternative energy sources. We need more solar, wind and biogas plants installed in the country, and we need more electricity. In the development of alternative energy sources, it is advisable to study the climatic conditions and conditions of the regions and

develop them according to the types of alternative energy sources.

When using alternative energy sources, first of all, we get natural energy without damaging the environment and transferring our fossils to future generations. Secondly, the population will be fully supplied with electricity. Thirdly, the society creates opportunities for production, service, export, and import. As a result, new businesses will be established, new jobs will be created and the welfare of the population will increase.

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