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RENEWABLE ENERGY SOURCES AND THEIR IMPORTANCE IN CENTRAL ASIAN COUNTRIES

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Abstract

Renewable energy is becoming increasingly important day by day, the main reasons for this are the constant increase in the world's population and the increasing demand for energy, the decreasing natural resources year by year, and climate change, which is a major problem worldwide. Renewable energy is not only considered a priority in the socio-economic sphere, but is also becoming a state priority for all countries today.

This article presents an econometric analysis of renewable energy sources in Central Asian countries (Uzbekistan, Kazakhstan, Kyrgyzstan, Tajikistan, Turkmenistan, and Afghanistan), their growth trends, and their current significance at the country level.and statistical analyses and forecasts for the next 5 years were carried out.

Keywords: Renewable energy, low-carbon energy, clean energy, energy efficiency, energy efficiency.

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INTRODUCTION

In the last few years, the concept of renewable energy has been rapidly increasing its impact on the life of every society, and we can point to several factors as the main reasons for this, for example, the steady increase in the world population, the daily depletion of natural resources, the negative externalities resulting from climate change, the direct dependence of all sectors of industry on energy sources today, issues of state security, the social sphere, etc. Therefore, the need for environmentally friendly, renewable, clean energy is one of the most pressing issues of our time.

Central Asian countries toois implementing a number of targeted plans and programs to increase the level of renewable energy within its capabilities.

A number of works are being carried out in our country on renewable and clean energy issues. In particular, in light of today's most pressing issues, the esteemedPresident Shavkat Mirziyoyev touched upon the issues of ecology and climate change in his speech at the session of the Legislative Chamber of the Oliy Majlis. Having thoroughly studied the opinions and wishes of our people and based on the recommendations made, in order to raise the work in this area to a new, higher level, President Shavkat Mirziyoyev proposed declaring 2025 the "Year of Environmental Protection and the "Green" Economy" in our country[1].

Also, Resolution No. 13 of the Cabinet of Ministers of the Republic of Uzbekistan dated January 8, 2024 “On the regulation and development of the sector of energy supply based on renewable energy sources”[2] sets out priority tasks for the development of this sector.

Resolution No. 128 of the Cabinet of Ministers of the Republic of Uzbekistan dated March 13, 2024 “On measures to implement the Innovation Development Strategy of the Republic of Uzbekistan for 2024-2025”[3] II. Goal 9 of the direction of increasing the share of innovatively active organizations by improving institutional mechanisms for state support of innovative activities sets the tasks of “concentrating resources in the implementation of artificial intelligence, the Internet of Things and digitalization technologies in strategic areas such as renewable energy, new composite materials, robotics, biotechnology, food safety, smart agriculture, smart medicine, smart industry and clustering (copper and winemaking) based on the principles of a green economy, creating new jobs and products, and organizing new services.”

The President of the Republic of Uzbekistan Sh.M. Mirziyoyev's decree of January 30, 2025 "The decree "On the State Program for the Implementation of the Uzbekistan-2030 Strategy in the Year of Environmental Protection and the "Green Economy""[4] has developed targeted plans to increase the share of renewable energy sources in electricity generation to 26 percent and their share in the total generation capacity to 40 percent by launching a large solar and wind power plant with a total capacity of 4.5 GW, installing solar panels with a capacity of 785 megawatts, and constructing hydroelectric power plants with a capacity of 225 megawatts, which in turn highlights the importance of this sector today.

As of 2023, Kyrgyzstan and Tajikistan are leading not only in Central Asia, but also in the entire former Soviet Union in terms of the share of renewable energy sources in electricity generation. By 2024, the share of renewable energy sources (primarily hydropower) will be 87 percent in Kyrgyzstan and 92 percent in Tajikistan. Kazakhstan and Uzbekistan lag

significantly behind them in this indicator. For comparison, the share of renewable energy sources in Kazakhstan is 11 percent, and in Uzbekistan it is 8 percent [5]. The difference between these two countries is that the basis of their energy resources is hydrocarbon energy resources. However, Uzbekistan and Kazakhstan also have the opportunity and are interested in using renewable energy sources. Uzbekistan, taking into account the potential growth in electricity consumption, consumes almost all hydrocarbons produced in the country.

In general, in recent years, we can see significant progress in renewable energy in all Central Asian countries, and at the heart of this work isWe must emphasize that it is important for countries to pursue rational policies on renewable energy.

Literature Review

The main goal of using renewable energy sources is to avoid depleting valuable resources, limiting greenhouse gas emissions and global salt migration, not negatively affecting the erosion of the earth's surface, and not producing energy in vain[6].

All types of energy resources are the result of natural transformations of solar energy. Coal, oil, natural gas, peat, combustible rocks, and wood are reserves of solar radiant energy captured and absorbed by plants[7].

The countries of the world are divided into the following groups in terms of electricity generation: the first group includes the Russian Federation, the United States and Western European countries, which mainly generate electricity through thermal power plants. They mainly use natural gas, fuel oil and coal to generate electricity; the second group includes China, Australia, Mexico, Romania, the Netherlands and Poland. They mainly use natural gas to generate electricity; the third group includes Honduras, Colombia, Kenya, Brazil, New Zealand, Austria and Paraguay. They mainly generate electricity through hydroelectric power plants; the fourth group includes Japan, France and Belgium. They mainly generate electricity using nuclear energy[8].

Research methodology

This article attempts to analyze the renewable energy development indicators of Central Asian countries over the past 13 years using econometric analysis in the Stata program based on sample observations and to provide forecasts for the next 5 years using ARIMA and Holt-Winters nonseasonal smoothing models.Also, the methods of comparative analysis of opportunities for increasing the efficiency of the use of renewable energy resources in the countries of Central Asia, the study of statistical data and economic comparison and analysis, logical thinking, scientific abstraction, analysis and synthesis, induction and deduction were widely used.

Analysis and Results

In general, today it is impossible to imagine any industry without energy.But energy sources are not an area with inexhaustible natural reserves, so today we can divide energy into the following types.

According to the conversion ability of energy resources:

a. Primary energy sources: coal, oil, natural gas, biomass, solar, wind, hydropower, nuclear, etc.

b. Secondary energy sources: electricity, heat, electromagnetic, etc.

In terms of the availability of energy resources:

a. Traditional energy sources: coal, oil, natural gas, nuclear, etc.

b. New energy sources: solar, wind, hydropower, biomass, etc.

In terms of renewable energy sources:

a. Againnon-renewable energy sources: coal, oil, natural gas, nuclear, etc.

b. Againrenewable energy sources: solar energy, wind, hydraulic, wave energy, temperature gradient energy, biomass energy, flow energy, water flow energy, etc.

According to the losses and damages they cause to the ecosystem:

a. Dirtyestimated energy sources: coal, natural gas, nuclear power, oil, large dams, etc.

b. Clean energy sources: wind energy, solar energy, biomass, non-dammed hydropower, hydrogen energy and etc.[9].

In this article, we have attempted to analyze the current state of renewable energy in Central Asian countries. The table below shows the renewable energy sources produced by Uzbekistan, Kazakhstan, Kyrgyzstan, Turkmenistan, Tajikistan, and Afghanistan over the past 13 years, as well as their growth and decline trends.

Table 1. Renewable energy production capacity in Central Asian countries [10]

Countries	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023
Afghanistan	1	1	1	1	1	1	1	1	1	1	1	1	1	1
Kazakhstan	8	8	8	8	8	9	12	12	11	11	12	13	13	15
Kyrgyzstan	11	14	14	13	13	11	11	14	14	14	14	13	12	12
Tajikistan	16	16	17	17	16	17	17	17	18	19	18	19	19	19
Turkmenistan	0	0	0	0	0	0	0	0	0	0	0	1	1	1
Uzbekistan	8	6	7	7	6	7	7	8	6	6	5	5	5	7

Source: Developed by the authors as a result of research

We will analyze this table in depth for each country.

Afghanistan. Afghanistan's index has been consistently at 1 every year from 2010 to 2023. This probably indicates that there have been no economic or social changes. It is no secret that several political processes are responsible for this. Therefore, in the coming years, this country will also try to fully exploit the potential of renewable energy sources.

Kazakhstan. In 2010-2014, the indicator was stable at 8. In 2015, the indicator increased to 9, and then annual changes were observed. In 2016, the indicator increased to 12, and then decreased slightly until 2018. In 2019-2021, the indicator was around 12-13. In 2023, the indicator reached its highest point, rising to 15.

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Kyrgyzstan.In 2010-2011, the indicator was 11, and in 2011-2012 it increased to 14. In subsequent years, the indicator fluctuated between 11-14. Since 2020, it has been steadily between 12-14.

Tajikistan. In 2010-2013, the indicator was 16. In 2014, it increased from 16 to 17, with subsequent annual changes. In 2018-2019, the indicator was in the range of 18-19. In 2020-2023, the indicator was stable at 19.

Turkmenistan. From 2010 to 2019, the indicator was 0, meaning there was no change in these years. By 2020, the indicator had increased to 1 and then remained stable until 2023.

Uzbekistan. In 2010-2011, the indicator was 8 and 6. In 2012-2013, the indicator increased slightly. In 2014, the indicator decreased again. In 2016-2017, the indicator was between 7-8. In 2018-2020, the indicator decreased, and in 2021-2023, it was stably between 5-7. Based on this analysis, it is possible to see in detail what economic, social or other changes were observed in each country in different years. From this analysis, we can see that among the Central Asian countries, Tajikistan, Kyrgyzstan and Kazakhstan are leading, while in Uzbekistan renewable energy has a stable growth and decline trend, but in Turkmenistan and Afghanistan, attention to the production of renewable energy sources is weak.

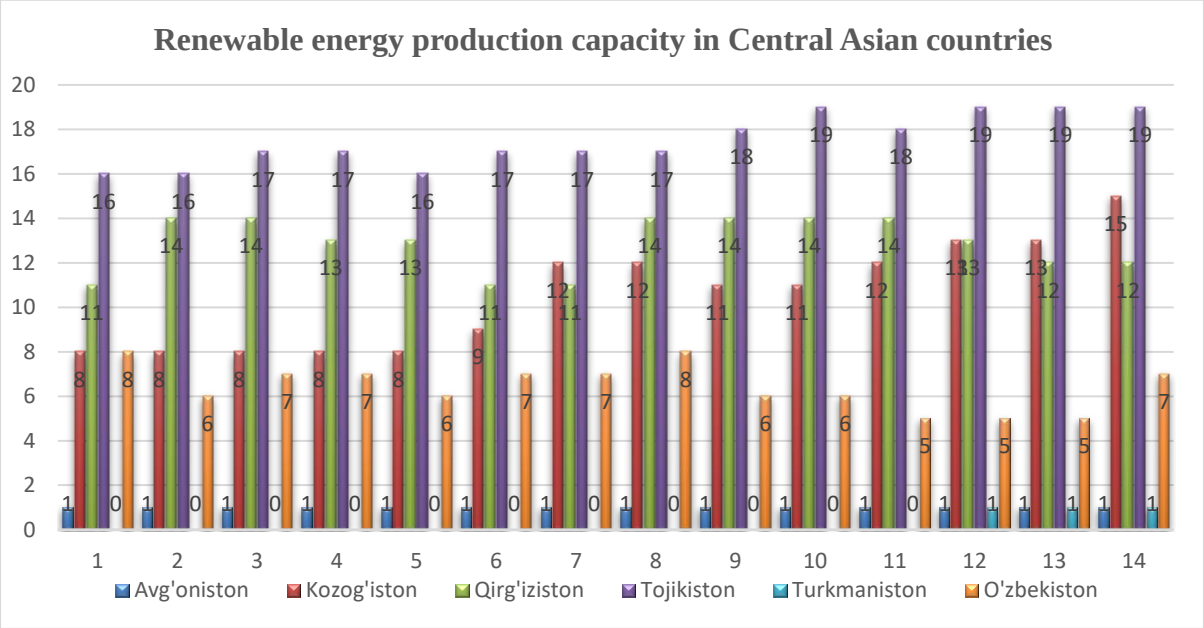

Figure 1. Infographic of renewable energy production capacity in Central Asian countries.

Based on the above statistical data, we tried to forecast the level of renewable energy production in the Central Asian countries for the next 5 years.

Uzbekistan

In our country, in recent years, efforts have been made to increase the share of renewable energy sources in the total energy resources, to promote public awareness of renewable energy. A number of works are being carried out to meet the growing demand. For example, over the past 6 years, 52 investment agreements have been signed in the electricity sector with a total

capacity of 27,687 megawatts. Accordingly, by 2030, 52 thermal, solar and wind power plants with a total capacity of the same amount will be commissioned.

As a result, in 2016, 59 billion kWh of electricity was produced in our country, while last year this figure was 81.5 billion kWh. This is an increase of 22.5 billion kWh or 1.1% compared to 2016 in 2024.

38 percent, It means a lot of electricity was produced.

This figure is planned to reach 91.1 billion kWh by 2025, and 117.2 billion kWh by 2030.

By 2035, it is projected that a total of 134.5 billion kWh of electricity will be generated in our republic. Of this, 86 billion kWh (64%) of electricity will be generated from renewable energy sources (RES) and 17 billion kWh (12.6%) of electricity will be generated by thermal power plants/thermal power plants.

It is clear that today the share of gas and coal plants in electricity generation is decreasing, and the main focus is on RES, that is, on the production of "green" energy. The head of our state has set the task of building additional "green capacities" by 2030 and increasing the share of renewable energy to 54 percent.

Based on the above, forecasts were made using the Holt-Winters nonseasonal smoothing models of the Stata program based on the collected statistical data for the next 5 years.

First of allLet's consider a graphical analysis and autocorrelation analysis of the time series of RES sources produced between 2010 and 2023. During this period, significant changes were observed in the RES values, which indicates a significant variability of the indicator. The range of autocorrelation values is from -0.50 to 0.50, and the blue dots and shaded area indicate the 95% confidence intervals of MA(q), which helps to understand the statistical significance of the autocorrelation.

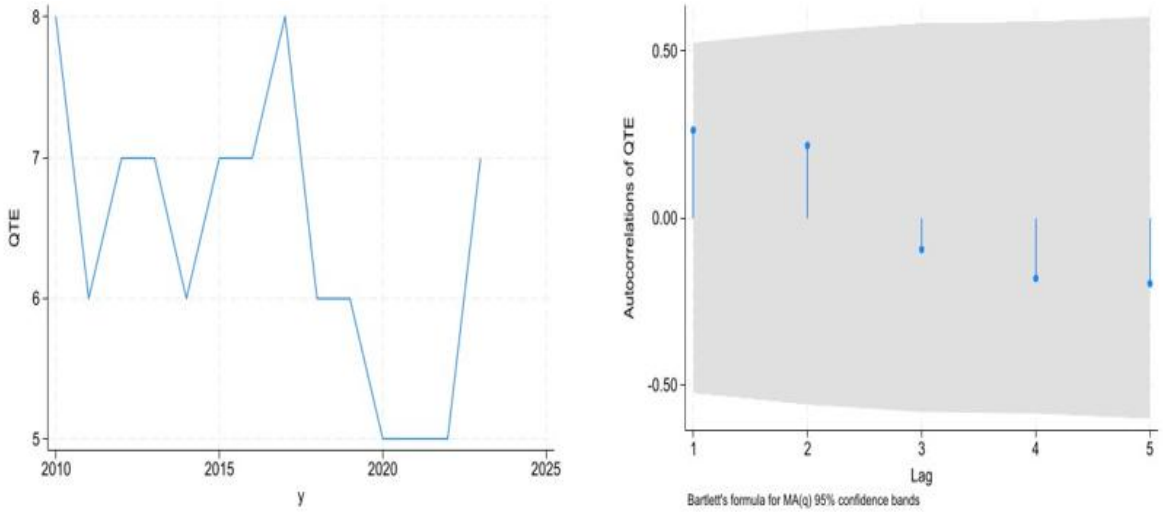

Figure 2. Time series graph of production of RES sources in Uzbekistan and autocorrelation

A time series graph shows how RES values change over time, while autocorrelation analysis helps to understand the relationship between RES values at different lags. Significant autocorrelation values at certain lags may indicate the presence of certain regressions or cycles in the data set.

```
Dickey-Fuller test for unit root                Number of obs   = 13
Variable: QTE                                   Number of lags  =  0

H0: Random walk without drift, d = 0

                                       Dickey-Fuller
                   Test        ────── critical value ──────
              statistic           1%           5%          10%
──────────────────────────────────────────────────────────────
 Z(t)            -2.809       -3.750       -3.000       -2.630
──────────────────────────────────────────────────────────────
MacKinnon approximate p-value for Z(t) = 0.0569.
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The p-value, MacKinnon's approximate p-value is 0.0569, which means that since the p-value is greater than 0.05, we cannot reject the null hypothesis at the 5% significance level. This indicates that the time series is not stationary. The results show that the RES variable has a sequential effect on the time series. We see that the time series is not stationary and that it is necessary to apply first differential or other transformations. All tests were performed until a positive result was obtained and a predictive value was developed.

Table 2 Forecast values of RES sources in Uzbekistan for 2024-2028

Years	2024	2025	2026	2027	2028
RES prognosis	7.5284	8.735963	9.943524	11.15109	12.35865

Source: Author's development

It can be seen that the RES values have been increasing over the years. From 2024 to 2028, the RES values have been steadily increasing, which shows a general trend. Each year, the increase in RES values is observed at a rate of 1.2-1.3. This means that the RES values are increasing steadily. The forecast value for 2024 is 7.5284, and for 2028 it is 12.35865, the total difference is 4.83025. This difference indicates a significant increase in future needs. We have also tried to implement forecast values for the remaining Central Asian countries of Kazakhstan, Kyrgyzstan and Tajikistan.

Kazakhstan

Let's look at the graphical analysis and autocorrelation analysis of the time series of RES sources produced between 2010 and 2023. During this period, significant changes in RES values were observed, which indicates a significant variability of the indicator. The range of autocorrelation values is from -1 to 1, and the blue dots and shaded area indicate the 95% confidence intervals of MA(q), which helps to understand the statistical significance of autocorrelation.

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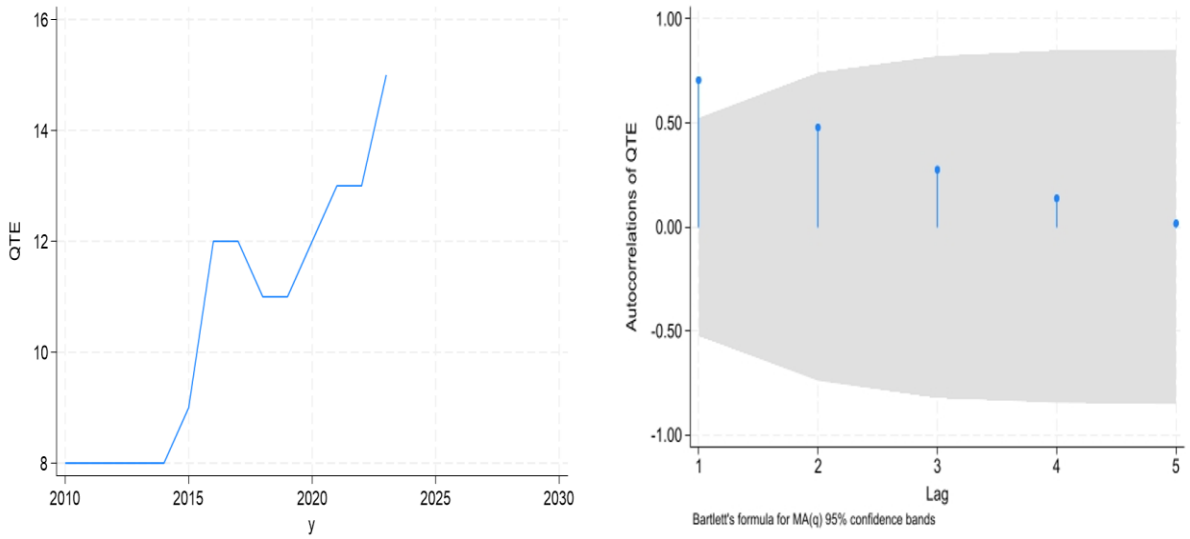

Figure 3. Time series graph of production of RES sources in Uzbekistan and autocorrelation

The graph on the left shows how RES values have changed over time, while the graph on the right helps us understand the relationship between RES values at different lags. Significant autocorrelation values at certain lags may indicate the presence of certain periods or cycles in the data set.

Dickey-Fuller test for unit root — Number of obs = 13
Variable: QTE — Number of lags = 0

H0: Random walk without drift, d = 0

	Test statistic	Dickey-Fuller critical value 1%	5%	10%
Z(t)	0.048	-3.750	-3.000	-2.630

MacKinnon approximate *p*-value for Z(t) = 0.9624.

Dickey-Fuller test for unit root — Number of obs = 11
Variable: d1dQTE — Number of lags = 0

H0: Random walk without drift, d = 0

	Test statistic	Dickey-Fuller critical value 1%	5%	10%
Z(t)	-3.230	-3.750	-3.000	-2.630

MacKinnon approximate *p*-value for Z(t) = 0.0183.

We see that the time series is not stationary and it is necessary to apply first differential or other transformations. All checks were carried out until a positive result was obtained and a forecast value was developed. After all the analyses, a forecast of the production of the RES resource of Kazakhstan for the next 5 years was made.

Table 3 Forecast values of RES resources in Kazakhstan for 2024-2028

Years	2024	2025	2026	2027	2028
RES prognosis	15.91258	17.20264	18.4927	19.78276	21.07282

Source: Author's development

The total increase in the RES value for the period from 2024 to 2028 is 5.16024 (21.07282 - 15.91258). This indicates a significant increase in RES values over the forecast period. These forecasts are based on the Holt-Winters nonseasonal smoothing model, and they show a regular

increase in RES values in the coming years. This model can help in developing economic or financial strategies, as it allows you to predict future needs in advance.

Kyrgyzstan and Tajikistan

The analysis processes were carried out in the same way as for Uzbekistan and Kazakhstan mentioned above, therefore Kyrgyzstan andWe will show the direct forecast values for the countries of Tajikistan.

Table 4 Forecast values of RES resources of Kyrgyzstan and Turkmenistan for 2024-2028

Years	2024	2025	2026	2027	2028
Kyrgyzstan RES prognosis	12.61532	12.61532	12.61532	12.61532	12.61532
Turkmenistan RES forecast	19.22572	19.27504	19.32436	19.37368	19,423

Source: Author's development

Growth Trend:

Kyrgyzstan: RES values remain the same for five years (12.61532). This indicates stability of RES indicators and no significant increase or decrease.

Turkmenistan: RES values increase slightly each year, indicating an overall upward trend. The value of 19.22572 in 2024 will reach 19.423 in 2028.

Stability and Volatility:

Kyrgyzstan: Stable RES values indicate that no changes or fluctuations are expected in the future. This may indicate a stable economic environment or a lack of growth.

Turkmenistan: A steady increase in RES values indicates a future growth and expansion of the economic environment. A steady increase in this indicator indicates an increase in economic activity and the need for resources.

General Differences:

Kyrgyzstan: Between 2024 and 2028, RES values will remain the same, meaning there will be no changes or increases.

Turkmenistan: RES values have been steadily increasing for five years, indicating the country's economic and resource activity.

Comparing the RES forecasts for Kyrgyzstan and Turkmenistan, it can be said that Kyrgyzstan's RES values have remained the same for five years and there is no growth. This indicates a lack of economic growth or expansion. On the contrary, the fact that Turkmenistan's RES values are constantly increasing indicates an increase in economic activity and demand for resources. This growth indicates the country's potential for economic growth and expansion.

Conclusion and Suggestions

Uzbekistan is making significant strides in developing renewable energy sources. In 2023, measures were adopted to accelerate the introduction of renewable energy sources and energy-

saving technologies. These measures include the construction of solar and wind power plants, increasing energy efficiency, and encouraging the transition to alternative energy. Also, in 2024, amendments and additions were made to the legislation to further develop the use of renewable energy sources.

Attracting investments: Continue to attract investments based on public-private partnerships for the development of renewable energy sources. This can be achieved by creating favorable conditions for investors and introducing incentive mechanisms.

Technological Innovation: Introducing modern technologies to increase energy efficiency and expand the use of renewable energy sources. This includes solar panels, wind turbines, and other energy-saving technologies.

Strengthening the legal framework: Strengthening the legal framework to support the use of renewable energy sources. This includes the issuance and circulation of "green energy" certificates, as well as state support for the use of renewable energy sources.

International cooperation: Strengthen international cooperation in the development of renewable energy sources. This can be achieved through the development of the scientific and technical base, joint research, and the introduction of innovative technologies.

Public awareness: Educating the public about the benefits of renewable energy sources and the importance of using them can help to save energy and encourage the transition to alternative energy.

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