

THE ROLE OF RENEWABLE ENERGY SOURCES IN THE ENERGY SYSTEM. WORLD AND UZBEKISTAN

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Abstract: *As the world develops and the population increases, the need for electricity is also growing on a large scale. As a result of striving to meet this need, many global pollution and climate change situations are occurring. The world is increasingly witnessing the importance of renewable energy sources in preventing them.*

In this article, the distribution of shares of electric energy produced in the world and Uzbekistan, as well as the role and amount of renewable energy sources in it, is more widely covered based on statistical facts. Which source contributes to how much? And the conclusions based on these facts are stated. At the same time, the role of renewable energy sources in the world energy system and the problems arising from these sources were also discussed.

Keywords: *electricity demand; climate change; renewable energy sources; barriers to renewable energy sources; the amount of electricity supply; electricity distribution; solar energy; wind energy; hydropower; bioenergy; geothermal energy; nuclear energy, thermal power plants; Net Zero Emission scenario; renewable power plants; non-renewable power plants.*

Introduction.

Today, the world's population is three times larger than in the middle of the 20th century. In mid-November 2022, the world's population will reach 8 billion. In the next 30 years, this figure is expected to increase to almost 2 billion people [1].

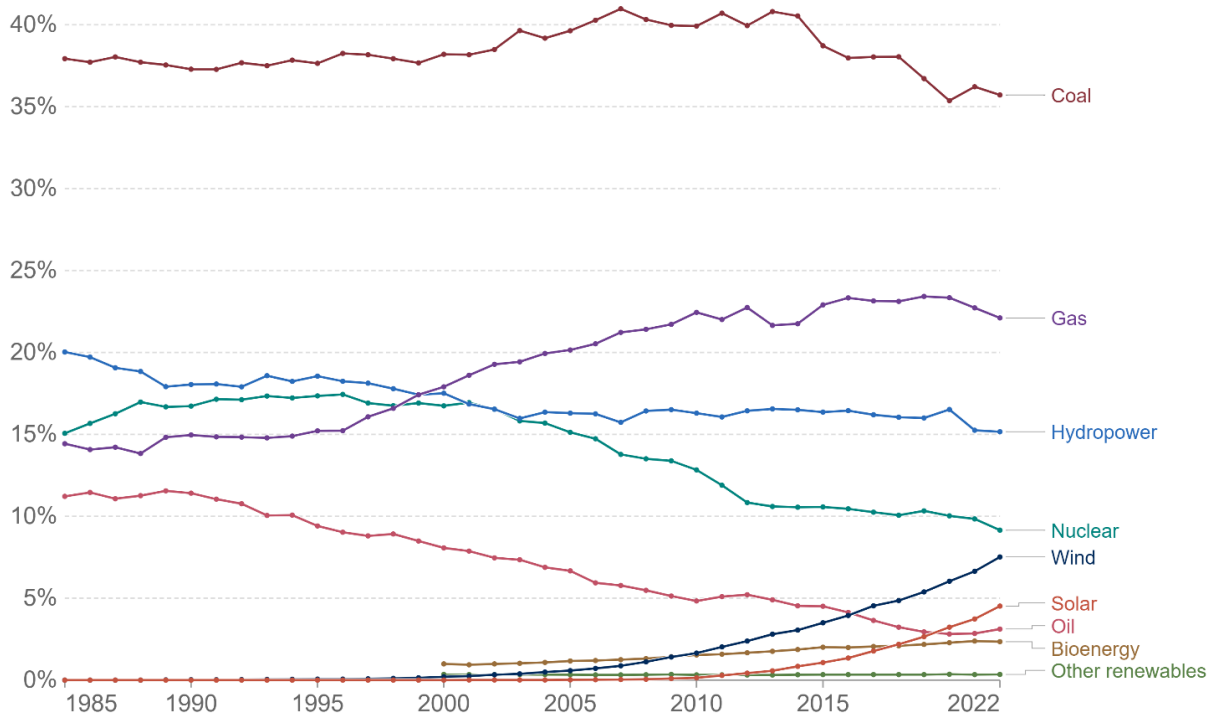
The rapid growth of humanity and the development of the world of modern technology are the reasons for the sharp increase in the need for electricity.

In 2022, global electricity consumption was 24 398 terawatt-hours (TWh), which is almost triple the amount consumed in 1981 (8 133 TWh) [2].

Accounts show that the world's per capita electricity consumption is on average 2-4 kWh. This full is not considered sufficient to meet all needs. The need for electric energy is not fully satisfied, and it continues to grow at a great rate. Also, there is no field that we can imagine without an electricity supply. The extent to which electricity needs are met easily determines the development trend of the state's economy and other urgent aspects. The easier and cheaper it is for us to produce electricity, the more we can increase our development speed comprehensively. From this point of view, our need and demand for any promising scientific research and powerful developments on the efficient production of electricity and their practical application in practice are more significant than ever. Also, the need for a faster transition to renewable energy sources for the world remains among the urgent issues of the day.

Distribution of electricity production. The world and Uzbekistan. Diagram 1 shows the sources of electricity generation worldwide, and we can see that the largest share of electricity generation comes from coal and gas-fired electricity. As of 2022, coal accounted for 35.71 percent of the total electricity production, and gas for 22.11 percent. While coal and gas account for over half of electricity generation, their carbon emissions are responsible for global pollution and

climate change. Global greenhouse gases from burning fossil fuels account for more than 75 percent of emissions and about 90 percent of all carbon dioxide emissions.



Source: Our World in Data based on BP Statistical Review of World Energy & Ember

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Diagram 1. Share of electricity production by source around the world [3].

The next dominant share corresponds to the electric energy obtained due to Hydropower (15.16% of the whole share;) and nuclear energy (9.15% of the whole share;). Their total share was more than 24 percent of the world's electricity production as of 2022. However, after 2013, only Wind (2.81% in 2013, 7.52% in 2022) and Solar (0.58% in 2013, 4.52% in 2022) energies showed intensive growth indicators in terms of share in total electricity production. With this, we can see that the world is gradually focusing its attention and potential on renewable energy sources. However, at the moment, renewable energy sources made up more than 11 percent of the total electricity production.

From diagram 2, we can see that as of 2022, the world's coal-fired electricity was 10 185 TWh, gas was 6 305 TWh, and oil was 888.5 TWh. These were rather large numbers (60.82% of the total share), and as a result of their burning, global pollution, global climate change, and damage to society's ecosystems are natural phenomena. The best and most effective solution to reduce gas emissions and environmental damage is to switch to renewable energy sources in electricity production and implement its efficient operation.

One of the more efficient types of energy is nuclear power. As of 2022, it currently had a share of the world's total electricity generation of 2610 TWh. However, in countries that do not have nuclear reactors, there are many difficulties in their construction processes, both politically and economically. The construction of nuclear reactors is much more expensive. Political opposition is also encountered sufficiently. Even countries with nuclear power and potential are abandoning the nuclear electricity industry.

We can cite Germany as a clear example of this. It has shut down its last three nuclear power plants, and as of April 16, 2023, Germany will not generate any electricity from nuclear power plants [5].

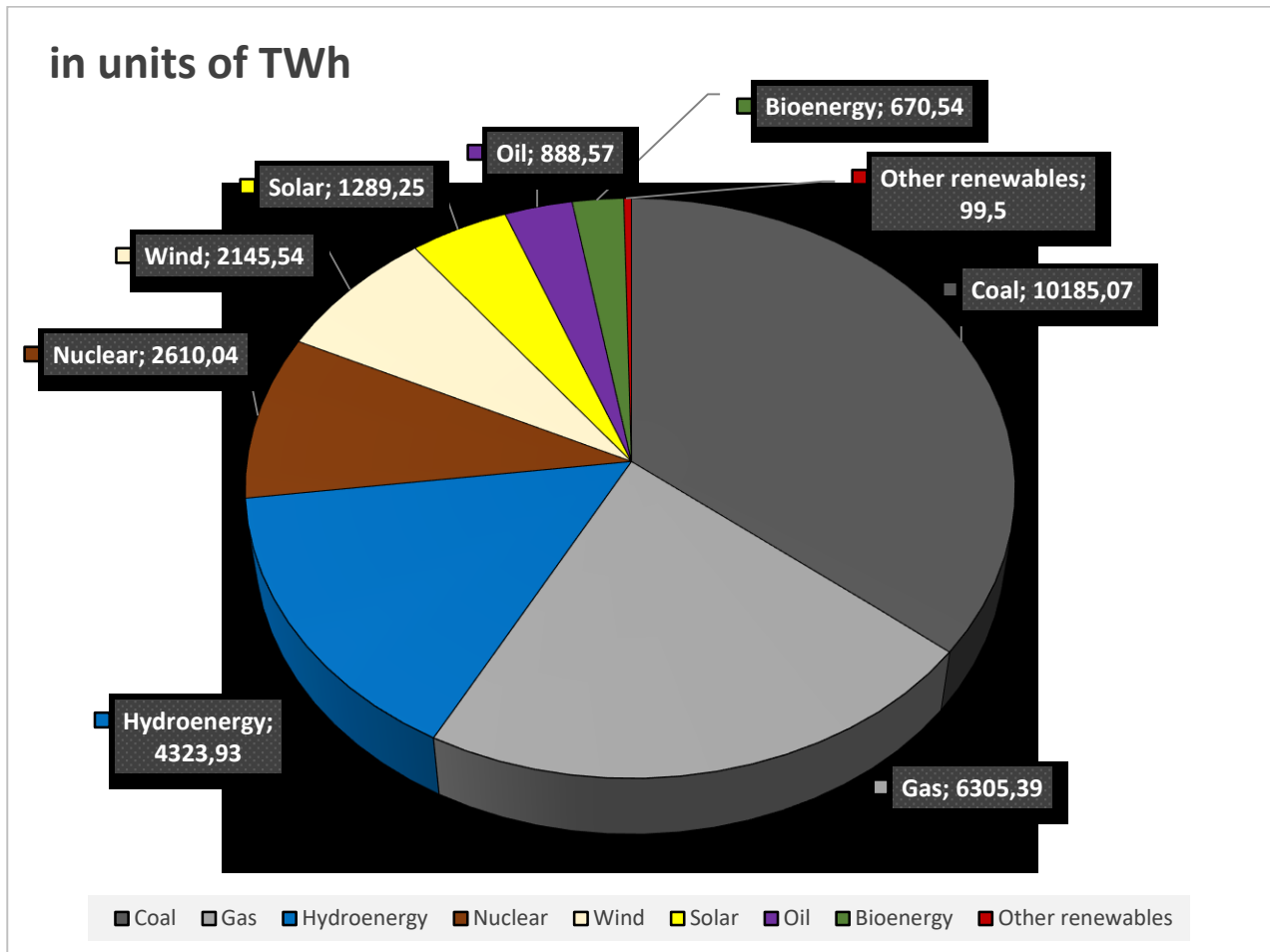


Diagram 2. Share of electricity production by source around the world [4]

As of 2022, the most dominant members of the renewable energy sources were wind and solar energy produced 2145.5 TWh and 1289 TWh of electricity, respectively. Also, Bioenergy produced 670.6 TWh, and other renewable energies 99.5 TWh of electricity. These all environmentally friendly green energy sources accounted for only 16 percent (4204.8 TWh) of total electricity production.

But for the world community to reach the Net Zero Emission Scenario milestones, it will be required to increase the share of renewable energy sources to 60 percent by 2030. That is, during 2022-2030, it should continue to grow by more than 12 percent annually [6].

Net zero emission means reducing greenhouse gas emissions to as close to zero as possible, with any remaining emissions being re-absorbed from the atmosphere, the oceans, and forests for instance.

Science shows that global temperature increases must be limited to 1.5°C above pre-industrial levels to avoid the worst effects of climate change and preserve a habitable planet. The Earth is currently 1.1°C warmer than it was in the late 1800s, and emissions continue to rise. According to the Paris Agreement, to keep global warming below 1.5°C, emissions must be reduced by 45% by 2030 and net zero by 2050.

But unfortunately, the current situation and the commitments made by the governments in this regard are not enough and cannot ensure the realization of the Net Zero Emission Scenario by the set deadline [7].

If we focus on the situation of our country Uzbekistan, it is among the countries that can fully satisfy its energy needs. Its energy independence is 100 percent.

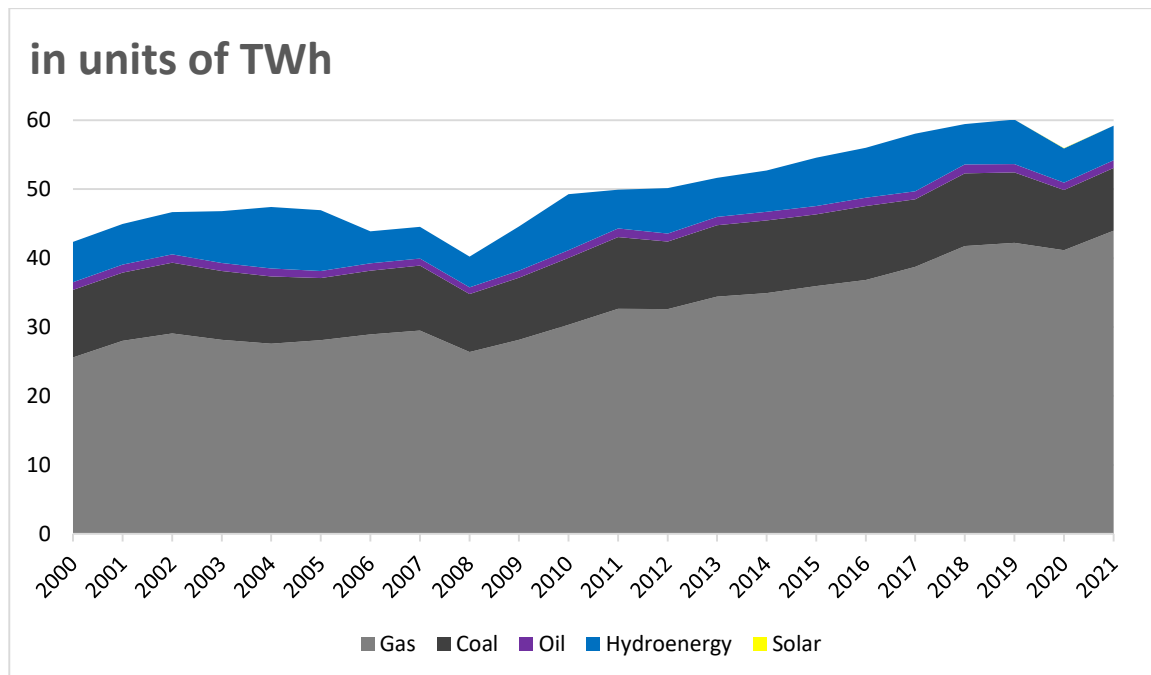


Diagram 3. Electricity production by sources in Uzbekistan [8].

Diagram 3 shows the role of sources in electricity generation and the capacity produced by Uzbekistan between 2000 and 2021. We can see in the diagram that in 2000, the generated electricity was 44.33 TWh, and by 2021 the total electricity was 33.5 percent (14.87 TWh), 59.2 TWh.

Uzbekistan covers 90 percent of its electricity needs with gas and coal. In 2000, gas-fired electricity was 27.59 TWh and made up 62% of the total electricity production, and by 2021, its power reached 43.97 TWh and made up 74% of the total electricity production.

Also, the electricity generated by coal in 2000 was 9.78 TWh, which accounted for 22 percent of total electricity generation, while by 2021 it reached 9.12 TWh, accounting for 15 percent of whole electricity generation.

It can be seen that the volume of electricity generated by gas in Uzbekistan has increased, and the volume of electricity generated by coal has been gradually reduced.

However, their total volume of electricity generation has hardly changed (about 90%). Hydro-energy electricity was 5.82 TWh in 2000, accounting for 13 percent of total electricity generation, and by 2021 we can see that these figures have decreased slightly, and the generated electricity fell by 5 TWh, accounting for 8.4 percent of total electricity generation.

Although Uzbekistan fully meets its electricity potential through gas and coal, the gas emissions cause enough damage to the ecosystem of Uzbekistan.

On the other hand, the gas extraction rate in Uzbekistan will decrease by 2.8% per year, and experts say that by 2025 there will be no gas left for export because the amount of gas produced will be equal to the amount of our consumption.

When we come to such periods, systems that burn one type of energy to obtain another energy type may start to cost us more.

It is also necessary to produce two times more electricity than today to ensure the security of our country by 2030.

Therefore, replacing traditional energy sources with renewable and alternative energy sources is one of the priority tasks of the country, and vital strategic actions are being developed.

Until 2030, the replacement of traditional energy sources from 90% to 75, and the replacement of renewable sources from 10% to 25 (hydroenergy-11.2%, solar energy-8.8%, wind energy-5%) specific plans and objectives of the release are included in the strategic actions.

Increasing the role and share of renewable energy sources in the production of electricity in all countries of the world is the demand of the time, which is even more important in the background of serious problems such as the global energy disaster due to fields exhaustion of gas, coal, and oil.

There is a deep need to increase the construction of modern power plants based on renewable energies and to conduct more research on their efficient operation.

The involvement of foreign and local investors and scientists in such work will further accelerate and enhance the development of the industry.

The role of renewable energy sources in electricity production.

The world and Uzbekistan.

Renewable energy sources play an essential role in the transition to clean energy, and the use of these types of energy sources is one of the main factors in keeping the average global temperature below 1.5 °C [9].

In the first half of 2022, global electricity demand grew by 3% over the same period last year. However, wind and solar energy met this demand growth of 77 percent, and water accounted for more than the rest.

Fossil generation remained vastly unchanged as renewable energy growth met all the additional electricity demand (coal was down 1%, gas was down 0.05%, and oil was up slightly).

Consequently, despite the rise in demand for electricity, the global CO₂ power sector emissions have not changed. The growth in wind and solar in the first half of 2022 prevented a 4% increase in fossil generation.

This avoided USD 40 billion in fuel costs and 230 Mt CO₂ in emissions. In China, the growth in wind and solar enabled fossil fuel power to fall by 3% instead of 1%. In India, it slowed down the rise in fossil fuel power from 12% to 9%.

In the US, it slowed down the rise in fossil fuel power from 7% to 1%. In the EU, it prevented a major rise in fossil fuel power – without wind and solar, fossil generation would have risen by 16% instead of 6%. [10].

All this evidence shows that renewable energy sources are one of the crucial factors in the transition to clean energy and in preventing energy and climate crises.

According to the statistical data of the international agency IRENA on March 10, 2023, at the end of 2022, the global renewable generation capacity was 3372 GW [11].

According to the statistics of the IRENA agency (which can also be seen in diagram 4), worldwide, 37% of the electricity generated from renewable sources is renewable hydropower (1256 GW), 31% is solar energy (1053 GW), and 27% is wind energy (899 GW), and the remaining 5% comes from other renewable energy sources (149 GW).

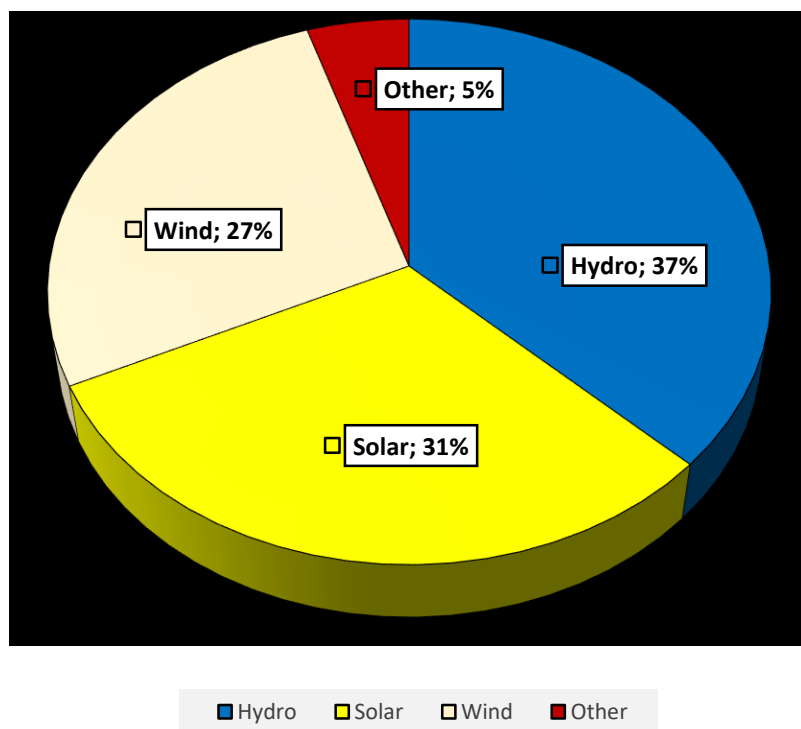


Diagram 4. Renewable generation capacity by energy source [11].

In Part 1 of Diagram 5, we can see that the overall growth rates of renewable hydropower, bioenergy, and geothermal energy sources were very gradual between 2017 – 2022, and no significant growth rate was recorded. But the growth tendencies of your solar and wind energy sources have been significantly higher. This can be interpreted as a result of many developed countries' emphasis on solar and wind energy sources over these five years.

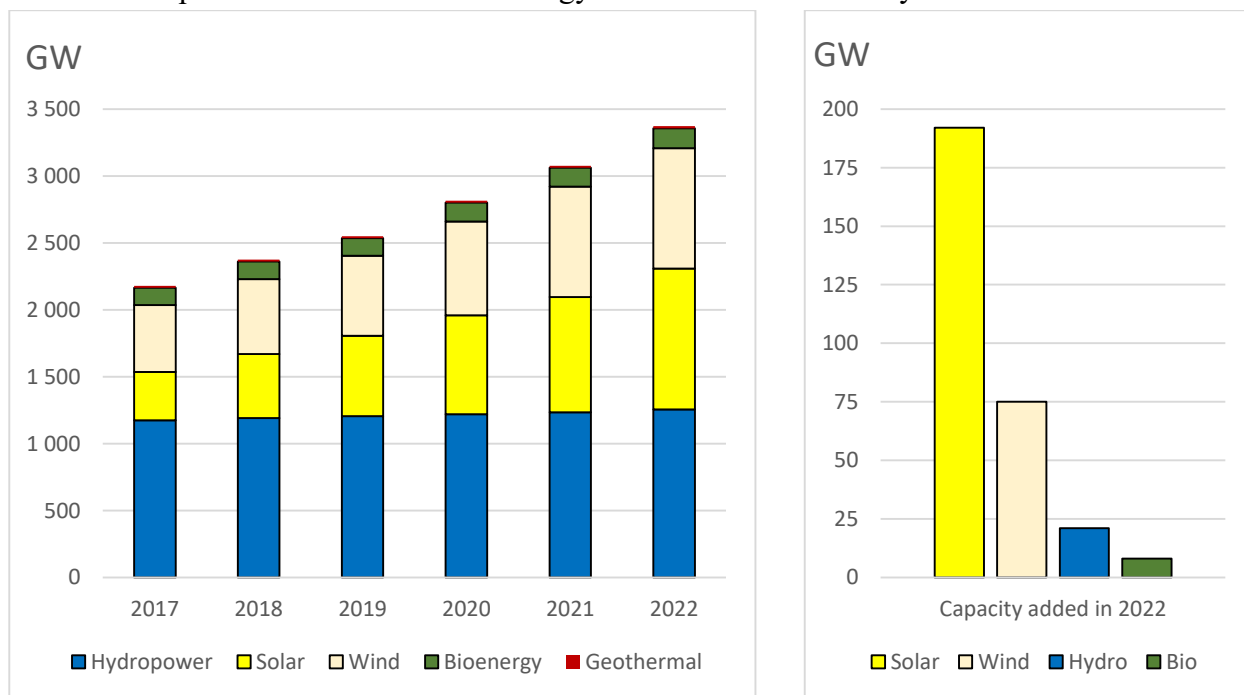


Diagram 5. Renewable power capacity growth[11].

In 2022, the growth rate of renewable energy sources increased by 9.6%, generating an additional 295 GW of electricity (it can be seen in Part 2 of Diagram 5). Solar energy registered an enormous growth indicator, accounting for 192 GW. It had a 22 percent increase over the previous pointer. Also, wind power capacity increased by 75 GW (+9%), renewable hydropower by 21 GW (+2%), and bioenergy by 8 GW (+5%). The solar and wind energy growth indicator, renewable energy sources accounted for 90 percent of the total growth rate and gained dominance. As a result, we can see that the world is concentrating more on building those two power plants.

Asia accounted again for about 60% of new capacity in 2022, increasing its renewable capacity by 174.9 GW to reach 1.63 TW (48% of the global total). China took the lead (+141 GW). Also, 57.3 GW (+8.8%) of new capacities were created in Europe and 29.1 GW (+6.3%) in North America. Africa recorded steady growth with 2.7 GW (+4.8%) capacity. In the countries of Oceania, mainly Australia, 5.2 GW (+10.6%) was achieved. In South America, 18.2 GW (+7.4%) of electricity was produced. The Middle East also posted the highest expansion on record, commissioning 3.2 GW of new capacity (+12.8%).

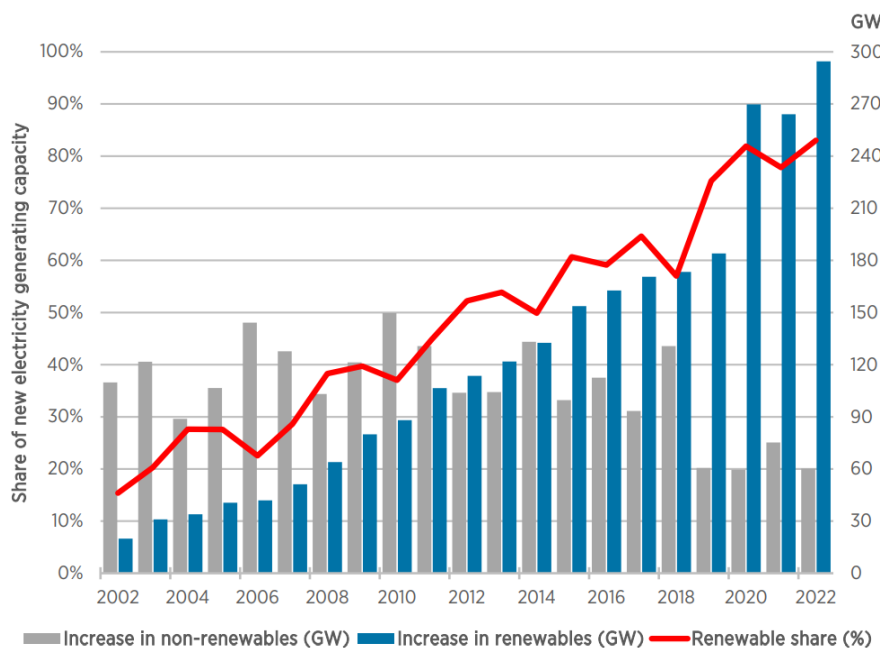


Diagram 6. The renewable share of annual power capacity expansion [11].

We can also see from Diagram 6 that the production of electricity based on renewable energy sources has a constant growth trend, especially after 2021. Non-renewable energy sources clearly showed their intensity until 2011, and from this year they began to record indicators of decline, especially after 2019, we can observe cases of serious decline. The facts in this chart show that the use of renewable energy sources is growing and expanding rapidly, while the expansion of conventional energy sources is declining. The share of non-renewable energy sources in the energy system of many countries has also expanded. In 2022, there was an increased rate of expanding non-renewable capacity, especially in Europe, compared to previous years. We can say that this happened against the background of certain global events. North America was the only region where non-renewable energy sources were significantly suspended.

What is being done to increase the role of renewable energy sources in our country, Uzbekistan? On August 22, 2019, based on the President's Decision “On increasing the energy efficiency of economic sectors and the social sector, introducing energy-saving technologies and developing renewable energy sources” [12], until 2030, it is planned to increase the total share of

renewable energy sources in electricity production by 25 percent. Also, on February 16, 2023, the PD “On measures to accelerate the introduction of renewable energy sources and energy-saving technologies” [13] led to the acceleration of the development of this sector. Significant work has been done and is being done based on the implementation of these decisions.

In particular, by the end of 2026, 25 modern power plants with a total capacity of 11 954 MW (9 thermal, 9 solar, and 7 wind power plants, (see Tables 1 and 2)) will be put into operation in Uzbekistan. Contracts and investment agreements worth 10 billion 148 million dollars were signed with companies. This will be more than 60 percent of Uzbekistan's current electricity production volume [14].

We can see from these projects that the attention to increasing the role of renewable energy sources in our country is getting bigger and bigger. As a real confirmation of these works, on August 27, 2021, the first 100 MW solar photoelectric plant was launched in the Karmana district of the Navoi region. 300 000 solar panels have been installed on 283 hectares of land, and 252 million kWh per year of electricity has been produced. Due to this, 80 million cubic meters of natural gas were saved, and 160 thousand tons of volatile gases were prevented from being released into the atmosphere. This new station is the first power station built by a private investor in the history of Uzbekistan. "Masdar" company of the United Arab Emirates invested 110 million dollars in this station, offered one of the lowest tariffs in the world in the amount of 2.67 US cents per 1 kWh of electricity, and undertook to use it for 25 years.

The second large 100 MW solar photoelectric plant was operated on May 24, 2022, in the Nurabad district of the Samarkand region. Over 295 000 solar panels have been installed on 353 hectares of land, producing 260 million kWh per year of electricity. In this way, 78 million cubic meters of natural gas are saved, and 100 000 tons of volatile gases are prevented from being released into the atmosphere. The French company "Total EREN" has invested 100 million dollars in this project, and this company has undertaken to use it for 25 years.

Thus, by 2025, another order of the President, such as creating all opportunities for producing at least 50 percent of electricity in private power plants, is being implemented step by step. Below is a complete list of all new power plants planned in Uzbekistan until 2026.

	Power Plant Place	Date of Implement	Type of Power Plant	Station Power	Company which responsible to build
1	Navoi region, Karmana district	2021 year August 27	Solar photoelectric plant	100 MW	Masdar Company, BAA
2	Samarkand region, Nurabad district	2022 year May 24	Solar photoelectric plant	100 MW	Total EREN Company, France
3	Navoi region, Tomdi district	At the end of 2023 year	Solar photoelectric plant	500 MW	Masdar Company, BAA
4	Samarkand region, Kattakurgon dist.	At the end of 2023 year	Solar photoelectric plant	220 MW	Masdar Company, BAA

5	Jizzakh region, Gallaorol district	At the end of 2023 year	Solar photoelectric plant	220 MW	Masdar Company, BAA
6	Surkhandarya reg, Sherabad district	At the end of 2023 year	Solar photoelectric plant	457 MW	Masdar Company, BAA
7	Samarkand region, Nurabad district	In 2024	Solar photoelectric plant	1000 MW	ACWA Power Saudi Arabia
8	Toshkent region, Upper Chirchik	In 2024	Solar photoelectric plant	400 MW	ACWA Power Saudi Arabia
9	Bukhara region, Peshku district	In 2024	Wind power station	500 MW	ACWA Power Saudi Arabia
10	Bukhara region, Gijduvan district	In 2024	Wind power station	500 MW	ACWA Power Saudi Arabia
11	Bukhara region, Olot district	In 2024	Solar photoelectric plant	250 MW	Masdar Company, BAA
12	Karakalpakstan, Karaozak district	In 2024	Wind power station	100 MW	ACWA Power Saudi Arabia
13	Karakalpakstan, Kangirot district	In 2024	Wind power station	500 MW	ACWA Power Saudi Arabia
14	Karakalpakstan, Kangirot district	In 2024	Wind power station	500 MW	ACWA Power Saudi Arabia
15	Karakalpakstan, Kangirot district	In 2024	Wind power station	500 MW	ACWA Power Saudi Arabia
16	Khorezm region, Toprak-Kala dist.	In 2025	Solar photoelectric plant	100 MW	Votalia company France
17	Kashkadarya reg, Guzar district		Solar photoelectric plant	300 MW	Masdar Company, BAA
18	Karakalpakstan, Beruni district		Wind power station	200 MW	During the tender process

Table 1. Power plants operating based on renewable energy sources [14].

	Power Plant Place	Date of Implement	Type of Power Plant	Station Power	Company which responsible to build
1	Bukhara region, Bukhara district	2022 year January 11	Thermal power station	270 MW	Aksa Energy Company, Turkey
2	Toshkent region, Kibray district	2022 year January 14	Thermal power station	240 MW	Aksa Energy Company, Turkey
3	Toshkent region, Kibray district	2022 year March	Thermal power station	230 MW	Aksa Energy Company, Turkey
4	Toshkent region, Kibray district	In 2022	Thermal power station	240 MW	Aksa Energy Company, Turkey
5	Khorezm region, Yangiariq district	2022 year March 10	Thermal power station	174 MW	Aksa Energy Company, Turkey
6	Syrdarya region, Xovos district	2022 year November 20	Thermal power station	220 MW	Aksa Energy Company, Turkey
7	Syrdarya region, Shirin City and Boyovut district	At the end of 2023 year	Thermal power station	1500 MW	ACWA Power Saudi Arabia
8	Surkhandarya region Angor district	In 2024	Thermal power station	1560 MW	Siemens Energy (Germany), EDF (France), Stone City Energy (Netherlands) companies
9	Syrdarya region, Boyovut district	At the end of 2026 year	Thermal power station	1573 MW	EDF (France), Nebras (Qatar), Sojitz Cor (Japan), Kyuden Int Cor (Japan) companies

Table 2. Power plants operate based on non-renewable energy sources [14].

By 2026, 51% of the new power stations will be renewable (6 447 MW), and 47% will be thermal (6 007 MW). It can be seen that in Uzbekistan, the role of renewable energy sources in meeting the electricity needs of the population is gradually increasing.

What are the problems with renewable energy?

Renewable energy sources are a strong pillar in the energy industry, but not perfect enough. Because these types of energy cannot be said to be stable.

The challenges facing the renewable energy industry are many. Political conditions, ancient energy infrastructures, lack of a proper energy storage system, and current market conditions prevent the wider adoption of this energy worldwide. Let's talk about some problems [15]:

Installation has a high initial price. There is a big difference in the initial cost of installing a renewable energy system and a gas-fired plant. For example, it is cheaper to install thermal power plants of the same capacity than to install large-scale solar energy systems.

Lack of infrastructure. The current energy infrastructure needs urgent reform as it is not capable of processing large amounts of renewable energy. The main problem with the electrical network is its age. Most transmission and distribution lines were built in the 1950s and 1960s. Therefore, they cannot respond to the demands of the times and serious climate changes. Deciding on the size of renewable energy sources is also very difficult. If the system is too small, building energy supplies can be difficult and inefficient. If the system is very large, then a large energy storage system is needed. Without a high-capacity storage system, the generated energy is wasted. **Power saving.** The lack of affordable power storage is another major drawback. Renewable energy sources produce most of their energy at certain times of the day. The timing of its electricity generation does not correspond to peak demand hours. Energy production by burning fuels is more consistent and sustainable. Continuous energy production through renewable energy sources requires an efficient battery storage system. An energy storage system helps to store excess energy for later use. This prevents network instability and unexpected power outages. Although technological advances have improved energy storage systems' longevity and battery capacity, their high cost has hindered widespread deployment.

High dependence on weather. For example, solar and wind energies are directly dependent on weather conditions. The instability of the weather is caused to the instability of energy sources. In some regions, the abundance of dust and pollen, and very high temperatures, significantly reduce the efficiency of solar panels. In areas with very low wind speeds, wind generators are not justified.

Lack of knowledge. The lack of widespread use of renewable energy sources is also caused by the lack of complete knowledge about it. Deeper knowledge about it and research, scientific developments, and discoveries on their more efficient operation will further increase the breadth of use of renewable energy types.

It makes it possible for us to seriously work on such problems, to provide them with effective solutions, and to use renewable energy on a wider scale.

Conclusion

As we have witnessed, the world continues to increase the role of renewable energy and strengthen its position in the energy industry. Also, a lot of work is being done in this regard in our country. The more our world meets its energy needs from renewable energy, the more global pollution and climate disasters will be prevented. Further increasing the efficiency of renewable energy types, ensuring their adequate application and any applicable discovery and scientific work related to them will seriously accelerate our goals of greening our energy. Further increase of state grants and awards for innovations made in this way, additional support of promising projects, and involvement of researchers, scientists, and investors in these works will considerably increase the achievements and opportunities in this field.

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