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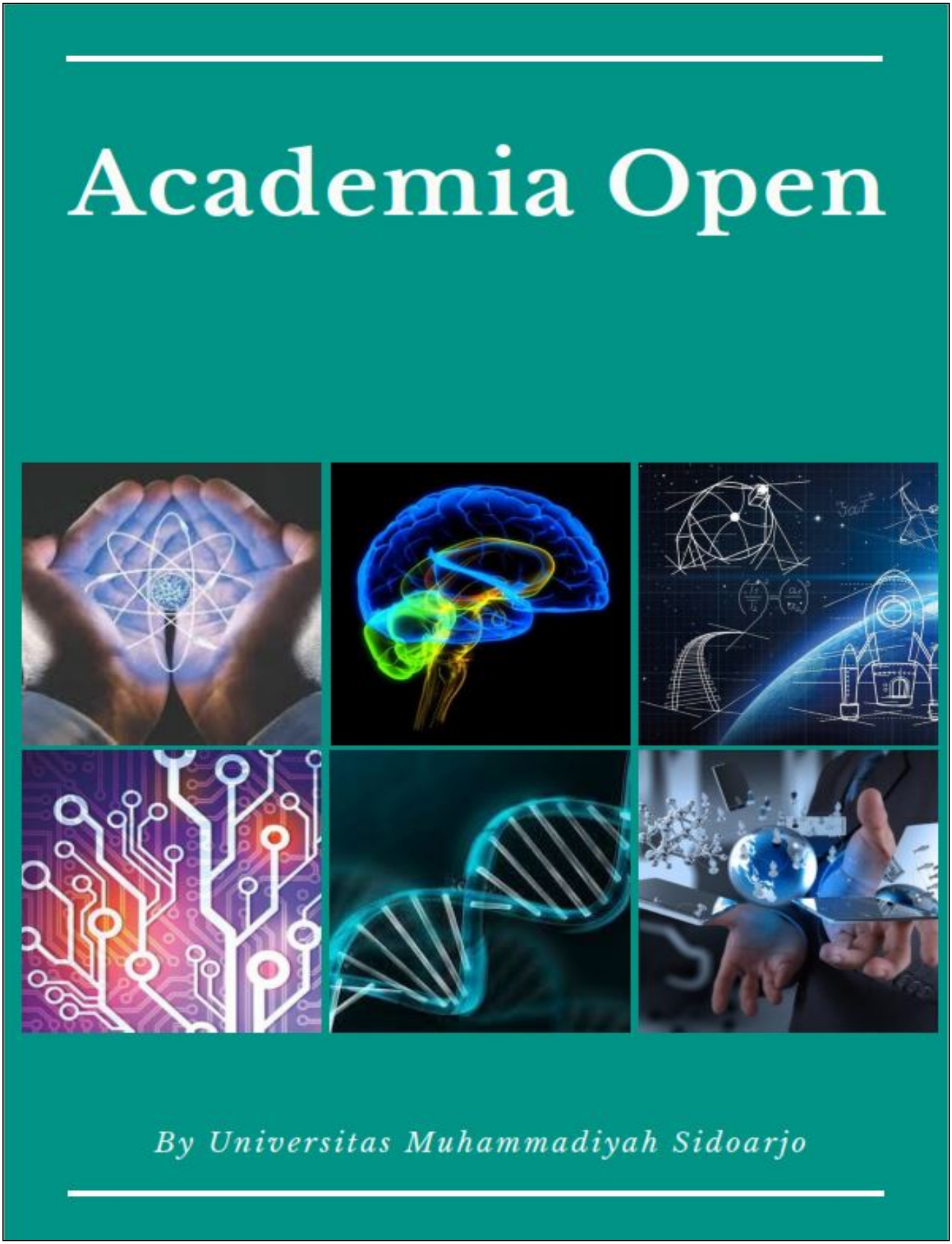

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Directions for Increasing Green Energy Capacity of Uzbekistan

Petunjuk untuk Meningkatkan Kapasitas Energi Hijau Uzbekistan

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Abstract

General background: The global transition to renewable energy is essential for mitigating climate change and ensuring energy security, and Uzbekistan, with its abundant natural resources, holds significant potential. **Specific background:** Despite progress, Uzbekistan still relies heavily on fossil fuels, and challenges remain in integrating renewable energy into the national grid. **Knowledge gap:** Previous studies have focused on the technical and economic benefits of green energy, yet there is limited research on the interplay between market reforms and renewable energy adoption in developing nations like Uzbekistan. **Aims:** This research aims to assess the current renewable energy policies and propose strategies to enhance Uzbekistan's capacity, particularly in solar and wind energy. **Results:** The findings reveal that while Uzbekistan has made strides, substantial reforms in market liberalization and increased investment are necessary to meet its 2030 green energy targets. **Novelty:** This study offers new insights by integrating a market-based approach to energy reforms with the need for targeted subsidies and international investment, filling a critical gap in the literature on green energy transitions in developing economies. **Implications:** The results suggest that further policy adjustments, enhanced international cooperation, and financial incentives are vital for accelerating Uzbekistan's green energy transition, providing a model for similar economies.

Highlights:

- Uzbekistan needs substantial market reforms to increase green energy capacity.
- Solar and wind energy are key to meeting the 2030 renewable energy goals.
- Targeted subsidies and international investment are essential for sustainable energy development.

Keywords: Solar Energy, Wind Energy, Energy Subsidies, Energy Investments, Market Liberalization

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Introduction

The global shift toward sustainable development has brought green energy to the forefront of policy discussions, especially in countries seeking to reduce their reliance on fossil fuels. Green energy, derived from renewable sources like solar and wind, is essential to mitigate climate change and ensure long-term energy security. Countries with abundant natural resources, such as Uzbekistan, have the potential to significantly contribute to global renewable energy production. However, the challenge remains in effectively integrating these resources into the national energy grid while promoting market reforms that support sustainable energy solutions [1].

In recent years, Uzbekistan has made notable strides in developing its renewable energy sector, setting ambitious targets for increasing the share of green energy in its national energy mix by 2030. Solar and wind energy are viewed as key components of the country's renewable energy strategy, given Uzbekistan's vast sunny days and favorable wind conditions. Despite this, challenges related to market liberalization, financial incentives, and infrastructural limitations persist, hindering the country's full transition to green energy. The present study aims to explore these challenges, assess current developments, and propose actionable recommendations to enhance Uzbekistan's renewable energy capacity [2].

Several theoretical frameworks guide this research, including the market-based approach to energy reforms and the theory of externalities, which highlights the need for governmental intervention in promoting public goods such as clean energy. Previous studies have emphasized the economic and environmental benefits of green energy but often overlook the complexities of transitioning within developing economies. This study fills the knowledge gap by examining the specific case of Uzbekistan, considering its unique socio-political and economic contexts, while also drawing comparisons with countries that have successfully transitioned to renewable energy [3].

The methodology employed in this study integrates both qualitative and quantitative approaches. Statistical data from national and international sources were analyzed to assess the trends in Uzbekistan's renewable energy development, while expert interviews provided qualitative insights into policy implementation and market dynamics. Additionally, case studies from other countries were examined to draw parallels and identify best practices applicable to Uzbekistan's energy sector. This mixed-method approach ensures a comprehensive understanding of the challenges and opportunities in expanding green energy in the country.

The findings suggest that while Uzbekistan has made progress in increasing its green energy capacity, substantial reforms in market liberalization and investment policies are needed to achieve its 2030 goals. The study's results underscore the importance of government-led initiatives to foster a conducive environment for renewable energy investment. Implications of this research indicate that further policy reforms, financial incentives, and international cooperation are crucial for Uzbekistan to fully leverage its renewable energy potential. This study contributes to the growing body of literature on green energy transitions and provides a foundation for future research into the socio-economic impacts of green energy adoption in Uzbekistan and other developing nations [4].

Methods

The methodology for this study involved a mixed-method approach, combining both qualitative and quantitative data analysis to comprehensively assess the current state of green energy in Uzbekistan and provide recommendations for increasing its capacity. The research began with a review of secondary data, including policy documents, government reports, and international energy agency publications, to identify the trends and gaps in the country's renewable energy sector. Statistical data from national and international sources, such as the International Energy Agency (IEA), were analyzed to track the growth of green energy investments, production, and pricing trends from 2015 to 2023. The data collected was compared to Uzbekistan's renewable energy targets set by the government for 2030, providing insights into the progress made and areas requiring improvement.

In addition to document analysis, expert opinions were solicited through interviews with key stakeholders in Uzbekistan's energy sector, including policymakers, industry experts, and renewable energy project managers. This qualitative data was essential in understanding the barriers to policy implementation and market liberalization. Furthermore, case studies from countries with successful renewable energy transitions were analyzed to identify best practices that could be applied to Uzbekistan's context. The findings from the quantitative analysis were integrated with qualitative insights to develop actionable recommendations for policymakers, focusing on market-based reforms, targeted subsidies, and investment in green technologies. This holistic approach ensured a comprehensive understanding of the energy sector's challenges and opportunities, guiding the proposed solutions for increasing Uzbekistan's green energy capacity [5].

Result and Discussion

Experts contend that with 300-320 days of sunshine each year in our country, the potential in this area is considerable. Subsequent to the implementation of pragmatic policies in the Republic of Uzbekistan after 2017, the

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economy is growing, the standard of living for the population is enhancing, and the demand for energy is steadily increasing [6].

By 2030, our nation aims to produce 25 gigawatts of renewable energy and increase its share of the energy mix to 40%. In 2023, it is launching significant wind and solar power installations with a capacity of 2 gigawatts. Preliminary actions are being executed in the field of "green hydrogen" production.

By 2023, the integration of renewable energy sources, the transition of customers to alternative energy, and the adoption of energy-efficient technology are anticipated to generate an additional 5 billion kilowatt-hours of electricity and conserve 4.8 billion cubic meters of natural gas. A total allocation of 15.4 billion US dollars is designated for these efforts, consisting of 13.4 billion US dollars from investors in state-partnership projects and 1.1 billion US dollars in loans from commercial banks [7].

Nomi	2015	2016	2017	2018	2019	2020	2021	2022
Electricity produced by solar power plants *	0,003	0,3	0,7	0,2	0,1	0,03	49,0	435,8
Electricity produced by wind farms*	-	-	-	-	15,5	-	1,2	-

Table 1. ***Production of electricity from alternative energy sources, mln . kW Time, * Data is collected from 2015 [10]***

Since 2015, statistics regarding renewable energy in the Republic of Uzbekistan have been compiled. In 2015, solar power plants generated 0.003 million kWh of energy; in 2021 In 2018, this indication was 49.0 million kWh, constituting 0.07% of the total power produced [8]. In 2021, the entire production in our Republic was 71,364.6 million kWh, and early data for 2022 indicates 74,269.3 million kWh produced, resulting in a number of 0.6% compared to the first data of 2022. We contend that these indicators are insufficient to satisfy the present needs and objectives (Table 1).

An analysis of green energy production, utilising data from the International Energy Agency (IEA), reveals a declining trend in the production and installation costs of wind turbines, solar panels, electric vehicle batteries, and energy storage systems. As seen in Figure 1.

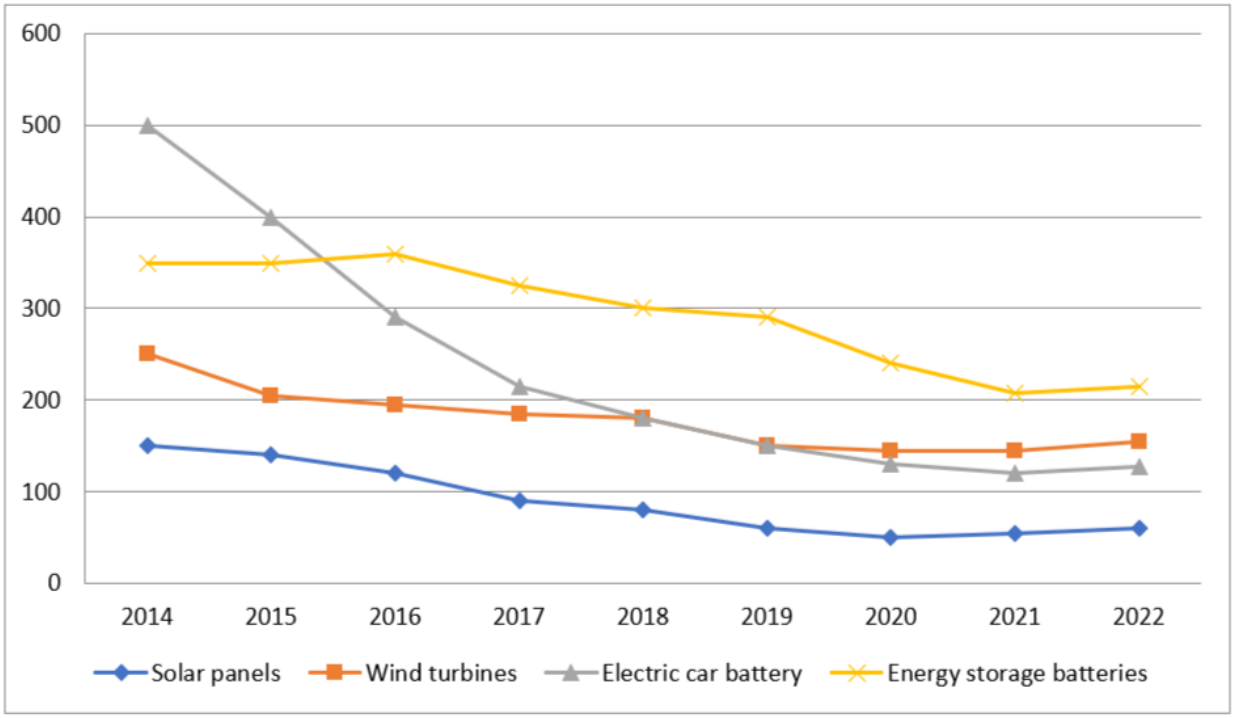

Figure 1. ***Green technology prices USD/kWh (nominal prices) (author's development based on data***

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from t he International Energy Agency)

The cost of bird panels will rise from 150-160 US dollars per kWh in 2014 to 70-80 US dollars in 2022. The cost of wind turbines will rise from 1240-260 USD per kWh in 2014 to 170-180 USD in 2022. Car battery prices decreased from $500-$550 per kWh in 2014 to $140-$150 per kWh in 2022, while energy storage battery prices fell from $350-$360 per kWh in 2014 to $210-$215 per kWh in 2022. This favourable trend is anticipated to persist in the forthcoming years.

In 2014, the price index for clean energy equipment was 230-240 million US dollars per megawatt, but by 2022, this amount had diminished to 100-110 million US dollars (Figure 2). This compels governments worldwide to consider these favourable tendencies when making choices in the energy sector [9].

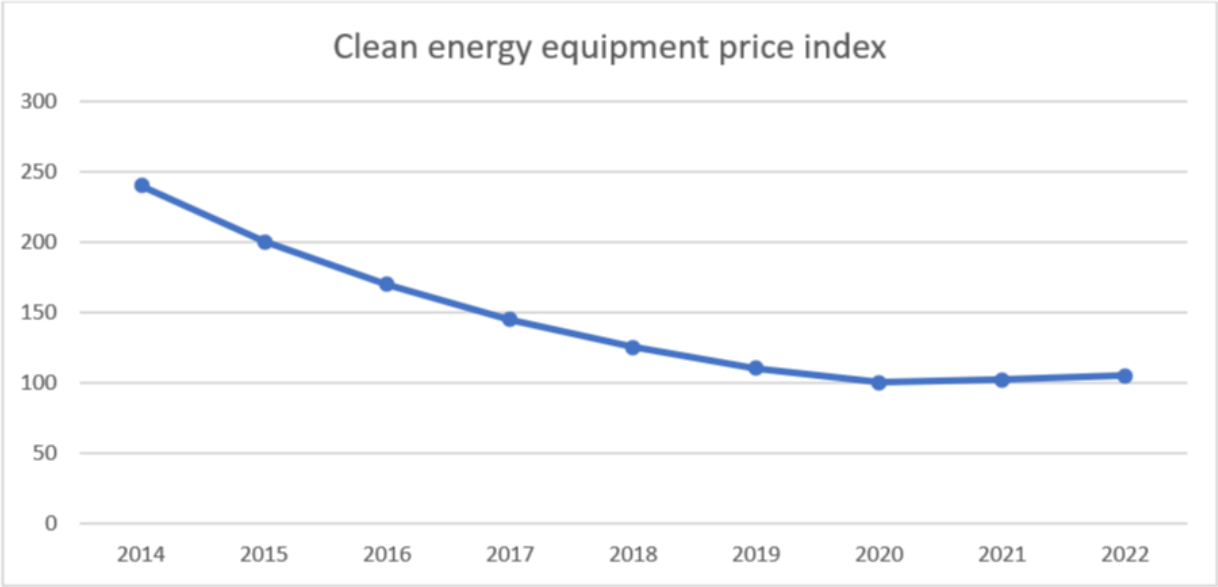

Figure 2. ***Clean energy equipment price index Million US dollars/megawatt (nominal prices) (author's development based on data from t he International Energy Agency)***

Investment in the global "green energy" business is rising each year. An examination of worldwide annual investments in energy production over the last three years indicates that in 2020, over 215 billion US dollars were invested in solar power plants, whereas 180 billion were allocated to wind power plants. Approximately US$ 1 billion, US$ 60 billion in coal-fired power plants, and US$ 40 billion in natural gas-fired power plants, with the total anticipated to reach US$ 360 billion in the Qushosh power plant sector by the conclusion of 2023. Surpassing US$215 billion, indicating a 68% rise relative to 2020. Wind power surpassed US$215 billion, indicating a 19% growth relative to 2020. Coal-fired power projects incur costs of around US$40 billion or greater compared to 2020. Natural gas-fired power plants are anticipated to invest around US$50 billion, indicating a 25% rise from 2020, in contrast to a 34% decline in investment during that year. The data reveals a growing emphasis on the green energy sector, with annual acceleration evident (Figure 3).

In recent years, the Republic of Uzbekistan has accelerated the construction of significant wind and solar power installations, and a framework for acquiring "green" electricity produced by citizens at "green" rates has been established. Subsidies are designated for the procurement of renewable energy sources. As a result, the use of renewable energy sources is increasing; nonetheless, we argue that the progress of the energy sector based on market principles and price liberalisation is still insufficient. The current residential electricity cost is 295 soums, equivalent to 0.024 US dollars (2.4 cents), although the original price is roughly 970 soums, according to the Ministry of Energy.

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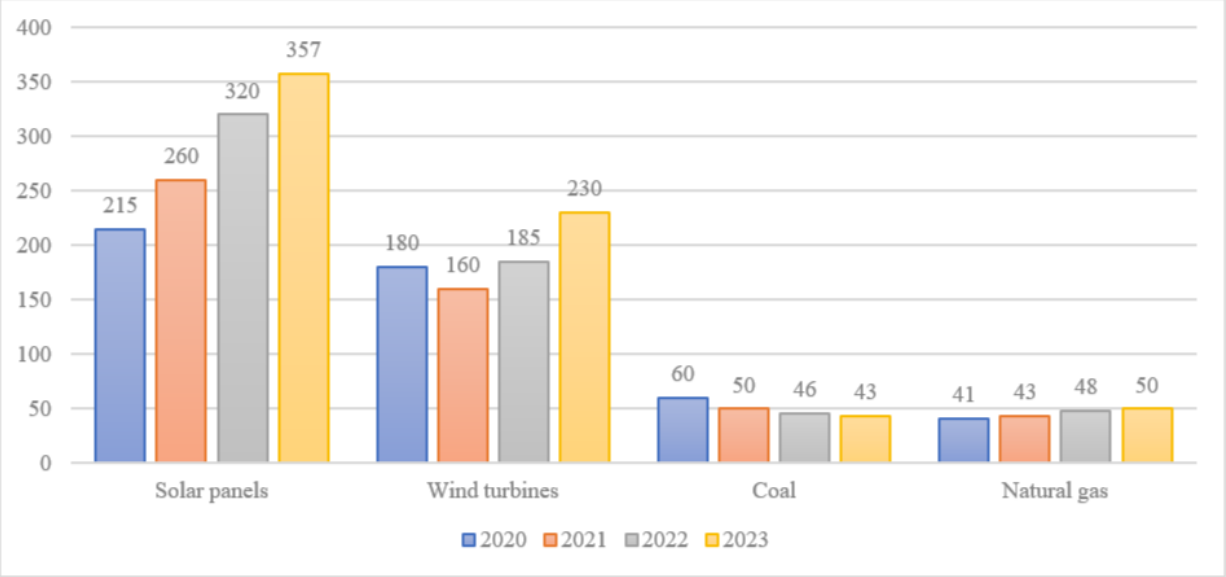

Figure 3. ***Global annual investment in energy production. billion US dollars (author's development based on data from the International Energy Agency) [4]***

The cost of one cubic metre of natural gas is 1,890 soums, whereas the price for consumers is 380 soums. Each year, around 14 trillion soums, surpassing 1.15 billion US dollars, are allocated from the state budget for the subsidisation of electricity and natural gas for the population [10].

A critical question arises: what is problematic with financing energy resources for the public via the state budget? The core logic of the matter is that, in our opinion, relevant questions arise: are these subsidies appropriately targeted? Are they fair? Are they logical? Article 68 of the Constitution of the Republic of Uzbekistan asserts that "Land, subterranean resources, water, flora and fauna, and other natural resources represent national wealth; their prudent utilisation is essential, and they are protected by the state..." Logical study of the aforementioned questions reveals that practically the entire population of Uzbekistan has access to electricity, although the natural gas supply level is roughly 50%. Moreover, Uzbekistan's per capita demand for natural gas is three times greater than that of wealthy nations and surrounding countries [11].

In foreign countries, the availability of fuel is 90 cubic meters per capita; nevertheless, in Uzbekistan, this figure exceeds 400 cubic meters [12]. A household utilises 5000 cubic meters of gas per year. Continuing the analysis, around 50% of the population receives state budget subsidies for both natural gas and electricity, and the other 50% receives subsidies exclusively for electricity. Analysis of power use (Table 2) reveals that around 75% of the population utilises around 26% of the total electricity, while over 25% of the population is responsible for more than 74% of the consumption. The administration intends to eliminate this irrational metric via differentiated tariffs. Nonetheless, we contend that this does not resolve the issue, as houses without natural gas typically consume more electricity [13]. The only just answer to this issue, guided by the experiences of industrialised countries, is market liberalisation, the implementation of market principles, and the allocation of targeted energy subsidies to the underprivileged population. In Germany, the energy supply operates on the principles of a fully competitive market, where consumers are billed according to their energy usage. This strategy encourages the utilisation of energy-efficient technologies and alternative energy sources by the public. Social protection is provided to the disadvantaged sector of the community in exchange for specific financial assistance [14].

№	Consumption volume	Subscribers (thousands)	share, %	Consumption (million kWh)	Share, %
1	Up to 200 kWh	5684	74,91%	5163	25,72%
2	201-300 kWh	737	9,71%	2258	11,25%
3	301-500 kWh	628	8,28%	2932	14,61%
4	501-1000 kWh	393	5,18%	3234	16,11%
5	1001-2000 kWh	82	1,08%	2529	12,60%
6	2001-5000 kWh	54	0,71%	1686	8,40%
7	5001-10000 kWh	6	0,08%	778	3,88%
8	10000 above kWh	4	0,05%	1491	7,43%
	Total:	7588	1	20071	1

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Table 2. ***Average electricity consumption of the population of Uzbekistan in 2023***

We assert that the organisational infrastructure is sufficient to apply market principles in our republic's energy sector, as electronic meters are installed in almost all residences, and the constitution recognises natural resources as public property; only political will is necessary to implement reforms [15].

Economic theory asserts that a reduction in the price of a product or service is associated with less scrutiny regarding its economic and accounting dimensions. A similar situation is seen in the supply of electricity and natural gas to the public. The utilisation of natural resources is a fundamental right of the Uzbek population, which can be managed judiciously, fairly, and appropriately. An allocation of 1.15 billion US dollars has been designated, yielding a subsidy of about 32 US dollars per capita for a population of 36 million, resulting in yearly subsidies of 32 US dollars from the State budget [16]. Nevertheless, the majority of these allocated subsidies is directed towards high-income families in the form of energy subsidies (Table 2). Official figures indicate that in 2022, 14.1% of Uzbekistan's population, totalling 36 million, resided in poverty, amounting to almost 5 million individuals. If these 5 million individuals receive energy subsidies of 32 ASH dollars apiece, the total would amount to 160 million US dollars. Thus, the remaining 1.15 billion US dollars, after deducting 0.16 billion US dollars, would result in 0.99 billion US dollars available for the state budget. Moreover, market-based pricing of energy resources facilitates their efficient utilisation by the public and encourages the use of renewable energy sources. Moreover, it will substantially increase the influx of foreign direct investments and investors into Uzbekistan's energy industry, augment the importance of renewable energy, and ensure that the supply of energy resources to the population remains stable and within defined norms. Price determination based on market demand fosters competition, hence positively impacting quality.

Conclusion

In conclusion, this study has highlighted the significant potential for expanding green energy capacity in Uzbekistan, particularly through solar and wind energy, given the country's favorable climatic conditions. Despite recent policy efforts and growing investments in renewable energy, the findings indicate that the current development pace falls short of meeting the country's ambitious 2030 targets. The implications of this research suggest the urgent need for further market liberalization, enhanced investment frameworks, and more targeted subsidies to accelerate the transition to green energy. Additionally, the study underscores the necessity for continued governmental support and international cooperation to overcome existing financial and infrastructural challenges. Further research is recommended to explore the integration of emerging green technologies, such as hydrogen energy, and to assess the socio-economic impacts of large-scale renewable energy adoption on local communities in Uzbekistan.

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