ISSN 2181-8622

Manufacturing technology problems

Scientific and Technical Journal Namangan Institute of Engineering and Technology

INDEX COPERNICUS INTERNATIONAL

Volume 10
Issue 1
2025

Google Scholar Crossref doi SLIB.UZ Scientific library of Uzbekistan

THE INFLUENCE OF THE COST OF ELECTRICITY PRODUCTION ON THE FORMATION OF TARIFFS

KADIROV KAMOLIDDIN
Senior researcher, Institute of Energy Problems, Tashkent, Uzbekistan
Phone.: (0890) 123-1133, E-mail.: kadirovkamoliddin8484@gmail.com
ORCID: 0009-0001-5806-5048

TOXTASHEV ALISHER
PhD student, Fergana State Technical University, Ferghana, Uzbekistan
Phone.: (0891) 147-3321, E-mail.: toxtashev.3321@gmail.com
ORCID: 0009-0007-2931-8951
**Corresponding author*

Abstract: This article examines the impact of renewable energy sources, specifically solar photovoltaic (PV) systems and hydropower, on load indicators and the cost of electricity production (tannarx) in Uzbekistan's industrial power grids. The study compares traditional thermal power plants (gas and coal) with renewable sources, analyzing their production costs. The article calculates the approximate tannarx for gas (305–596 UZS/kWh), coal (848.4 UZS/kWh), solar PV (253–483 UZS/kWh), and hydropower (300–400 UZS/kWh). Additionally, the challenges of integrating solar PV systems into the grid, including issues related to daily and seasonal production stability, are explored, and energy storage solutions are considered. The results indicate that increasing the use of renewable sources can minimize the current costs associated with gas and coal power plants by improving performance indicators.

Keywords: Thermal power plants, Production cost (cost price), Renewable energy, Solar PV (Photovoltaic), Hydropower, Load variation, Energy storage

Introduction. Despite the increasing number of electricity generation sources in the next stage of development, thermal power plants continue to dominate this sector in Uzbekistan, as in many countries around the world. In Uzbekistan, the share of thermal power plants in the total electricity production volume is approximately 85% (IES JSC), indicating that the primary responsibility for electricity supply lies with thermal power plants [1]. One of the key areas of the country's energy supply strategy is ensuring the affordability and reliability of electricity. Electricity prices are particularly significant for international competitiveness, as electricity typically constitutes a substantial portion of the overall energy costs for industrial and service enterprises. Factors such as climate, energy, transportation, value-added taxes, and other elements are taken into account to determine realistic tariff rates. The formation of electricity prices encourages fair competition by prompting consumers to choose between various energy sources (oil, coal, natural gas, and renewable energy sources) and different suppliers. Ensuring transparency in electricity pricing and providing broader clarity in pricing systems are considered effective approaches.

Considering seasonal impacts, prices are always distributed uniformly. Electricity tariff rates are determined by suppliers for all consumers, based on negotiated contracts for large non-state consumers. For smaller consumers, tariffs are typically set based on the amount of electricity consumed.

The average price of 1 kWh of electricity in developed countries is presented in the graph in Figure 1 [2].

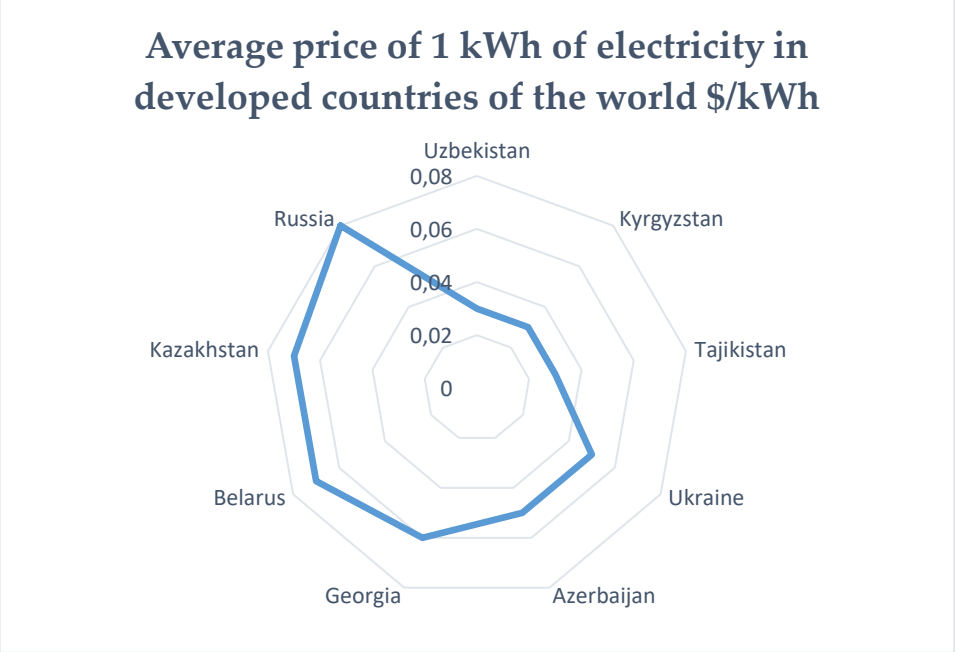

Figure 1. The average price of 1 kWh of electricity in developed countries

As can be seen from Figure 1, although energy efficiency in developed countries is high, prices are set at a higher level. This can serve as a basis for encouraging consumers to use electricity more rationally.

The average price of 1 kWh of electricity in Uzbekistan and neighboring countries is presented in the graph in Figure 2 [2].

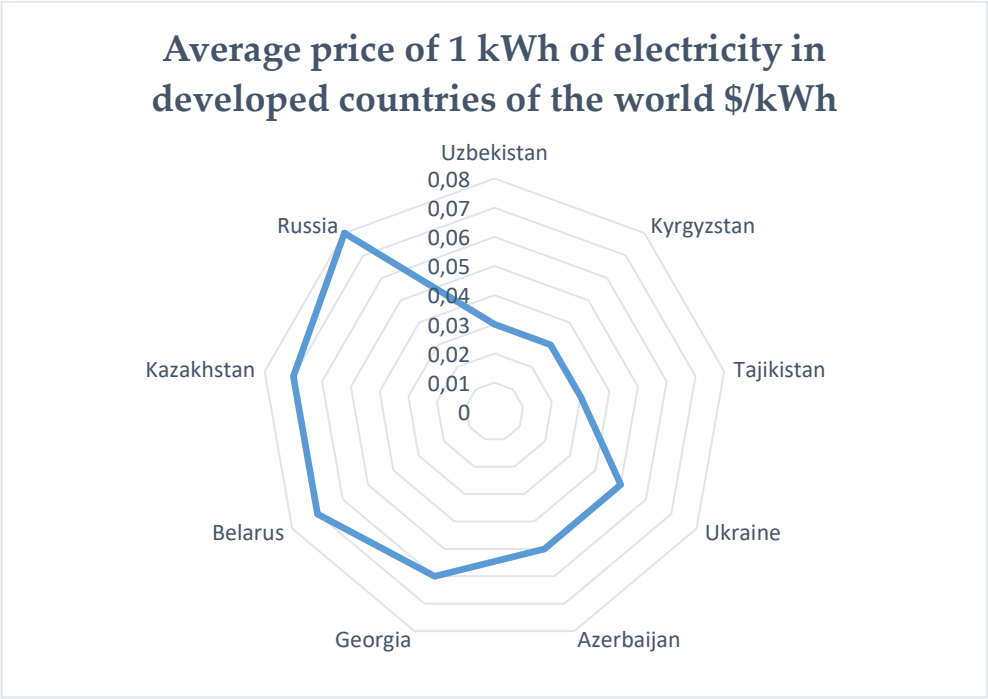

Figure 1. Average prices of 1 kWh of electricity in Uzbekistan and neighboring countries

As can be observed from Figure 2, which provides an example of Uzbekistan and neighboring countries, although electricity production in Kyrgyzstan and Tajikistan primarily relies on hydropower plants (HPPs), the average tariff rates are similar to those in Uzbekistan, where electricity is mainly generated by burning natural gas. In some of the developed countries mentioned in Figure 1, electricity is also produced by burning natural gas. However, the tariff rates in Uzbekistan do not currently align with the rates established in those countries. Therefore, it is deemed appropriate to shape tariff policies based on market mechanisms.

Methodology & empirical analysis. The study is based on empirical data analysis and cost calculations to assess the impact of renewable energy sources on Uzbekistan's industrial power grids. The article utilizes data obtained from the Ministry of Energy of Uzbekistan and "Issiqlik elektr stansiyalari" AJ, including the price of gas (660 UZS/m³), coal price (425,000 UZS/ton), and the installation cost of solar PV (5.5 million UZS/kW). The cost calculations (tannarx) for thermal power plants (gas: 305–596 UZS/kWh, coal: 848.4 UZS/kWh), solar PV (253–483 UZS/kWh), and hydropower (300–400 UZS/kWh) were conducted, taking into account fuel consumption and additional expenses (maintenance, depreciation). The research is grounded in Uzbekistan's 2020–2030 Energy Supply Concept [3], and it analyzes the technical and economic aspects of integrating renewable energy sources.

Results. According to the Resolution No. 204 of the Cabinet of Ministers of the Republic of Uzbekistan dated April 16, 2024, titled "On Additional Measures to Introduce Market Mechanisms in the Fuel and Energy Sector," the "Hududiy elektr tarmoqlari" AJ announced an increase in electricity prices starting from May 1, 2024 (Table 1) [4].

Table 1. Changes in Tariff Rates in the Republic

№	Consumers name	Unit of measure in soums for 1 kWh 01.05.2024
1.1.	Consumer groups I and II:	
	a) “Olmaliq kon metallurgiya kombinati” AJ, “Navoiy kon metallurgiya kombinati” AJ, “O‘zbekiston metallurgiya kombinati” AJ its constituent manufacturing enterprises, budget organizations, as well as pumping stations financed from the state budget;	
	b) for other consumers	1000 900
1.2.	Consumer group III, including the population:	
1.2.1.	For household consumers living in multi-apartment buildings and dormitories equipped with centralized electric stoves for cooking, based on monthly consumption:	
	- up to 200 kWh per month;	
	- from 201 kWh to 1,000 kWh per month;	
	- from 1,001 kWh to 5,000 kWh per month;	225

	- from 5,001 kWh to 10,000 kWh per month;	450
	- from 10,000 kWh per month and above.	675
		787,5
		900
1.2.2.	For the rest of the consumers, based on the consumption in one month:	
	- up to 200 kWh per month;	
	- from 201 kWh to 1,000 kWh per month;	450
	- from 1,001 kWh to 5,000 kWh per month;	900
	- from 5,001 kWh to 10,000 kWh per month;	1350
	- 10,000 kWh per month and above.	1575
		1800
1.3.	Consumer group IV:	900

In Uzbekistan, the main source of electricity is thermal power plants, where the fuel consumption for generating 1 kWh of electricity is 420 g/kWh in old power units, while in new combined heat and power plants (CHPs) it is 219-230 g/kWh [5]. In developed countries, this indicator is much lower. In particular, in Russia, the TPP is 285-309 g/kWh, in CHPs it is 197-214 g/kWh, in Kazakhstan, the TPP is 350 g/kWh, in CHPs it is 210-219 g/kWh, in Germany, the TPP is 191-211 g/kWh [6].

The difference in electricity production between countries is different, it is about 65% of total production in developed countries, 22% in developing countries, and 13% in countries with economies in transition. In developed countries, the cost of electricity production per capita per year is as follows [5]:

- Norway - 26 thousand kWh;
- Sweden - 26 thousand kWh;
- Canada - 18 thousand kWh;
- USA - 14 thousand kWh;
- France - 9 thousand kWh.

In Uzbekistan, this situation is considered quite low, with per capita electricity consumption at 2.2 kWh in 2024. According to forecasts, by 2030, per capita electricity consumption is expected to increase to 2,665 kWh per year. The amount of electricity produced per capita remains low [3].

In coal-fired thermal power plants (such as Angren and Yangi Angren in the republic), approximately 0.5 to 1.4 kg of brown coal is consumed to produce 1 kWh of electricity, depending on the quality of the coal.

The amount of water resources required to produce 1 kWh of electricity in hydropower plants (HPPs) depends directly on the potential energy of the water, particularly the height difference between the upper reservoir and the turbine, as well as the efficiency of the system. Therefore, the height of dams in small, low-altitude HPPs is significantly lower than that of larger ones. For a dam with a height of 100 meters,

approximately 250 UZS worth of water is consumed to produce 1 kWh of electricity [7]. For comparison, the height of the Charvak reservoir is 168 meters [8].

In 2024, hydropower plants (HPPs) in Uzbekistan generated 7.4 billion kWh of electricity [9,10], marking a 16% increase compared to 2023. Additionally, in 2024, solar and wind power plants in the country produced 4.5 billion kWh of electricity [11]. Below is a comparative table of the production costs (tannarx) for generating 1 kWh of electricity at various power plants [12].

Table 2. Cost of Producing 1 kWh of Electricity at Various Power Plants in the Republic

Power Plant Type	Fuel cost (sum/kWh)	Additional costs (sum/kWh)	Total cost (sum/kWh)
Thermal Power Plant (Gas - Old Units)	396	100–200	496–596
Thermal Power Plant (Gas - New CCGT)	205–218	100–200	305–418
Thermal Power Plant (Coal)	510–595	253–339	848.4
Solar PV	0	253–483	253–483
Hydropower (HPP)	200–250	100–150	300–400

According to the information provided by the Chairman of the Board of "Issiqlik elektr stansiyalari" AJ in this article [12], the cost of 1 cubic meter of gas is 660 soums. Old units (496–596 soums) are more expensive than new PGQ (305–418 soums) because of their lower efficiency. If the gas price is 660 soums/m^3, new technologies reduce the cost. According to the Information Service of the Ministry of Energy, based on information received from "Issiqlik elektr stansiyalari" AJ, the average cost of one ton of this mixed coal, including transportation and loading costs, is 425 thousand soums. An average of 1.2–1.4 kilograms of the same mixed coal are used to produce 1 kWh of electricity. It should be noted that the cost of electricity generation at a coal-fired power plant includes 60% fuel costs, 8% labor costs, 8.2% depreciation of buildings and power equipment, 5% repair costs, 8% exchange rate losses, 4% interest payments on loans, 1.5% tax payments, and 5.3% other costs. Today, the cost of electricity generation at coal-fired thermal power plants is 848.4 soums including value-added tax [13]. There are no fuel costs when using solar energy, but due to the high initial investment (5.5 million soums/kWh), the cost is 253–483 soums/kWh. In the long term (without storage), it is one of the cheapest options.

Thermal power plants (TPPs), which account for 85% of electricity in Uzbekistan, are based on gas and coal, and old gas units in particular have high fuel consumption (420 g/kWh) and are expensive (496–596 soums/kWh). New combined-cycle gas-fired

power plants (CCPPs) provide 305–418 soums/kWh with a consumption of 219–230 g/kWh. Therefore, it is necessary to gradually modernize old power plants or replace them with new CCPPs. Based on the "Concept of Electricity Supply of the Republic of Uzbekistan in 2020-2030", it is advisable to increase the overall efficiency of gas-fired power plants to 50–60%. This process will reduce fuel costs by 20–30% (approximately 100–150 soums/kWh) and optimize gas dependence. At the same time, it will be possible to reduce the burden on the state budget by attracting private sector investment in modernization projects.

The study showed that solar PV systems are economically competitive with gas (305–596 soums/kWh) and coal (848.4 soums) due to their fuel-free operation, with a cost of 253–483 soums/kWh. Although 4.5 billion kWh will be generated in 2024, the problem of seasonality and evening power supply requires storage systems. Therefore, it is proposed to increase solar PV capacity to 20–25% of total generation by 2030. In this case, short-term and long-term alternatives for energy storage, such as lithium-ion batteries, hydrogen storage systems, pumped hydro storage systems or thermal energy storage methods, should be tested. This approach will significantly reduce the dependence on gas and coal from 85% to 60–70%, significantly reducing the total cost and optimizing the costs of integration into the grid [14,15,16,17].

Hydroelectric power plants (HPPs) stand out as one of the most sustainable and long-term affordable sources with a cost of 300–400 soums/kWh. Although HPPs will generate 7.4 billion kWh in 2024, this will cover a small part of total consumption. In this regard, it is proposed to modernize existing infrastructure, such as the Charvak HPP, and build low-head HPPs on small rivers. For example, small HPP projects with a capacity of 5–10 MW in the mountainous regions of Uzbekistan can increase total production to 10–15 billion kWh. These projects cover the initial investment over a service life of 50–70 years and are much more environmentally friendly than coal and fuel oil. The use of a public-private partnership model will accelerate this process.

Co-firing hydrogen with natural gas (743–1,762 soums/kWh), coal (5,283–9,089 soums/kWh) or fuel oil (2,177–2,848 soums/kWh) has been found to be economically inefficient under current conditions (62% efficiency). However, hydrogen has significant potential for energy storage and emission reduction. Therefore, it is necessary to invest in scientific research to increase the efficiency of electrolyzers and fuel cells to 80–90%. At the same time, subsidies should be introduced to reduce the cost of hydrogen production via solar PV to 10,000–15,000 soums/kg. If this goal is achieved, in the future (within 5–10 years), the cost of hydrogen mixed with gas could be reduced to 500 soums/kWh, solving the problem of seasonal energy supply. This approach should be considered as a long-term strategy.

Conclusions. The article shows the impact of renewable energy sources on the quality and cost of electricity in Uzbekistan's industrial sectors. Compared with gas (305–596 soums/kWh) and coal (848.4 soums/kWh) thermal power plants, solar PV (253–483 soums/kWh) and hydropower (300–400 soums/kWh) are found to be economically competitive. However, the seasonality of solar PV systems and grid connection problems

require modernization of storage systems and infrastructure. Although an increase in the production of hydropower (7.4 billion kWh) and solar PV (4.5 billion kWh) is noted in 2024, they will constitute a small part of the total volume. To reduce costs, it is recommended to modernize gas plants, increase the share of solar PV and hydropower, as well as introduce energy storage solutions. This approach will serve to develop Uzbekistan's energy strategy.

References

1. Zaripov, O., Nimatov, S., Tovboev, A., Eralieva, Y., Zaripova, S., Zakirov, M., Nomozova, D., & Akhmedov, J. (2024). Calculation of the nominal power and electrical energy of the hydro power plant on an electronic calculator. E3S Web of Conferences. https://doi.org/10.1051/e3sconf/202448601027.

2. Аллаев К.Р. Замонавий энергетика ва унинг ривожланиш истиболлари. // Т.: “Фан ва технологиялар нашриёт-матбаа уйи” 2021 й. 952-б.

3. “2020-2030 yillarda O'zbekiston mamlakatni elektr energiya bilan ta'minlash kontsepsiyasi ” htt r s://min e n e rg u .uz/uz/lists/vi e w/28.

4. http://lex.uz//docs/6884060 Ёқилғи-энергетика соҳасида бозор механизмларини жорий этишнинг қўшимча чора-тадбирлари тўғрисида.

5. Saitkamolov, M., & Ilkhamova, Y. (2024). Econometric Model of Electric Power Sector’s Development in Uzbekistan. E3S Web of Conferences. https://doi.org/10.1051/e3sconf/202457401005.

6. Салибгареева К. В. Мировое производство электроэнергии // European science № 12(22), С. 37-41.

7. “Ўзбекгидроэнерго” АЖ ахборот хизмати.

8. https://qomus.info/encyclopedia/cat-ch/chorvoq-suv-ombori-uz/ 1-б.

9. Х.М.Муратов, К.Ш.Кадиров, А.П.Кушев, Х.У.Юсупалиева Increase efficiency at the expense of changing the working mode using time-differentiated tariffs // E3S Web of Conferences 563, 01011 (2024) ICESTE 2024 https://doi.org/10.1051/e3sconf/202456301011

10. https://sputniknews.uz/20231228/2024-ozbekiston-ges-74-milliard-kvt-elektr-energiya-41862995.html.

11. https://gov.uz/uz/minenergy/news/view/29602

12. https://kun.uz/07595733

13. https://www.uzbekcoal.uz/uz/news/bir-kilogramm-komirdan-qancha-elektr-ishlab-chiqariladi

14. AR Jordehi, "Yirik iste'molchining saqlash tizimi va talabga javob beradigan elektr energiyasini xarid qilish uchun xavfni biladigan ikki bosqichli stokastik dasturlash", "Energiyani saqlash jurnali", jild. 51, p. 104478, 2022 yil.

15. Muratov K., Kodirov K., and Kodirov D. Mechanisms of electrical energy management on different tariffs of industrial enterprises. In IOP Conference Series: Materials Science and Engineering, Vol. 883, p. 012163. (2020).

16. Isakov A. et al. Characteristics of application of different time rates for electricity consumed in industrial enterprises //E3S Web of Conferences. – EDP Sciences, 2023. – T. 401. – C. 05049.

17. Muratov K. et al. Investments reduction on developing the generating capacity with differentiated electricity tariffs //E3S Web of Conferences. – EDP Sciences, 2023. – T. 402. – C. 05019.

CONTENTS

CHEMICAL SCIENCES

TECHNICAL SCIENCES: MECHANICS AND MECHANICAL ENGINEERING