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Article

Energy Policy and Sustainable Development in Uzbekistan: From Economic Growth to The Introduction of Small-Scale Nuclear Generation

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Abstract: Uzbekistan's economic growth has been heavily dependent on its energy sector, which is characterized by high energy intensity and limited diversification, primarily reliant on natural gas and coal. Recent government reforms have prioritized renewable energy, efficiency improvement, and decarbonization, while simultaneously initiating the development of nuclear energy through small modular reactors (SMRs) as part of the national decarbonization strategy and energy independence agenda. Despite strong policy direction, there remains limited techno-economic analysis of SMRs' feasibility and their integrated impact on Uzbekistan's energy balance, environmental goals, and economic resilience. This study assesses the economic, technical, and environmental feasibility of constructing a 330 MW small modular nuclear power plant in Jizzakh region, analyzing profitability scenarios, energy security benefits, and emission reductions. Findings indicate that SMR deployment will provide stable base-load electricity of approximately 2.66 million MWh annually, reduce CO_2 emissions by up to 112,000 tons over 30 years, and enhance regional energy security. The calculated internal rate of return is 12%, with a payback period of 8 years under a hybrid tariff scenario, demonstrating investment viability. This article integrates energy policy analysis with detailed financial modelling of SMRs, emphasizing their environmental co-benefits and contribution to Uzbekistan's sustainable development strategy. The results support policy recommendations for integrating nuclear energy into the national energy mix, highlighting the importance of strategic financing models, safety standards adherence, and regional infrastructure adaptation to ensure effective implementation.

Keywords: Energy policy, economic growth, energy transition, renewable energy sources, nuclear energy, small modular nuclear power plant, techno-economic assessment, energy efficiency, sustainable development, energy consumption

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1. Introduction

Energy policy plays a decisive role in shaping the economic and social trajectory of any country, particularly for developing states striving to balance rapid growth with sustainability. In Uzbekistan, the energy sector has historically underpinned industrialization and socioeconomic advancement, yet the heavy reliance on fossil fuels has constrained long-term environmental goals. Recent reforms have intensified the government's focus on modernizing the energy system, integrating renewable sources, and enhancing efficiency to meet increasing domestic demand and international decarbonization commitments. Presidential decrees issued between 2023 and 2025 illustrate strategic priorities ranging from energy efficiency initiatives and green standards to the construction of solar, wind, hydroelectric, and micro-hydropower plants.

The declaration of 2025 as the Year of Environmental Protection and the Green Economy further emphasizes Uzbekistan's ambition to align economic development with sustainability goals. Despite these measures, energy consumption remains dominated by natural gas and coal, and the share of renewable energy is still negligible. This backdrop has prompted consideration of small modular nuclear reactors as a strategic addition to the national energy mix to ensure energy security while reducing emissions. Against this context, the article explores Uzbekistan's energy policy evolution, evaluates the techno-economic viability of the proposed small-scale nuclear project, and considers its potential to enhance energy independence and drive sustainable development. By analyzing macroeconomic indicators, sectoral energy dependencies, and financing scenarios, this study situates nuclear energy within broader national priorities to illustrate its relevance for Uzbekistan's long-term resilience and decarbonization strategy[1].

2. Materials and Methods

This study employed a comprehensive techno-economic assessment methodology to evaluate the feasibility of small modular nuclear power plants (SMNPPs) as a strategic component of Uzbekistan's sustainable energy development. The analysis began with a review of national energy policies, including Presidential Decrees and state programs on energy efficiency, renewable energy expansion, and nuclear power development. Macroeconomic data from the Statistical Portal of Uzbekistan and international organizations such as the World Bank and IRENA were used to analyze GDP growth, energy consumption trends, and sectoral energy intensity, establishing the economic context for nuclear investment. The research then developed an econometric model incorporating capital expenditure (CAPEX), operating expenditure (OPEX), revenue forecasts, depreciation, and tax impacts to calculate key financial indicators such as net profit, cash flow, discounted cash flow (DCF), internal rate of return (IRR), payback period, and profitability index under different financing scenarios, including public, credit-based, and hybrid schemes. Sensitivity analysis was performed to determine the project's resilience to risks related to capital costs, electricity generation, and tariff fluctuations. Environmental impact assessment included CO_2 emission reduction calculations, aligning the SMNPP project with Uzbekistan's decarbonization goals under the Paris Agreement. Technical parameters, including capacity factor, operational lifetime, cooling system design, and spent nuclear fuel management, were assessed based on Rosatom's Generation III+ VVER RITM-200N reactor specifications. This integrated methodological approach provided a holistic evaluation of the SMNPP project's economic viability, environmental benefits, and alignment with national strategic energy priorities[2].

3. Results and Discussion

The energy sector is an integral part of the economic system and is characterized by a complex network of interconnections with various sectors of the economy. The growth rate and structure of the fuel and energy complex have a direct impact on the development of numerous industries that produce goods and services for both the economy and the population. Energy supply is a key factor in increasing labor productivity and a fundamental condition for sustainable economic growth in both developed and developing countries[3].

In recent years, Uzbekistan has undertaken large-scale reforms of its energy sector, as evidenced by a series of regulatory documents. In particular, Presidential Decree No. PP-57 dated February 16, 2023, is aimed at introducing accelerated measures in the field of renewable energy sources and energy-saving technologies. Presidential Decree No. UP-118 dated August 23, 2024, emphasizes the improvement of the state control system within the fuel and energy complex[4].

Special attention is being given to institutional strengthening and increasing market transparency. For example, Presidential Decree No. PP-96 dated February 29, 2024, provides for active attraction of foreign investment in the construction of solar, wind, and hydroelectric power plants, as well as the development of energy storage systems. Under

Presidential Decree No. UP-63 dated March 27, 2025, "green" standards are being developed and a national strategy for improving energy efficiency in the medium term is being formulated[5].

Simultaneously, measures are being taken to ensure social protection for vulnerable population groups. Presidential Decree No. PP-134 dated April 2, 2025, provides for government support for low-income households in paying utility bills in the context of tariff policy reform . In addition, infrastructure projects continue to develop, including the construction of photovoltaic power stations and micro-hydropower plants, indicating a comprehensive approach to building a sustainable and diversified energy system[6].

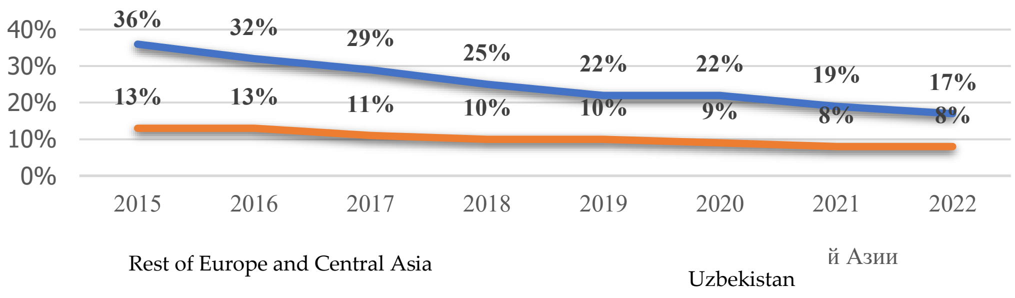
It is also worth noting that 2025 has been declared the Year of Environmental Protection and the Green Economy. During his address to the Legislative Chamber, the President of Uzbekistan, Shavkat Mirziyoyev, emphasized that "green" energy is becoming one of the main drivers of the national economy[7].

Uzbekistan possesses significant industrial and mineral-resource potential, unique agricultural raw materials, large volumes of intermediate products obtained during processing, rich natural resources, and developed infrastructure. A wide range of mineral resources has been identified across the country, comprising around 100 types of raw materials, of which 60 are already being utilized in the national economy [8].

According to the latest updated data from the World Bank on global poverty statistics as of March 2024, new data on Uzbekistan was included in the report for the first time, allowing for conclusions about the country's success in combating poverty both globally and regionally. Although Uzbekistan is classified as a lower-middle-income country, it has made significant progress. By 2022, the share of the population living below the poverty line fell by 5% according to the poverty threshold for lower-middle-income countries ($3.65 per person per day in 2017 PPP) [9].

According to international poverty level estimates, poverty in Uzbekistan (based on the upper-middle-income countries' poverty line) declined from 36% in 2015 to 17% in 2022. This reduction occurred at a faster pace than in the rest of Europe and Central Asia, where poverty fell from 13% to 8% during the same period, see Figure 1[10].

Figure 1. Share of Population Living Below the Poverty Line



Source: compiled by the author based on World Bank data.

A retrospective analysis also shows that the gross domestic product (GDP) per capita, calculated based on purchasing power parity (PPP), reached its highest level in 2024 over the past ten years[11].

As a result of the assessment of Uzbekistan's macroeconomic indicators over the past five years (from 2020 to 2024), we can observe significant and sustained economic growth in the Republic, see Table 1[12].

Table 1 Macroeconomic indicators of Uzbekistan

Indicator	**Unit**	**2020**	**2021**	**2022**	**2023**	**2024**
Gross Domestic Product (production approach, current prices, annual)	UZS billion	668 038,0	820 536,6	995 573,1	1 204 485,4	1 454 573,9
GDP Deflator Index	Point	111,6	112,5	115,9	113,1	113,3

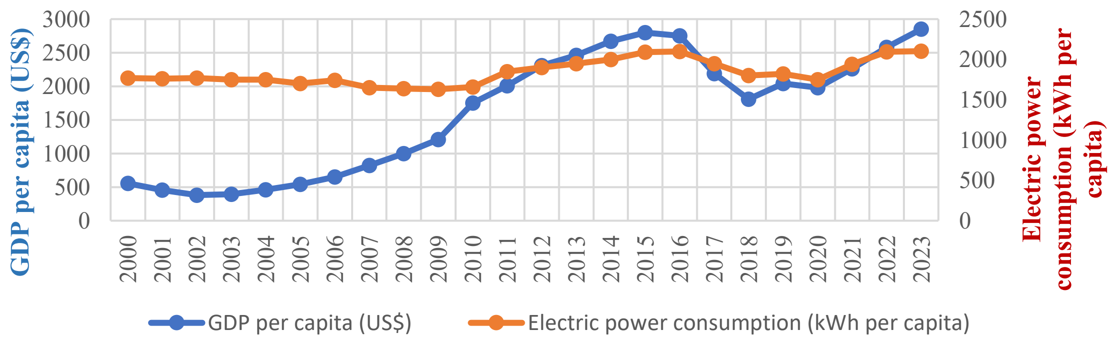
Indicator	Unit	2020	2021	2022	2023	2024
Inflation Rate	%	9,8	9,98	12,25	8,77	9,8
Volume of Industrial Production	UZS billion	368 740,2	456 056,1	553 265,0	658 991,7	703 803,1
Volume of Consumer Goods Production	UZS billion	129 348,6	155 159,1	145 011,7	164 747,9	176 280,3
Agriculture, Forestry and Fisheries	UZS billion	261 892,2	317 027,6	362 898,0	426 030,2	502 715,6
Volume of Investments in Fixed Capital	UZS billion	210 195,1	239 552,6	266 240,0	356 071,4	484 257,1
Volume of Construction Works	UZS billion	88 130,3	107 492,7	130 790,9	150 792,6	174 919,4
Retail Turnover	UZS billion	199 518,8	216 694,6	270 687,2	330 448,1	76 003,1
Volume of Market Services Rendered	UZS billion	219 978,5	284 388,1	366 891,0	477 469,9	171 889,2
Volume of Foreign Trade Turnover	USD mln	36 256,1	42 170,5	50 500,3	63 528,6	65 934,0
Volume of Exports	USD mln	15 102,3	16 662,8	19 732,6	24 869,5	26 948,2
Volume of Imports	USD mln	21 153,8	25 507,7	30 767,8	38 659,1	38 985,8
Balance	USD mln	-6 051,5	-8 844,9	-11 035,2	-13 789,6	-12 037,6

Source: compiled by the author based on data from the Statistical Portal of Uzbekistan

Based on the analysis of changes in GDP per capita and electricity consumption per capita in the Republic of Uzbekistan during the period from 2000 to 2023, a stable positive correlation between these indicators is observed, indicating a strong energy dependency of economic development, see Figure 2.

GDP growth throughout this period—particularly during phases of active industrialization and post-crisis recovery, including the aftermath of the COVID-19 pandemic—was accompanied by a parallel increase in electricity consumption.

Figure 2. Relationship Between GDP and Energy Consumption in Uzbekistan

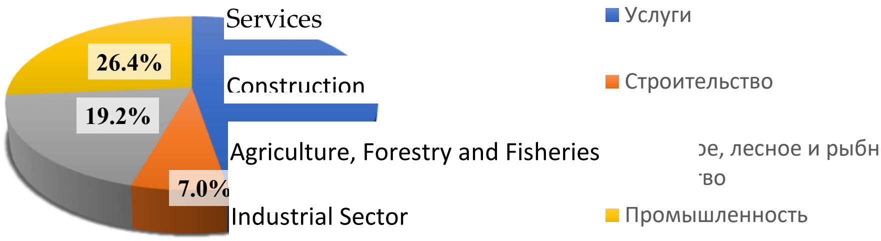


Source: compiled by the author based on World Bank data

This highlights the fundamental role of the energy sector as a core element of economic resilience. In this context, Uzbekistan's energy policy should focus on improving energy efficiency, modernizing the technical infrastructure of the energy complex, and actively integrating renewable energy sources with the aim of reducing the energy intensity of GDP without slowing the pace of economic growth[13].

A structural analysis of Uzbekistan's gross domestic product for the 2023–2024 fiscal year indicates that GDP more than doubled in nominal terms, with the increase primarily driven by a 47.4% growth in the services sector, see Figure 3.

Figure 3. Structure of Uzbekistan's GDP in 2024

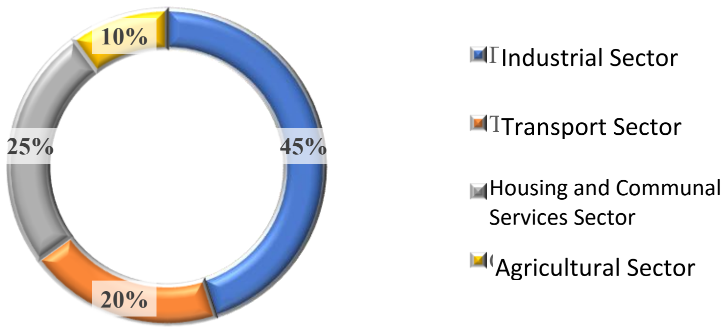


Source: compiled by the author based on data from the Statistical Portal of Uzbekistan

This disproportion is driven by the dominance of energy-intensive technological processes in sectors such as metallurgy, chemicals, and the textile industry. Agriculture, forestry, and fishing account for 19.2% of GDP while consuming only 10% of total energy, indicating relatively low energy intensity—a characteristic feature of agrarian sectors in developing economies, which largely rely on labor-intensive and low-mechanized production methods[14].

At the same time, the distribution profile of energy consumption across sectors significantly differs from the GDP structure, reflecting varying degrees of energy intensity among economic segments, see Figure 4. The industrial sector accounts for 26.4% of Uzbekistan's GDP while consuming 45% of total energy used, indicating its high energy intensity[15].

Figure 4. Distribution of Energy Consumption by Economic Sector in Uzbekistan in 2024



Source: compiled by the author based on data from the United Nations Economic Commission for Europe (UNECE) report

Despite accounting for the largest share of GDP (47.4%), the services sector demonstrates a relatively moderate level of energy consumption, while the housing and communal services sector (HCS) consumes 25% of total energy. This discrepancy may be attributed to the high level of wear and tear of engineering infrastructure and the insufficient energy efficiency of communal systems. Although transport is not separately accounted for in GDP calculations, it consumes 20% of all energy, indicating its heavy dependence on hydrocarbon fuels and the limited development of electric transport[16].

Overall, there is a marked divergence between the levels of economic productivity and the scale of energy consumption across sectors, necessitating adjustments in the directional priorities of energy policy.

According to the International Renewable Energy Agency (IRENA) report, Uzbekistan showed a significant decrease in primary energy exports from 378,186 TJ in 2016 to 197,489 TJ in 2021—nearly halving during this period, see Table 2[17].

Table 2 Primary energy trade in Uzbekistan

Parametr	2016	2021
Imports (TJ)	141 123	122 754
Exports (TJ)	378 186	197 489
Net Exports (TJ)	237 063	74 735
Imports (% of Supply)	8%	6%
Exports (% of Production)	18%	10%
Energy Self-Sufficiency (%)	114%	102%

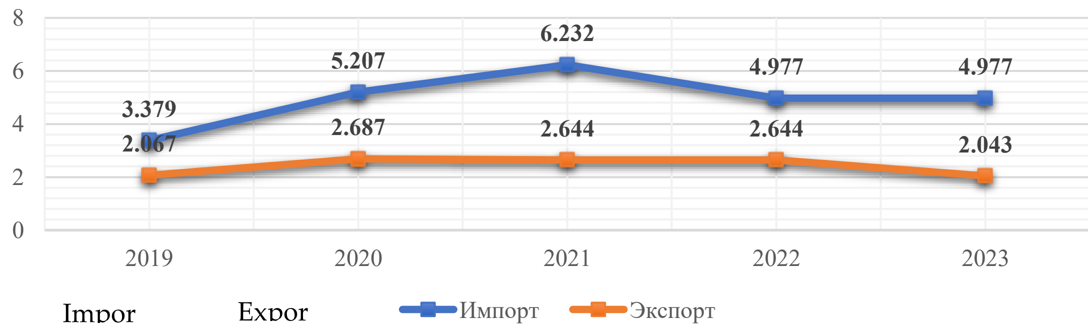
Source: compiled by the author based on data from the Uzbekistan Energy Profile report by IRENA

This trend may indicate a reduction in the scale of extraction or production of energy resources, as well as an increase in domestic demand, which in turn limits export potential. This is further evidenced by the decline in the share of exports within the overall production structure—from 18% to 10%—highlighting the growing reorientation of the energy sector toward meeting internal needs[18].

At the same time, a moderate decrease in primary energy imports was observed—from 141,123 TJ to 122,754 TJ. This led to a reduction in the share of imports in total energy supply from 8% to 6%, which may be the result of both import substitution policies and a decreased reliance on certain types of foreign energy carriers[19].

The decline in the net energy trade balance indicates a weakening of the country's position as a net exporter of primary energy resources, reflecting a shift in the structure of foreign economic flows in the energy sector, see Figure 5.

Figure 5. Primary Energy Exports and Imports in Uzbekistan, TWh



Source: compiled by the author based on data from the Statistical Portal of Uzbekistan

Given the annual population growth averaging 2% and the active economic growth of the Republic, primary energy consumption indicators in Uzbekistan show stability and moderate increase, aligning with the policy of rational use of energy resources. In terms of primary energy consumption, Uzbekistan occupies an intermediate position compared to Kazakhstan and Turkmenistan, see Figure 6.

Figure 6 . Primary Energy Consumption in Selected Central Asian Countries, Exajoules

Source: compiled by the author based on data from the 2024 World Energy Statistical Review

In the medium and long term, we can expect active growth in consumption due to investment activity, but this growth will likely be based on technological innovation and environmental priorities.

Between 2012 and 2022, Uzbekistan, there was steady growth in final consumption from 43.46 billion kWh in 2012 to 56.62 billion kWh in 2022, equivalent to an increase of more than 30%, see Figure 7. Despite minor fluctuations, the industry and construction sector has consistently held the leading share in the structure of final consumption, reaching 22.4 billion kWh in 2022.

Figure 7. Dynamics of Useful Electricity Consumption, billion kWh

Source: compiled by the author based on data from the Uzbekistan Energy Profile

The observed decline in 2018 may be associated with industry restructuring or production modernization, which led to a short-term reduction in energy consumption. While in 2012 the industrial sector's share significantly exceeded that of household consumption, by 2022 the structure has leveled out, indicating an increasing role of the consumer sector in the overall energy balance. This reflects socio-economic shifts and growing energy saturation among the population. Such dynamics highlight the need for a balanced energy policy aimed simultaneously at meeting rising demand, improving energy efficiency, and ensuring the resilience of the energy system.

Final Electricity Consumption foreca Industry and Construction c Commission for Europe

is entering a phase of accelerated energy consumption growth.

Household Consumers

...uld be given to the sharp increase in electricity consumption (including reserves) projected for 2028–2030, with an annual increase approaching 15 billion kWh. This underscores the necessity for timely expansion of generating capacity as well as modernization of electricity transmission and distribution infrastructure.

At the same time, it should be noted that as of 2024, the structure of Uzbekistan's energy sector shows a pronounced dependence on natural gas, which holds a dominant position in the national energy balance, see Figure 8.

Meanwhile, the share of renewable energy sources remains extremely low, limiting progress toward sustainable development.

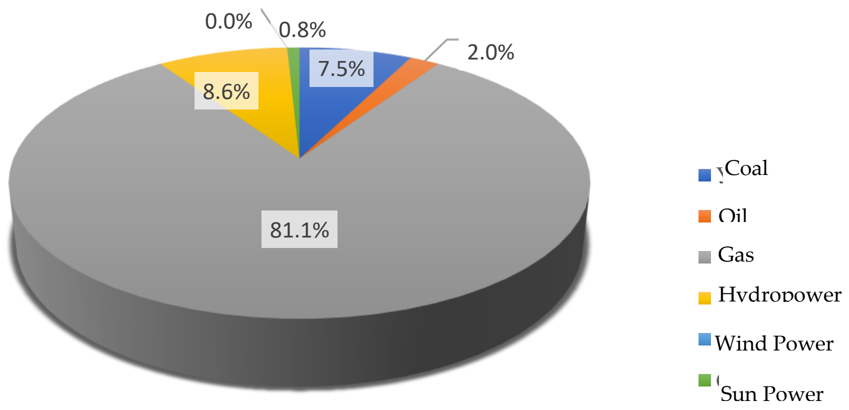


Figure 8. Structure of the Energy Sector in Uzbekistan in 2024

Source: compiled by the author based on data from the International Energy Agency (IEA)

Within the framework of Uzbekistan's international commitments, as outlined in the updated Nationally Determined Contribution (NDC) under the Paris Agreement, achieving emission reduction targets requires systematic and focused measures. Among the priority areas for our Republic, a key task is attracting strategic investments for the development of renewable energy sources and nuclear power. It is also worth noting that from 2012 to 2022, CO_2 emissions attributable to Uzbekistan's energy sector remained at a consistently high and fluctuating level, reflecting the dominance of fossil fuels—primarily natural gas and coal—in the national energy balance, see Figure 9.

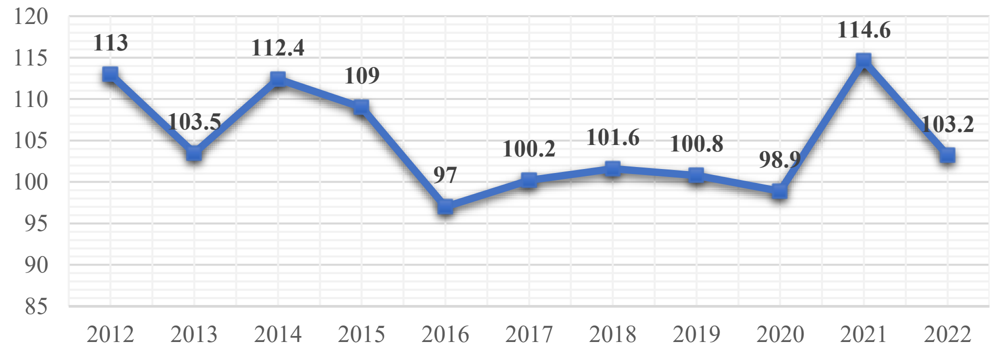


Figure 9. CO_2 Emissions Related to Energy, million tons

Source: compiled by the author based on data from the 2023 World Energy Statistical Review

However, the achievement of the declared goals in the field of renewable energy sources (RES) is accompanied by a number of systemic challenges that require a comprehensive institutional and infrastructural response. Among the factors hindering the development of RES in our Republic are infrastructural and technical limitations, financial and investment barriers, administrative and institutional obstacles, a shortage of skilled personnel and informational resources, as well as the persistent energy dependence on hydrocarbons.

In this context, nuclear power generation is considered one of the key energy sources in the long term.

A milestone in the development of nuclear energy was the Presidential Decree of the Republic of Uzbekistan dated July 19, 2018, "On Measures for the Development of Nuclear Energy," which established the authorized state body — the Agency for the Development of Nuclear Energy ("Uzatom"). This agency is entrusted with the functions of forming and implementing a unified state policy and strategic directions in this sector .

By the Presidential Decree No. PP-4165 dated February 7, 2019, the Concept for the Development of Nuclear Energy for 2019–2029 and the corresponding roadmap for its implementation were approved. These documents enshrine the key principles of state policy in the use of nuclear energy, including: the exclusively peaceful nature of nuclear technologies; ensuring protection of the population and the environment from ionizing radiation; compliance with international safety norms and standards established by the International Atomic Energy Agency (IAEA); and adherence to the nuclear non-proliferation regime .

In May 2024, a contract was signed between Uzatom and the State Corporation Rosatom for the construction of a small modular nuclear power plant (SMNPP).

The Uzbek SMNPP project will be implemented using Russian technology developed by Rosatom. The main technical parameters of the SMNPP project in Uzbekistan are as follows:

Location: Jizzakh region;
Planned commissioning period: 2029–2033;
Construction start: 2025;
Total installed capacity: 330 MW;
Configuration: 6 units of 55 MW each;
Reactor type: VVER RITM-200N (Generation III+);
Thermal capacity: 190 MW;
Electrical capacity per unit: 55 MW;
Projected operational lifetime: up to 60 years;
Refueling interval: once every 5–6 years.

Given the increasing water deficit in the Republic, Hungary has proposed organizing localized production of dry cooling systems for the nuclear power plant. This approach, widely used at Hungarian facilities, will significantly reduce water consumption for cooling nuclear reactors.

It is important to note that under the intergovernmental agreement between Uzbekistan and Russia, issues related to spent nuclear fuel (SNF) and radioactive waste (RW) management will be governed by separate agreements and contracts. The Russian side has undertaken obligations for the transportation and processing of SNF and RW, making it the sole partner offering such a comprehensive approach. In the future, within the structure of Uzatom, the establishment of a unified national operator for radioactive waste management is planned.

Furthermore, future monetization of avoided greenhouse gas emissions through participation in international carbon trading systems is possible. The potential economic benefit of this practice during 60 years of the NPP's operation is estimated at up to USD 19 billion when replacing gas-fired power plants and up to USD 35 billion when replacing coal-fired plants.

This is the first nuclear power plant project in Uzbekistan with strategic importance for the Republic. According to official statements, 14 potential sites are currently being considered for subsequent deployment of small nuclear power plants across the country's regions.

Within this framework, a proprietary econometric model for the construction of a small nuclear power plant in Uzbekistan was developed, and based on the calculation of key technical and economic indicators, conclusions were drawn about the possible prospects of nuclear energy in the Republic. Forecast calculations were carried out for the period 2025–2060. Several financing scenarios were considered: construction fully funded by the state (base case), fully credit-financed, and a 50/50 scheme to optimize the balance between risks and profitability — 50% state funds and 50% borrowed capital.

To justify the plant's feasibility, technical and economic indicators were calculated, forming the basis for conclusions regarding the advisability of building the plant in the Republic. The project provides for the construction of a small modular nuclear power plant based on the parameters listed above.

The cooling system in the project is based on dry cooling towers. The construction period is 7 years. The capacity factor of the plant is estimated at 85% — a typical level for such plants designed to operate at base load without frequent shutdowns (including 5% planned outages for inspections, 4% maintenance, and 6% load regulation). The annual electricity generation is expected to be 2.66 million MWh, with a total electricity output over 30 years of operation amounting to 79.8 million MWh.

The main technical and economic parameters of the base scenario for the entire calculation period from 2025 to 2060 are presented in Table 3.

Table 3. Key Technical and Economic Indicators of the Small Modular Nuclear Power Plant Construction Project in the Republic of Uzbekistan

№	Indicator name	Measurement unit	Option funded by public funds
1.	Capital Expenditures (CAPEX)	USD million	2 092,0
2.	Operating Expenditures (OPEX)	USD million	1 602,4
3.	Electricity Generation	million MWh	79,8
4.	Electricity Tariff (Hybrid)	USD million	в 2032 – 109,4 в 2060 – 117,2
5.	Revenue from Electricity Sales	USD million	9 037,8
6.	Depreciation Charges	USD million	2 092,0
7.	Earnings Before Interest, Taxes, Depreciation and Amortization (EBITDA)	USD million	7 435,4
8.	Earnings Before Interest and Taxes (EBIT)	USD million	5 326,4
9.	Tax Payments to the Budget	USD million	309,1
10.	Net Profit	USD million	5 057,7
11.	Cash Flow (CF)	USD million	5 057,7
12.	Discounted Cash Flow (at 10%)	USD million	339,9
13.	Discounted Cash Flow (at 12%)	USD million	47,7
14.	Payback Period	years	8,0
15.	Internal Rate of Return (IRR)	%	12
16.	Discounted Payback Period (at 10%)	years	15,9
17.	Discounted Payback Period (at 12%)	years	24,3
18.	Profitability Index (at 10%)	years	1,16
19.	Profitability Index (at 12%)	years	1,02

Source: compiled by the author

Capital expenditures were structured and incurred in stages according to the project construction roadmap, totaling USD 2,092 million over the entire 7-year construction period.

Operating costs over 30 years of operation are estimated at USD 1,602.4 million. The structure of operating expenses is presented in Table 4.

Table 4. Structure of Operating Expenses from 2032 to 2060

№	Indicator name	Measurement unit	Values	Share, %
	Operating Expense Item	USD million	1 602,4	100%
1.	Operating Expenditures (OPEX)	USD million	184,8	12%
2.	Payroll Fund (400 employees)	USD million	45,0	3%
3.	Insurance and Safety	USD million	120,0	7%
4.	Dry Cooling	USD million	150,0	9%
5.	Decommissioning Reserve	USD million	312,1	19%
6.	Maintenance (Scheduled Inspections)	USD million	1,5	0%

7.	Emergency Diesel Generators	USD million	319,5	20%
8.	Fuel Assemblies (+ Logistics)	USD million	135,0	8%
9.	Maintenance	млн.долл/кг	180,0	-
9.1.	Spent Nuclear Fuel (SNF) Disposal	кг	600 000,0	-
9.2.	Annual Volume of SNF	долл/кг	9 000,0	-
10.	Cost of Removal and Reprocessing	USD million	153,0	10%
11.	Waste Disposal	USD million	1,5	0%

Source: compiled by the author

The calculations were performed conservatively under conditions of neutral inflation relative to operating costs. The expenses include the full structure of fixed and variable items over the entire operational period. These values are presented as average annual figures based on the full capacity utilization of the plant. Expenses may vary depending on inflation, wage levels, tariffs for services, and logistics related to fuel and waste management.

Depreciation was calculated using the straight-line method: depreciation of buildings and structures ends in 2052, while depreciation of equipment ends in 2045. This is due to special depreciation benefits provided in Uzbekistan for energy facilities, including small modular reactors, which allow accelerated write-offs and reduce the taxable base. Up to 30% of the value of fixed assets can be written off in the first three years of operation. This results in reduced income tax during the initial years when the project has not yet reached full capacity.

A key parameter in the economic calculation of the small modular reactor (SMR) project is the electricity tariff, which determines the project's revenue. In Uzbekistan, three main tariff formation options are possible: hybrid tariff, fixed tariff, and market tariff. The hybrid tariff was used in this study as it is the most preferable, providing protection against inflation, accounting for cost growth, and balancing the interests of investors and consumers. In the first year of operation (2032), the electricity tariff will be $109.4 per MWh. Subsequently, it will escalate to $117.2 per MWh by 2060.

Revenue from electricity sales over the 30-year period will amount to $9,037.8 million. The gross financial result (EBITDA), calculated as the difference between revenue and operating costs, will total $7,435.4 million over the forecast period. Earnings before interest and taxes (EBIT) will amount to $5,326.4 million over the entire period. EBITDA and EBIT margins are 82% and 60%, respectively, indicating stable operational cash flow and strong potential for leveraging credit.

The share of total taxes paid as a percentage of revenue for the entire period is 3.6%. The largest tax contribution to the budget of the Republic of Uzbekistan under the project is corporate income tax, amounting to $268.7 million for the forecast period.

In the base case, net profit from the project over 30 years of operation will be $5,057.7 million. The cash flow in the base case—when construction is fully funded by government funds—is negative in 2032 at -$1,854.4 million due to capital expenditures. Over the entire project period, the cash flow will total $5,057.7 million. The average annual cash flow growth rate is 2–3%.

The discounted cash flow (DCF) at a discount rate of 10% is $339.9 million, and at 12% is $47.7 million. The payback period of the project is 8 years at an internal rate of return (IRR) of 12%. Discounted payback periods are 15 years and 9 months (at 10% discount rate) and 24 years and 3 months (at 12% discount rate).

Profitability indexes when financing the project fully with equity are 1.16 (at 10% discount rate) and 1.02 (at 12% discount rate).

Financial models considering loan financing for full capital coverage and a 50/50 scheme (50% government funds and 50% borrowing) show better financial indicators than the base case. This is because loan interest reduces the taxable base, thus increasing net cash flow during debt servicing. The 50/50 option is the most preferable due to its balance between maximizing returns and minimizing risks.

In addition to scenario analysis, a risk assessment was conducted relative to the base case using two methods: project scenario analysis and sensitivity analysis of the project's net present value (NPV).

The scenario analysis included pessimistic and optimistic project outcomes:

In the pessimistic scenario, electricity sales revenue will be $7,430.4 million, net profit $3,161.0 million. Total taxes paid to the Uzbekistan budget will be $340.0 million. Discounted cash flows turn negative during the project period: -$400.3 million and -$611.8 million at 10% and 12% discount rates, respectively. The payback period extends to 12 years with an IRR of 7%. Profitability indexes are 0.83 and 0.73 at 10% and 12% discount rates.

In the optimistic scenario, electricity sales revenue will reach $10,840.7 million, net profit $7,139.2 million. Taxes paid to the state budget will be $278.2 million. Discounted cash flows during the project period are $956.1 million and $580.6 million at 10% and 12% discount rates, respectively. Payback period shortens to 6 years with an IRR of 17%. Profitability indexes are 1.51 and 1.31 at 10% and 12% discount rates.

The final part of the model involved a sensitivity analysis of key project parameters against various risks. The most sensitive parameters identified were capital expenditures, annual electricity generation, and electricity tariff.

To conclude the sensitivity analysis and visually demonstrate how changes in key project indicators affect the net present value, see Figure 10.

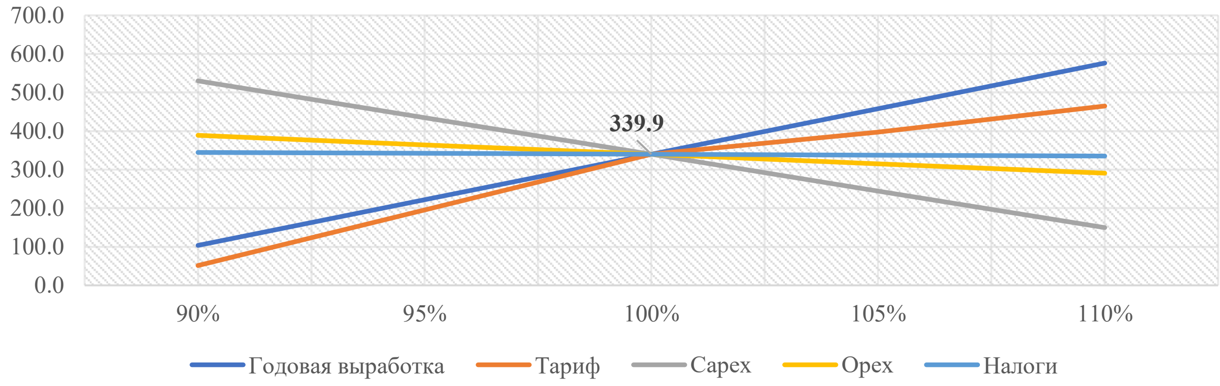


Figure 10. Sensitivity graph of the project's key parameters

Source: compiled by the author

This project is a pilot for Uzbekistan, aimed at providing a reliable, safe, and environmentally friendly source of electricity for the needs of industry and the population.

The commissioning of this 330 MW plant will reduce CO_2 emissions annually by approximately 1,200 tons compared to gas-fired power plants, and by more than 2,500 tons compared to coal-fired thermal power plants. The cumulative environmental benefit over 30 years of operation will amount to up to 112,000 tons of CO_2, which is equivalent to planting more than 5 million trees or completely eliminating 25,000 cars. This effect supports Uzbekistan's goals of reducing the carbon intensity of its economy and aligns with its international commitments under the Paris Agreement as well as the national decarbonization strategy.

4. Conclusion

The small modular reactor with an annual output of 2.66 million MWh will cover the electricity consumption of approximately 1.1 million households (assuming an average consumption of 2,500 kWh per year). Furthermore, considering the electricity consumption data for Jizzakh region—where the plant is expected to be built—at about 1,768.6 million kWh, the generated energy will be sufficient to meet the demand of approximately 1.5 such regions. Additionally, the generated electricity will replace 300 million cubic meters of natural gas, which would otherwise be required for a thermal power plant of similar capacity.

The results of this work make it clear that the small modular reactor project in Uzbekistan aligns with the strategic priorities of sustainable development, enhancing energy independence, and technological modernization of the economy. The financial indicators confirm its investment attractiveness, while adherence to international safety standards ensures its acceptability from environmental and social perspectives.

REFERENCES

[1] «Decree of the President of the Republic of Uzbekistan dated August 23, 2024, No. UP-118 „On measures to improve the state control system in the fuel and energy sector“». 2024 .

[2] «Decree of the President of the Republic of Uzbekistan dated July 19, 2018, No. UP-5484 „On measures to develop nuclear energy in the Republic of Uzbekistan“». 2018 . https://lex.uz/ru/docs/3829106

[3] «Decree of the President of the Republic of Uzbekistan dated March 27, 2025, No. UP-63 „On measures to improve state governance in the field of energy efficiency enhancement and development of the energy service companies market“». 2025 . https://lex.uz/ru/docs/7455525

[4] «Energy Profile Uzbekistan», International Renewable Energy Agency, Abu Dhabi, 2023. https://www.irena.org/-/media/Files/IRENA/Agency/Statistics/Statistical_Profiles/Asia/Uzbekistan_Asia_RE_SP.pdf

[5] «Energy system of Uzbekistan». 2025 . https://www.iea.org/countries/uzbekistan

[6] «Off-grid Solar Could Provide First-time Electricity Access to Almost 400 Million People Globally by 2030». 2024 . https://www.worldbank.org/en/news/press-release/2024/10/08/off-grid-solar-could-provide-first-time-electricity-access-to-almost-400-million-people-globally-by-2030

[7] «Open data of the Agency of Statistics under the President of the Republic of Uzbekistan». 2024 . https://stat.uz/ru/

[8] «Open data of the energy agency Enerdata». 2024. https://www.enerdata.net/

[9] «Report on electricity consumption in the cooling and air conditioning sector in the Republic of Uzbekistan», UNECE and UNDP Uzbekistan, 2021. https://unece.org/sites/default/files/2022-01/Report-UNDP_Data-on-energy-consumption_Rakhmanov.pdf

[10] «Resolution of the President of the Republic of Uzbekistan dated April 30, 2025, No. PP-158 „On measures to implement the investment project «Construction of a 500 MW solar photovoltaic power plant and overhead power lines in Farish district of Jizzakh region»“». 2025. https://www.lex.uz/en/docs/7508016

[11] «Resolution of the President of the Republic of Uzbekistan dated February 7, 2019, No. PP-4165 „On approval of the Concept for the development of nuclear energy in the Republic of Uzbekistan for the period 2019–2029“». 2019 . https://lex.uz/uz/docs/4194042

[12] «Resolution of the President of the Republic of Uzbekistan dated February 16, 2023, No. PP-57 „On measures to accelerate the introduction of renewable energy sources and energy-saving technologies in 2023“». 2023 https://lex.uz/uz/docs/6385720?ONDATE=10.01.2024

[13] «Resolution of the President of the Republic of Uzbekistan dated February 29, 2024, No. PP-96 „On measures to implement the investment project «Construction of an electric energy storage system with a capacity of 100 MW (200 MWh) in Parkent district of Tashkent region»“». 2024. https://lex.uz/docs/6824313

[14] «Resolution of the President of the Republic of Uzbekistan dated March 28, 2025, No. PP-129 „On additional measures for the development of the network of micro-hydroelectric power plants in the territories of the republic“». 2025 . ttps://lex.uz/ru/docs/7464356

[15] «Statistical Review of World Energy 2020», International Energy Agency, France, 2021. https://www.bp.com/content/dam/bp/business-sites/en/global/corporate/pdfs/energy-economics/statistical-review/bp-stats-review-2020-full-report.pdf

[16] «Statistical Review of World Energy 2024», Energy Institute, London, 2024. https://www.energyinst.org/statistical-review

[17] «Sustainable Development Goals». 2024 . https://www.un.org/sustainabledevelopment/ru/about/development-agenda/

[18] «The World Bank is supporting Uzbekistan's efforts to reduce poverty, create more and better jobs, enhance human capital, and build a more inclusive, resilient, and sustainable market economy». 2025. https://www.worldbank.org/en/country/uzbekistan/overview#economy

[19] «World Bank Data». 2024 . https://data.worldbank.org/