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Sociological analysis of public opinion on the construction of a nuclear power plant in Kazakhstan

Abstract: The prospect of constructing a nuclear power plant (NPP) in Kazakhstan has been intermittently discussed since the mid-1990s. It was not until 2021 that the issue received significant governmental attention due to predictions of an imminent energy deficit. An information imbalance exists, with authorities presenting the NPP as the sole solution to potential energy shortages and economic stagnation. The Kazakh government has announced a national referendum to decide, highlighting the country's leadership in uranium production and the need to advance its nuclear science.

Despite these developments, significant concerns remain regarding the risks and consequences of building the NPP, as the public lacks sufficient information about the project's prospects and potential impacts. The population has more questions than answers, reflecting a need for comprehensive and accurate information from the state.

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Public engagement is essential for the successful implementation of the NPP project. The government has initiated public discussions and hearings to achieve consensus and address public concerns. These efforts are critical, as public support is necessary for the project.
This study explores public awareness, transparency, and trust in the government's nuclear energy policy. It employs a sociological online survey to gauge public opinion and includes information from government materials, news articles, and a review of international experiences in nuclear energy. The findings underscore the importance of informed public engagement and transparent communication in successfully implementing nuclear energy projects in Kazakhstan.

Keywords: public awareness, nuclear policy, energy security, nuclear power plant, public opinion

Introduction

The quest for safe, environmentally friendly, reliable, and economically efficient energy sources has become paramount in the contemporary world. Population growth and economic development have heightened the demand for additional and alternative energy sources. However, traditional energy sources such as coal and oil significantly harm the environment by emitting numerous harmful substances, including greenhouse gases.

With its substantial coal reserves, Kazakhstan ranks among the top ten countries globally in this respect. Additionally, it holds the world's second-largest explored uranium reserves, constituting approximately 14% of the global total. Since becoming the leading global uranium producer in 2009, Kazakhstan has maintained a significant market presence, contributing about 40% of the world's uranium production (Opakhai et al. 2024).

As a signatory of the Kyoto Protocol and the Paris Agreement, Kazakhstan is committed to mitigating its environmental impact and reducing carbon emissions. The nation aims to reduce greenhouse gas emissions by 35% by 2040 and 40% by 2050, relative to 1992 (Movkebayeva et al. 2020). Despite these substantial natural resource reserves, Kazakhstan's energy system is gradually experiencing a power capacity deficit. To achieve energy security and balance capacity, the government of Kazakhstan intends to implement a nuclear power plant construction project.

In 2021, President Kassym-Jomart Tokayev instructed the government to promptly address the country's energy security issues, noting that Kazakhstan remains energy-dependent on neighboring states. In response, the government is developing a Low-Carbon Development Concept for Kazakhstan until 2050 and working on the National Project for the Development of the Electric Power Industry. Many of Kazakhstan's primary generating capacities, including thermal power plants, have been operational for over 40 years, with overall wear and tear exceeding 50%. This has led to increased technological disruptions at power plants. Despite these challenges, the country has successfully increased the share of renewable energy sources within the total energy balance to 3%.

President Tokayev has emphasized that Kazakhstan, as a primary energy producer, should maintain its leading position in the new energy sector. He argues that dismissing nuclear energy entirely is premature and erroneous, as the developed world relies heavily on it. He advocates for persistent explanatory work among the public to address unfounded fears, stressing the importance of not delaying the matter (Akorda 2021).

In his 2023 address to the nation, President Tokayev emphasized that the decision to construct a nuclear power plant should be made through a nationwide referendum. However, many citizens and experts have concerns regarding the safety of nuclear power plants. As newcomers to nuclear energy, the residents of Kazakhstan are particularly interested in understanding both the positive and negative aspects of nuclear power. Public acceptance of nuclear energy is a crucial factor influencing the development and implementation of nuclear power projects. Historical nuclear accidents have significantly altered public attitudes. The incidents at Three Mile Island (1979) and Chornobyl (1986) shifted public opinion, as evidenced in Finland in 1986. The 1999 Tokai Mura criticality accident in Japan led to a decline in support for nuclear power. Public trust in nuclear operators is influenced by the timeliness and transparency of information disclosure, with modern practices emphasizing shorter response times and greater openness (NEA 2010). (Alzahrani et al. 2022) found that past nuclear accidents, such as those at Chernobyl, Three Mile Island, and Fukushima, have heightened public concerns about nuclear safety, leading to a decline in trust towards nuclear energy. This decline is particularly notable given the availability of cleaner and renewable energy sources. The authors highlight anti-nuclear protests as evidence of public opposition, emphasizing the importance of public perception and acceptance of nuclear program development.

For the government to successfully implement the nuclear power plant construction project, it is essential to conduct public hearings and achieve public consensus. There are instances where nuclear power plant construction in other countries has been postponed due to a lack of public agreement. Consequently, if the government of Kazakhstan decides to proceed with the nuclear power plant project, it is necessary to increase public support for the project now. (Duliba and Chudyk 2023) Argue that recent nuclear events in Ukraine necessitate a reassessment of nuclear safety standards and the establishment of a new global nuclear safety paradigm. The radiation risks faced by Ukraine have potential transboundary impacts, emphasizing the need for an updated approach to nuclear safety.

(Karaeva et al. 2022) Argue that public opinion and ecological perspectives can either accelerate or hinder the development of green energy. Governments must adopt comprehensive strategies to achieve climate goals, including public awareness programs and integrating relevant courses into university curricula. (Kim et al. 2014) examined nuclear power acceptance in 19 countries, categorizing them into four groups based on acceptance levels. Their analysis found that more excellent knowledge of nuclear inspection and lower perceived terrorism risk increased acceptance. Trust in inspection authorities was crucial for reluctant acceptance, especially in regions opposed to nuclear facilities. Geographical proximity and cultural differences also impacted acceptance levels.

The primary aim of this study is to evaluate the public perception, awareness, and trust in governmental policies regarding the construction of nuclear power plants in Kazakhstan. This

research approach, however, has broader applicability beyond Kazakhstan. Countries like Poland, Egypt, and Turkey, also considering or actively developing nuclear energy projects, face similar challenges in balancing public opinion, environmental concerns, and energy security. By examining public attitudes and the importance of transparent governmental communication, this study provides a framework that could inform public policy strategies and social acceptance efforts in other regions contemplating nuclear power.

1. Materials and methods

This study aims to examine the level of public perception and understanding of nuclear energy among the Kazakhstani population, including its benefits and developmental risks. It also evaluates the effectiveness of current measures to improve public understanding of nuclear energy.

The research will be conducted in two phases:

1. PEST Analysis: This analysis will evaluate the Political, economic, Social, and Technological factors influencing public perception and acceptance of nuclear energy in Kazakhstan. The PEST framework helps identify external factors that could impact the development of nuclear energy in the country.

2. Online Survey: Over 100 respondents from Kazakhstan will participate in a voluntary online survey. The primary demographic includes citizens aged 31–40 (59%) and 21–30 (35%), representing a mature group with established political viewpoints. Respondents were not categorized by urban or rural residency, as energy transition concerns affect all demographics equally.

This study utilized an online survey conducted via Google Surveys. The survey was conducted from February 28 to March 10, 2023, and included 108 respondents.

The survey includes questions designed to identify key predictors of nuclear energy development in Kazakhstan, such as:

- Knowledge and Awareness of Nuclear Energy: Assessing public understanding of nuclear energy, its operation, potential benefits, and risks.
- Support for Nuclear Energy: Gauging overall public support for nuclear energy as a source of electricity.
- Risk Perception: Understanding public perception of the risks and benefits associated with nuclear energy, including safety, environmental impact, and security concerns.
- Trust in Government Institutions: Evaluating public trust in authorities, companies, and other stakeholders involved in nuclear energy.

Additionally, the study will incorporate data from the Demoscope Bureau's 2023 survey on „Kazakhstanis' Attitudes towards the Construction of a Nuclear Power Plant (NPP)," which surveyed 1,100 individuals across 17 regions and cities of national significance. This survey included 57% male and 43% female participants over 18 years old (Demoscope 2023).

The findings will provide insights into public opinion on nuclear energy and identify factors influencing its acceptance, informing strategies for effective communication and policy development in the nuclear energy sector.

2. Nuclear energy and test sites in Kazakhstan

Energy security is a critical component of Kazakhstan's national security framework. It ensures a reliable, sustainable, and economically efficient energy supply that meets the needs of the economy and population while minimizing risks associated with energy supply and usage. It involves safeguarding against fuel and energy resource shortages, maintaining supply stability for domestic consumption, adapting to global price changes, and ensuring the safety of energy infrastructure. This is particularly significant for Kazakhstan, a leading producer and exporter of oil, gas, and uranium (Nurlan 2023).

Globally, the nuclear power sector is expanding, with 431 operational nuclear reactors worldwide and seven new reactors becoming operational in 2022. Additionally, construction of ten reactors is underway in China, Egypt, and Turkey. Approximately thirty countries are in various stages of considering, planning, or initiating nuclear power programs (Duliba and Chudyk 2023).

Since gaining independence, the Kazakh government has intermittently considered constructing a nuclear power plant. Initially, experts deemed it unnecessary, leading to indefinite postponement (Mussin and Mussina 2023a). However, in 2013, during a meeting on the implementation of the "Kazakhstan-2050 Strategy," the first President of Kazakhstan, Nursultan Nazarbayev, emphasized the necessity of building a nuclear power plant (Tengrinews 2014).

Kazakhstan has a long-standing history in the nuclear industry, with facilities dedicated to producing uranium pellets and operating the National Nuclear Center (Mussin and Mussina 2023a). The country ensures the safe operation of research reactors, including the IVG.1M and IGR at the National Nuclear Center in Kurchatov, and the VVR-K at the Institute of Nuclear Physics in Almaty. The interdisciplinary research complex with a heavy ion accelerator (DC-60) in Astana has been operational since 2006. In 2016, the VVR-K reactor was converted from highly enriched uranium to low-enriched uranium fuel, enhancing nuclear non-proliferation and safety. Additionally, the Nuclear Medicine and Biophysics Center, established in 2016, produces medical isotopes and provides radiation sterilization services (Ministry of Energy 2020).

Kazakhstan's nuclear sector spans a wide array of developmental domains, including the nuclear industry, advancements in science and technology, nuclear medicine, thermonuclear and accelerator technologies, and the operation of research reactors. However, the local population harbors significant apprehension towards nuclear energy, primarily due to fears of potential radiation leaks, challenges in managing radioactive waste, and general concerns about radioactivity.

The persistent delays in constructing a nuclear power plant in Kazakhstan can be partly attributed to the country's negative experiences with radioactive fallout from nuclear tests

conducted during the Soviet era. These tests, performed at sites such as the Semipalatinsk Test Site, have ingrained a sense of caution and fear among the populace regarding nuclear technologies. Historical nuclear tests have left an indelible mark on public consciousness, leading to substantial concerns about the safety of nuclear energy.

Kazakhstan's extensive steppe regions, historically vulnerable to disruptions from wars and disasters, prompted the Soviet Union to establish the Semipalatinsk site in the northern part of Kazakhstan as a nuclear testing ground. Between 1949 and 1991, a total of 456 nuclear tests were conducted at Semipalatinsk. Initial studies at the site assessed radioactivity and radiation doses, revealing that acute radiation syndrome affected approximately 250,000 residents in Ust-Kamenogorsk in 1956. The Soviet government concealed information regarding contamination, leaving residents unaware of the dangers, including those posed by the "atomic lake" Chagan.

The Semipalatinsk nuclear test site (STS) is located in the steppe, approximately 150 km west of Semey in eastern Kazakhstan. Kurchatov, a classified military city, lies 60 km west of Semey. The site conducted 126 atmospheric tests, including some with yields up to 1,000 kilotons, and 340 underground tests. The Soviet government kept the incidence of acute radiation syndrome from these tests highly confidential, noting that the cases were four times more numerous than those resulting from the Chornobyl disaster. Residents living downwind were not informed about the tests and observed mushroom clouds without understanding their origin (Nakamura et al. 2020).

STS served as the primary location for nuclear weapons testing in the former Soviet Union, resulting in extensive and highly variable radioactive contamination across the STS and surrounding areas. The most severe radioactive contamination is concentrated in several technical areas, including the "Experimental Field," "Degelen," "Balapan," "Sary-Uzen," and "4A" (Geras'kin et al. 2021). The cumulative yield of nuclear charges at Semipalatinsk from 1949 to 1963 exceeded the yield of the atomic bomb dropped on Hiroshima by 2500 times, exposing approximately 1.3 million residents of the Semipalatinsk, Karaganda, and Pavlodar regions to radiation (Orda 2021).

In 1991, by a decree of the First President of the Republic of Kazakhstan, Nursultan Nazarbayev, the world's largest nuclear test site at Semipalatinsk was closed (Ministry of Energy 2020). Additionally, nuclear tests were conducted at Kapustin Yar, situated in Western Kazakhstan, where ten nuclear explosions were carried out between 1957 and 1962. These tests included both atmospheric and underground detonations, and the site was also crucial for the Soviet missile development program, contributing significantly to advancements in missile technology. The legacy of these tests has had enduring impacts on the environment and public health in the region, highlighting the long-term consequences of such activities (NTI 2023).

Kazakhstan is home to several significant nuclear test sites, including the Semipalatinsk Test Site, established in 1949, the "Kapustin Yar" missile-nuclear test site, the "Taysogan" missile range in Atyrau Region, operational since 1962, and the "Azgir" nuclear test site, also in Atyrau Region. The "Lira" site saw six explosions aimed at creating storage cavities for condensate at the Karachaganak field. The average volume of active nuclear test site waste in Kazakhstan is estimated at 6.5 million tons, with an activity level of 11,600 curies. These areas, shown in

Figure 1, have been designated as ecological disaster zones due to extensive military testing and subsequent chemical contamination.

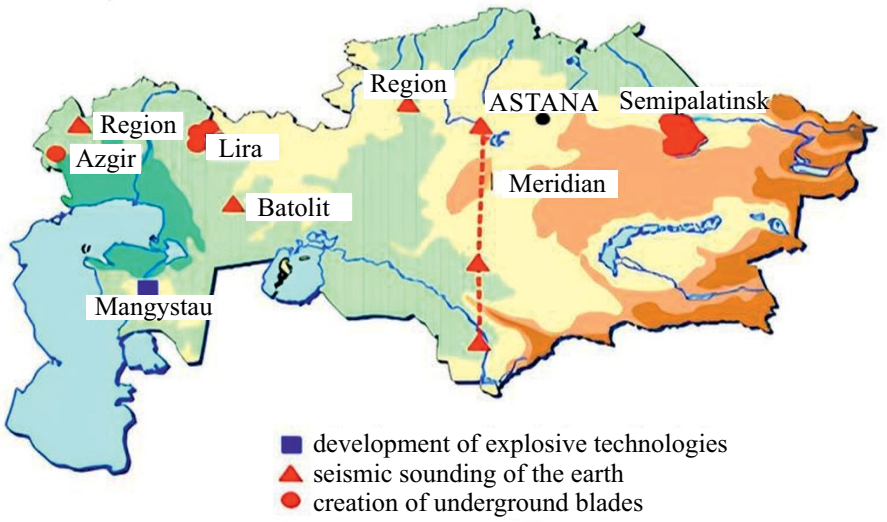

Fig. 1. Map of nuclear testing sites in the territory Kazakhstan (NNC RK Bulletin 2012)

Rys. 1. Mapa miejsc prób jądrowych na terytorium Kazachstanu

The combined yield of nuclear explosions in Kazakhstan is 45,000 times greater than the bomb dropped on Hiroshima during World War II. Currently, Kazakhstan operates five reactors: one power reactor in Aktau, three research reactors at the Semipalatinsk Test Site, and one research reactor in Almaty. The intense development of oil fields in the Mangistau and Atyrau regions has resulted in significant technogenic radioactive contamination, creating crisis zones. Twelve cities and settlements, with a combined population of 100,000 people in these areas, are within radioactive hazard zones. At 22 major oil fields, 267 sources of radioactive contamination, with radiation levels ranging from 100 to 17,000 μR/h, have been identified (NNC RK Bulletin 2012).

In Mangystau, Kazakhstan, the BN-350, recognized as the world's first industrial fast neutron reactor utilizing a sodium coolant, is currently undergoing decommissioning (informburo 2017). This reactor was part of the Mangyshlak Atomic Energy Complex, a pioneering facility that integrated a reactor, thermal power plants, and desalination units. The BN-350 achieved its physical launch in 1972, followed by its energy launch in 1973, and maintained a commendable operational safety record over its 26-year lifespan. Distinguished as the sole nuclear desalination plant globally, the BN-350 was engineered for a lifespan of 45–50 years and had an electrical capacity of 350 MW, allocated as 150 MW for electricity, 100 MW for heating, and 100 MW for desalination. Following its shutdown in 1999, a comprehensive decommissioning plan was executed, encompassing five key areas: fuel management, handling of liquid radioactive waste, solid radioactive waste management, sodium management for the primary and secondary circuits, and maintenance of the

facility's structural integrity. The reactor fuel has been relocated to the former Semipalatinsk test site, and current steam generation is solely reliant on natural gas combustion.

Significant concerns regarding the BN-350 reactor in Kazakhstan were raised due to its capability to produce both energy and plutonium, a material used in weapons (Kursiv 2022). Following Kazakhstan's independence in 1991, fears arose that plutonium could potentially be diverted for non-peaceful purposes. To address this concern and prevent potential misuse, the US government proposed decommissioning the reactor and funding the conversion of desalination units to be powered by thermal power sources.

Research by (Markabayeva et al. 2018) reveals that the majority of uranium mines in Kazakhstan are located in the southern and northern regions. Environmental pollution from these mining activities arises due to open-pit uranium mining, ore grinding and processing, and the storage of uranium reserves. The study found that the effective dose of radon exposure in East Kazakhstan is 1.5 times higher than the global average, with annual individual doses in Ust-Kamenogorsk City exceeding 5 mSv/year, indicating high exposure levels to natural radiation sources.

Since gaining independence, Kazakhstan has transformed from possessing the world's fourth-largest nuclear arsenal to becoming a leader in global non-proliferation. The Government of Kazakhstan has undertaken ambitious measures to construct a nuclear power plant, aiming to enhance the country's energy security and reduce its dependence on fossil fuels. However, historical events, such as the numerous nuclear tests conducted on Kazakh territory during the Soviet era, have significantly influenced public perception of nuclear initiatives. These tests, particularly at the Semipalatinsk nuclear test site, have left a profound impact on the population's consciousness, leading to substantial concerns and negative attitudes toward new nuclear projects. Despite the government's efforts to implement safe and environmentally friendly technologies, overcoming historical fears and ensuring public support remain critical challenges.

In light of these concerns, the government needs to engage in transparent communication with the public, providing comprehensive information on the safety measures and benefits of nuclear energy. This approach will help address the deep-seated fears stemming from past experiences and build a foundation of trust and informed support for Kazakhstan's nuclear energy initiatives.

3. Current situation and prospects for nuclear power development in Kazakhstan

In 2022, Kazakhstan produced 21.3 thousand tons of uranium. Due to geopolitical instability in 2023, the country is exploring the diversification of uranium supply routes. Throughout 2023, energy, particularly nuclear energy, became a prominent topic of discussion in Kazakh society.

President Tokayev began emphasizing the necessity of constructing a nuclear power plant in 2022, citing anticipated electricity shortages in the near future.

The Agreement on Partnership and Cooperation (APC) between Kazakhstan and the EU has facilitated progress to a new stage in their relationship, including sector-specific contracts. In 2006, they signed an Agreement on the Peaceful Uses of Nuclear Energy and a Memorandum of Understanding on Energy Matters. The EU's strategy for Central Asia prioritizes combating common threats, ensuring environmental sustainability, enhancing energy and transport links, promoting human rights and governance, advancing youth and education, and fostering economic development (Baizakova and Yergeshkyzy 2013).

In recent years, unresolved issues in Kazakhstan's energy sector have remained a significant concern for the government. In 2019, President K. Tokayev addressed these challenges in a national address, highlighting the increasing depreciation of key power-generating facilities, many of which have been in operation for over 40 years (Mussin and Mussina 2023b).

According to the forecast balance of electrical energy of the Unified Electric System of the Republic of Kazakhstan, a shortage of electricity is expected between 2022 and 2028.

The forecast data from the Ministry of Energy of the Republic of Kazakhstan for the years 2022–2028 indicate an anticipated electricity deficit. This deficit is driven by an annual increase in electricity consumption, projected to rise by an average of 3.5–4 billion kWh each year. As of January 1, 2021, the total installed capacity of all power plants in the country was 23.6 GW. Kazakhstan operates 68 thermal power plants, with 70% of the installed capacity having an average age of 50 to 55 years. Analyzing electricity production in the wholesale market over the past 20 years reveals that in 2000, electricity production was 51.4 billion kWh, while in 2022, production reached 115.1 billion kWh (Mussin and Nurlan 2023).

Kazakhstan is grappling with a shortage of electrical energy and capacity, amounting to more than 1.3 GW as of the fall of 2021, particularly during evening hours. According to forecasts, this electricity shortage is expected to persist until 2025, with the deficit reaching a maximum of 5.5 billion kWh by 2029. It is noteworthy that there is currently a reduction in available power reserves. The present situation raises concerns that a power shortage may occur earlier than predicted and in much larger volumes (Forbes 2023).

The Ministry of Energy of the Republic of Kazakhstan forecasts a significant electricity shortage until 2035, anticipating a deficit of 4 GW starting from 2031 (Ministry of Energy of the RoK 2022). To address this shortage, the state plans to construct a nuclear power plant and increase the share of renewable energy sources in the energy mix (Kursiv 2022).

The looming energy shortage and rising consumption have led the Government of Kazakhstan to import electricity from the neighboring Russian Federation at market rates or higher. This strategy not only aims to generate additional income for Russia but also to bolster its power plants, thus influencing regional energy dynamics.

Kazakhstan has substantial potential for solar and wind energy; however, these resources remain underutilized due to inadequate infrastructure and the lack of a comprehensive institutional and legislative framework (Karatayev et al. 2017). Some experts argue that the electricity shortage in Kazakhstan has been artificially created and that constructing a nuclear

power plant (NPP) will not resolve the energy deficit. They advocate for the development of renewable energy sources (RES), leveraging the country's successful auction mechanism for building renewable energy power plants. Over six years, this mechanism has driven down electricity prices from new power plants by threefold. The latest auctions have seen wind power costs drop below 10.5 tenge per kWh (approximately $0.023). By conducting sufficient auctions, Kazakhstan could meet all its energy needs and eliminate the electricity deficit within the next 2–4 years.

The argument that nuclear energy is cost-effective is also challenged. The cost of 1 kWh of electricity from NPPs is five times higher than that of renewable energy. For instance, the Akkuyu NPP in Turkey, a project by Rosatom, has a contract price of 12.35 cents per kWh (GEM 2023). The proposed NPP in Kazakhstan is expected to produce 15 billion kWh of electricity annually. This price difference results in an annual overpayment of approximately 675 billion tenge (about $1.5 billion), with each resident paying over $65 more for electricity each year (petrocouncil.kz 2024).

(Mussin and Nurlan 2023) Investigated the proportion of fuel costs in the overall operational expenses of nuclear power plants. They found that fuel costs constitute approximately 15% of the total operational expenses, while the remaining 85% is allocated to maintenance, staffing, and other operational requirements.

The analysis indicates that fuel costs constitute a significant portion of electricity generation expenses, with gas turbine plants accounting for 70% and coal-fired plants for 40%. In contrast, the cost of nuclear fuel is relatively low, potentially warranting a reevaluation of Kazakhstan's electricity tariff structure. Currently, Kazakhstan's electricity production is predominantly coal-based (73%), with hydropower contributing 12.3%, gas 10.6%, and oil 4.9%. Notably, a doubling in nuclear fuel prices would only increase electricity generation costs by 2–4%, whereas a similar price hike for natural gas or oil would result in a 70% escalation (Mussin and Nurlan 2023).

On October 4, 2023, the Ministry of Energy of the Republic of Kazakhstan held a session of the Public Council on the fuel and energy complex, primarily focusing on the nuclear sector. The session discussed the nuclear power plant construction project in Kazakhstan, evaluating potential suppliers such as CNNC (China, HPR-1000 reactor), Rosatom (Russia, VVER-1200 and VVER-1000 reactors), KHNP (South Korea, APR-1400 reactor), and EDF (France, EPR1200 reactor). Detailed negotiations with these suppliers are ongoing to finalize the conditions for the nuclear power plant construction project (Ministry of Energy of the RoK 2023).

(Karatayev et al. 2017) Highlighted that, according to the Nuclear Development Programme (Directive No. 728 of June 29, 2011), Kazakhstan plans to construct a nuclear power plant with a capacity between 600 and 2000 MW by 2030, with the project slated for implementation between 2020 and 2030. The authors emphasize the potential increase in water consumption in the energy sector if the current energy mix and technologies remain unchanged, a particularly critical issue for regions reliant on external water sources. A key future development in the energy system is the planned introduction of nuclear power. The study analyzed freshwater requirements for the energy sector in Kazakhstan's eight major river basins, finding that power generation, especially coal power plants using open-loop cooling technology, is the dominant freshwater consumer.

The Irtysh and Nura-Sarysu basins have the highest water demand due to the concentration of coal power stations. The study underscores the critical interdependence between energy infrastructure and water resources, warning that future energy policies could exacerbate water stress, particularly in basins already under pressure or dependent on international inflows. An integrated approach is essential for quantifying water requirements and improving efficiency in electricity generation to mitigate water security risks.

Moreover, the research conducted by (Rivotti et al. 2019) underscores the substantial impact that future changes in Kazakhstan's energy system will have on regions reliant on transboundary water resources. Approximately 45% of Kazakhstan's water supply originates from transboundary inflows, which are projected to decrease by up to 30% by 2030. This reduction will particularly affect regions designated for new nuclear capacities, specifically Ulken in the Balkash-Alakol basin and Kurchatov in the Irtysh basin.

Key findings include:

1. Increased Water Withdrawals:

- At Ulken, the introduction of new nuclear capacities will increase water withdrawals in the Balkash-Alakol basin by a factor of 14 compared to the baseline year.
- At Kurchatov, water withdrawals in the Irtysh basin are expected to rise by 60%.

2. Competition for Water Resources:

- The placement of future nuclear power plants is critical due to the significant competition for water in these areas, which could limit the resources available for efficient energy system operations.

These findings underscore the necessity of effective water resource management and policy alignment for the sustainable development of Kazakhstan's energy sector (Rivotti et al. 2019).

According to Article 12 of the Law "On the Use of Atomic Energy" in Kazakhstan (Adilet 2016), the decision to build nuclear facilities, including their locations, requires governmental approval and must also receive consent from the local representative bodies, known as maslikhats, in the areas where the construction is planned.

In November 2022, the Almaty Region Maslikhat decided to approve the construction of a nuclear facility, contingent upon the residents' support. Consequently, the Akimat of Almaty Region initiated public discussions to ensure this community support. Following comprehensive studies, the Ministry of Energy selected the village of Ulken in the Zhambyl district of the Almaty region as the preferred site for Kazakhstan's first nuclear power plant (Tengrinews 2023).

The proposed site for Kazakhstan's first nuclear power plant is in the Balkhash region, a major industrial area in central Kazakhstan. The region, fed by the Ili River from China, is strategically located near four other regions and 500 kilometers from Kyrgyzstan. The village of Ulken, situated on the shore of Lake Balkhash and 400 kilometers from Almaty, was initially developed in the 1980s for a thermal power plant project, which was halted following the collapse of the Soviet Union.

Following the dissolution of the Soviet Union, Kazakhstan shifted its plans from constructing a thermal power plant (GTPP) to building a nuclear power plant in the region. A decade later, in 2012, the government revisited the idea of a thermal power plant, signing an agreement with

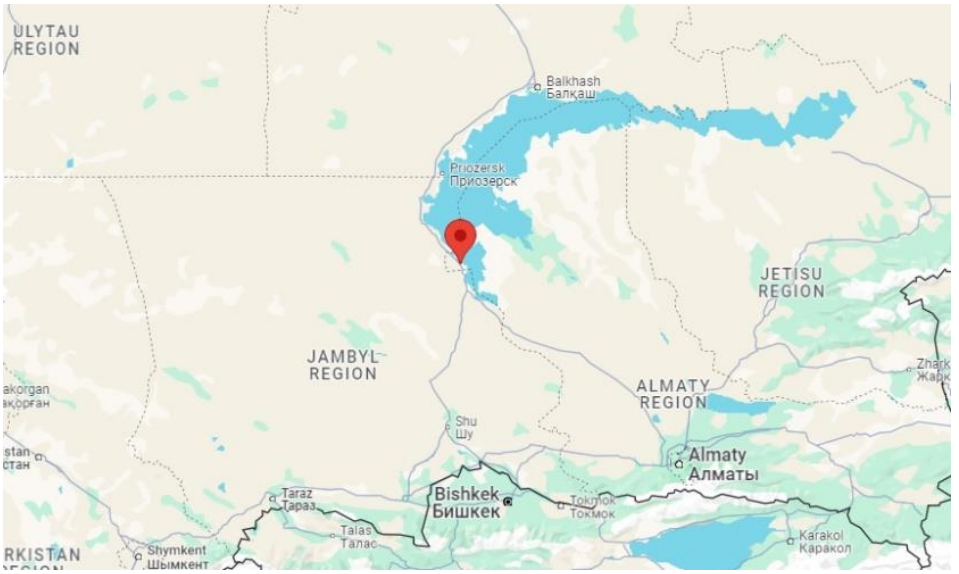

Fig. 2. Location of the nuclear power plant in the Ulken Village (Akipress 2023)

Rys. 2. Lokalizacja elektrowni jądrowej we wsi Ulken

a Korean company to construct the Balkhash Thermal Power Plant in Ulken. Preparations and dam construction continued until 2016, but the project was halted and never realized. Recently, the government has renewed its focus on nuclear energy, with Ulken being considered as a potential site for a nuclear power plant (Inbusiness 2023).

Lake Balkhash, a significant lake in Asia and a vital water source for Almaty, Kazakhstan's largest city, is under significant ecological threat due to the proposed construction of a nuclear power plant (NPP) on its shores. This development could intensify pre-existing environmental issues, notably water scarcity. Concerns regarding the lake's degradation were initially raised two decades ago during the international environmental forum 'Balkhash-2000'. Since then, the situation has deteriorated as Central Asia experiences increasing warmth and aridity. The NPP's water extraction and potential contamination present severe risks to the lake's ecosystem. Moreover, the Ili River, which contributes 80% of Lake Balkhash's water, is extensively utilized for agricultural purposes in China's Xinjiang region. China has escalated its water extraction for rice farming, further straining Lake Balkhash. The absence of China from international transboundary water agreements compounds this issue, posing additional threats to the lake's sustainability (CPC 2024).

Nevertheless, the majority of Ulken's residents are supportive of building a power plant, be it thermal or nuclear, on the shores of Lake Balkhash. They perceive this project as an opportunity for regional development, bringing permanent jobs with good wages to their community and surrounding areas (Inbusiness 2023).

4. Results and discussion

A PEST analysis (political, economic, social, and technological) can be conducted to identify the key external factors influencing the development of nuclear energy in Kazakhstan. This analysis will provide a comprehensive overview of the various elements impacting the nuclear energy sector in the country.

The PEST analysis highlights the multifaceted considerations involved in the development of nuclear energy in Kazakhstan. Political commitment and regulatory frameworks are in place, economic factors favor the diversification of energy sources, public opinion is cautiously supportive but requires careful management, and technological advancements provide the tools needed for safe and efficient nuclear energy production. Addressing these factors holistically is crucial for the successful implementation of Kazakhstan's nuclear energy ambitions.

Kazakh experts express concerns about the environmental and health risks associated with constructing and operating a nuclear power plant (NPP). They also highlight the potential for nuclear facilities to become targets of military blackmail, as demonstrated by the Zaporizhzhia NPP situation in Ukraine. Experts argue that Kazakh citizens receive one-sided information ahead of the referendum on NPP construction. Discrepancies in official statements foster mistrust, and the ongoing preparatory steps for NPP construction, despite the forthcoming referendum, suggest a predetermined decision. Ensuring transparency, full public information, and alternative options during the campaign are crucial for maintaining public trust in the government (Azattyk 2024).

Experts argue that the political dynamics surrounding nuclear energy have rendered it a cumbersome asset for countries with established nuclear industries. These nations, which provide significant employment through their nuclear sectors, struggle to compete with the advancements in renewable energy. As a result, they actively seek to export their nuclear technologies to developing countries. Russia, for instance, uses its geopolitical influence to promote its nuclear solutions to Kazakhstan, thereby attempting to secure a foothold in the country's energy infrastructure. Experts contend that due to current market dynamics, acquiring a nuclear reactor inherently includes a dependency on a specific type of nuclear fuel. This dependency arises because reactors built, for example, for Russian fuel, are not easily convertible to alternative fuels from other suppliers, such as French or American sources. Thus, purchasing a reactor involves committing to the entire fuel technology chain. Kazakhstan, lacking full-scale fuel production capabilities and participating only marginally in this process, would inevitably become dependent on the fuel supplier. Specifically, if the supplier is Russian, Kazakhstan would be subject to significant influence from Rosatom, thereby granting Russia considerable political leverage (Azattyq 2021).

The current approach to developing nuclear energy in Kazakhstan is flawed due to a lack of transparency and public engagement. Authorities intermittently announce potential construction sites without providing detailed information or supporting documents, which causes public concern. There is a significant information gap, possibly because concrete plans are not yet in

Table 1. PEST analysis of nuclear energy development in Kazakhstan

Tabela 1. Analiza PEST rozwoju energetyki jądrowej w Kazachstanie

1. Political Factors:
Government Policies and Regulations: ✦ The adoption of updated legislation, such as the "Law on the Use of Atomic Energy," establishes the legal framework for nuclear energy development. ✦ The establishment of the Committee for Atomic and Energy Supervision and Control (CAESC) as the regulatory body ensures compliance with safety and operational standards. International Agreements: ✦ Kazakhstan participates in major international conventions and agreements on the peaceful use of nuclear energy, reflecting its commitment to global nuclear non-proliferation and safety standards. Political Stability and Security: ✦ The geopolitical climate, especially in relation to neighboring countries, affects the strategic decisions regarding nuclear energy. For instance, regional conflicts could impact the perceived safety and stability of nuclear facilities.
2. Economic Factors:
Investment and Funding: ✦ The cost of building and maintaining nuclear power plants is high, requiring significant investment from both domestic and international sources. The selection of technologies and potential partnerships with countries like China, Russia, South Korea, and France are crucial economic considerations. Cost of Energy Production: ✦ The cost of nuclear fuel is relatively low compared to other energy sources, which could potentially reduce overall electricity tariffs. However, the initial capital expenditure is substantial. Market Demand and Energy Needs: ✦ Projections indicate an increasing demand for electricity in Kazakhstan, with current energy production heavily reliant on coal, hydropower, gas, and oil. Diversification into nuclear energy could address future energy shortages.
3. Social Factors:
Public Opinion and Acceptance: ✦ Public perception of nuclear energy is influenced by historical events such as the Semipalatinsk nuclear tests and concerns about safety and environmental impact. Public information campaigns and transparency are essential to gain public trust. Employment and Local Development: ✦ The construction of a nuclear power plant in areas like Ulken is seen as a development opportunity, providing employment and economic growth to local communities. Health and Safety Concerns: ✦ Potential risks associated with nuclear energy, such as radiation leaks and waste management, pose significant health concerns for the population. Addressing these concerns is critical for public acceptance.
4. Technological Factors:
Advancements in Nuclear Technology: ✦ The development and adoption of modern nuclear technologies, such as those offered by international partners (e.g., HPR-1000, VVER-1200, APR-1400, EPR1200), are essential for ensuring safety and efficiency. Infrastructure and Maintenance: ✦ The existing infrastructure must be upgraded to support nuclear energy, including safety measures, waste management systems, and maintenance protocols. Research and Development: ✦ Continuous investment in R&D is necessary to advance nuclear technology, improve safety standards, and develop efficient waste management solutions.

place or because preliminary assessments are not suitable for public release. This opacity fails to build trust and leaves the population anxious about the safety and security implications of such projects for millions of people and the entire region.

According to information from (Kaztag 2021), satisfaction with the coverage of state policies in the media increased from 50.6 to 68.5% between 2012 and 2021. Today, citizens of the Republic of Kazakhstan have access to information through television, social media, radio, and other channels, allowing them to stay informed about government programs in the country. However, despite extensive media coverage, public trust in the government has not increased, as citizens remain skeptical about the effectiveness of government actions.

One of the reasons the public believes Kazakhstan is not ready for nuclear energy is the high level of corruption in the country. Some concerns are that allocated funds may not be used as intended, leading to substandard construction of the nuclear power plant. In 2023, Kazakhstan was again listed among highly corrupt countries. (Transparency International 2024) published the Corruption Perceptions Index for 2023, where Kazakhstan ranked 92nd out of 180 countries, scoring 39 out of 100. Countries scoring below 50 are considered highly corrupt, which hampers economic development and the social well-being of citizens.

For comparison, Kazakhstan's score improved by only 11 points, from 28 to 39, over the first 12 years of the current rating methodology, from 2012 to 2023.

In 2021, Kazakh activists from a public organization, recognizing that the interests of local citizens were being overlooked, decided to survey the opinions of residents in the Southern region of Kazakhstan near the Uzbekistan border, where a nuclear power plant (NPP) is planned. The anonymous survey was conducted at approximately 30 locations. Questions included: «Are you aware of the planned NPP construction 40 kilometers from your area?», «How did you learn about this?», and «What is your opinion on it?». Nearly 70% of respondents had not heard about the NPP construction in Uzbekistan near their regions. An overwhelming majority (90%) opposed the construction, and 92% believed that both Kazakhstan and the neighboring country should have discussed it with them. However, around 10% did not oppose or even support the development of nuclear energy (Azattyq 2021).

This survey highlighted the lack of communication from responsible parties regarding safety measures, evacuation plans, and overall impact in the event of an accident, revealing that the local population had not been informed or consulted about the project.

Between September 22 and October 4, 2023, (Demoscope 2023), in partnership with Paperlab, conducted a survey assessing public attitudes in Kazakhstan towards the construction of a nuclear power plant (NPP). The survey results indicated a significant split in public opinion: 46.6% of respondents expressed support for the initiative, with 30.8% strongly endorsing it and 15.8% somewhat supporting it. Conversely, 37.7% opposed the construction of the Nuclear Power Plant (NPP), with 25% firmly against it and 12.7% somewhat opposed. Public awareness levels played a crucial role in shaping these opinions; 36.8% of respondents were unaware of the government's plans, whereas 34.1% were well-informed. Supporters of the NPP cited several reasons for their approval, including resolving energy shortages (51.5%), reducing electricity tariffs (10.6%), fostering technological advancement (8.7%), utilizing clean energy

to minimize environmental impact (7.8%), and improving Kazakhstan's international standing (6.3%). Conversely, opponents expressed concerns about the risks of accidents and radiation leaks (47.9%), environmental impacts (31.3%), potential corruption during construction (7.4%), lack of expertise (6.7%), and high construction costs (5%).

Energy shortages emerged as a critical issue, with over 70% of respondents acknowledging its relevance, which likely contributes to the support for the NPP. The survey also gauged potential voter turnout for a referendum on the NPP, showing moderate interest: 31.2% would definitely vote, and 14.4% would likely vote. Trust in the referendum results was moderate, with 56.9% expressing some level of trust.

Regarding preferred partners for the NPP construction, the survey revealed no clear preference among respondents: Russian company: 23.3%, South Korean company: 19.7%, Chinese company: 7.2%, French company: 4.5%, company from another country: 5.3%.

Notably, language preferences influenced opinions, with more Russian-speaking respondents favoring collaboration with Russia, while more Kazakh-speaking respondents preferred partnership with South Korea.

The split in public opinion underscores the need for comprehensive public engagement and transparent communication from the government. Addressing concerns through detailed information on safety measures, environmental protection strategies, and economic benefits could shift opinions toward greater acceptance. Additionally, understanding the underlying reasons for both support and opposition is vital for policymakers to navigate the complex landscape of public sentiment and foster a more informed and balanced discourse on nuclear energy in Kazakhstan.

Subsequently, a survey was conducted to gather information from a group of individuals regarding their attitudes and to identify trends concerning the construction of a nuclear power plant in the country.

A survey was conducted to assess public awareness and understanding of organizations, laws, and policies related to nuclear energy in the country. Respondents were asked if they knew any laws or regulatory acts related to nuclear energy in Kazakhstan, with 73% responding "No" and 27% responding "Yes." When asked if they understood the government's policy on the development of nuclear energy, 51.9% answered "No" and 48.1% answered "Yes." These findings indicate that citizens have an insufficient understanding of the government's energy policy and its objectives.

Respondents were asked if they knew the advantages of nuclear energy, with 71% responding "No" and 28% responding "Yes." Another question was posed to gauge the transparency of the authorities: "Do you believe the government transparently discloses information about plans to build a nuclear power plant?" Here, 76% answered "No," while 23% answered "Yes." Additionally, when asked if explanatory work on the safety of planned nuclear power plants is being conducted by authorized bodies, over 82% of respondents said "No," and 17% said "Yes."

The majority of citizens lack sufficient knowledge about the laws and advantages of nuclear energy. This indicates a need to intensify information campaigns and improve public education in this area. A high percentage of respondents believe that the government is not transparent enough regarding its plans for building a nuclear power plant. This lack of transparency can

lead to public distrust and resistance. Most respondents also noted the absence of explanatory work on the safety of nuclear power plants. Authorized bodies should enhance communication with the public by providing comprehensive information on safety measures and the benefits of nuclear energy. The high level of negative responses to key questions suggests significant potential for improving the communication strategy of the government and stakeholders.

Conclusions

This study aimed to assess public opinion, awareness, and trust regarding the construction of a nuclear power plant in Kazakhstan, focusing on the implications of transparency and public engagement. The findings underscore the importance of public opinion in national energy decisions, especially as the Kazakhstani government has proposed a referendum on the nuclear power plant. Given the potential risks associated with nuclear accidents, the decision must be made collectively and informed by accurate information.

Key issues affecting public support include low transparency from authorities on the nuclear project, the public's distrust of government energy policies, and geopolitical concerns that influence nuclear energy decisions. Achieving the research goal required identifying areas where government action could improve public trust and support for nuclear energy, which is vital for securing energy security and stability.

To move forward successfully, the government should:

1. Enhance Transparency: Greater openness in decision-making around the nuclear power plant will help reduce distrust, enabling citizens to feel included in the process.

2. Educate the Public: Comprehensive public education campaigns are essential to inform people about nuclear safety measures, environmental benefits, and the role of nuclear energy in addressing future energy shortages.

3. Address Geopolitical Concerns: The government must consider the geopolitical climate's impact on nuclear energy strategy, particularly given Kazakhstan's unique regional position and the need for a stable, conflict-resilient energy source.

4. Engage Stakeholders: Active engagement with environmental groups, local communities, and international organizations can build a broader consensus, creating an environment where public concerns are acknowledged and addressed.

By pursuing these actions, the Kazakhstani government can achieve a more informed, supportive public, which is essential for the successful implementation of its nuclear energy strategy. The research demonstrates that fostering public trust and transparency can facilitate national support for nuclear projects in Kazakhstan and potentially guide other nations considering similar paths.

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Socjologiczna analiza opinii publicznej na temat budowy elektrowni jądrowej w Kazachstanie

Streszczenie

Perspektywa budowy elektrowni jądrowej (EJ) w Kazachstanie była z przerwami dyskutowana od połowy lat 90. ubiegłego wieku. Dopiero w 2021 r. kwestia ta zyskała znaczącą uwagę rządu ze względu na prognozy dotyczące zbliżającego się deficytu energii. Obecnie brakuje równowagi informacyjnej, a władze przedstawiają elektrownię jądrową jako jedyne rozwiązanie potencjalnych niedoborów energii i stagnacji gospodarczej. Rząd Kazachstanu ogłosił ogólnokrajowe referendum w celu podjęcia decyzji, podkreślając wiodącą pozycję kraju w produkcji uranu i potrzebę rozwoju nauki o energii jądrowej.

Pomimo tych wydarzeń, nadal istnieją poważne obawy dotyczące ryzyka i konsekwencji budowy elektrowni jądrowej, ponieważ społeczeństwo nie posiada wystarczających informacji na temat perspektyw projektu i jego potencjalnych skutków. Społeczeństwo ma więcej pytań niż odpowiedzi, co odzwierciedla potrzebę uzyskania wyczerpujących i dokładnych informacji od państwa.

Zaangażowanie społeczeństwa jest niezbędne dla pomyślnej realizacji projektu elektrowni jądrowej. Rząd zainicjował publiczne dyskusje i przesłuchania w celu osiągnięcia konsensusu i rozwiania obaw społecznych. Wysiłki te mają kluczowe znaczenie, ponieważ poparcie publiczne jest niezbędne dla realizacji projektu.

Niniejsze badanie dotyczy świadomości społecznej, przejrzystości i zaufania do rządowej polityki w zakresie energii jądrowej. Do oceny opinii publicznej wykorzystano socjologiczną ankietę internetową, a także informacje z materiałów rządowych, artykułów prasowych i przeglądu międzynarodowych doświadczeń w dziedzinie energii jądrowej. Wyniki badania podkreślają znaczenie świadomego zaangażowania społeczeństwa i przejrzystej komunikacji dla pomyślnego wdrożenia projektów energetyki jądrowej w Kazachstanie.

Słowa kluczowe: świadomość społeczna, polityka jądrowa, bezpieczeństwo energetyczne, elektrownia jądrowa, opinia publiczna