

# The Impact of Electric Power on Industrialization in Mongolia

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## Abstract

The study analyzed the relationship between electricity consumption and industrial growth in Mongolia. The research uses statistical data from 1989 to 2023 (including variables such as electricity consumption, per capita electricity use, inflation rate, gross domestic product, and the structure of the industrial sector), the analysis applies correlation analysis methods and error correction techniques to examine the data and estimate electricity consumption for 2030. The results indicate that, over the long term, industrial growth and electricity consumption are directly related to changes in gross domestic product, while changes in the inflation rate show no correlation. The study also identifies key factors influencing industrial development in Mongolia and specifies the impact of electricity on these factors.

## Keywords

Energy, Industry, Growth, Gross Domestic Product, Inflation

## 1. Introduction

In the historical economic development of highly developed countries, significant growth began with the initiation of household production and small and medium-sized industries before major industrialization (Anudari & Zolzaya, 2023). Industrialization is a process that creates the necessary social capital to stimulate the development of other economic sectors by producing widely used consumer and capital goods. Furthermore, industrial growth or industrialization involves the deliberate and sustainable utilization and combination of suitable technologies, infrastructure, management experience, and other critical resources for product

manufacturing (Anudari & Zolzaya, 2023; Tegshjargal et al., 2022; Urgamalsuvd & Altanzul, 2024). Industrialization plays a crucial role in economic development. Recently, countries with developed economies have paid significant attention to this area (Ekpo, 2014).

Industrialization increases changes and diversification in economic structure, allowing countries to fully utilize their potential factors and reduce dependence on imported finished products and raw materials, thereby enhancing economic growth and development (Gan-Ochir, 2020; Sankaran et al., 2019). Recognizing the importance of industrialization for economic growth, the Mongolian government has implemented various policies to support industrial development. Key documents defining Mongolia's industrial policy include programs, plans, and legal acts approved by the government and relevant ministries and agencies. These documents aim to support national production development, enhance competitiveness in international markets, and ensure sustainable development (Parliament of Mongolia, 2020). They include:

- The Constitution of Mongolia;
- The Law on Industrial Policy;
- State Policy on Industry;
- Vision 2050—Long-term Development Policy;
- National Program for the Development of Heavy Industry;
- Law on Small and Medium Enterprises;
- National Strategy for Economic Development;
- Concept of Sustainable Development for Mongolia;
- Plans from the National Development Agency and the Ministry of Industry.

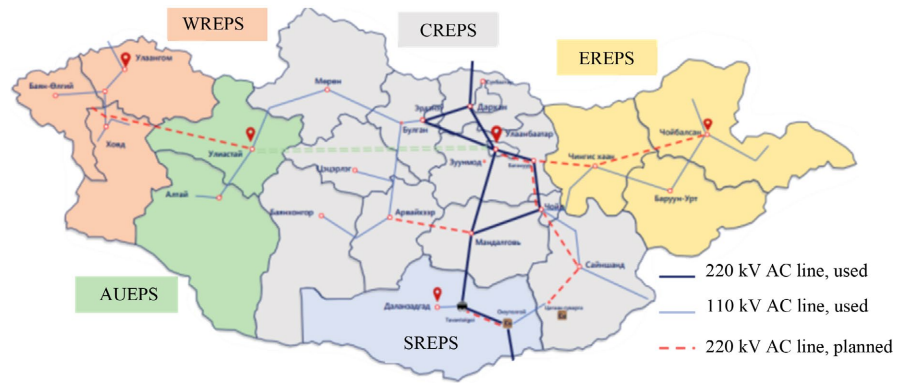
The “Government Policy on Industry” (approved in 2015) is a crucial document aimed at supporting, diversifying, and increasing the competitiveness of the industrial sector and producing value-added products (Tsenddorj & Byambatsogt, 2017). The implementation of this policy involves collaboration between government agencies and the private sector to create structural changes in the economy and support export-oriented industries. The implementation continues through industrial programs, increases in export products, investment and support, technological innovation, regulation, legal frameworks, principles of sustainable development, and job creation. Major issues faced in the implementation of this policy include limited investment, underdeveloped infrastructure, and technological obsolescence (Abokyi et al., 2018; Shahid, 2006; Jamil & Ahmad, 2010). Electricity is one of the fundamental factors of industrialization, and its supply, price, and quality significantly impact the industrial sector. Therefore, this study aims to investigate the influence of electricity on industrialization in Mongolia.

## 2. Energy System of Mongolia

### 2.1. Current State of Energy System of Mongolia

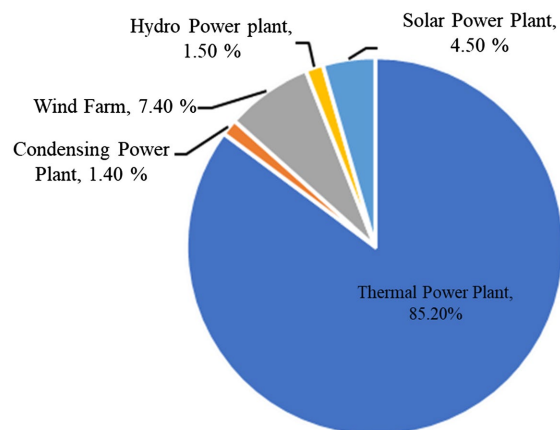
In Mongolia, 5 independent electricity systems classified by region are operating and providing electricity to consumers (Bat-Erdene et al., 2021) (Figure 1). It includes:

- 1) Central Regional Electric Power System (CREPS);
- 2) Western Region Electric Power System (WREPS);
- 3) Southern Region Electric Power System (SREPS);
- 4) Altai-Uliastai Electric Power System (AUEPS);
- 5) Eastern Region Electric Power System (EREPS).



**Figure 1.** Geographical location of EPS of Mongolia.

Renewable energy sources account for 13.4% of the total installed capacity (**Figure 2**), which is a significant achievement, bringing us closer to the target set in the “Government Policy on Energy” to increase the share of renewable energy sources to 20% of the total installed capacity by 2020 (*Munkhbaatar et al., 2023*).



**Figure 2.** Structure of the total installed capacity in EPS of Mongolia.

Mongolia is gradually advancing its renewable energy sector, aiming to reduce its reliance on coal, which currently dominates the country’s energy mix. Mongolia has set ambitious goals to increase renewable energy to 20% of its installed capacity by 2023 and 30% by 2030. As of the latest data, renewables constitute approximately 18.3% of Mongolia’s total installed power capacity, though they only generate around 9.6% of the nation’s electricity, highlighting a gap between installed capacity and practical energy output. Most of this capacity is attributed to wind and solar projects, along with small hydropower plants, underscoring the country’s

emphasis on its abundant wind and solar potential.

Mongolia has significant renewable energy resources. Its solar and wind potential is immense, with estimates suggesting that Mongolia could generate up to 2600 GW from these resources, enough to meet its domestic needs and support regional energy demand. However, challenges remain, including insufficient transmission infrastructure, a dependency on coal-based power plants, and harsh winters that require heating solutions beyond what renewable sources alone can currently provide.

To support this transition, projects like the Asian Development Bank-backed battery storage initiative are underway, which could help stabilize Mongolia's renewable energy supply. Additionally, international support from organizations like the UNDP is aiding Mongolia in developing policies to enable a just and inclusive energy transition, with a focus on reducing greenhouse gas emissions and preparing the workforce for new green energy jobs.

For the Central Regional Electric Power System (CREPS), aside from the Wind Farm (50 MW) and the Solar Power Plant (20.4 MW), the other facilities operate as coal-fired Thermal Power Plants (TPPs) that produce both heat and electricity.

In Mongolia's electricity system, there are currently 100 substations operating at 110 kV, of which 30 are system generators, while the remaining 70 are intermediate and terminal substations (Munkhbaatar et al., 2023). The numerical data on substations is summarized in **Table 1**.

**Table 1.** Numerical data of power transmission and distribution substations.

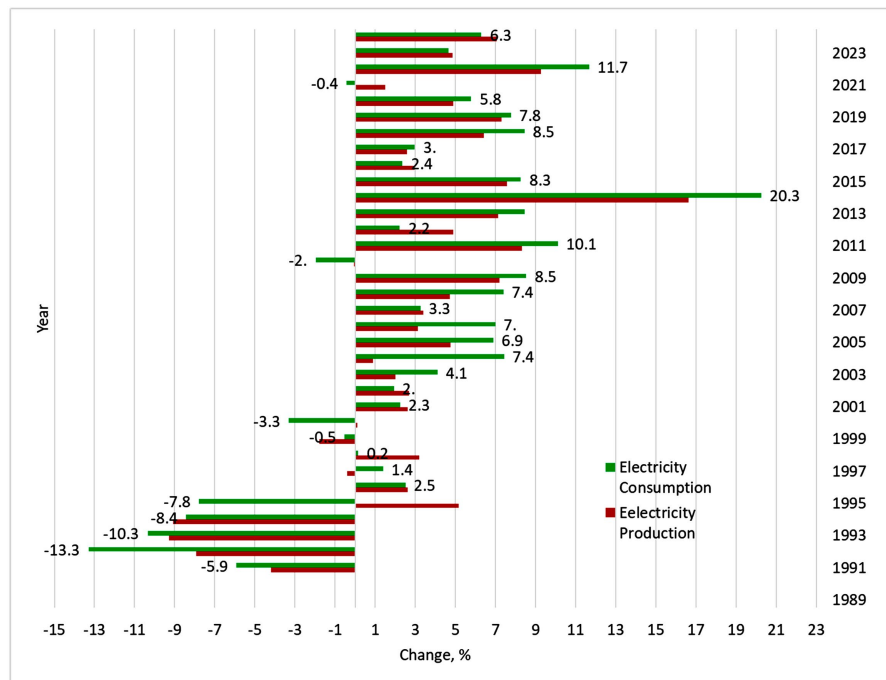
	Voltage (kV)	CREPS	WREPS	AUEPS	EREPS	SREPS	Total
	220	11	-	-	-	-	11
	110	73	11	5	11	-	100
Substation	35	245	23	25	26	34	353
	15	177	100	62	112	31	482
	6 - 10	6065	880	253	417	387	8002
Total	-	6571	1014	345	566	452	8948

Note: Statistics on energy performance 2023.

Industrial development has led to rapid urbanization, with nearly 70% of Mongolia's population residing in three cities: Ulaanbaatar, Erdenet, and Darkhan. These cities fall within the coverage area of the Central Regional Electric Power System. As electricity consumption in this region increases, the flow of power capacity rises, and the load on transmission lines and substations also increases, which in turn reduces the reliability of the Central Regional Electric Power System.

The country is facing electricity shortages due to insufficient capacity to meet demand, resulting in energy imports from neighboring countries. This situation negatively impacts the nation's energy security.

Changes in electricity production and consumption from 1989 to 2023 are illustrated in **Figure 3**.



**Figure 3.** Electricity consumption and production.

Since transitioning from a centrally planned economy to a market economy in 1990, electricity consumption and production in Mongolia initially declined due to a contraction in industrial output. However, from the end of 1990 to the early 2000s, the resurgence of small and medium-sized enterprises led to a steady increase in electricity consumption. This trend intensified from 2013 onwards, with a significant rise in electricity use as large-scale production began to increase.

In recent years, despite a strong trend of economic growth and industrialization in Mongolia, the demand for electricity is not fully met by production, which negatively impacts the industrial sector.

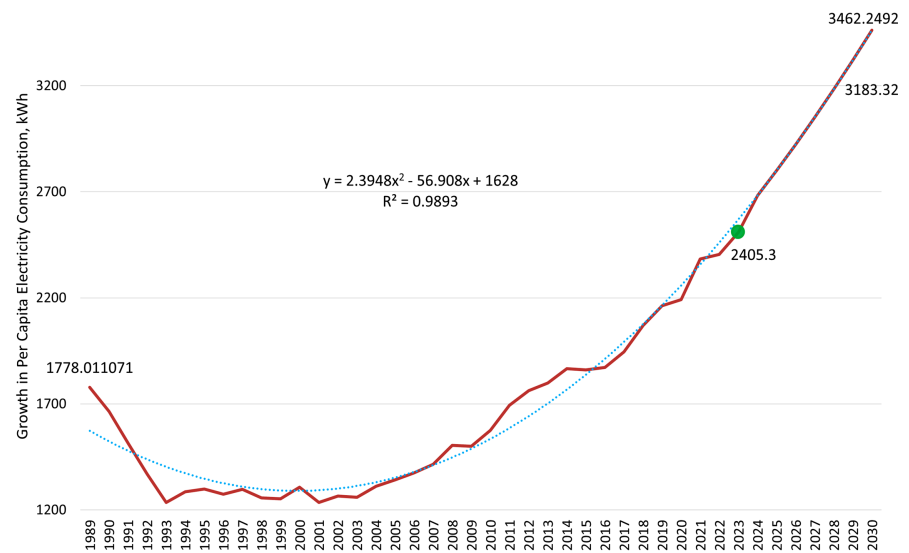
## 2.2. Outlook for the Energy System of Mongolia

To enhance the reliability of independent systems, it is essential to connect them through a centralized transmission network and establish an Integrated Mongolian Energy System (IMES). Careful consideration of the location for new generation sources and substations, along with the development of a scientific methodology, will serve as the foundation for establishing the IMES. Currently, while the five independent systems are interconnected, this connection is weak and does not meet the technical requirements for a unified system (see **Figure 1**).

The policy document “Government Policy on Energy 2015-2030”, approved by the State Great Hural on June 19, 2015, specifies the establishment of the IMES.

Article 1.2 states that the goal of this policy is to ensure a continuous and reliable supply of energy to meet the country's growing energy needs and to become an energy-exporting nation. We believe that constructing new and additional electricity generation sources will be essential to achieving this goal.

Based on actual performance from 1989 to 2023, per capita electricity consumption is projected to experience significant growth, reaching 2405.3 kWh in 2024 and 3462.2 kWh by 2030 (see **Figure 4**).



**Figure 4.** Growth of per capita electricity consumption and projected normal levels.

When selecting suitable energy sources to meet consumption growth, careful consideration of the geographic location of consumers is essential. This means deciding whether to connect large-capacity power plants to the system or to use smaller, localized plants based on the consumer's location.

The actual performance of electricity consumption from 1989 to 2023 indicates that a “static growth” in system usage has been consistently maintained. As the industrial sector in Mongolia develops rapidly, electricity consumption is projected to grow by approximately 10% per year. By 2030, market forecasts estimate that electricity consumption will reach around 3.5 GW, while the current total installed capacity is only 1.5 GW. Given this expected growth in demand, relying solely on imported electricity is not feasible, necessitating the urgent establishment of additional generation sources.

### 3. Industrialization in Mongolia

The industrialization of the country plays a crucial role in the development of the national economy, expanding and diversifying industrial sectors, introducing new technologies and advanced equipment, and enhancing production capacity through workforce specialization (Anudari & Zolzaya, 2023).

Industrial policy not only supports economic growth but is also connected to

various social and economic issues such as unemployment, poverty, technological advancement, and the green economy. Production-based, export-oriented industries play a vital role in the country's development (Kassim & Isik, 2020).

### 3.1. Current State of Mongolia's Industrial Sector

Define abbreviations and acronyms the first time they are used in the text, even after they have been defined in the abstract. Abbreviations such as IEEE, SI, MKS, CGS, sc, dc, and rms do not have to be defined. Do not use abbreviations in the title or heads unless they are unavoidable.

Historical Phases of Industrialization in Mongolia.

#### 1) Socialist Era (1921-1990)

After transitioning to a socialist society, Mongolia implemented policies to develop heavy and light industries with the assistance of the Soviet Union. During this period, food production, light industry (textiles, footwear, leather goods, etc.), and mining industries (coal, copper extraction) were significantly developed. In 1934, one of Mongolia's first major factories, the Darkhan Metallurgical Plant, was established, followed by the creation of energy, chemical, and construction materials industries in the 1950s.

#### 2) Transition to Market Economy (1990-Present)

In the early 1990s, Mongolia shifted to a market economy, leading to a transition of the industrial sector to private ownership. This process brought about changes in investment and production structures. The mining sector has had a dominant influence on modern industrialization, with major projects such as the Erdenet copper-molybdenum plant and Oyu Tolgoi becoming significant economic resources.

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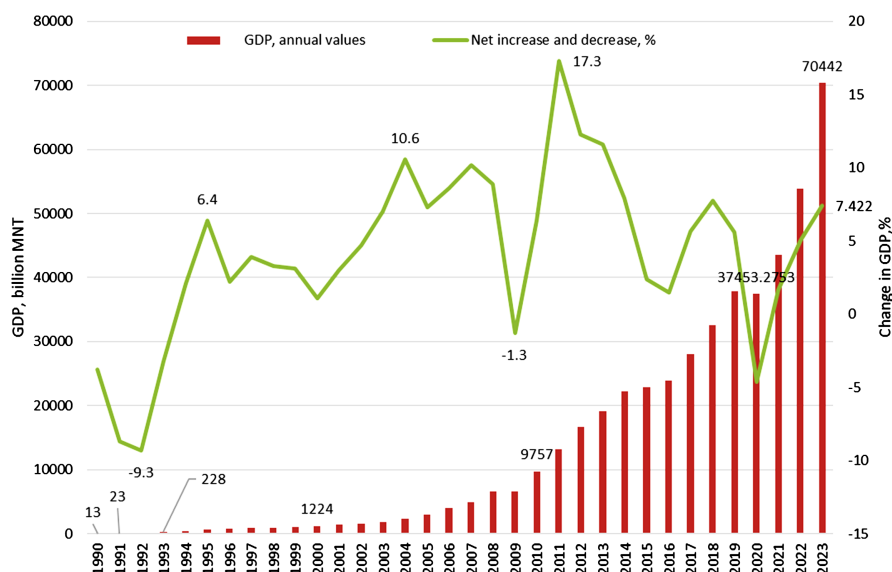
Today, Mongolia's industrial sector is heavily dependent on mining, which constitutes a major part of the economy. However, other sectors, such as light industry based on agriculture and food production, also play important roles. There is a continuous need to restructure the production sector, diversify, and implement advanced technologies.

Since 1990, Mongolia's transition from a centrally planned socialist economy to a market economy has led to significant changes in the conditions and structure of the industrial sector, transforming it into a component of the global market. However, its geographical location, bordering Russia and China, has created limited conditions for accessing the global market. Consequently, Mongolia relies on its two neighboring countries to access international markets (Bayarjavkhlan & Battulga, 2024).

To analyze the current state of Mongolia's industrial sector, the following factors have been highlighted:

Gross Domestic Product (GDP). Based on data from Mongolia's National

Statistical Office, the net growth and decline of GDP from 1990 to 2023 are illustrated according to the annual values (**Figure 5**).



Note: Mongolian statistical information service.

**Figure 5.** GDP and net growth and decline.

Mongolia's GDP was 12.8 billion tugriks in 1990, 1224.1 billion in 2000, 9756.6 billion in 2010, and 37.1 trillion in 2020. The GDP declined by 3.2% - 9.3% between 1990 and 1993, by 1.3% in 2009, and by 4.6% in 2020. Starting in 2002, economic growth reached 4.7%, marking a significant recovery since 2000. Consequently, economic revival gradually emerged, and from 2002, GDP reached a stable growth level. The years with the highest growth during the study period were 2004, with a growth rate of 10.6%, and 2011, with a growth rate of 17.3%.

**Industrial Structure.** The economy consists of 21 sectors that contribute to GDP, which can be divided into four industrial production sectors:

- Mining and extraction;
- Manufacturing;
- Electricity, gas, steam, and water supply;
- Construction.

As of 2023, in terms of GDP contribution from industrialization, the structure of the industrial sector consists of 69% from mining and extraction, 18% from manufacturing, 9% from construction, and 5% from electricity, gas, steam, and water supply sectors (**Figure 6**).

The changes in each of the four sectors from 1990 to 2023 are illustrated in **Figure 7**. Considering the average growth during the studied years, mining and extraction showed a growth rate of 58%; manufacturing had 24%; construction was at 10%; and electricity, gas, steam, and water supply had 7%. This indicates that the structure of the industrial sector has remained stable, with consistent changes observed in these sectors.

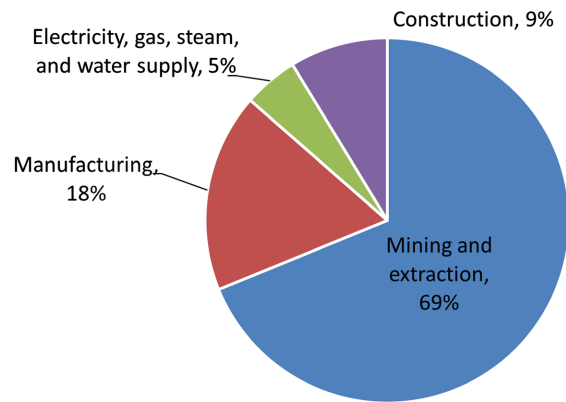


Figure 6. Structure of the industrial sectors.

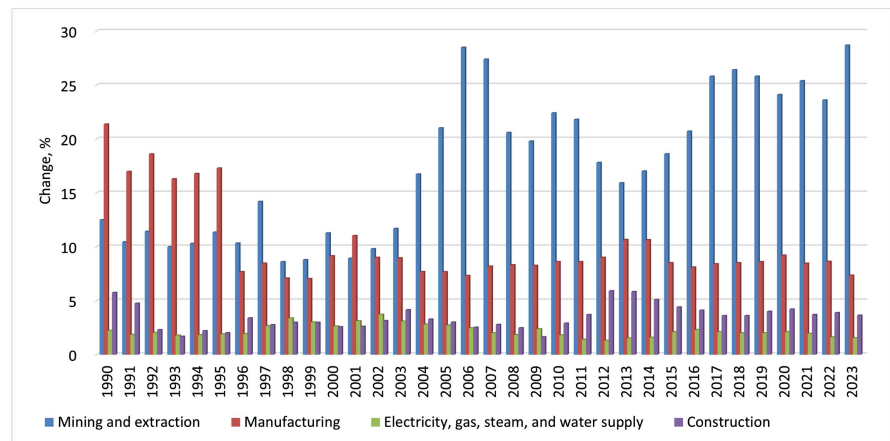


Figure 7. Changes in the industrial sector (percentage).

### 3.2. Modern Industrialization

Mongolia aims to diversify its industrial sector to reduce excessive reliance on mining and create a sustainable economy. The focus is on implementing policies that support the production of value-added products, innovation, and technological advancement, with the goal of enhancing competitiveness in international markets as a key future objective.

Industrial policy is linked to various social and economic issues, including supporting economic growth, addressing unemployment and poverty, advancing technology, and promoting a green economy. Production-based, export-oriented industries play a crucial role in national development. In recent years, an increasing number of countries have developed and officially announced industrial policy documents. For instance, from 2013 to 2018, 84 countries formally adopted strategies for the development of their industrial sectors. One of the key issues highlighted at the World Economic Forum was “Industry 4.0”, or the “Fourth Industrial Revolution”, which has further fueled attention on this topic.

The future prospects of Mongolia’s industrial sector should focus on supporting economic diversification, producing value-added products, and fostering technological innovation. This approach aims to diversify an economy that is overly reliant

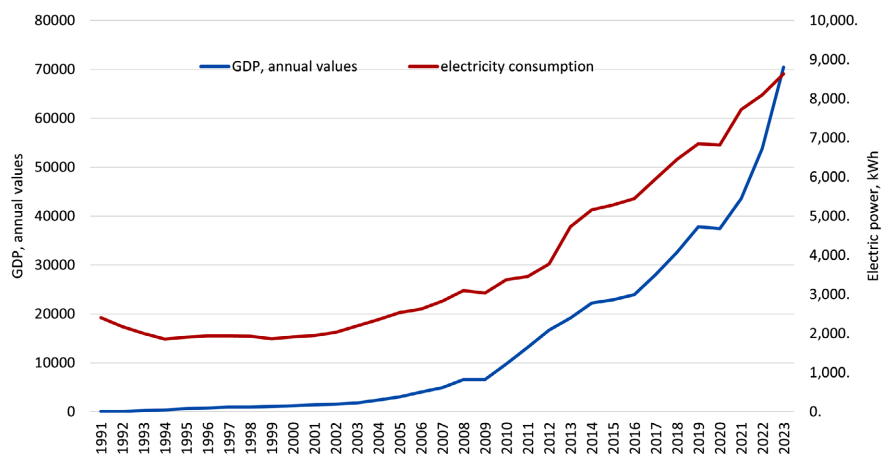
on mining, increase domestic production capacity, and enhance competitiveness in international markets.

#### 4. Impact of Electric Power on Industrialization

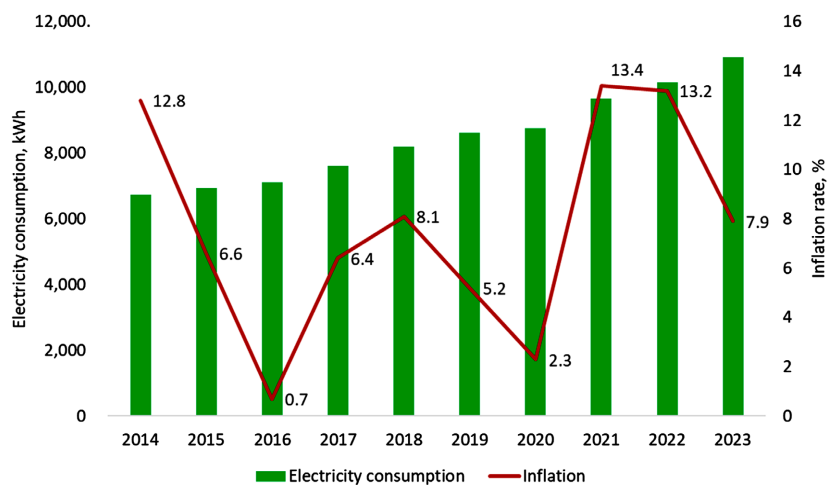
In modern times, the economic activities of any country occur within a complex network of interdependencies among various sectors. Consequently, the development of the industrial sector is closely linked to other sectors. However, one of the most significant factors influencing industrialization in Mongolia is undoubtedly electricity production.

We based our analysis on data from the National Statistical Office covering the years 1989 to 2023. We compared Mongolia’s electricity consumption, changes in GDP, and the relationship between electricity consumption and inflation, as illustrated in the following figures.

The results shown in **Figure 8** indicate that changes in GDP are directly correlated with electricity consumption. In contrast, as illustrated in **Figure 9**, changes in electricity consumption do not depend on the level of inflation.



**Figure 8.** Electricity consumption and changes in GDP.



**Figure 9.** Electricity consumption and inflation rate.

Electricity is one of the fundamental factors of industrialization, and its supply, price, and quality significantly impact the production sector. For Mongolia, the key factors influencing industrial development can be identified as follows, along with the impact of electricity on each (Table 2).

**Table 2.** Main factors influencing industrial development and the impact of electricity.

Factors	Impact
Production Capacity	<ul style="list-style-type: none"> <li>• Continuous and reliable electricity supply is a crucial condition for maintaining normal production processes. Power interruptions can halt production lines, reduce product quality, and pose risks of damage to machinery and equipment.</li> <li>• The majority of electricity consumption in our country is accounted for by heavy industries, particularly in the mining and metallurgy sectors. Insufficient electricity supply can hinder the full utilization of production capacity.</li> </ul>
Cost and Competitiveness	<ul style="list-style-type: none"> <li>• The cost of electricity directly affects production costs. High electricity prices increase the cost of products, which in turn impacts the competitiveness of export-oriented industries in international markets.</li> <li>• In Mongolia, maintaining stable electricity prices is a key factor in reducing operational costs for domestic industries, lowering production costs, and ultimately enhancing the competitiveness of products.</li> </ul>
Production Diversification	<ul style="list-style-type: none"> <li>• Heavy industries, particularly the metallurgy and chemical sectors, require significant amounts of electricity, making electricity supply and capacity critical factors. Without addressing the stable supply of electricity in Mongolia, developing such industries poses considerable challenges.</li> <li>• For example, copper and iron ore processing and smelting plants require substantial amounts of electricity, which plays a vital role in economic growth and industrialization.</li> </ul>
Renewable Energy	<ul style="list-style-type: none"> <li>• Mongolia has substantial reserves of renewable energy (solar and wind), which provides an opportunity to develop industrialization in an environmentally friendly and sustainable manner. Utilizing renewable energy can ensure a stable electricity supply and reduce energy costs for industries.</li> <li>• Increased utilization of renewable energy resources can reduce dependence on electricity imports and create opportunities to save on electricity costs associated with imports.</li> </ul>
Development of Heavy Industry	<ul style="list-style-type: none"> <li>• Heavy industries, particularly the metallurgy and chemical sectors, require significant amounts of electricity, making electricity supply and capacity critical factors. Without addressing the stable supply of electricity in Mongolia, developing such industries poses considerable challenges.</li> <li>• For example, copper and iron ore processing and smelting plants require substantial amounts of electricity, which plays a vital role in economic growth and industrialization.</li> </ul>

**Continued**

- |                                 |   |
|---------------------------------|---|
| Regional Industrial Development | <ul style="list-style-type: none"> <li>• When energy infrastructure is poorly developed in certain regions, it poses challenges for centralized industrial development. While Ulaanbaatar and nearby major cities have a concentration of energy resources, remote areas often face limited infrastructure.</li> <li>• Improving regional electricity supply and infrastructure would create opportunities to establish processing plants in rural areas, thereby increasing job creation.</li> </ul> |
| Export Production               | <ul style="list-style-type: none"> <li>• Export-oriented industries have high energy consumption. For Mongolia, which pursues a strategy of producing and exporting value-added products, it is essential to have reliable energy resources and stable supply.</li> <li>• If the energy supply is reliable and costs remain competitive, Mongolian products will have a greater chance of success in international markets.</li> </ul>  |
| Sustainable Development Policy  | <ul style="list-style-type: none"> <li>• The stability of energy supply and the diversity of energy sources play a crucial role in supporting environmentally friendly and green production within Mongolia's industrial policy.</li> <li>• With advancements in technology and increased use of renewable energy, the negative impact on the environment can be reduced, allowing industries to operate in a more efficient and sustainable manner.</li> </ul>                                       |

## 5. Conclusion

From 1990, Mongolian economy has shifted from centrally planned economy to tradable economy, resulting in insufficient industrial productivity of industry, which leads to decreased usage of producing and using energy. However, from end of 90's beginning to 2000, the development of small to medium-sized enterprises in industry sector has begun to smoothly develop, resulting in sustainable usage of energy and from 2013, intensive mining industry development has resulted in aggressive usage of energy.

Based on database of energy usage for per person growth from 1989-2023, calculating high-increasing usage from 2024-2030: in 2024, per person energy usage is 2682.9 kW-h and in 2030, per person energy usage will be 3462.2 kW-h. However, present settled energy source of 1.5 GW, including internal and imported, is impossible to supply expected usage-growth unless building additional extra source.

It has been proved that energy production and usage are directly related to GDP while not related to inflation ratio. Therefore, to define main factors for developing industrial development and energy effects on defined factors, energy sufficiency, price, and quality have great impacts. For all above reasons, supporting development of energy sector is highly effective to development of industry and building qualified energy source, reducing costs and developing renewable energy will increase competitive capability of industries and economic growth.

Mongolia's renewable energy potential is vast and aligns with its sustainable development goals. With continued investment and policy reform, the country is well-positioned to harness its natural resources and reduce its carbon footprint in the coming decades.

## Conflicts of Interest

The authors declare no conflicts of interest regarding the publication of this paper.

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