

Long Term Trend of Uranium Production and Price

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(Received January 16, 2023 / Revised March 6, 2023 / Approved March 22, 2023)

To broaden the utilization of nuclear energy, uranium as a fuel should be mined indispensably. Mining accounts for the largest portion of the cost of producing the uranium assembly. Therefore, this study analyzes the trends of uranium prices, which have a significant impacts on the mining cost. Uranium production contributing to the price fluctuations is explained in five periods from 1945 to the present. Moreover, the series of events affecting uranium prices from the 1970s until the present are verified. Among them, the most recent incidents considered in this study are the following: COVID-19 pandemic, Kazakhstan unrest, and Russia-Ukraine war. European countries have started to reconsider the transition to nuclear power to reduce their dependence on Russian oil and gas, which has contributed to the surge in uranium prices. Based on the results of this study, various international issues have been closely associated with the nuclear power industry and uranium, affecting the production of uranium and its price.

Keywords: Uranium oxide (U_3O_8), Uranium production, Uranium price

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1. Introduction

Uranium is one of the most important nuclear materials for utilizing nuclear energy. Most of the world's 440 commercial nuclear power plants use uranium as their energy source. Uranium as a nuclear power plant fuel has four main processes to go through: mining, conversion, enrichment and fabrication. Assuming that 1 kg of uranium is produced, mining takes up the most cost among mining, conversion, enrichment, and fabrication processes [1]. Accordingly, this study aims to explain the uranium price trend and production, as past and present. In this study, uranium oxide refers to as U_3O_8 , which is the product produced after uranium is extracted from the uranium ore and refined [2, 3].

With the development of nuclear power plants, uranium use increased, but uranium production was affected by various reasons, resulting in fluctuations in uranium prices. These price fluctuations have a significant impact on judging the economic feasibility of nuclear power, and some countries may decide policies depending on the economic justification. Considering this situation, it is an important study to analyze production and price fluctuations continuously. In this study, we investigate uranium production history from 1940s to 2020s. In uranium prices trends are analyzed from 1970s to 2020s. Thus, we focus on the factors that influenced uranium production and prices - nuclear power plant accidents, political uncertainty, and uranium mine accidents. It is also confirmed the results of the COVID-19 pandemic, anti-government protests in Kazakhstan, and Russia-Ukraine war have affected uranium production and prices in recent years.

2. Uranium Production History

Uranium has been successfully mined since the 1940s. Uranium production can be divided into five eras: military era (1945 to the mid-1960s), nuclear reactor expansion (mid-1960s to mid-1980s), cut back of nuclear program

(mid-1980s to 2002), nuclear renaissance and Fukushima accident (early 2000s to 2010s), and recent trends (2010s to present) as shown in Fig. 1 [4, 5].

2.1 Military Era (1945 to the Mid-1960s)

Uranium was mainly dedicated to military requirements at first. Uranium had been used for a nuclear bomb project called Manhattan Project. In the 1950s, East Germany was the world's largest producer of uranium. Production rose rapidly in the 1950s to meet the demand for highly enriched uranium and plutonium. After the end of World War II, the uranium industry had to be changed due to the Cold War and the demand for nuclear energy to generate electricity.

2.2 Nuclear Reactor Expansion (Mid-1960s to Mid-1980s)

Since the first commercial nuclear power plant came on line in 1956, uranium production for the commercial nuclear power plant had expanded. Many new mines were in production and produced the uranium to supply the utility. After the oil crisis in 1973, nuclear power emerged as an alternative to fossil fuels, and it led to rising demand for nuclear power. From 1960 to 1980, world uranium production rose 53 percent to a record high of about 70,000 (exactly 69,692) tU [5]. The Cold War drove global production to a record high, and uranium production in the U.S. and the Union of Soviet Socialist Republics (USSR) peaked.

2.3 Cut Back of Nuclear Program (Mid-1980s to 2002)

Nuclear accidents such as the Three Mile Islands accident in 1979 and the Chernobyl disaster in Ukraine in 1986 contributed to mitigating the rapid growth of nuclear power. Consequently, the slow nuclear power growth affected the uranium production. In addition, due to the end of the Cold War, military inventories of uranium were used

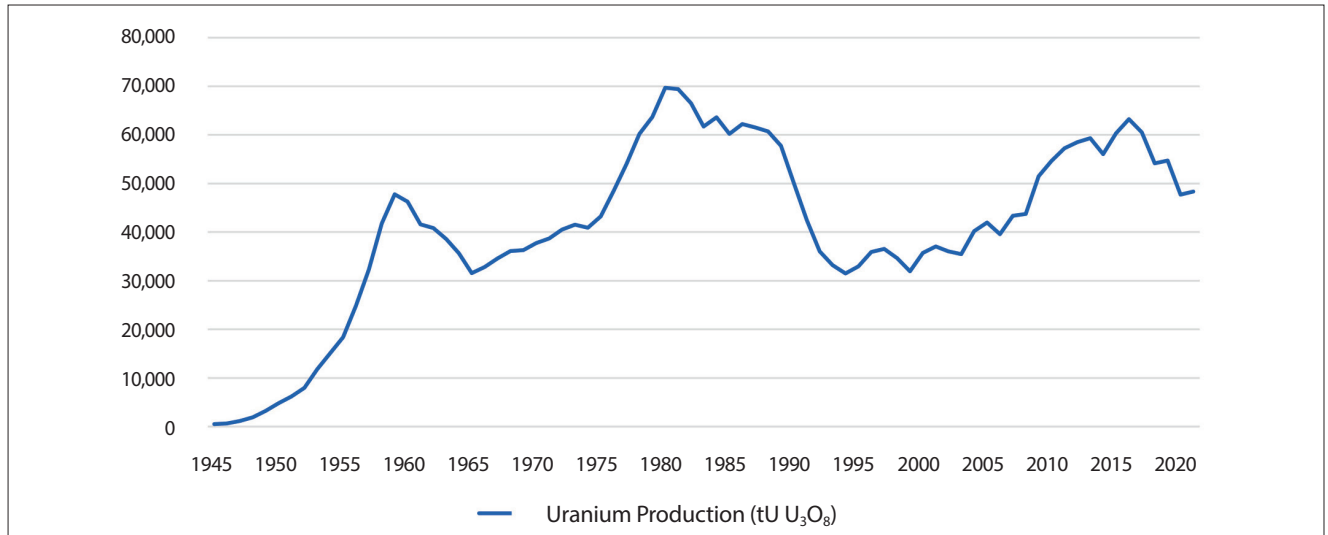


Fig. 1. Historic production of uranium oxide (U₃O₈) from the 1945 to the 2020s [2, 3].

as “secondary supply”, which also reduced the mine production. As a result, uranium production decreased dramatically after 1987.

2.4 Nuclear Renaissance and Fukushima Accident (Early 2000s to 2010s)

As nuclear power drew attention as an energy capable of responding to climate change, the nuclear power renaissance in the 2000s promoted uranium production and also affected uranium prices. The spot market price increased between early 2003 and mid-2007, but went into a downward correction, accelerated by the Fukushima accident in 2011. After the accident, uranium price temporarily declined.

2.5 Post-Fukushima Era (2010s to Present)

Overall, global uranium production fell 4.7% from 62,997 tU in 2016 to 60,025 tU in 2017, and further decreased 10.8% to 53,516 tU in 2018 as producers implemented production cuts to reduce supply in the saturated market. This trend was the largest in Canada, Kazakhstan, and Niger. U.S. production also declined sharply as mining

production was suspended in some facilities due to the market condition. In 2019, global production increased slightly to 54,224 tU through an increase in Kazakhstan. In Canada, mining at Rabbit Lake was halted in mid-2016, and mining and smelting at the MacArthur River and Key Lake were subsequently suspended in late January 2018.

According to IAEA (International Atomic Energy Agency) and WNA (World Nuclear Association) data, a total of 16 countries produce uranium in 2018, with about 53,516 tU of uranium being produced. Although there had been a series of growth in Kazakhstan, production has been declining since 2017.

In the last five years, uranium production has been greatly affected by several events. Uranium production is expected to decrease due to the major events such as the impact of COVID-19 pandemic in 2020, anti-government protests in Kazakhstan in 2022, and Russia-Ukraine war.

3. Uranium Price History

Fig. 2 indicates the spot price of uranium oxide (U₃O₈) monthly for forty years [6]. As shown in Fig. 2, uranium oxide prices have a lot of fluidity caused by a number of

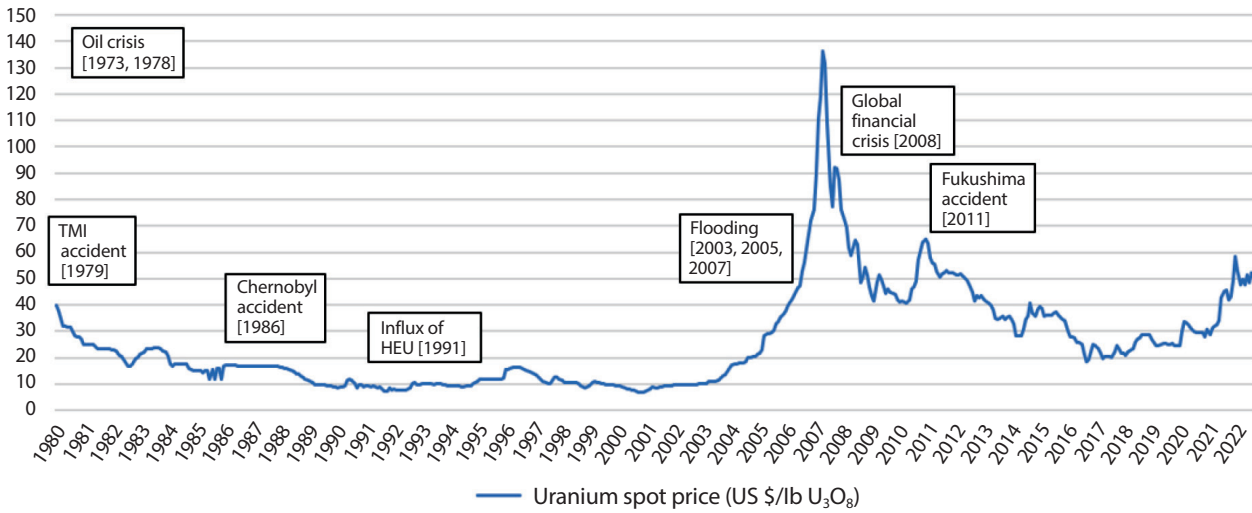


Fig. 2. Historic price of uranium oxide (U₃O₈) in US dollars per pound along with major events from the 1980s to the 2020s.

factors. These can be natural disasters interfering with uranium production, nuclear plant accidents, political uncertainty and nuclear capacity. This section will identify some major events before the 2000s that have influenced on uranium price fluctuations.

3.1 Oil Crisis

In the 1970s, the first and second oil shocks of 1973 and 1978 caused a tremendous surge in the uranium price. The Middle East war, which began in October 1973, used oil as a political weapon, causing increased crude oil prices from about \$3 per barrel to \$11.65. This was the first oil crisis and resulted in the global recession and inflation. In addition to this first oil crisis, the second crisis occurred in 1978 was caused by Iran’s reduction in oil production and the suspension of exports, which eventually led to the price of crude oil at \$40 a barrel. These two oil crises have motivated many countries to create a nuclear boom for the energy security. With the construction of many new reactors, the demand of uranium had increased dramatically, and eventually the price of uranium rose to about 120 USD/lb U₃O₈ in the late 1970s. Lack of uranium supply and increased use of uranium for military purposes also contributed to this price increase [7].

3.2 Three Mile Islands (TMI) and Chernobyl Accidents

The Three Mile Island Unit-2 reactor accident in 1979 ended a massive rise in the uranium price. This terrible accident had silenced the nuclear industry by canceling the planned construction of nuclear power plants and shutting down some of them in operation immediately [7]. This led to a sharp drop in demand for uranium along with the Chernobyl accident in 1986 that helped continue to reduce the price. In addition, relatively less electricity than expected at this time was demanded, provoking the price decline [8]. Ultimately, the uranium price, which peaked at nearly \$120 per pound before the TMI accident, hovered in the mid-10 dollar range due to the rapid cooling of the nuclear industry.

3.3 Influx of Highly Enriched Uranium (HEU)

The former Soviet system collapsed in 1991 and the Cold War era came to an end. Afterwards, Russia begun supplying diluted HEU as the secondary supply into the international uranium market. In 1993, the U.S. and Russian governments signed a contract to supply enriched uranium to use HEU, which is produced by the dismantlement of nuclear weapons, for civilian purpose. Accordingly, several tons of HEU were

supplied to the U.S. every year in the form of diluted low-enriched uranium for the next few decades [9]. In addition to the inflow of HEU, uranium producers and electric power companies have dumped uranium stocks because of the steep decline in the price [10]. As the result of a combination of such factors, the price of uranium dropped to around 10 USD/lb U_3O_8 in the 1990s and this had been maintained over the years due to the supply-demand balance.

3.4 Flooding

Several uranium mines in Australia and Canada were hit by disasters in the 2000s. The McArthur River mine and the newly developed Cigar Lake mine were flooded in 2003 and 2005, respectively, and the Australian Ranger mine was damaged by a record rainfall caused by a cyclone in 2007. Due to these accidents, uranium production was significantly affected. The uranium price soared and peaked at nearly 140 USD/lb in 2007. Besides, the investment sentiment had helped this surge together with the flooding. During this period, uranium speculation occurred due to not only the prospect of increasing nuclear power generation in several countries such as China, Russia, and India, but also the nations trying to hoard before the uranium price go higher. Moreover, other factors—the decrease in uranium stocks, the slump in development of new mines, supplier-oriented market restructuring, and the sustainability of HEU inflow—had accelerated the rush in the uranium price [10, 11].

3.5 Global Financial Crisis

In 2008, the global recession, which began with the U.S. real estate bubble crash and the subprime mortgage crisis occurred in April 2007, also caused excessive disruption in the uranium market. Due to this incident, the skyrocketing uranium price trend was dampened, and the price plunged while the speculative uranium poured out. The price of uranium decreased to about 30% of the peak price at the

time of the sharp rise, reaching 40 USD/lb U_3O_8 in the late 2000s. Despite the low uranium price during this economic downturn, Kazakhstan's uranium production rate rose by about 76 percent in 2008 and this is likely to have contributed to the further price reduction [12].

3.6 Fukushima Accident

After the global financial crisis, the price started to increase again due to power growth, extended lifespan, and new construction of nuclear power plants caused by interest in climate change issues. In addition, China's nuclear power business expansion plan and large-scale long-term contracts announced in 2010 encouraged this price rise [13]. However, in 2011, a sizable earthquake in Japan completely changed the atmosphere for the price increase. The tsunami, which the earthquake generated, struck Fukushima Daiichi Nuclear Power Plant and eventually caused radiation to leak from nuclear power plants in the area. Japan shut down most of the reactors in consequence and demand for uranium declined considerably together with the German government's nuclear phase-out policy. The spot price of uranium went down from about 70 USD to 50 USD per pound and continued to fall since then. Uranium production capacity increased before the Fukushima accident, which also affected the drop in the uranium price [7].

4. Current Issues

4.1 COVID-19 Pandemic

Since 2020, with the spread of COVID-19 pandemic, uranium producers have announced a reduction in uranium production. To prevent the spread of COVID-19 pandemic, various measures have been taken in Canada and Kazakhstan, such as reducing the operation of uranium mines and temporarily shutting down refineries. As a result, the spot price of uranium at the beginning of 2019 was about 20

USD/lb U_3O_8 , but in May 2020 it recorded about 34 USD/lb U_3O_8 .

4.2 Kazakhstan Unrest in 2022

Kazakhstan has been the world's largest uranium producer since 2009. In 2020, Kazakhstan supplied 40% of the world's uranium [14]. Therefore, uranium supply from Kazakhstan appears to be one of the key factors in uranium prices. As we studied, in the early 2000s, the uranium supply shortage caused by uranium mine accidents affected uranium prices. After the government of Kazakhstan decided to abolish the price ceiling system, the price of liquefied gas soared. The unrest in Kazakhstan lasted nine days, but it affected uranium prices. The starting price of uranium in 2022 was 42 USD/lb U_3O_8 , but the spot price soared to around 47 USD /lb U_3O_8 due to the Kazakhstan unrest.

4.3 Russia-Ukraine War

Since the start of Russia-Ukraine war, uranium prices have risen. Although it did not have a direct impact on uranium supply and demand, it seems that European countries started to reconsider the transition to nuclear power to relieve their dependence on Russian oil and gas, which contributed to the surge in the uranium price. The price was \$30.35 per pound in January 2021, \$45 per pound on February 28 (four days after the start of the invasion) and \$52.35 per pound on March 8. The price continued to rise even after April, reaching \$63.75 on April 13.

5. Conclusion

Uranium production and price trend have been addressed in this study. This study presented uranium production trend according to the following years: 1945 to the mid-1960s, mid-1960s to mid-1980s, mid-1980s to 2002, early 2000s to 2010s, and 2010s to 2022. The history of

uranium prices and the key factors such as oil crisis, TMI and Chernobyl accidents, inflow of HEU from Russia, flooding in main mines, global financial crisis, and Fukushima accident have been discussed.

Beyond this history, current issues such as COVID-19 pandemic, the Kazakhstan unrest, and Russia-Ukraine war have also been covered. As we have seen in this study, various international issues have been significantly associated with nuclear power industry and uranium, affecting the uranium production and its price. It also confirmed the importance of a comprehensive and long-term perspective on the supply and price of uranium. This study will help predict uranium prices and establish strategies to secure supplies. Therefore, countries such as South Korea that rely heavily on imported uranium resources could consider diversifying their uranium suppliers and supply chains for a stable supply and demand of uranium. In addition, the endorsing of mid to long term supply contracts will contribute to securing a stable supply of uranium.

Acknowledgements

This study was supported by the Korea Institute of Energy Technology Evaluation and Planning (KETEP No. 20204010600130) and the Ministry of Trade, Industry & Energy (MOTIE) of the Republic of Korea.

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