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# Feasibility Analysis of Cryptocurrency Mining using Nuclear Surplus Electricity

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## 1. Introduction

In modern society, electricity is essential, and its stable supply plays a crucial role in national economic growth and industrial operations. To endure the stable operation of the power system, electricity must be generated in accordance with the expected demand. However, the East Coast region of South Korea, there is a lack of sufficient transmission infrastructure to effectively deliver generated electricity to demand centers. As a result, even when adequate electricity is produced, it cannot be efficiently transmitted to where it is needed, leading to excess electricity (surplus electricity). Therefore, various methods are being explored to effectively utilize this surplus electricity. Legal measures have been established to provide surplus electricity to businesses located in regions affected by transmission constraints, and plans are being developed to utilize surplus electricity in industries such as hydrogen production and steel manufacturing.

This study aims to propose a new strategy for utilizing surplus nuclear electricity generated in the East Coast region by conducting an economic feasibility analysis of its application in high-power consumption industries, such as cryptocurrency mining. This approach could enhance the utilization of nuclear power plants while fostering the development of new industries in the region.

## 2. Methods and Definitions

For the economic feasibility analysis of supplying surplus nuclear electricity to cryptocurrency mining facilities, economic evaluation indicators such as the Benefit-Cost Ratio (BCR), Net Present Value (NPV), and Internal Rate of Return (IRR) are commonly used. Among these, BCR is the most fundamental metric applied in economic feasibility assessments.

### *2.1 Benefit-Cost Ratio (BCR)*

The BCR is calculated by comparing the total costs incurred over the entire project period with the expected benefits. If the BCR exceeds 1, the project is considered economically viable. Additionally, as an indicator representing the benefits relative to costs, a higher BCR value in various economic analysis scenarios suggests superior economic feasibility. Small-scale projects, which generally require lower costs, may exhibit greater economic efficiency than large-scale projects. In Fig. 1, B represents benefit, C represents cost, t denotes time, and r refers to the social discount rate.

$$BCR = \frac{\sum_{t=0}^{n} \frac{B_t}{(1+r)^t}}{\sum_{t=0}^{n} \frac{C_t}{(1+r)^t}}$$

Fig. 1. BCR formula.

### *2.2 Levelized Cost of Mining (LCOM)*

The LCOM serves as a supplementary indicator to the BCR. LCOM represents the cost required to mine a single unit of cryptocurrency and is calculated by dividing the total costs incurred in the operation by the total amount of cryptocurrency mined. While BCR measures the profitability of a project by comparing the costs incurred to the revenue generated, LCOM specifically indicates the cost required to obtain one unit of cryptocurrency.

Given the significant price volatility of cryptocurrency over time, using LCOM alongside BCR provides a more comprehensive assessment of the economic feasibility of the mining operation. By incorporating both indicators, business operators can better determine whether the project is financially viable. For instance, if the LCOM is lower than the market price of the cryptocurrency, it suggests that mining operations could be profitable for the operator.

$$LCOM = \frac{Total\ Mining\ Cost\ (electricity, equipment, etc.)}{Total\ Mined\ (BTC)}$$

Fig. 2. LCOM formula.

### *2.3 Definition of Nuclear Surplus Electricity*

Before analyzing the economic feasibility, it is essential to first define the quantify surplus electricity. Since electricity cannot be stored and must be generated and consumed simultaneously, it is crucial to forecast the required demand and calculate the corresponding electricity production. In South Korea, electricity is not generated, traded, or consumed in real-time. Instead, the power system operates based on an estimation method, where the electricity demand of the previous day is analyzed to forecast the required power generation for the following day.

As of April 2024, the surplus electricity in the East Coast region is approximately 6.7 GW. Based on the proportion of installed capacity, the surplus electricity from NPPs accounts for 3.3 GW. The total installed capacity of power plants in the East Coast region is around 18 GW, with NPPs contributing 8.7 GW. Considering these figures, the proportion of surplus electricity generated by each nuclear power source can be inferred, as shown in Table 1.

Table I: Nuclear Surplus Electricity

| | MW | Capacity (%) | Surplus (MW) |
|---|---|---|---|
| Hanul #1 | 950 | 10.92 | 360.34 |
| Hanul #2 | 950 | 10.92 | 360.34 |
| Hanul #3 | 1000 | 11.49 | 379.31 |
| Hanul #4 | 1000 | 11.49 | 379.31 |
| Hanul #5 | 1000 | 11.49 | 379.31 |
| Hanul #6 | 1000 | 11.49 | 379.31 |
| Shin-Hanul #1 | 1400 | 16.09 | 531.03 |
| Shin-Hanul #2 | 1400 | 16.09 | 531.03 |
| East-Coast | 8700 | 100 | 3300 |

## 3. Results

Before conducting the economic feasibility analysis, assumptions were established as shown in Table II, with the mining period set to a total of five years from January 2019 to December 2023. The selected ASIC model for Bitcoin mining was the Bitmain Antminer S19 Pro, while the AMD Radeon R9 390 was chosen for Ethereum mining using a GPU.

Table II: Elementary Assumption for Calculating

| Item | | Value |
|---|---|---|
| <Capital Costs> | | |
| Loan Cost | | (Initial) 50,000,000 KRW<br>(Monthly) 5,000,000 KRW |
| Equipment Cost | | Mining Machine Price × Number of Mining Machines |
| Additional Cost | | 20% of (Loan + Equipment) |
| Operational and Maintenance Cost | | |
| Electricity | Basic | 7,750 KRW/kW per month |
| | Usage | Generation Tariff of NPP |
| Water Supply | Basic | 1,080 KRW per month |
| | Usage | 1,000 KRW per ton |
| Maintenance Rate | | 2% of Capital Cost |
| Others | | 1% of Capital Cost |

Additionally, the BCR calculation presents the results for both individual NPPs located in the East Coast region and the total combined scenario. In the scenario for individual NPPs, 50 mining machines were assumed to be in operation.

In the case of Ethereum, the consensus mechanism transitioned from Proof of Work (PoW) to Proof of Stake (PoS) on September 16, 2022. However, since the primary objective of this study is to evaluate the economic feasibility of GPU-based cryptocurrency mining, it is assumed that PoW mining was maintained throughout the entire five-year period considered in this analysis.

### *3.1 BCR*

#### 3.1.1 Bitcoin with ASIC

The results of Bitcoin mining using ASIC showed that the BCR exceeded 1 for all NPPs in the East Coast region, except for Shin-Hanul Unit 2. In the case of Shin-Hanul Unit 2, the mining machines operated only during the last two months of the five-year period (January 2019 – December 2023). As a result, the revenue generated was insufficient to offset the costs incurred over the full 60-month operation period. Furthermore, the BCR values not only exceeded 1 but were approximately 10, indicating that the revenue potential could be more than ten times the initial investment under the given business scenario.

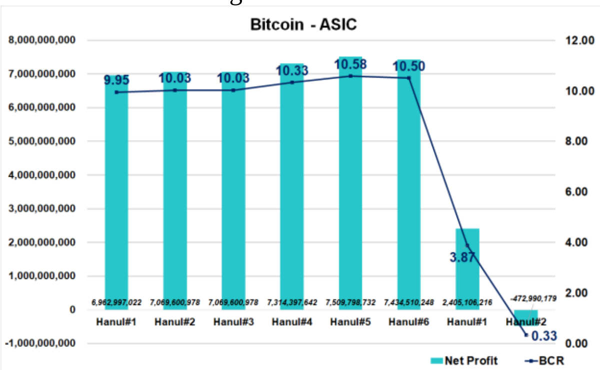

Fig. 3. BCR result of scenario using ASIC to mine Bitcoin.

#### 3.1.2 Ethereum with GPU

The results of Ethereum mining using GPU showed that the BCR exceeded 1 for all NPPs except for Shin-Hanul Units 1 and 2. Shin-Hanul Unit 1 operated for only 19 out of the 60 months, and due to Ethereum's lower market price compared to Bitcoin, the BCR was calculated to be below 1, unlike the Bitcoin mining scenario. Additionally, even for NPPs where BCR was greater than 1, the values remained below 2, confirming that while mining Ethereum could still generate profit, the excepted revenue was significantly lower compared to Bitcoin mining.

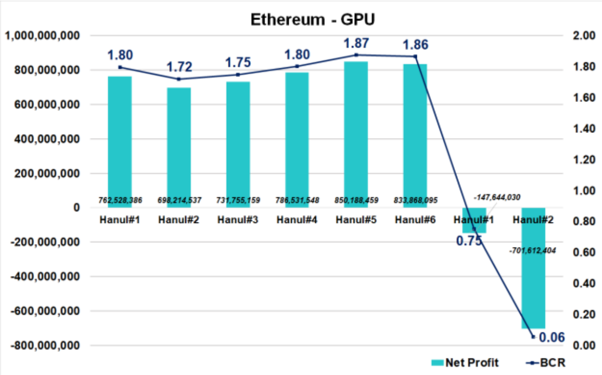


Fig. 4. BCR result of scenario using GPU to mine Ethereum.

A comparison of Bitcoin and Ethereum mining results using surplus nuclear power is presented in Fig. 5. While the BCR values for both scenarios exceed 1, Bitcoin mining demonstrates results that are approximately 22 times higher than Ethereum mining. Net profit and total profit exhibit also disparities of 47 times and 31 times, respectively.

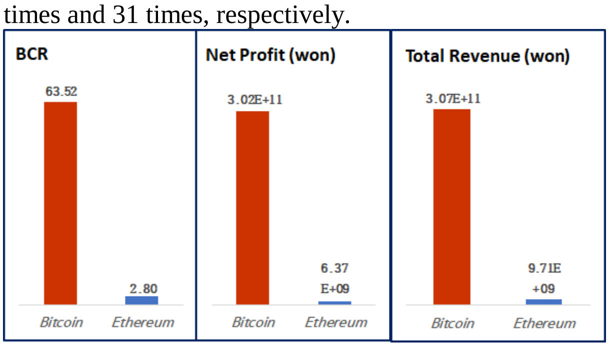


Fig. 5. Comparison of BCR result between Bitcoin and Ethereum scenarios.

Furthermore, although not explicitly shown in the Fig. 5, the break-even point (BEP) for Bitcoin mining is calculated to be just 3 days, whereas for Ethereum mining, it is approximately 30 months. Based on these results, utilizing surplus nuclear power for Bitcoin mining with ASICs appears to be the more efficient approach. However, from a long-term perspective, if a business strategy involves periodically shifting between different cryptocurrencies, GPUs can still be considered a viable alternative in terms of flexibility and adaptability.

### *3.2 LCOM*

The LCOM for Bitcoin using surplus nuclear power was compared with the market price of Bitcoin at different times. The calculation results indicate that the cost of mining one Bitcoin under the proposed scenario is approximately 20 million KRW. As of March 2025, the market price of Bitcoin is approximately 120 million KRW. From the perspective of a business operator, the revenue from the selling the mined Bitcoin is approximately 6 times higher than the incurred mining cost. This suggests that Bitcoin mining under this scenario could be economically viable and worth pursuing.

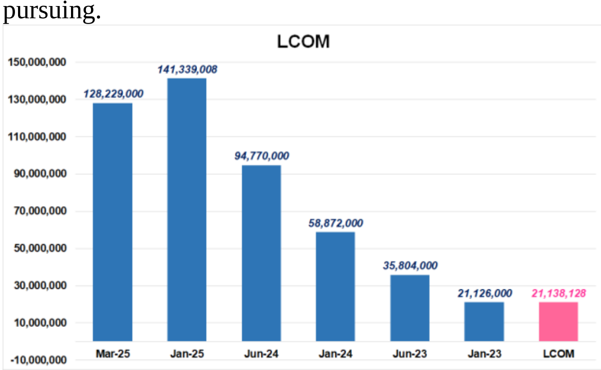


Fig. 6. Comparison of LCOM and Market Price of Bitcoin.

Since cryptocurrency prices exhibit relatively high volatility over time, relying solely on the BCR to determine economic feasibility may be burdensome for business operators. However, by calculating the LCOM and comparing it with the fluctuating market price in real time, it becomes easier to assess the project's economic viability.

### *3.4 Sensitivity Analysis*

The mining results for Bitcoin were analyzed based on the quality of ASIC miners, while the mining results for Ethereum were summarized according to the type and number of GPUs used.

#### 3.4.1 Type of Mining Machinery

Table IV and V present the BCR results for different types of ASICs and GPUs, respectively. A clear trend is observed where a higher hashrate correlates with an increase in BCR. However, models with higher hashrate tend to have higher purchase costs, necessitating careful consideration of factors such as the operator's initial capital and expected BEP.

Table IV: BCR of Bitcoin mining by different type of ASICs

| ASIC | Price ($) | Hashrate (TH/s) | BCR |
|---|---|---|---|
| Bitmain Antminer S19 Pro | 3,230 | 110 | 65.176 |
| Bitmain Antminer S9 | 246 | 14 | 24.426 |
| Whatsminer M30S++ | 2,455 | 112 | 70.206 |
| Canaan AvalonMiner 12 | 3,890 | 90 | 48.274 |
| Bitmain Antminer S17+ | 2,500 | 73 | 50.219 |
| Whatsminer M31S | 2,000 | 70 | 48.720 |
| Innosilicon T3+ Pro | 2,100 | 67 | 45.321 |
| Innosilicon T2 | 1,200 | 32 | 31.978 |

| | | | |
|---|---|---|---|
| Turbo+ | | | |
| Ebang Ebit E12+ | 1,800 | 50 | 41.635 |
| StrongU STU-U8 Pro | 2,000 | 60 | 45.378 |
| Baikal BK-G28 | 1,800 | 28 | 32.051 |

Table V: BCR of Ethereum mining by different type of GPUs

| GPU | Price ($) | Hashrate (MH/s) | BCR |
|---|---|---|---|
| AMD Radeon R9 390 | 2,100 | 29 | 2.801 |
| GeForce GTX 1060 6GB | 293 | 25 | 3.622 |
| Radeon RX 570 8GB | 353 | 29.8 | 2.979 |
| GeForce GTX 1660 Ti | 459 | 29.7 | 3.568 |
| Radeon RX 5600 XT | 555 | 39.6 | 3.511 |
| GeForce RTX 3060 Ti | 916 | 60.6 | 3.844 |
| Radeon RX 6700 XT | 825 | 47.1 | 3.108 |
| GeForce RTX 3080 | 1,666 | 94 | 1.994 |
| Radeon VII | 1,585 | 85.6 | 1.800 |
| GeForce RTX 3090 | 2,620 | 115 | 1.285 |
| GeForce RTX 3070 Ti LHR | 1,167 | 51 | 2.031 |

In the mining hardware industry, the performance of a graphics card is one of the most critical factors. Even when consuming the same amount of power, higher mining performance can result in greater yields; however, more powerful mining equipment tends to be more expensive. Additionally, the cost of mining hardware varies depending on its mining capacity and power consumption. Therefore, selecting the most suitable models based on the business operator's circumstances is crucial. Rather than selecting mining hardware solely based on high performance, it is essential to prioritize models that offer superior price-to-performance ratios.

3.4.2 Number of Mining Machinery

This section focuses on analyzing how the BCR changes as the number of mining machines increases under the same conditions for all NPPs located along the East Coast. As shown in Table VI, the BCR for Bitcoin mining significantly increases as the number of mining machines grows. Given that the maximum number of mining machines that can be operated with 3,300 MW of surplus electricity exceeds 100 million, it is evident that in scenarios involving hundreds of machines, increasing the number of miners leads to greater profitability. If the criterion is simply surpassing a BCR of 1, the results indicate that at least 14 ASIC units are required for the economic benefit to outweigh the costs.

Table VI: BCR of Bitcoin mining by different number of ASICs

| ASIC Number | BCR | | ASIC Number | BCR |
|---|---|---|---|---|
| 10 | 0.566 | | 13 | 0.892 |
| 20 | 1.822 | | 14 | 1.011 |
| 30 | 3.432 | | | |
| 40 | 5.246 | | | |
| 50 | 7.189 | | | |
| 60 | 9.218 | | | |
| 70 | 11.309 | | | |
| 80 | 13.444 | | | |
| 90 | 15.612 | | | |
| 100 | 17.807 | | | |
| 110 | 20.022 | | | |
| 120 | 22.253 | | | |
| 130 | 24.498 | | | |
| 140 | 26.753 | | | |
| 150 | 29.018 | | | |
| 160 | 31.291 | | | |
| 170 | 33.570 | | | |
| 180 | 35.854 | | | |
| 190 | 38.144 | | | |
| 200 | 40.438 | | | |
| … | … | | | |
| 250 | 51.954 | | | |
| 300 | 63.524 | | | |
| 350 | 75.127 | | | |
| 400 | 86.750 | | | |
| 450 | 98.388 | | | |
| 500 | 110.036 | | | |

On the other hand, Table VII reveals a different trend for Ethereum mining. In this case, the BCR surpasses 1 when the number of GPUs reaches 21, peaking at a maximum value of 2.314 at 122 GPUs. However, beyond this point, the BCR gradually declines, dropping below 1 when the number of GPUs reaches 491. This indicates that Ethereum mining using GPUs is less efficient than Bitcoin mining, with peak efficiency occurring at a specific number of GPUs.

Table VII: BCR of Ethereum mining by different number of GPUs

| GPU Number | BCR | | GPU Number | BCR |
|---|---|---|---|---|
| 10 | 0.577 | | | |
| 20 | 0.979 | | 20 | 0.979 |
| 30 | 1.275 | | 21 | 1.012 |
| 40 | 1.502 | | | |
| 50 | 1.683 | | | |

| | | | | |
|---|---|---|---|---|
| 60 | 1.829 | | | |
| 70 | 1.949 | | | |
| 80 | 2.051 | | | |
| 90 | 2.138 | | | |
| 100 | 2.215 | | | |
| 110 | 2.279 | | | |
| 120 | 2.313 | | 122 | 2.314 |
| 130 | 2.298 | | 123 | 2.313 |
| 140 | 2.249 | | | |
| 150 | 2.174 | | | |
| 160 | 2.102 | | | |
| 170 | 2.034 | | | |
| 180 | 1.970 | | | |
| 190 | 1.911 | | | |
| 200 | 1.855 | | | |
| … | … | | | |
| 250 | 1.617 | | | |
| 300 | 1.433 | | | |
| 350 | 1.287 | | | |
| 400 | 1.168 | | | |
| 450 | 1.069 | | 490 | 1.001 |
| 500 | 0.985 | | 491 | 0.999 |
| 550 | 0.914 | | | |
| 600 | 0.852 | | | |

Nevertheless, even in this case, the total profit continues to increase as the number of GPUs grows up to 490. Therefore, if an operator seeks a rapid return on investment, selecting the number of GPUs that maximizes BCR would be ideal. Conversely, if the goal is to achieve higher total profits over a longer period, opting for the maximum number of GPUs that maintains a BCR above 1 would be more strategic choice.

## 4. Conclusions

This study confirms that utilizing surplus nuclear electricity for cryptocurrency mining is economically feasible, as both Bitcoin and Ethereum mining exhibit BCR values exceeding 1 under various conditions. However, Bitcoin mining with ASICs demonstrates higher profitability compared to Ethereum mining with GPUs, primarily due to its greater efficiency and sustained profitability as mining scale increases.

The LCOM analysis further supports the viability of Bitcoin mining, revealing that the cost of mining one Bitcoin is significantly lower than its market price, reinforcing its economic potential. The sensitivity analysis highlights that mining profitability depends on selecting the optimal combination of hardware type and quantity, considering factors such as initial investment, electricity consumption, and expected breakeven periods.

Overall, surplus nuclear electricity presents a viable opportunity for cryptocurrency mining, offering a new avenue for energy utilization in regions with transmission constraints. Future research should explore regulatory frameworks, operational optimization strategies, and potential applications beyond cryptocurrency mining.

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