Economic Feasibility Analysis of Innovative Small Modular Reactor (i-SMR) Applications in South Korea

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1. Introduction

Nuclear energy has been a key component of South Korea's energy mix, contributing to energy security, carbon neutrality, and economic growth [1]. However, traditional large-scale nuclear power plants face challenges such as high initial capital costs and long construction times.

To address these issues, Small Modular Reactors (SMRs) have been developed as an innovative alternative, offering enhanced safety, scalability, and cost-effectiveness [2]. The International Atomic Energy Agency (IAEA) highlights that SMRs can play a crucial role in decarbonization and energy security, particularly in countries with increasing energy demands [3].

South Korea is currently developing the Innovative Small Modular Reactor (i-SMR), a next-generation nuclear reactor designed for higher efficiency and diverse applications. This study examines the economic feasibility of i-SMR in four key application areas:

1. Electricity Generation – Supplying stable power to the national grid.
2. District Heating – Providing heat for residential and commercial areas.
3. Industrial High-Temperature Steam Supply – Meeting process heat demands in chemical and manufacturing industries.
4. Waste Heat Utilization – Repurposing residual heat for secondary applications such as desalination and hydrogen production.

Approximately, the economic feasibility assessment is performed based on construction costs (around $4,000 per kW of electrical output), financing costs, and profitability over an 80-year operational period.

2. Construction Cost Analysis

The construction cost of i-SMR is a major determinant of its economic viability.

The base construction cost is estimated to be $4,000 per kW in terms of electricity output, which is lower than conventional large reactors.

The benefits of modular construction are that factory-made parts can be used to reduce construction time, reduce labor costs, and minimize regulatory delays.

Financial expenses are calculated by assuming a loan interest rate of 5% per year and a 10-year repayment period [3].

Total investment cost factors include design, site preparation, licensing, equipment procurement and installation costs.

The OECD Nuclear Energy Agency (NEA) has emphasized that SMRs can mitigate financial risks by enabling incremental capacity expansion and standardized manufacturing, making them an attractive investment option [3].

3. Operational Profitability Analysis

The economic feasibility of i-SMR is assessed based on South Korea′s energy market prices and expected reactor performance over an 80-year lifespan [2].

Table I: Economic Feasibility of i-SMR Applications

Application Field	Revenue Model	Market Price	Annual Output	Net Present Value (NPV) (Million $)	Profitability Assessment
Electricity Generation	Electricity sales	$0.08 /kWh	7,000 FLH	1,200	High, but market risk
District Heating	Heat supply	$20/ GJ	Seasonal	800	Moderate, stable demand
Industrial Steam Supply	High-temperature steam	$30/ GJ	Continuous	1,500	Highest profitability
Waste Heat Utilization	Heat recovery	Varies	Dependent	900	Moderate, infrastructure -dependent

Industrial Steam Supply is the most profitable application (NPV = 1,500M$) due to stable industrial demand and high energy prices.

Electricity Generation is viable (NPV = 1,200M$) but sensitive to market price fluctuations.

District Heating (800M$) and Waste Heat Utilization (900M$) require policy support and infrastructure investment

4. Comparative Economic Analysis

A cost-benefit comparison of i-SMR applications is illustrated in Figure 1.

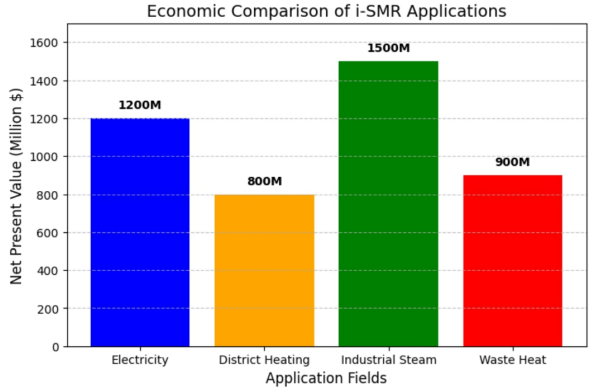

Fig. 1. Economic Comparison of i-SMR Applications

5. Conclusion

Through this study, it was confirmed that industrial high-temperature steam supply is the most economical use of i-SMR. Generation remains a profitable option but requires market stability. District Heating and Waste Heat Utilization need policy incentives and infrastructure investments to be fully viable [3].

To improve SMR economics, regulatory reforms should reduce initial investment risks and simplify licensing and procedures. Various markets, such as stabilizing profits through the introduction of long-term power purchase contracts (PPA), should be developed. The market for technology development should be expanded through cooperation with overseas nuclear institutions through international cooperation.

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