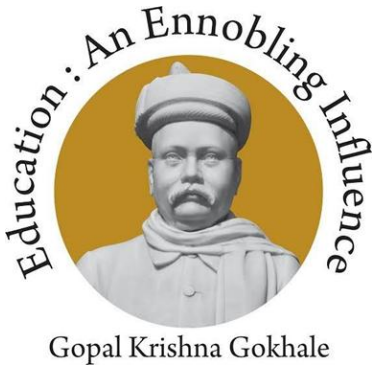
MICROECONOMICS ASSIGNMENT



Risk and Uncertainty in the Application and Usage of Nuclear Energy

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Abstract

The emergence of nuclear energy has received perpetual attention since its inception, yet the uncertainties attached are difficult to calculate and the associated risks have taken various manifestations, growing over time. One of the risks related to difficulty in nuclear decision-making is the possibility of escalatory actions brought about by errors in perception, calculation, or infrastructure. The catastrophic outcomes are well documented in the histories of Chernobyl (1986) and Fukushima (2011), but even so the advancement and development of nuclear energy remains a critical focal point for all policy makers to address the increased complexity of nuclear policies and safety measures surrounding it. We have performed a comprehensive cost-benefit analysis to address the uncertainty of the future of nuclear energy as a result of various socio-economic risks attached to it in the present time, with vital importance to environmental and economic uncertainties. Furthermore, the paper engages in the discussion regarding the dangers of accumulating nuclear waste and its sensitive impact on climate change, in the backdrop of the paradox of choice between hope of clean and abundant energy and the fear of calamitous precedents of nuclear tragedies.

Keywords: *nuclear energy, uncertainty, risk, nuclear waste management, environmental cost.*

Introduction

With the advancement of modern science and technology, there are countless projects that carry an uncertain but potentially high-impact risk of causing catastrophic accidents. One such activity is the application and usage of nuclear energy due to its volatility. Since the very emergence of nuclear power, risks associated with it have taken various manifestations, growing over time. One of the risks related to difficulty in nuclear decision-making is the possibility of escalatory actions brought about by errors in perception, calculation, or infrastructure.

The disastrous outcomes can be sparked by mistakes made by humans or machines during times of crisis and calm alike, owing to incognisance, political agendas, and other irrational or unpredictable variables. For example, the 1986 Chernobyl and the 2011 Fukushima tragedy completely altered the map of the nuclear industry and slowed down the progress of research and development in the field due to the increased complexity of nuclear policies and enhanced safety measures surrounding it.

With that context, this paper tries to engage in a cost benefit analysis to address the uncertainty of the future of nuclear energy as a result of various socio-economic risks attached to it in the present time along with the dangers of nuclear waste accumulation threatening generational sustainability.

Source: The Economist

Literature Review

Nuclear power generates 16% of global electricity and 6% of primary energy, with OECD projecting potential growth to 93,000 TWh/year by 2100, despite ongoing debates about its role in the energy landscape [1]. However, this promising outlook is tempered by significant risks and uncertainties that demand careful consideration.

Matthew Bunn's work provides a balanced perspective on nuclear energy, highlighting its benefits of low-cost fuel usage and low carbon emissions. However, these advantages are counterbalanced by major risks including nuclear accidents, sabotage, and proliferation concerns [2]. This dichotomy underscores the need for a nuanced approach to nuclear energy policy that carefully weighs potential benefits against inherent risks.

Aliberti et al. reminds us of the nuclear data's complexities, stressing energy correlation analysis and database consistency [3]. This uncertainty echoes through Patrick Moriarty's historical perspective on nuclear power, tracing its evolution from early optimism to current challenges [4]. The International Atomic Energy Agency (IAEA) emphasizes the importance of systematic risk management in nuclear facilities [5]. There is an influence of human factors, biases, and cultural elements on nuclear policy [6].

Another research underscores the importance of considering psychological and sociological aspects in nuclear risk assessment and policy formulation. Shifting our focus to economic considerations, a comprehensive study [7] emphasizes the need for thorough cost-benefit analyses in nuclear power investments. H. Stuart Burness draws our attention to the critical issue of nuclear waste disposal, highlighting the limitations of traditional risk assessment methods when dealing with low-probability, high-consequence events [8].

As we look into the future, Ioannis N. Kessides provides a comprehensive analysis of the nuclear industry's future, examining historical trends, the impact of disasters like Fukushima, and the potential of small modular reactors [9]. Finally, insights from managing complex capital projects [10] remind us of the need for flexible, adaptive strategies in this high-stakes, uncertain domain.

Research Gap

- Insufficient methods were stated for quantifying long-term uncertainties in nuclear waste management, especially for low-probability, high-consequence events over millennial timescales.

- Lack of an integrated risk analysis was noticed for next-generation nuclear technologies like small modular reactors and fusions, not combining technical, economic, and social factors at one place to give holistic analysis.

Methodology

To investigate risk and uncertainty in nuclear energy application, this study employed a systematic review and qualitative research analysis. To find pertinent studies published between 2000 and 2024, we searched academic databases and institutional repositories extensively. We extracted information focusing on key themes, such as risk management strategies, public perception, and regulatory challenges. We then synthesized our findings using thematic analysis to highlight common trends and contradictions in the existing literature.

Results

1. Economic Uncertainties:

- Capital Cost: Capital costs involve construction, machines, equipment and labor. These costs are considered to be uncertain simply because the expenses may be high or low depending on the type of nuclear power plant that is being used. To set up a nuclear power plant, initially a huge amount of investment is needed.

- .Operational Cost: The possibility of risk may arise due to the maintenance of the minimum level of cost which may be affected by inflation. Moreover due to safety concerns surrounding the containment of extremely powerful nuclear energy, a lot of investment is sought for security budget in NPPs which makes it an unattractive market for investors.

- Financial Risk: Power plants owned by businessmen have high costs as they are profit oriented. To that end, the fact that Nuclear energy is high profile as well as volatile in nature, requires it to have only quality and state of the art facility and equipment which makes it a financial burden on a lot of investors especially with least to no results given its “blue sky project” nature.

2 . Social uncertainties:

- Environmental Cost: There is a high level of risk involved in accidents due to nuclear reactions. These nuclear reactions may be harmful for the environment specially the quality of air and water may get highly damaged. This has high health impacts and can be harmful not only for this generation but also for the future generations to come, potentially causing body deformity etc. due to its high radioactivity.

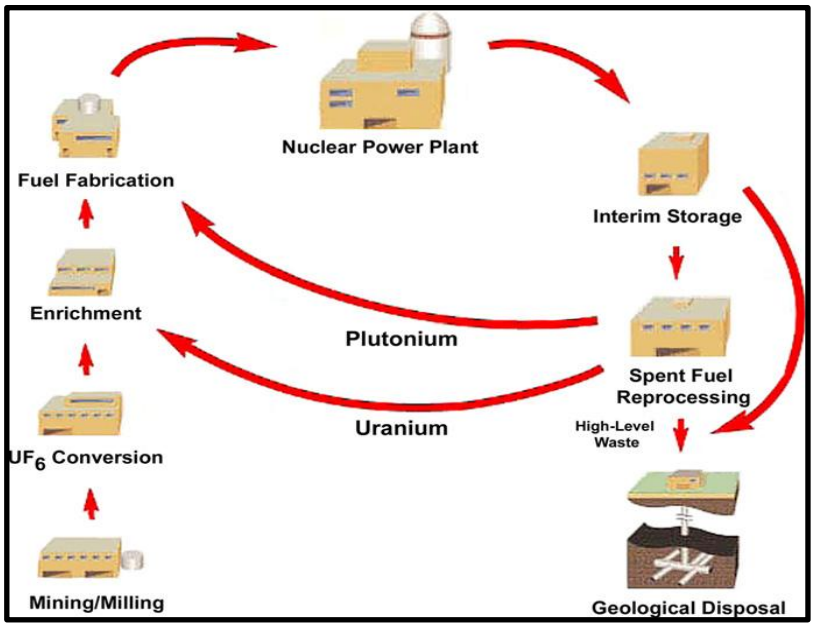
- Political Risk: With political tensions increasing and national sentiments on an all time high, many conservative countries have already threatened use of nuclear weapons on each other to gain hegemony despite the existence of nuclear treaties and policies.

Discussion

The issue of waste disposal has received minimal attention even though nuclear defense projects and public concern over waste disposal exist. The public's fear of catastrophic nuclear mishaps, has grown with government defense and private power initiatives. This worry has recently spread to the field of waste management. The management of radioactive waste is important regardless of one's stance on nuclear technologies. Even if the output of nuclear weapons and technologies were abruptly stopped, a sizable repository of radioactive waste from previous operations would continue to exist.

The disposal of radioactive waste has given rise to a number of distinct and philosophical issues, primarily because of the extremely lengthy time-scales. Waste disposal systems are generally characterized by the uncertainty around their long-term performance.
There can be two types of uncertainty: (1) actual outcomes forecasts, such as individual risk assessments; and (2) safety cases, such as regulatory compliance. The main focus is on how uncertainty affects regulatory decision-making.

Developing countries are facing major problems in the safety management of radioactive wastes because of lack of awareness, infrastructure and absence of regulatory framework. The International Atomic Energy Agency (IAEA) provides technical assistance to developing countries for radioactive waste management including technical coordination projects, coordinated research programmes, training courses and study tours.



Elements of a nuclear power system.
Source: NEEDS (2007a)

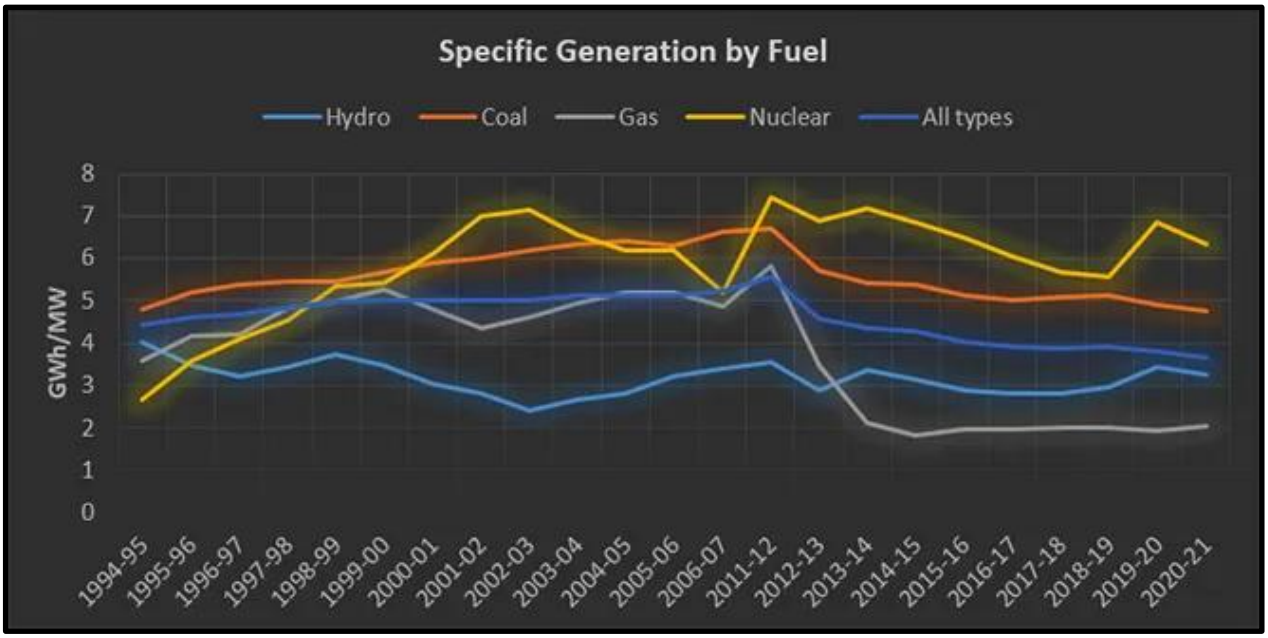
Conclusion

Nuclear energy is at a critical juncture, facing a future full of risks and uncertainties. We uncovered economic challenges, environmental dangers, and difficult waste management issues. The path forward for the nuclear industry is unclear, as it struggles with past disasters and promises of future innovations.While nuclear power offers a potential solution to climate change, it also carries the risk of catastrophic events. This paradox leaves us in a precarious position. On one hand, the allure of clean, abundant energy beckons us forward, promising a world free from the choking grip of fossil fuels. Yet on the other hand, the specter of Chernobyl and Fukushima looms large. As we stand at this crossroads, we must ask ourselves: are we willing to gamble our future on the promise of nuclear energy, or will the weight of its risks prove too heavy a burden to bear?

Limitation

Our study had significant challenges that limited its scope. A key issue was the lack of a comprehensive risk assessment model, making it difficult to navigate the complex factors involved. Additionally, our analysis of India's nuclear landscape was hindered by a lack of reliable data, resulting in a broader, less detailed picture than we aimed for.

Future Scope



Source: Central Electricity Authority

The use of nuclear energy has been encouraged by governments globally, increasing demand for this power source. This change reflects the trend toward accepting nuclear energy as a key part of the world's energy mix.

We can research effective worldwide nuclear projects, prepare scenarios to reduce risks, and push for favorable legislative reforms for the development of sustainable nuclear energy to better understand the Indian context.

Surveys and focus groups can be used to learn more about how the public feels about nuclear energy and how widely accepted it is. It would also be beneficial to look at how nuclear energy may help reduce energy poverty and improve access to clean energy in developing nations. Furthermore, researching international safety regulations and regulatory frameworks pertaining to nuclear energy can offer a thorough grasp of the industry and its prospects going forward.

References

[1] Canton, H. (2021). Organization for economic co-operation and development—OECD. In The Europa Directory of International Organizations. Routledge.

[2] Bunn, M., Roth, N., & Tobey, W. H. (2019). Revitalizing nuclear security in an era of uncertainty. Harvard Kennedy School, Belfer Center for Science and International Affairs.

[3] Aliberti et al. (2006). Nuclear data sensitivity, uncertainty and target accuracy assessment for future nuclear systems. Annals of Nuclear Energy.

[4] Moriarty P. (2021). Global nuclear energy: an uncertain future. AIMS Energy.

[5] Risk Management: A Tool for Improving Nuclear Power Plant Performance. IAEA, Vienna. (2001).

[6] Unal, B., Cournoyer, J., Inverarity, C., & Afina, Y. (2022). Uncertainty and complexity in nuclear decision-making.

[7] Kessides, I. N. (2010). Nuclear power: Understanding the economic risks and uncertainties. Energy Policy.

[8] Burness, H. S. (1981). Risk: accounting for an uncertain future. Natural Resources Journal.

[9] Kessides, I. N. (2012). The future of the nuclear industry reconsidered: Risks, uncertainties, and continued promise. Energy Policy,

[10] Alessandri, T. M., Ford, D. N., Lander, D. M., Leggio, K. B., & Taylor, M. (2004). Managing risk and uncertainty in complex capital projects. The Quarterly review of economics and finance.

[11] Jenkins-Smith, H., & Bassett, G. W., Jr. (1994). Perceived risk and uncertainty of nuclear waste: Differences among science, business, and environmental group members. Risk Analysis.

[12] Kessides, I. N. (2010). Nuclear power: Understanding the economic risks and uncertainties. Energy Policy.

[13] Thomas, K., Baehr, W., & Plumb, G. R. (1989). Radioactive waste management in developing countries: New activities have been initiated to address needs and problems. IAEA Bulletin, 4.

[14] NEEDS (New Energy Externalities Developments for Sustainability), 2007a. Final report on technical data, costs and life cycle inventories of nuclear power plants.