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Studies on Nuclear Cogeneration Plant- A Review

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Abstract

The rise in the standard of living, worldwide growing population and development plans will result in an increase in energy and growing water consumption. For this, we have to install more Nuclear Cogeneration Plant (NCP) or utilized the already installed NCP flexibly and more efficiently within the area of cogeneration applications having power and heat demands of varying nature such as in District heating systems, for seawater or cleaner desalination. The purpose of this study is to discuss how to manage varying energy demands and the need to reduce greenhouse gas emissions. A thermal heat storage system is included in the NCP for this reason, assisting in the delivery of heat to the District heating system while also charging the NCP.

Keywords: *Cogeneration, TESS, SMR, Seawater Desalination, HTTR.*

1. INTRODUCTION

The modern power system is confronted with some major issues that are difficult to reconcile: rising energy consumption and the requirement to reduce emissions of greenhouse gases.By 2040, worldwide main energy demand is expected to grow from 578 to 857 EJ. Several currently operational nuclear reactors can provide heat and power for district heating, which is both main sources of energy.According to predictions, power consumption will increase from 21,500 TWh in 2012 to 36,700 TWh in 2050. Nuclear power, as the world's one of the greatest minimal carbon source of electricity, is currently supplying energy for cogeneration purposes, which have received considerable attention and are being implemented in several countries. Through cogeneration, energy consumption can be improved, CO2 emissions can be reduced, and the final performance of the combined cycle of the power plants can be enhanced.Nuclear power is a technique that helps the production of energy and utility thermal heat without emitting dangerous gases into the environment. By using energy to fulfill the need of heating and cooling is a way for improving the performance of thermal power stations to around 75% while also assisting in meeting the increased demand for heat and moisture without emitting any additional carbon pollution or other damaging pollutants.

Later in the paper, successful existing nuclear cogeneration implementations and failed nuclear cogeneration development proposals are discussed. NPP waste heat can be used for a variety of purposes, including district heating, desalination, hydrogen production, and process heat. The past and present state of district chilling and warming plants around the worldwide, as well as expected developments in hot and cold production is also discussed. Except these considerations, the goal is to provide an up-to-date overview of all nuclear power local heating purposes, both existing and planned.

2. EARLIER STUDIES ON NUCLEAR COGENERATION PLANT

Ghazaie et al. [1] discussed the cogeneration station equipped with latent heat storage that is consistent with the special requirements of an SMR to increase the power plant's pliability in meeting energy demands and minimizes the adverse effects of changing the energy output from the Nuclear power plant's cycle. The proposed TESS design and the ALFRED-based nuclear power plant's economic analysis procedures are also explained. The potential to consider various Nuclearreactors as power sources and other kinds of TESS, like the effects of reactor size, and design savings, that all play a major part in the generated energy price, and also the influence of vapor separation points from the Nuclear power plant's second cycle on the delivered heat price to District heating system, is the technique's key strengths.

Lipkaaand Rajewski[2] investigated the parameters that must be met to expand the number of such plants. Utilizing nuclear reactor energy for local heating and cooling might enhance nuclear power stations' reduced thermal performance while simultaneously meeting growing consumption for heating and cooling and lowering CO_2 from the atmosphere and other emissions.

Sadeghi et al. [3] analyzed the possibility of utilizing the discarded water from the Nuclear power plant's condenser as DP source water. The report's major feature was its extensive testing of power sources for operating the heat DP to enhance the effectiveness of the RO unit's produced water. Integrating solar and SMR-based Nuclear power plant's in a hybrid model, on the other hand, is a viable technique that may be utilized for several other applications.

Jovan et al. [4] studied the creation of green hydrogen by combining hydrogen techniques with electro-energetic networks that use a higher proportion of renewable energy sources to store excess power, as a feedstock in different process sectors, and also as renewable fuels in the warming and automotive industries. In this manner, green hydrogen generation connects various industries, including energy, transportation, and industry.

Dong et al. [5] studied the concept of active disturbance reduction was examined and applied to develop a dynamic control mechanism for NCPs with saturated principal steam. As per numerical modeling findings in capacity-stepping situations, the adaptability of this NCP is enough in managing the matrix.

Kowal [6] established the HTTR electrical system's lifetime dependability and availability in both regular and emergencies. Aside from the data collected, this research demonstrates how to handle the complications and uncertainty of an actual-world interdependence analysis. A high-difficulty problem including lifespan dependability and accessibility parameters for the electricity supply of an HTGR-regulated cogeneration station was effectively solved using the modeling element supplied in this work.

Kowalczyk et al. [7] studied the possibilities of electricity and hydrogen cogeneration, which aims to boost power station flexibility and energy performance under limited loads. Using thermo-electric procedures to produce hydrogen is more cost-effective than using simply electric technologies.Karameldinand Mekhemar[8]studied the site for a station in a water-deficient environment. As per the preceding step for the water shortage and the experimental option for a cogeneration detoxification electricity reactor, a moderate plant for cogeneration of power and groundwater is a viable and practical solution.

Asiedu-Boateng et al. [9]conduteda loop examination of a cogeneration nuclear power plant to examine its performance and distillation vapor needs. To use a mathematical framework of the thermal vapor compaction (TVC) distillation process, the influence of planning and operational variables on parameters determining the price of getting clean water from the TVC procedure was also examined. The analysis indicate that as the productivity of the co - generation nuclear power plant increases, so does the thermal efficiency of the TVC distillation process, but as vapor demand rates rise, so does the thermal efficiency.

Schmidtand Gude[10] recommended that the desalination option has gotten more attractive as the plan's size has grown through the techno-economic study. Water and electricity prices can be cheaper whereas the procedure is more versatile, according to a joint examination of nuclear and other non-renewable forms of energy.Jaskolski et al. [11] presented an innovative analytical technique for a nuclear station operating in half cogeneration state, including its execution. According to a thermal evaluation, running a nuclear power plant at a maximum thermal load of up to 200 MW does not involve modifying main process topologies or nuclear reactor thermal capabilities.

Dong and Pan [12] suggested a lumped criteria dynamic systems framework of an NHR200-II cogeneration, which is mainly comprised of model types of the NHR200-II nuclear heating reactor, U-tube steam generator, deaerator, heat exchangers, and backup gas flow connection, and is focused primarily on the conservation laws of mass, energy, and momentum.McDonald [13] proposed that the major goal of a small transportable mixed nuclear or oil-red co - generation power station is to provide electricity and power to consumers in isolated places such as arctic regions, islands, as well as for urgent usage.

Verfondernet al. [14] conducted an analyticalanalysis on the transfer, dissipates travel, and detonation of a hydrogen cloud in the atmosphere, or the relieve and transport of hazardous substances from the hydrogen production plant to the Nuclear power plant control room.Rosen [15] studied the research on convenience based co - generation would assist Ontario or a location with similar characteristics and energy networks. At the nation's thermal power facilities, co-generation can be accomplished in a number of ways. Utility-cogenerated heat has potential markets in the settlement, particularly in the household and business areas.

3. CONCLUSION

As a result, from the literature review discussed above the different areas that will be covered in this study are as follows.

- The use of this cogeneration facility reduces carbon dioxide emissions by around 119,250 tonnes per year.
- There have been fewer significant fluctuations in power generation ratios among some of the essential goods.
- For the thermal vapour compression distillation process, the heat transfer performance ratio and achieve higher output ratio are the major performance indications, and they reduce when the salt boiling temperature increases and the compression ratio grows.

- The analysis indicates that as the effectiveness of the co - generation nuclear power plant increases, so does the heat transfer performance of the TVC distillation process, but as vapor demand interest rates go up, so does the thermal performance.

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Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

REFERENCES

[1] Ghazaie, S. H., Sadeghi, K., Chebac, R., Sokolova, E., Fedorovich, E., Cammi, A., Ricotti, M.E.&Shirani, A. S. (2022). On the use of advanced nuclear cogeneration plant integrated into latent heat storage for district heating. *Sustainable Energy Technologies and Assessments*, *50*, 101838.

[2] Lipka, M., &Rajewski, A. (2020). Regress in nuclear district heating. The need for rethinking cogeneration. *Progress in Nuclear Energy*, *130*, 103518.

[3] Sadeghi, K., Ghazaie, S. H., Chebac, R., Sokolova, E., Fedorovich, E., Cammi, A., Ricotti, M.E.,&Shirani, A. S. (2022). Towards net-zero emissions through the hybrid SMR-solar cogeneration plant equipped with modular PCM storage system for seawater desalination. *Desalination*, *524*, 115476.

[4] Jovan, D. J., Dolanc, G., &Pregelj, B. (2021). Cogeneration of green hydrogen in a cascade hydropower plant. *Energy Conversion and Management: X*, *10*, 100081.

[5] Dong, Z., Jiang, D., Guo, Z., & Huang, X. (2020). Flexible Control of Nuclear Cogeneration Plants for Balancing Intermittent Renewables. *IFAC-PapersOnLine*, *53*(2), 12560-12565.

[6] Kowal, K. (2022). Lifetime reliability and availability simulation for the electrical system of HTTR coupled to the electricity-hydrogen cogeneration plant. *Reliability Engineering & System Safety*, *223*, 108468.

[7] Kowalczyk, T., Badur, J., & Bryk, M. (2019). Energy and exergy analysis of hydrogen production combined with electric energy generation in a nuclear cogeneration cycle. *Energy Conversion and Management*, *198*, 111805.

[8] Karameldin, A., &Mekhemar, S. (2001). Siting assessment of a water—electricity cogeneration nuclear power plant in Egypt. *Desalination*, *137*(1-3), 45-51.

[9] Asiedu-Boateng, P., Akaho, E. H. K., Nyarko, B. J. B., &Yamoah, S. (2012). Modeling and simulation of cogeneration nuclear power plant for seawater desalination. *Nuclear Engineering and Design*, *242*, 143-147.

[10] Schmidt, J. M., &Gude, V. G. (2021). Nuclear cogeneration for cleaner desalination and power generation–a feasibility study. *Cleaner Engineering and Technology*, *2*, 100044.

[11] Jaskólski, M., Reński, A., &Minkiewicz, T. (2017). Thermodynamic and economic analysis of nuclear power unit operating in partial cogeneration mode to produce electricity and district heat. *Energy*, *141*, 2470-2483.

[12] Dong, Z., & Pan, Y. (2018). A lumped-parameter dynamical model of a nuclear heating reactor cogeneration plant. *Energy*, *145*, 638-656.

[13] McDonald, C. F. (1998). Mobile hybrid (nuclear/oil fired) gas turbine cogeneration power plant concept. *Applied thermal engineering*, *18*(6), 353-368.

[14] Verfondern, K., Yan, X., Nishihara, T., &Allelein, H. J. (2017). Safety concept of nuclear cogeneration of hydrogen and electricity. *International Journal of Hydrogen Energy*, *42*(11), 7551-7559.

[15] Rosen, M. A. (2009). Energy, environmental, health and cost benefits of cogeneration from fossil fuels and nuclear energy using the electrical utility facilities of a province. *Energy for Sustainable Development*, *13*(1), 43-51.