Research Proposal for International MSc thesis
(In collaboration with The University of Sheffield)

Enhancing Safety in Nuclear-Powered Green Hydrogen Production

Project Description:

As the global energy sector shifts toward net-zero carbon emissions, green hydrogen has emerged as a key energy carrier due to its clean-burning nature and potential for decarbonizing hard-to-abate sectors. To ensure truly zero emissions, the production of green hydrogen must be powered by clean energy sources. While renewables like solar and wind are commonly used, nuclear energy provides a highly reliable, low-carbon alternative with the ability to support large-scale hydrogen generation continuously. However, the integration of nuclear power with hydrogen production, particularly through high-temperature electrolysis (HTE) or thermochemical cycles, introduces a novel and complex set of safety challenges. Both nuclear energy and hydrogen systems are inherently hazardous, nuclear facilities involve radiation and reactor safety concerns, while hydrogen is flammable, explosive, and involves high-pressure storage and distribution systems.

This project aims to explore the interfacing safety risks, potential hazard interactions, and risk management strategies necessary to ensure safe and resilient operation of nuclear-powered green hydrogen production facilities.

Research Aim and Objectives

- To identify and evaluate the key safety hazards and develop a comprehensive risk assessment framework for nuclear-powered green hydrogen production systems.
- To review current and emerging technologies for hydrogen production powered by nuclear energy.
- To identify and classify hazards associated with both nuclear power and hydrogen production processes.
- To analyse potential interactions and cascading risks between the two systems.
- To develop a tailored risk assessment methodology applicable to this hybrid system.
- To propose safety design principles, mitigation strategies, and operational guidelines.

Skills Required:

Motivation and skills for data collection, analysis, and modelling. Ability to work collaboratively and communicate effectively. Critical thinking and problem-solving skills.

Learning Outcomes for Students:

By completing this project, students will gain:

- Knowledge of Hydrogen and Nuclear Systems: Understanding design principles and operational challenges.
- Safety and Risk Engineering Expertise: Ability to identify, analyse, and mitigate safety hazards in complex, high-risk systems combining nuclear and hydrogen technologies.
- Data Analysis Proficiency: Skills in collecting, analysing, and modelling data for energy systems.
- Critical Thinking and Problem-Solving: Capability to identify vulnerabilities and develop solutions.
- Collaboration and Communication: Enhanced teamwork and effective communication of technical findings.
- Project Management Experience: Competence in managing research projects and presenting results.

Extra Information or Reading List:

Hoseyni, Seyed Mojtaba, Mohamed Osman Mesbah Mostafa, and Joan Cordiner. "Mitigating risks in hydrogen-powered transportation: A comprehensive risk assessment for hydrogen refuelling stations, vehicles, and garages." *International Journal of Hydrogen Energy* 91 (2024): 1025-1044.

Amer, Mohamed Omar, Seyed Mojtaba Hoseyni, and Joan Cordiner. "Fuelling the future with safe hydrogen transportation through natural gas pipelines: a quantitative risk assessment approach." *Transactions of the Indian National Academy of Engineering* (2024): 1-19.

Najjar, Y. S. (2013). Hydrogen safety: The road toward green technology. International Journal of Hydrogen Energy, 38(25), 10716-10728.

Wei, Ruichao, Jiamei Lan, Liping Lian, Shenshi Huang, Chen Zhao, Zhurong Dong, and Jingwen Weng. "A bibliometric study on research trends in hydrogen safety." Process Safety and Environmental Protection 159 (2022): 1064-1081.

Piera, Mireia, José M. Martínez-Val, and Ma Jose Montes. "Safety issues of nuclear production of hydrogen." Energy conversion and management 47, no. 17 (2006): 2732-2739.

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

Nadaleti, Willian Cézar, Eduarda Gomes de Souza, and Samuel Nelson Melegari de Souza. "The potential of hydrogen production from high and low-temperature electrolysis methods using solar and nuclear energy sources: The transition to a hydrogen economy in Brazil." International Journal of Hydrogen Energy 47, no. 82 (2022): 34727-34738.

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