Energy Transition towards Renewable and Green Hydrogen Energy Systems: Technologies and Prospectives

By Dr. Muhammad Bakr Abdelghany

Course summary

The course "Optimal control of renewable and green hydrogen energy systems for grid services'' provides an in-depth technical foundation for understanding the role of hydrogen in achieving net zero emissions. It addresses the integration of renewable energy sources and the decarbonization of the transportation, industrial, and heating sectors. Participants will engage with the economic considerations of green hydrogen production via water electrolysis, examining cost drivers such as technological advancements and economies of scale. The course delves into key hydrogen technologies, including electrolyzers for hydrogen production, storage systems for gaseous hydrogen, and fuel cells for power and heat generation. Learners will explore advanced modeling methodologies, focusing on the time-dependent dynamics, accuracy constraints, and computational requirements necessary for efficient system design. Optimization strategies, including hybrid dynamical systems and model predictive control (MPC), will be applied to hydrogen energy systems, with in-depth case studies demonstrating their application in real-world scenarios. By combining theoretical knowledge with practical examples, this course equips participants with the technical expertise to optimize hydrogen systems for effective renewable integration and grid service management, contributing to the development of sustainable energy infrastructures.

Key Learning Objectives

- Develop a deep understanding of the role of hydrogen in decarbonizing transportation and industry sectors
- Analyse the cost dynamics of green hydrogen production, focusing on technological advancements
- Develop technical knowledge of hydrogen technologies
- Apply advanced modeling methodologies accounting for time-dependent dynamics
- Implement optimization strategies to enhance the efficiency of hydrogen energy systems
- Apply theoretical knowledge to real-world scenarios, optimizing hydrogen production and grid services

Pre-requisites

- While there are no formal prerequisites for this course, participants are encouraged to have a basic knowledge of Matlab and Python in order to fully engage with the technical content and maximize the learning experience.

Outline

- Introduction to renewable hydrogen production
- Hydrogen technologies and applications
- Value of curtailed hydrogen
- Techno-economic analysis of hydrogen-based systems
- Operation of hydrogen energy systems
- Abstraction modeling of hydrogen energy systems
- Optimization techniques for hydrogen energy systems
- Real-time application of control strategies to integrated hydrogen management systems

Biography

Muhammad Abdelghany

Muhammad Bakr Abdelghany (Senior, IEEE) received the B.Sc. degree in Computer and Systems Engineering and the M.Sc. degree in Electrical Engineering from the Faculty of Engineering, Minia University, Minia, Egypt, in 2010 and 2015, respectively, and the Ph.D. degree in Systems and Control Engineering from the University of Sannio, Benevento, Italy, in 2022. In 2010, he served as a Teaching Assistant with the Department of Computer and Systems Engineering at Minia University, Egypt. He is currently with Khalifa University of Science and Technology (Tenure-track Researcher) and on leave from Minia University (Assistant Professor). His research interests include control synthesis, cyber-physical systems, computer-controlled systems, green hydrogen production, renewable energy systems, and embedded systems. Dr. Abdelghany has supervised/co-supervised 15 Ph.D./Master's students. He is a reviewer for various reputed journals, including the Control Community, Power and Energy Society, and Robotics and Automation Society. He is also a guest editor for a special issue under IEEE Trans. on Industry Applications on control applications in hydrogen energy systems. He was honored with prestigious academic awards, such as an outstanding Reviewer for IEEE Trans. on Sustainable Energy in 2023. Dr. Abdelghany is a senior researcher in several international projects, such as HAEOLUS, H2GLASS, and H2STEEL.