ABSTRACT:

From Hydrogen Production to System Impact: Pathways for Net-Zero Energy Transitions

Canan Acar
Sustainable Energy Transition & Hydrogen Research Group
Faculty of Engineering Technology
University of Twente, 7500 AE Enschede, The Netherlands

Hydrogen can be a key enabler of deep decarbonization across energy, industrial, and transport systems. However, the contribution of hydrogen to net-zero targets depends not only on advances in production technologies but also on how effectively the entire hydrogen value chain is integrated into broader energy systems. This talk provides a panoramic and system-level perspective on hydrogen deployment, linking production pathways to their ultimate system impacts.

The talk first reviews the status of low-carbon hydrogen production routes, highlighting their technological maturity, efficiency, and scalability challenges. It then examines the critical role of infrastructure, storage, and transport solutions in enabling a reliable hydrogen supply that supports industrial integration.

Building on this, the talk focuses on end-use applications in hard-to-abate sectors such as industry, long-distance transport, and flexible power systems, emphasizing the importance of sector coupling and system integration. Attention is given to the techno-economic and environmental implications of hydrogen deployment, addressing efficiency losses across the chain, resource requirements, and the conditions under which hydrogen delivers genuine emissions reductions.

Finally, the presentation discusses realistic transition pathways for hydrogen in Europe and globally, identifying key gaps between current ambitions and practical implementation. Policy frameworks, market design considerations, and system-level optimization needs are highlighted as essential factors for scaling hydrogen in a cost-effective and sustainable way.

By connecting technological developments to the realities of system integration and deployment, this contribution aims to provide a balanced perspective on how hydrogen can most effectively support the transition toward net-zero energy systems.