

## Hydrogen Industry 4.0: A Review on Digital Twin Approaches

**Delaram Ghofrani**

Politecnico di Milano, Italy

**Dr. Narges Fallah**

PhD. Associate Professor, Amirkabir University of Technology, Italy

### Abstract:

Hydrogen is a clean, versatile energy carrier and is considered one of the most favored ways of transitioning into a more sustainable energy future. However, it faces significant challenges in the industry, especially in production, storage, and distribution, which handicap large-scale deployment. On the other hand, Industry 4.0 is expected to lead to advanced new tools and techniques that can solve most of these challenges, with the most promising solution being the digital twin. Digital twins are real-time virtual representation of actual physical systems and allow realtime monitoring, simulating, and optimizing processes relevant to hydrogen. This review will, therefore, present a compact analysis of digital twins' applicability within the hydrogen industry. Building on a brief review of the role of hydrogen in the energy transition and its associated challenges, and introducing the principles and technologies that underpin digital twins and their application to enhancing the efficiency, safety, and reliability of hydrogen systems, A detailed case study is presented where the implementation of digital twins was performed for a hydrogen production facility. The main aim of this review is to reveal the potential of digital twins in this sector, and bring up the main concerns and shortcomings for future research directions.

### Keywords:

Hydrogen production, Digital twin technology, Industry 4.0, Energy transition, Sustainable energy.