


Chapter 23

Scaling Green Hydrogen Production Through AI Innovations: Review of Production Technologies and Global Policies Impact

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ABSTRACT

Green hydrogen, which is produced via water electrolysis powered by renewable energy, has emerged as a favored solution to decarbonize sectors such as transportation, heavy industry and power generation. But things like high production cost, inefficiency, and a difficult operation still pose challenges for its widespread adoption. The transformative potential usually sits with artificial intelligence (AI). The analytics on data through AI algorithms means far better adjusted to live demands with solar and wind inputs for instance. Less energy is wasted and production costs fall. Predictive maintenance, backed with AI-driven algorithms, enables electrolysis systems to run continuously with less downtime, thereby reducing operational risks while ensuring better scalability.

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1. INTRODUCTION

The world's energy landscape is poised for transformation as the pressure to address climate change rises. Such energy carrier that has emerged as a key enabler of this transition is green hydrogen, which represents an abundant and clean renewable option (Islam et al., 2024). Green hydrogen is a zero-emission replacement to fossil fuels created via water electrolysis running from renewable energy sources, providing a sustainable pathway for the decarbonisation of (sectors) hard to abate such as steel-making, chemicals production, aviation and heavy transportation (Sinha et al., 2021). Today, governments, industries and researchers acknowledge the potential of this technology, but scaling production to meet the skyrocketing demand on a global level remains an important challenge alongside technological or economical barriers. Predicting output fluctuations of renewable energy sources, machine learning models can help integrate intermittent renewables to the grid and produce hydrogen continuously.

Green hydrogen is unique in the energy pecking order due to its versatile and spatially diverse opportunities for sector integration. It can be kept for a long time, transferred through pipelines and buses, used in fuel cells to produce electricity or applied as an energy carrier in industrial activities. Even so, the scalability is severely constrained by the high price of production, scarcity of rare earth catalysts materials, low energy efficiency of existing production technologies and absence of storage and distribution system (Salam & Salam, 2020). However, while improvements in production techniques are being investigated, including water electrolysis, biomass-based production and photocatalytic methods, the progress is still too slow to match a decarbonized world by the 2050.

A new paradigm in the form of artificial intelligence (AI) can be the solution to this. With its ability to analyze large volumes of data, discover patterns and trends, and offer predictive analytics, AI has the potential to be a game changer when it comes to scaling up production for green hydrogen. The scope of its application ranges from production upside such as increased electrolysis efficiency to the discovery of new alternative catalysts and other materials. In addition, AI is instrumental in strengthening the coupling of variable renewable energy sources such as solar and wind with hydrogen production systems by guaranteeing that the intermittency associated with these resources does not limit accelerated deployment of green hydrogen. AI impact is not limited to production but spans the complete green hydrogen value chain. For instance, it can automate supply chains by predicting the demand in the market while also allocating resources and optimizing logistics such as storage and distribution. Digital twin and simulation models powered by AI provide stakeholders the unique ability to design and manage hydrogen production facilities through simulations providing a high-fidelity viewpoint of operational conduct (Bibri, 2018). They improve operational efficiencies while providing insights to cut costs, carbon footprints and make the system more reliable.

While there is a strong case for the potential of green hydrogen as a technology, its applicability and widespread adoption are indelibly linked to global policy. The role of governments and international organizations is crucial for its development by enabling through important frameworks, funding mechanisms and regulatory opportunities. Noteworthy sectoral developments spurring traction include the European Union Hydrogen Strategy, U. S. clean energy programs, and hydrogen initiatives in Asia-Pacific to mention a few. Clean Hydrogen Policies Industry-related measures are being implemented in the form of tax incentives for clean hydrogen production, research & development funding, infrastructure investments which have fueled innovation. Divergences in regulatory frameworks, standards and how to define “green” hydrogen differ from country to country presenting a challenge for global cooperation and the functioning of markets. At the same time, AI innovations can help raise matching creative and

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