

Track: Sustainable and responsible business

Green Hydrogen Technology Adoption Model: A framework for sustainable energy transitions for EU 2050 agenda

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Abstract:

This is an integrated literature review (work in progress) to develop a conceptual framework for a green hydrogen technology adoption model (GHTAM). For this purpose, we are currently reviewing the previous research on the theory of planned behavior, the technology acceptance model, and the cognitive appraisal theory in energy transition studies. The methodology is finalized, but the data collection is currently a work in progress. This paper will contribute to the adoption theory for niche energy markets such as green hydrogen (GH) and will help the practitioners to develop business cases through the examination of potential endogenous and exogenous factors that affect GH adoption in diverse ways. We are working on the development of a GHTAM that can be applied in the industry to make the industrial adoption of green hydrogen easy for the achievement of SDG7 i.e., “Ensure access to affordable, reliable, sustainable and modern energy for all”. Additionally, the EU 2050 agenda of curbing overall carbon emissions by 80 to 90 % less as compared to the 1990s levels is our motivation to work on the theoretical development of this model. Achieving this goal involves rigorous efforts in carbon capture, enhancing supply chain efficiency, and transitioning from fossil fuels to green energy. Therefore, this paper aims to support the industry and the policymakers to make necessary interventions in the infrastructure, and policy framework, which can help in the fulfillment of EU’s green future.

Keywords: Technology Acceptance, Technology Adoption, Green Hydrogen, SDG 7, Theory of Planned Behavior, Cognitive Appraisal.

Introduction

Centuries-long usage of non-renewable energy sources with hazardous greenhouse gas emissions in the environment has caused tremendous fluctuations in climate. Around the world, nations are now looking forward to curbing the carbon emissions of industry and households to make this planet sustainable for future generations. One progressive step towards net zero emissions is the usage of green hydrogen to produce electricity. It may look like just extracting hydrogen from a molecule of water through a straightforward process called electrolysis in a scientific lab, but it has become a challenge for governments, and multi-billion-dollar companies. Thus, small & medium scale enterprises are far from acting upon this innovative technology in any way. There is a stark difference between the scientific production of green hydrogen and the industrial production and application of the same for producing electricity for industrial and domestic usage. The theoretical and scientific acceptance of hydrogen has long been achieved but the practical adoption in day-to-day life nearly seems impossible (Hassan et al., 2022).

Production and utilization of green hydrogen at a large scale across the industries, and for domestic use is currently not feasible due to the economic and scientific risks associated with it. While it can be produced using renewable sources such as water and wind, there are significant challenges associated with its complete adoption at potential sites due to its high volatile nature (Velazquez Abad & Dodds, 2020). Mega production requires robust electrolysis of water that would release

highly dense hydrogen, but the current processes produce hydrogen with low density, which is very risky in terms of storage, and transportation for distant locations. Also, the current energy infrastructure is not compatible with transporting, storing, and utilizing green hydrogen and investment in new infrastructure is an economic challenge with ongoing financial crises all over the world. The net cost of producing electricity with fossil fuels is far less as compared to the water electrolysis process, which is a big question mark for this energy transition: Is it politically and economically feasible to adopt GH? The two major concerns are: 1: this huge price gap must be turned around through government subsidies to ensure safe energy transitions, which is indeed a difficult task, and 2: despite the awareness and acceptance of green hydrogen by the governments and the public the current policy framework to support the energy transitions is not clear. Thus, the lack of a clear policy framework delays the readiness for the adoption of green hydrogen by the producers and end users.

The significance and the challenges of a green hydrogen economy are under consideration by global organizations and one such example is the net zero 2050 agenda of the European Union. This agenda includes decarbonization of the current (9.7 Mt) annual production of hydrogen and ensuring a promising GH future by curbing GHG emissions in two steps one from now till 2030, and then a significant increase in GH production by 2050 (Kakoulaki et al., 2021). To address Sustainable Development Goal 7 namely **affordable, and green energy**, the European Commission plans to invest approximately 400 billion Euros in different phases to promote research, and investment in the private sector. These steps are proposed to move one step ahead of hydrogen awareness and ensure adoption in the industry.

To address the problems of private sector businesses for the adoption of GH for a sustainable environment this study proposes to develop a comprehensive theoretical green hydrogen technology adoption model (GHTAM) through an integrated literature review.

Research Methodology

An integrative literature review is found suitable for this study because first, this GH topic is an emerging field that got attention in the literature in 2015 with most of the papers published in the last 4 years, second, the current literature is mostly focused on the awareness, and acceptance of green hydrogen utilization as an energy resource. However, acceptance is an attitude (Lazarus, 199; Oreg et al., 2018) but the current need is to focus on the readiness to change, and adoption of green hydrogen by the business players in the value chain of the GH from production till the utilization, which is yet to be addressed theoretically. According to Torraco (2005), for niche or emerging topics like green hydrogen technology adoption, an integrated literature review is necessary, therefore a synthesis of the representative literature to introduce a new conceptual framework on the aforementioned topic. This is according to the observations of Whetten (1989) that “*the mission of a theory-development journal is to challenge and extend existing knowledge, not simply to rewrite it*” (p. 491). The objective will be accomplished with a detailed analysis of the peer-reviewed papers identified in databases such as Web of Sciences and Scopus.

Synthesis of literature/Green Hydrogen Technology Acceptance Model (work in progress)

This study will integrate the literature on the theory of planned behavior (TPB), the technology acceptance model (TAM), and cognitive appraisal theory to move forward toward the technology adoption model. It will identify the attitudes, emotions, and personal and contextual factors that can design the adoption behavior of businesses for green hydrogen technology. In the context of

sustainable energy transitions, Neves et al. (2022) and Gordon et al., (2024) have provided a unified theory of hydrogen acceptance for the domestic context but the adoption of GH in business-to-business transactions is yet to be addressed. We argue that adoption is an outcome of acceptance, i.e., an attitude in this equation, positive behavior depends on the strength of exogenous, and endogenous factors behind acceptance. Active acceptance would lead to the sustainable adoption of green hydrogen technology, but passive acceptance cannot turn into an adoption behavior (Oreg et al., 2018). The green hydrogen technology adoption is based upon the strength of endogenous and exogenous factors (as shown in figure: 1) which are the potential challenges to achieving a net zero economy and minimizing the internal obstacles of the businesses to change. Initially, it is identified from the narrative literature review that an individual business's capacity to go through an energy transition phase, value chain cost management for adapting green hydrogen technology, and internal risk assessment for adapting green hydrogen technology are the endogenous factors that impact the acceptance of green hydrogen (Gordon et al., 2024). Whereas, the exogenous factors include social justice, trust in the change agents i.e., policymakers and the regulating bodies, growth potential in the market, and external risk assessment (profit projections, and safety risks) can lead to the adoption of green hydrogen (Scott and Powells, 2020).

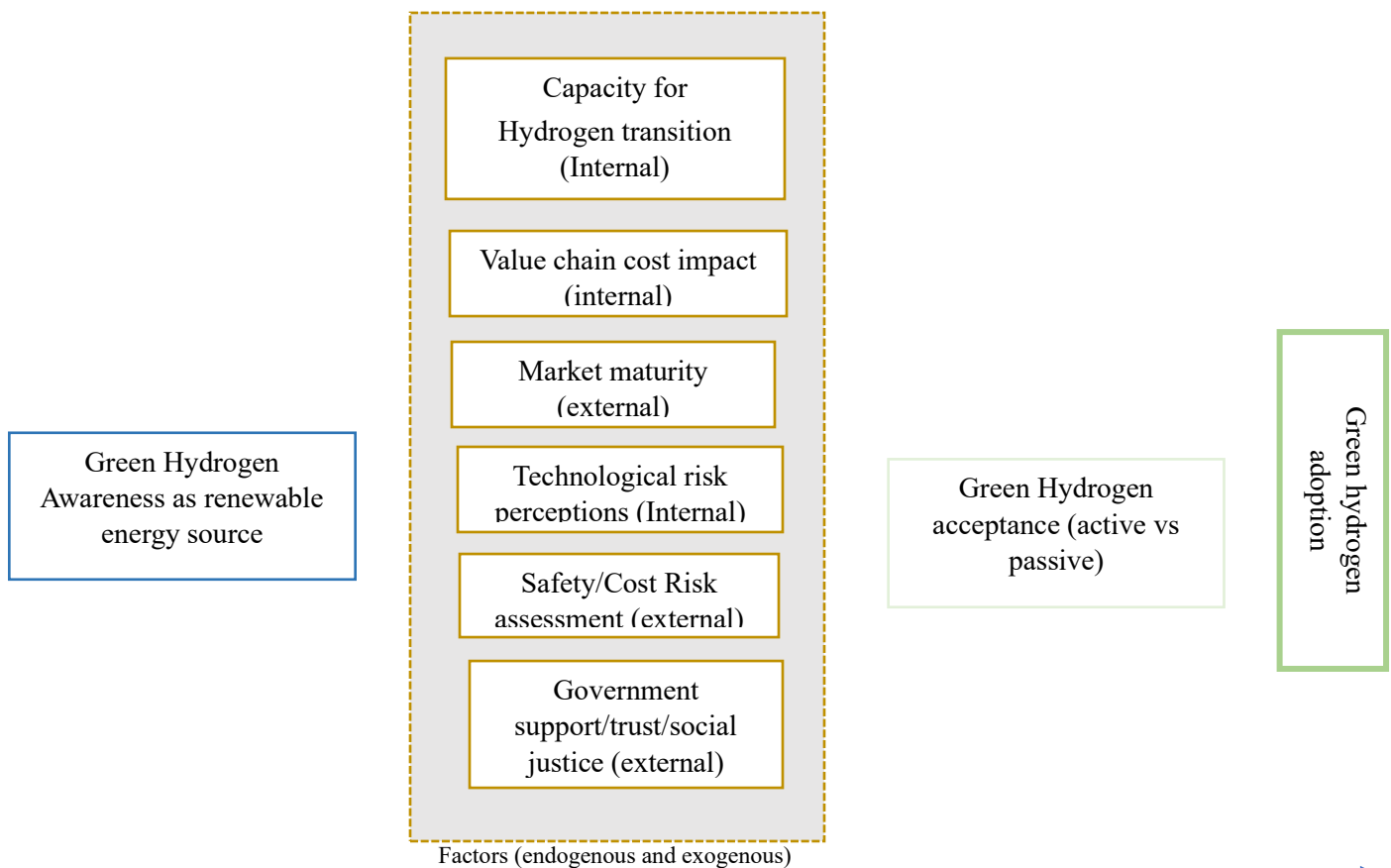


Figure 1: Behavioral Pathway Development for Green Hydrogen Technology Adoption (The cognitive appraisal)

So, the general awareness about the significance of green hydrogen in achieving a net zero economy is there, but the active acceptance or adoption behavior depends upon the coping

appraisal of the endogenous and exogenous factors by the businesses. Based upon the initial literature review of data extracted from Scopus and Web of Science, the above-mentioned flow of factors is identified towards GH adoption behavior that is subject to a redefinition with further development in our literature review synthesis.

Conclusion

This paper is focused on the development of a technology adoption model for the business producers and users of hydrogen. Recently, the awareness of hydrogen has increased multifold but the practical adoption that can make a significant difference in the net carbon emissions of the EU is far from near. The composition of green hydrogen has the potential to fulfill the EU agenda for a green future, but challenges associated with electrolyzers' cost-durability, storage-transportation of highly volatile hydrogen, and development of supportive infrastructure require huge investment, research & development, and long-term commitment to related stakeholders.

The proposed adoption model will help to integrate the upstream user preferences in the overall supply chain of the hydrogen energy sector to achieve a desirable technology framework for businesses. The skepticism associated with hydrogen adoption has been a big question in the proclaimed awareness and acceptance of hydrogen so far. EU 2020 strategy on hydrogen to create demand and products of green hydrogen with the development of supportive infrastructure to accomplish SDG 7 requires a robust practical intervention which will be theoretically supported by this study.

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