

The Chicken and Egg Dilemma of the Hydrogen Economy

Green hydrogen, as an energy carrier, provides a promising solution to various critical energy challenges, including energy security, environmental sustainability, and economic development. It is also an important tool towards meeting the European Union's climate neutrality commitments by 2050. As discussed in an earlier article of our ongoing series on the hydrogen economy, **green hydrogen** - produced by electrolysis of water powered by renewable energy - remains in the very early phases of its development, representing only a small share of the total hydrogen market.

The scaling of the production and consumption of green hydrogen faces a significant hurdle, often termed the **'chicken and egg' dilemma** of the hydrogen economy. The chicken and egg dilemma, simply put, refers to the lack of demand inhibiting production, and vice versa. Although green hydrogen is a potential solution to challenges associated with the energy transition, demand for the commodity remains nascent due to a lack of hydrogen infrastructure and the absence of large-scale production. In this latest article of our ongoing series on the hydrogen economy, we delve into the details of the 'chicken and egg' dilemma examining **hurdles in the supply and demand dynamics**. Additionally, we explore the potential **impact of government incentives** in mitigating this quandary and various strategies to foster the development of this burgeoning industry over the long term.

The Chicken and Egg Dilemma of Green Hydrogen Production

Classically, a 'chicken and egg' dilemma in market dynamics refers to potential market buyers being reluctant to engage with a marketplace lacking a robust array of products or services, and sellers hesitate to enter a market with few buyers. This is reflective of the current state of the green hydrogen market where, on the **demand side**, potential consumers remain cautious due to a lack of clear indicators on the availability, affordability, and reliability of hydrogen. Furthermore, substantial investments are needed to adapt industrial processes that currently rely on natural gas to utilize hydrogen as a viable alternative energy source. Moreover, certain markets lack a clear regulatory framework encouraging the adoption of hydrogen which inhibits the demand growth needed to incentivize production.

On the **supply side**, the major hurdle relates to cost competitive production of green hydrogen. Indeed, achieving cost competitiveness with traditional energy sources requires large-scale investments to achieve economies of scale and sink costs. Significant costs involved in the production of green hydrogen include capital expenditures for constructing electrolysis facilities, the cost of green electricity to power electrolyzers, and expenses related to operations and storage. This makes investors hesitant to commit substantial capital in the green hydrogen sector, without assurances of a stable and expanding market for offtake.

The absence of extensive hydrogen **transportation and storage infrastructure** poses significant challenges for the evolution of both supply and demand in the hydrogen market. Essential infrastructural elements include dedicated hydrogen pipelines and modifications to existing natural gas pipelines for hydrogen compatibility. Additionally, the development of port facilities for hydrogen importation is crucial. However, the realization of such infrastructure necessitates considerable upfront investments, which investors are often reluctant to make due to the currently low levels of supply, demand, and trading.

To overcome these obstacles and establish a stable hydrogen market, considerable investments and proactive government interventions are pivotal.

The Role of the Government

To effectively address the 'chicken and egg' dilemma in hydrogen market development, government initiatives should focus on accelerating growth. It is advisable for governments to design and implement financial incentives, regulatory frameworks, and other supportive stimuli that encourage the construction of hydrogen infrastructures, which affects hydrogen demand and supply. These should particularly target the private sector to promote hydrogen adoption among consumers. Furthermore, regulatory measures tailored to the development of the hydrogen market should complement the financial incentives. Here are some examples of the key strategies and interventions that can be employed:

- **Financial incentives and guarantees**
 - Hydrogen infrastructure bonds: Issuance of bonds backed by future revenues from hydrogen projects to finance the construction of infrastructure.
 - Guarantees on offtake agreements: Agreements to assure hydrogen suppliers of payment for their production and/or purchase of a minimum amount of hydrogen.
 - Government debt guarantees: Guarantees for low-interest loans for private hydrogen project developers.
- **Public-Private Partnerships (PPPs)**
 - Shared infrastructure financing: Collaboration between governments and private entities to develop hydrogen infrastructure.
- **Policy frameworks and supportive regulations**
 - Green hydrogen incentives: Introduction of regulatory and policy frameworks that incentivize green hydrogen production and usage, thereby fostering both supply and demand.
 - Guidelines for carbon offsetting: Establishment of a supportive regulatory framework that includes clear guidelines for carbon offsetting, enabling industries to hedge against emissions by incorporating green hydrogen into their processes.

- **Market creation and demand stimulation**
 - Strategic market creation: Creation of green hydrogen demand through mandates, quotas, or indirect government consumption.
 - Targeted demand stimulation in key sectors: Strategically establishment of green hydrogen consumption in sectors facing challenges related to decarbonization, such as public transport, government facilities, and industries like steelmaking and chemicals.
 - Carbon Contracts for Difference (CCfD) auctions: Implementation of CCfD auctions ensuring stable income for industries using green hydrogen through fixed payments, compensating the difference between an agreed price and the market value for a specified period.
 - Financial risk reduction: Enactment of government intervention, through demand stimulus or auctions, attracts financing for green hydrogen projects, covering investment costs and reducing financial risks.
- **Research and Development (R&D) support**
 - Financing guarantees: Governments guarantees to private entities performing R&D for innovative hydrogen technologies and infrastructure.
 - Grant programs: Competitive grants from the government to support R&D activities focused on advancing hydrogen technologies.

Specific Measures to Promote the Proliferation of Green Hydrogen in the EU and USA

EU

In the EU, promoting the adoption of green hydrogen is a priority, driven by the region's commitment to achieving climate neutrality by 2050. For this, the EU has allocated funds from the European Green Deal, a package of policies launched in 2021 to support research and development within the green hydrogen industry. The funds comprise a combination of grants, subsidies, and low-interest loans, which are sourced from the EU budget, the NextGenerationEU program, national funds, among others. At a national level, member states also seek to develop their policy and funding frameworks. For example, the German National Hydrogen Strategy aims to establish green hydrogen as a key energy carrier, opening new markets and providing a reliable investment framework with international collaboration. Below are a few concrete examples of EU-based funding projects:

- Important Projects of Common European Interest (IPCEI) Hy2Tech: Supports research, innovation, and industrial deployment in the hydrogen technology value chain, which includes the generation of hydrogen, fuel cells, storage, transportation and distribution of hydrogen, and end-users' application by fifteen EU Member States.

- The H2Global Foundation: Introduces a hydrogen auction mechanism to promote the international production of green hydrogen, which is offered at a higher price than conventional hydrogen and resold domestically at a competitive price.
- The H2-Uppp Program: Functions as a development and funding tool, identifying green hydrogen and power-to-X projects in foreign markets through PPPs with German companies commissioned by the German Federal Ministry for Economic Affairs and Climate Action.

USA

Historically, the European Union has taken a leading role in offering incentives to promote climate-friendly policies. In contrast, the United States has at times been less ambitious in its climate policies. Nonetheless, a substantial change occurred in 2022 which aims include the enabling of long-term decarbonisation objectives, increasing U.S. energy independence, and build a robust domestic market for clean hydrogen supported by domestic supply chains. Its main source of funding are tax incentives in the form of transferable tax credits. Long-term goals also include a U.S. leadership role in enabling energy security and resilience across the world. Below are a few additional examples of USA-based funding programs:

- The IRA Clean Hydrogen Production Tax Credit: Offers a range of credit values based on the carbon intensity of the hydrogen production pathway to incentivize the hydrogen industry.
- The H2@Scale: Unites stakeholders to advance affordable hydrogen production, transport, storage, and utilization, fostering decarbonization and revenue opportunities across multiple sectors.
- H2Matchmaker: Supports hydrogen suppliers and users in identifying cooperation partners and opportunities to develop regional hydrogen centres via an online resource tool.
- The individual states implement many more initiatives such as, hydrogen power generation and transportation projects at a local level.

Conclusion

In conclusion, addressing the 'chicken and egg' dilemma of the hydrogen economy is crucial for the successful proliferation of green hydrogen as a key component of the global energy transition. The journey towards a robust hydrogen economy requires overcoming significant supply and demand hurdles through strategic investments, government incentives, and the development of a supportive regulatory framework. Both the European Union and the United States are taking decisive steps to foster the growth of the green hydrogen market

through financial incentives, public-private partnerships, and targeted demand stimulation strategies. By enhancing research and development efforts and creating a conducive environment for the adoption of green hydrogen, these regions aim to catalyze the energy sector's transition towards sustainability and climate neutrality. The transition to a hydrogen economy still however requires substantial investments in large-scale production, transportation, distribution, and storage capacity. The collaborative efforts between governments, industries, and stakeholders promise to navigate the complexities of the hydrogen economy, gradually resolving the 'chicken and egg' dilemma and paving the way for a greener, more sustainable energy future.