THE FUTURE OF HYDROGEN ENERGY: TRENDS, CHALLENGES AND NEEDS OF HYDROGEN WITHIN EACH STAGE OF THE VALUE CHAIN

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Overview

The European Union is aiming greenhouse gas emissions reduction of 95% by 2050 Weidner et al. (2016), which means that there is an urge for a less polluting, zero-emission, and sustainable energy alternative Árnason (2000). Hydrogen, with its favorable physical characteristics, is considered to be the future of the energy sector. In the recent years, the vast amount of literature in the subject has focused on forecasting, backcasting, roadmaping, and writing visionaries about the hydrogen economy. But, none of them has targeted the value chain technologies and the challenges that the hydrogen energy will face within the each stage of the value chain in the future. This paper contributes to the technological transition theories in general, and the technology push and market pull theory in particular. It uses one of the completest worldwide patent publication data sources (Lens patent database) for 56 years (1960-2016), and combines both quantitative and qualitative methods to forecast not only the technological trends but also the challenges that the hydrogen technologies in each stage of the value chain (production, storage, delivery, and application) will face within the next 5 years. The results show that hydrogen production, storage, and usage technologies are in their maturity phase, while hydrogen transportation and delivery technologies have already saturated. High production costs, system efficiency, and generation of hydrogen from the fossil fuels are considered to be the main challenges of hydrogen production. System weight and volume, system cost, and efficiency will be the three main challenges of hydrogen storage, while infrastructure and costs will challenge the transportation and price, infrastructure, and efficiency will limit the usage of hydrogen.

Methods

This study uses both quantitative and qualitative methods to forecast the technological trends and challenges of hydrogen in the medium term of 5 years. Although various techniques exist for forecasting technological performance, this paper applies logistic growth curve model using patents because patents contain up-to-date and reliable information about inventions Yoon, Choi, & Kim (2010). The data collected from the Lens is used as input for the logistic fits. Besides, the parametric bootstrapping is applied with 95% confidence level to determine the precision of the fits. The bootstrapping method is used to recreate and resample data using Monte Carlo iteration methods Efron (1979). Since the historical data and statistical techniques are not sufficient and feasible to forecast the challenges that hydrogen will face in each stage of the value chain, the qualitative method of expert opinion is used in this paper to extract information from the experts and forecast the probable challenges and needs of each component of hydrogen value chain. This method can assist us in problem identification and collecting some economic, social, environmental, and technical perspective from the experts.

Results

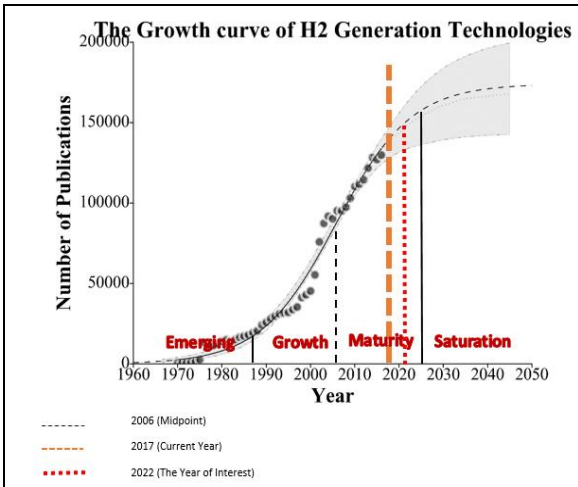

Fig 1) The hydrogen generation technology

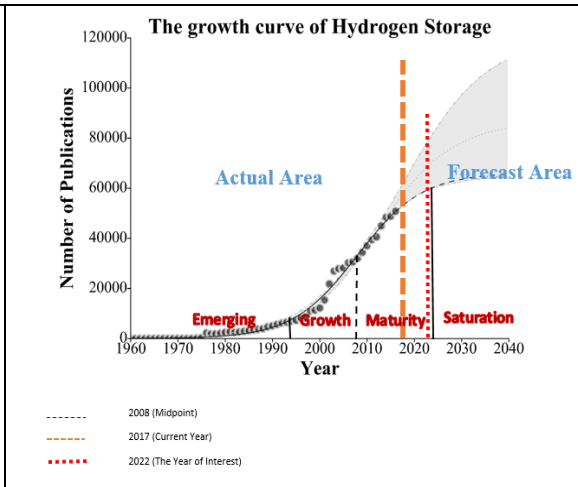

Fig 2) The hydrogen storage technology

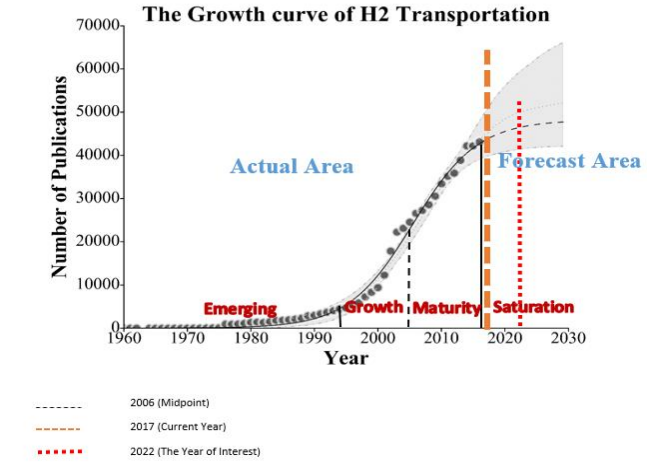

Fig 3) The hydrogen transportaion technology

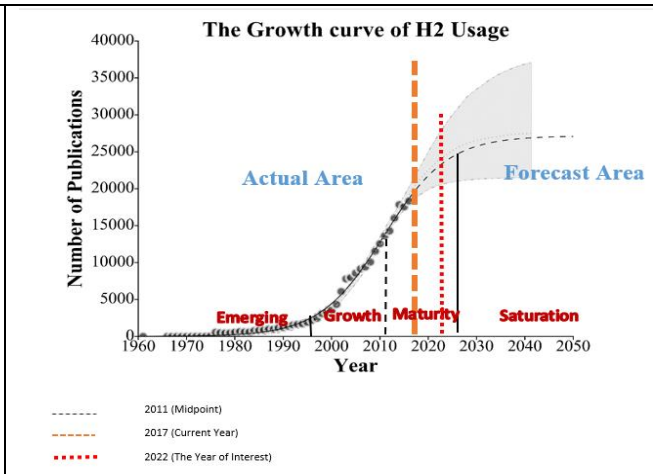

Fig 4) The hydrogen usage technology

The hydrogen generation technologies along with hydrogen storage technologies are in their maturity phase and will continue to grow slowly until the forecasting year of our interest (2022). The hydrogen transportation technologies have already saturated. It is predicted that the saturation stage of the hydrogen usage will start in 2026 and currently the technology is in the maturaty stage. Expert's believe that production costs, system effecieny, environmental concerns, and policies are considered as the main challenges of H2 production, while system cost, system weight and volume, and efficiency are mentioned as main barriers for H2 storage. Infrastructure, costs and safety conditions are conserning the transportation of H2, and price, infrastructure and efficiency are the main challenges for the end usage of H2 energy.

Conclusions

It can be concluded that the rapid growth of energy demand, high dependence on fossil fuels, and environmental contamination is urging a renewable, non-polluting, and sustainable energy source. Although there have been many studies done in the field, none of the forecasts are for the medium term, based on a theory, done for all the stages of the value chain, and used a compact worldwide dataset. This paper fills the gap and its findings can be used to gain insight into the relative payoff of investment in competing technologies. It can be suggested to investors and managers of the companies to invest in technologies that still have not saturated and for the researches to investigate topics related to the technologies that are still in their earlier stages of development.

Despite all the advantages that hydrogen as an energy carrier have, the question is why it has not succeeded yet? Why the countries have failed to adopt the technology although it is in its maturity stage? Most experts believe that the answers to these questions go back to the policies and the interests of the nations. High costs of capital and low costs of incumbents have created a barrier to adoption of hydrogen and fuel cells.

References

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