

( 続紙 1 )

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| 論文題目  | Clarifying Progress and Potential of the Transition to a Hydrogen Economy:<br>A Study of Historical Developments, Societal Perceptions, and Expert Perspectives<br>(水素社会への移行における進捗と可能性の明確化：歴史的発展、社会的認識、<br>専門家意見の調査) |    |             |
| (論文内容の要旨)   |  |    |             |
| <p>The Hydrogen Economy has been a concept for the mitigation of greenhouse gas emissions and other pollutants from our current carbon-based economy, as well as for potential energy security benefits, since the 1970`s. Japan, along with a number of other countries, has invested heavily in the research and development of hydrogen technologies to achieve this vision. However, in the 50 years that this idea has been discussed in academic, government and industrial spheres, there appears to have been minimal progress. This study aimed to examine the progress of the hydrogen economy from multiple perspectives, and to gauge to what extent there has been real progress, or alternatively, to what extent the idea remains in a cycle of hype. It also sought to understand the current status of the hydrogen economy.</p> <p>The thesis is composed of five chapters.</p> <p>Chapter 1 provides the broad introduction to the background of the research.</p> <p>Chapter 2 systematically reviews the literature with regards to the progress and plans for the hydrogen economy at different scales and from alternative perspectives.</p> <p>In Chapter 3 an extensive and systematic bibliometric study examines the academic and mass media literature, and the International Energy Agency (IEA)'s hydrogen project database to trace the progress of the hydrogen economy and the developing drivers since its inception in 1972. It indicates the apparent hype cycles, in which the hydrogen economy`s progress has been minimal, while media and academic publication have shown waves of increased and decreased interest.</p> <p>In Chapter 4, the opinions and understanding of Japanese general stakeholders were surveyed online with 2,880 respondents, and the results were compared to three prior surveys to examine potential changes since 2008. The results show a gap in public understanding of hydrogen, with factual knowledge lower than self-reported knowledge. The respondents were divided on their</p> |  |    |             |

preference for green vs grey hydrogen production, with cost and environment being key factors. Public perception is mostly neutral with more positive than negative responses, while acceptance for hydrogen applications varies, with transportation receiving the most support.

Chapter 5 shows the results of a survey of 65 experts in energy and hydrogen from 22 countries to understand their perspective on the past, present and future prospects of the hydrogen economy. These experts anticipate the emergence of a hydrogen trade landscape, with countries acting as exporters, importers, or transit hubs. In the short term, experts are divided on the preferred hydrogen method (grey, blue and green all considered to be required). However, in the mid and long term, there is a clear consensus among experts that it is preferable to transition towards green hydrogen.

Chapter 6 then provides overall conclusions and indicates potential future research to extend and improve knowledge from this study.

The novel contributions of this thesis lie in its multi-stakeholder perspective, temporal focus, and a series of studies that consider various types of data (retrospective publications, community and expert opinions) in the development of the hydrogen economy. Unlike existing studies, this research uniquely integrates a historical overview, as presented in Chapter 3, dating back to the inception of the hydrogen economy in 1972, with contemporary primary data from both community and expert surveys covered in Chapters 4 and 5. This synthesis provides a nuanced understanding of how public and expert opinions have evolved over time, set within a broader historical context. Moreover, the thesis adopts a holistic systems perspective to comprehensively evaluate the entire hydrogen supply chain, from production to distribution, offering intricate details about its development and implementation. Lastly, the study serves as a real-time snapshot of current perspectives, laying the groundwork for future academic inquiries, policymaking, and industry strategies.

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(論文審査の結果の要旨)

This thesis aimed to conduct a comprehensive analysis of the transition to a hydrogen economy. To achieve this, the study provides a detailed overview of the hydrogen economy through historical, public, and expert perspective. This thesis methodically examines these aspects through an historical analysis and two survey questionnaires. The novel contributions of this thesis are as follows:

#### 1. Historical Overview of the Hydrogen Economy

This study conducts an analysis of the historical development of the hydrogen economy since its inception in 1972, including a bibliometric analysis tracing the evolution of the hydrogen economy and its drivers over time. The study sheds light on the cycles of hype apparent in this period. Understanding the historical context is crucial to recognizing how perceptions of the hydrogen economy have, and might continue, to evolve.

#### 2. Primary Data Collection

The study undertook two surveys, producing primary data from the perspective of experts and the community.

- Community Survey: This provided insights into attitudes on the hydrogen economy in a Japanese context, highlighting a knowledge gap, a degree of optimism, and the need for effective communication strategies to bridge this gap.
- Expert Survey: Expert opinions on the hydrogen economy were obtained, identifying past and current challenges, drivers, and views on future potential.

#### 3. Holistic Systems Temporal Perspectives

The study adopts a system perspective, evaluating the hydrogen supply chain from production to distribution. The study also emphasized temporal perspectives to consider the evolution of attitudes and opinions over time.

Overall this thesis provides a multi-dimensional exploration of the hydrogen economy, capturing its historical development, current perspectives and future prospects. The results from this research can significantly inform policy decisions, industry strategies, and future research directions in the realm of the hydrogen economy.

よって、本論文は博士（エネルギー科学）の学位論文として価値あるものと認める。また、令和5年10月26日実施した論文内容とそれに関連した試問の結果合格と認めた。

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